Final Damage Assessment and Restoration Plan/ Environmental Assessment for the July 25-26, 2010 Enbridge Line 6B Oil Discharges near Marshall, MI

Prepared by:

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Nottawaseppi Huron Band of the Potawatomi Tribe
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In Cooperation with:

National Oceanic and Atmospheric Administration
Michigan Department of Environmental Quality
Michigan Department of Natural Resources
Michigan Department of Attorney General

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EXECUTIVE SUMMARY

On July 25, 2010, Lakehead Line 6B (Line 6B), a 30-inch diameter pipeline owned and/or operated by Enbridge[1], ruptured near Marshall, Michigan, and began discharging crude oil into a wetland adjacent to Talmadge Creek. The oil flowed through Talmadge Creek into the Kalamazoo River, a Lake Michigan tributary. The Kalamazoo River was in floodstage at the time of the discharge, and the oil flowed down the river and into its floodplain for approximately 38 miles, to Morrow Lake. The Kalamazoo River is bordered by wetlands, floodplain forest, residential properties, farm lands and commercial properties between Marshall and the Morrow Lake dam. Aquatic and floodplain habitats were oiled as were birds, mammals, turtles and other wildlife. The river was closed to the public for the remainder of 2010 and all of 2011, reopened by sections during 2012, but then some sections were closed again in 2013 and 2014 for additional dredging of submerged oil.

The Trustees have not made an independent determination of the volume of oil discharged and estimates made by others vary. Enbridge, for example, has estimated that the discharges of July 25 and July 26, 2010 resulted in the release of more than 20,000 barrels (840,000 gallons) of oil (Enbridge Line 6B Oil Discharges) while other estimates have been substantially greater than this. Response actions have been intensive and have included recovery of floating oil, stranded oil in the floodplains of Talmadge Creek and the Kalamazoo River, and submerged oil. The United States Environmental Protection Agency has directed the response and the Michigan Department of Environmental Quality is responsible for the long-term remediation and restoration of areas affected by the spill under authorities provided by state law.

This Final Damage Assessment and Restoration Plan/Environmental Assessment (Final DARP/EA) has been prepared by U.S. Fish and Wildlife Service, Nottawaseppi Huron Band of the Potawatomi Tribe, and Match-E-Be-Nash-She-Wish Band of the Pottawatomi Indians in coordination with the National Oceanic and Atmospheric Administration, Michigan Department of Natural Resources, Michigan Department of Environmental Quality, and Michigan Department of the Attorney General, collectively acting as Trustees for the restoration of natural resources and public use services that were exposed and/or injured by the Enbridge Line 6B Oil Discharges. This Final DARP/EA is issued to inform the public concerning the Trustees' authorities and responsibilities under the Oil Pollution Act (33 U.S.C. § 2701, *et seq.*) and the National Environmental Policy Act, as amended, 42 U.S.C. § 4321 *et seq*.

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[1] Responsible Parties in this matter include: Enbridge Energy, L.P., Enbridge Pipelines ("Lakehead") L.L.C., Enbridge Energy Partners, L.P., Enbridge Energy Management, L.L.C., Enbridge Energy Company, Inc., Enbridge Employee Services, Inc., Enbridge Operational Services, Inc., and Enbridge Pipelines Inc. (hereinafter "Enbridge" or "Responsible Party")

The Trustees evaluated a range of restoration alternatives which would provide resource services to compensate the public for losses pending natural recovery of resources exposed or injured by the Enbridge Line 6B Oil Discharges. The Trustees have selected restoration alternatives, including projects that provide for wetland and floodplain restoration, upland habitat enhancements, dam removal, culvert replacements, lake fisheries habitat improvements, projects to specifically benefit significantly impacted species, wild rice restoration, and projects to improve natural resource use by the general public and tribal members.

Some types of restoration are expected to be achieved through restoration projects that will be implemented in accordance with requirements of Michigan law, under the direction of the State of Michigan in consultation with Trustees, and some recreational use projects that Enbridge has completed in the area affected by the Enbridge Line 6B Oil Discharges. Restoration projects which have been or will be implemented under the direction of the State of Michigan include wetland restoration, restoration of Talmadge Creek, removal of the dam on the Kalamazoo River at Ceresco and restoration of over 2.5 miles of river channel, erosion control and restoration of large woody debris along the impacted sections of the Kalamazoo River, and several types of monitoring with potential additional restoration actions as necessary.

To adequately compensate for injured natural resources and lost services, the Trustees have selected additional restoration alternatives that will be implemented under the joint direction and control of all Trustees. These additional projects include three projects to improve aquatic connectivity and water quality in Rice Creek and Pigeon Creek, tributaries to the Kalamazoo River that join it near Marshall, Michigan and Talmadge Creek, by replacing undersized and perched culverts and lowering a berm to connect the creek and its floodplain; funding to improve the fishery in at least two lakes within the Fort Custer State Recreation Area by controlling invasive species for at least 3 years; funding to restore 175 acres of oak savanna uplands in the Fort Custer State Recreation Area; a project to improve and monitor turtle reproduction in the impacted section of the Kalamazoo River; a project to restore wild rice in at least two locations in the Kalamazoo River; and a project to better understand and encourage the use of the river corridor by tribal members.

The Final DARP/EA briefly summarizes the Enbridge Line 6B Oil Discharges, spill response, restoration to pre-spill baseline conditions, and legal authorities (Chapter 1); summarizes natural resources found in the area affected by the Enbridge Line 6B Oil Discharges (Chapter 2); describes the nature and extent of the natural resources exposed and/or injured and the lost public uses resulting from the Enbridge Line 6B Oil Discharges (Chapter 3); provides a discussion of restoration options to enhance natural resources affected by the Enbridge Line 6B Oil Discharges (Chapter 4); and provides additional analysis of the selected Trustee actions pursuant to the National Environmental Policy Act (Chapter 5) .

ABBREVIATIONS

Abbreviation	Description
CCCD	Calhoun County Conservation District
DARP/EA	Damage Assessment and Restoration Plan/Environmental Assessment
DOI	U.S. Department of the Interior
DSAYs	Discounted Service Acre Years
EA	Environmental Assessment
EIS	Environmental Impact Statement
FCRA	Fort Custer Recreation Area
FONSI	Finding of No Significant Impact
GLEC	Great Lakes Environmental Center
HAI	Health Assessment Index
HEA	Habitat Equivalency Analysis
MAG	Michigan Department of the Attorney General
MDEQ	Michigan Department of Environmental Quality
MDNR	Michigan Department of Natural Resources
NEPA	National Environmental Policy Act
NHBP	Nottawaseppi Huron Band of the Potawatomi Tribe
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NRDA	Natural Resource Damage Assessment
NREPA	Natural Resources and Environmental Protection Act
OPA	Oil Pollution Act of 1990
PAH	Polycyclic Aromatic Hydrocarbons
RP	Responsible Party
SCAT	Shoreline Cleanup and Assessment Technique
SHPO	State Office of Archeology and Historical Preservation
SORT	Shoreline and Overbank Reassessment Technique
SSCG	Scientific Support Coordination Group
U.S. EPA	United States Environmental Protection Agency
USDA APHIS	U.S. Department of Agriculture's Animal and Plant Health Inspection Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

COMMON AND SCIENTIFIC NAMES

Common Name	Scientific Name
Insects:	
Aquatic Weevil	*Euhrychiopsis lecontei*
Mitchell's Satyr Butterfly	*Neonympha mitchellii*
Birds:	
American (Common) Merganser	*Mergus merganser*
American Black Duck	*Anas rubripes*
American Coot	*Fulica americana*
American Gallinule (Moorhen)	*Gallinula chloropus*
American Widgeon (Baldpate)	*Anas americana*
American Woodcock	*Scolopax minor*
Blue-winged Teal	*Anas discors*
Bufflehead	*Bucephala albeola*
Canada goose	*Branta canadensis*
Canvasback	*Aythya valisineria*
Cerulean Warbler	*Setophaga cerulea*
Common Goldeneye	*Bucephala clangula*
Gadwall	*Anas strepera*
Grasshoper Sparrow	*Ammodramus savannarum*
Great Blue Heron	*Ardea herodias*
Green Heron	*Butorides virescens*
Green-winged Teal	*Anas crecca*
Henslow's Sparrow	*Ammodramus henslowii*
Lesser Scaup	*Aythya affinis*
Mallard	*Anas platyrhynchos*
Northern Bobwhite Quail	*Colinus virginianus*
Northern Pintail	*Anas acuta*
Redhead Duck	*Aythya americana*
Red-headed Woodpecker	*Melanerpes erythrocephalus*
Ring-necked Pheasant	*Phasianus colchicus*
Snow Goose	*Chen caerulescens*
Trumpeter Swan	*Cygnus buccinator*
Whistling (Tundra) Swan	*Cygnus columbianus*
Wild Turkey	*Meleagris gallopavo*
Wilson's Snipe	*Gallinago delicata*
Wood Duck	*Aix sponsa*
Mammals:	
American Beaver	*Castor canadensis*
Coyote	*Canis latrans*
Eastern Cottontail Rabbit	*Sylvilagus floridanus*

Fox squirrel	*Sciurus niger*
Indiana Bat	*Myotis sodalis*
Muskrat	*Ondatra zibethicus*
Racoon	*Procyon lotor*
Red Fox	*Vulpes vulpes*
Striped Skunk	*Mephitis mephitis*
White-tailed Deer	*Odocoileus virginianus*
Amphibians/Reptiles:	
Blanding's Turtle	*Emydoidea blandingii*
Eastern Box Turtle	*Terrapene carolina carolina*
Eastern Massasauga Rattlesnake	*Sistrurus catenatus catenatus*
Eastern Spiny Softshell Turtle	*Apalone spinifera spinifera*
Map Turtle	*Graptemys geographica*
Northern Copperbelly Water Snake	*Nerodia erythrogaster neglecta*
Painted Turtle	*Chrysemys picta*
Snapping Turtle	*Chelydra serpentina*
Spotted Turtle	*Clemmys guttata*
Fish:	
Blacknose Dace	*Rhinichthys atratulus*
Blackside Darter	*Percina maculata*
Brown Trout	*Salmo trutta*
Central Mudminnow	*Umbra limi*
Common Carp	*Cyprinus carpio*
Common Shiner	*Notropis cornutus*
Creek Chub	*Semotilus atromaculatus*
Golden Redhorse Sucker	*Moxostoma erythrurum*
Grass Pickerel	*Esox americanus*
Green Sunfish	*Lepomis cyanellus*
Johnny Darter	*Etheostoma nigrum*
Largemouth Bass	*Micropterus salmoides*
Mottled Sculpin	*Cottus bairdii*
Northern Pike	*Esox lucius*
Rock Bass	*Ambloplites rupestris*
Sand Shiner	*Notropis stramineus*
Smallmouth Bass	*Micropterus dolomieu*
Spotfin Shiner	*Notropis spilopterus*
White Sucker	*Catostomus commersoni*
Yellow Bullhead	*Ameiurus natalis*
Yellow Perch	*Perca flavescens*
Plants:	
Black Locust	*Robinia psuedoacacia*
Black Walnut	*Juglans nigra*
Box Elder	*Acer negundo*

Carolina Fanwort (Cabomba)	*Cabomba caroliniana*
Downy Sunflower	*Helianthus mollis*
Eurasian Watermilfoil	*Myriophyllum spicatum*
False Boneset	*Kuhnia eupatorioides*
Hackberry	*Celtis occidentalis*
Hickory	*Carya spp.*
Lead Plant	*Amorpha canescens*
Oak	*Quercus spp.*
Starry Stonewaort	*Nitellopsis obtusa*
Water lilies	*Nuphar spp. & Nymphea spp*
Wild River Rice (Mnomen)	*Zizania aquatica var. aquatica*

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1.0 INTRODUCTION

1.1 Purpose and Need for Restoration

This Final Damage Assessment and Restoration Plan/Environmental Assessment (Final DARP/EA) is intended to inform members of the public concerning the natural resource injuries caused by the Enbridge Line 6B Oil Discharges and selected restoration projects that will compensate for those injuries. This document is part of a Natural Resource Damage Assessment (NRDA) being performed pursuant to the Oil Pollution Act of 1990 (OPA) by the Department of the Interior, represented by the U.S. Fish and Wildlife Service (USFWS); the Department of Commerce, represented by the National Oceanic and Atmospheric Administration (NOAA); the Nottawaseppi Huron Band of the Potawatomi Tribe (NHBP); the Match-E-Be-Nash-She-Wish Band of the Pottawatomi Indians (Gun Lake Tribe); the Michigan Department of Natural Resources (MDNR); the Michigan Department of Environmental Quality (MDEQ); and the Michigan Department of the Attorney General (MAG), collectively known as the Trustees.

This Final DARP/EA also serves as an Environmental Assessment under the National Environmental Policy Act (NEPA) and addresses the potential impact of the selected restoration actions to be implemented under the direction of the Trustees pursuant to this DARP/EA on the quality of the physical, biological, and cultural environment. As described in detail below, this plan includes a variety of restoration projects to be undertaken in the Kalamazoo River watershed.

The purpose of restoration, as outlined in this Final DARP/EA, is to make the public whole for injuries to natural resources and natural resource services resulting from the Enbridge Line 6B Oil Discharges by returning the injured natural resources and natural resource services to their "baseline" condition (i.e., the condition that would have occurred but for the spill) and compensating for associated interim losses.

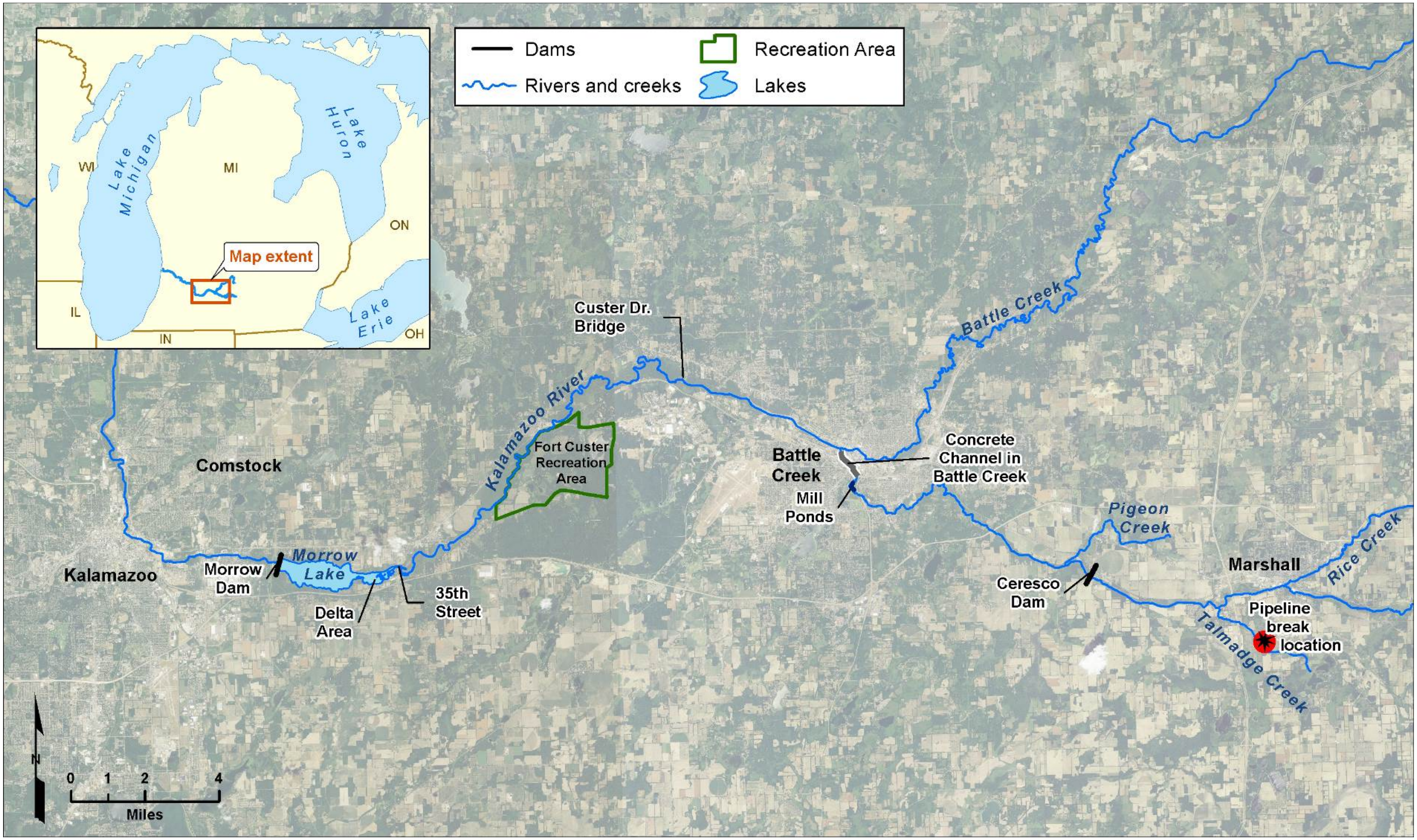
The regulations for conducting a sound NRDA to achieve restoration are found at 15 C.F.R. Part 990. These regulations were promulgated pursuant to the OPA to determine the nature and extent of natural resource injuries, select appropriate restoration projects, and implement or oversee restoration. This Final DARP/EA presents information about the affected environment (Chapter 2), the Trustees' estimates of exposure and/or injury and service losses to natural resources caused by the Enbridge Line 6B Oil Discharges (Chapter 3) and the Trustees' selected restoration alternatives (Chapter 4). Additional analysis of the selected Trustee actions pursuant to NEPA is provided in Chapter 5. Trustees sought comments on the restoration alternatives proposed in the draft DARP/EA and considered the comments (Appendices J and K) when creating this Final DARP/EA.

The Trustees have reached a proposed settlement of natural resource damage claims with Enbridge, the Responsible Party under OPA for the Enbridge Line 6B Oil Discharges. Terms of the proposed settlement are subject to public notice and comment, and the settlement is subject to approval by the United States district court. Following the public comment period on the proposed settlement, if the Trustees seek judicial approval of the settlement, and the district court approves the settlement, then the Trustees will implement restoration projects and/or oversee implementation of restoration projects that are consistent with this Final DARP/EA and the Consent Decree.

1.2 Summary of Enbridge Line 6B Oil Discharges

On July 25, 2010, Lakehead Line 6B, a 30-inch diameter pipeline owned by Enbridge, ruptured near Marshall, Michigan, and began discharging crude oil into a wetland adjacent to Talmadge Creek. The oil saturated that wetland and then flowed through Talmadge Creek into the Kalamazoo River, a Lake Michigan tributary. The Kalamazoo River was in floodstage at the time of the discharge, and the oil flowed down the river and into its floodplain for approximately 38 miles, to Morrow Lake (Figure 1.1). The Kalamazoo River floodplain that was oiled includes wetlands, floodplain forest, residential properties, farm lands and commercial properties. The source area and Talmadge Creek floodplain that were oiled or impacted by the response consisted primarily of wetlands, including a fen-like community.

Figure 1.1. Map Showing Location of Enbridge Line 6B Oil Discharges



Although the Trustees' evaluation of natural resource injuries resulting from the Enbridge Line 6B Oil Discharges that occurred during July 25 and 26, 2010 depends on the studies and analyses discussed below in Chapter 3, rather than on the volume of oil discharged, the Trustees note that there have been numerous estimates of the volume of oil discharged. For example, Enbridge has estimated that the July 25 and 26, 2010 discharges from Line 6B released 20,082 barrels or 843,444 gallons of crude oil. Other estimates have been substantially higher, and the Trustees have not made an independent determination of the volume of oil discharged. The discharged oil consisted of two batches of heavy bituminous crude oil from the oil sand regions of Western Canada diluted with lighter petroleum products to enable the crude to flow more easily (National Transportation Safety Board, 2012).

Initially, the oil appeared to be floating on the surface of the river and flooded areas, but after several days MDNR Fisheries biologists reported that black flakes and sheen appeared when they disturbed the bottom of the river, and the responders realized that oil was sinking to the bottom of the river. Submerged oil was eventually found throughout Talmadge Creek and in depositional areas of the Kalamazoo River up to and including parts of Morrow Lake. Oil was also found stranded in vernal pools and other low areas in the floodplain.

1.2.1 Summary of Response Actions

Enbridge began responding to the Enbridge Line 6B Oil Discharges on July 26, 2010. Within the first day, they constructed an underflow dam in the wetland near the source area, installed oil sorbent and containment boom in the Kalamazoo River at two parks in Battle Creek and used vacuum trucks to recover oil from the source area underflow dam, from the Talmadge Creek stream crossings on Division Drive and 15 1/2 Mile Road, and from the Kalamazoo River at Heritage Park (National Transportation Safety Board, 2012; selected photographs in Appendix A). MDNR and the public were already observing oiled wildlife on July 26, so the U.S. Fish and Wildlife Service (USFWS) advised Enbridge to mobilize professional rehabilitators and begin building rehabilitation facilities that evening. Enbridge activated a hotline for the public, and USFWS provided recommendations on what information to collect and what advice to give anyone calling to report oiled wildlife sightings.

On July 27, 2010, the United States Environmental Protection Agency (U.S. EPA) issued an Administrative Order under Section 311(c) of the Clean Water Act to Enbridge and assumed leadership of a Unified Command in its role as Federal On-Scene Coordinator (FOSC). The Unified Command changed over time, but on August 9, 2010, for example, it included representatives from U.S. EPA, Enbridge, the Michigan Department of Natural Resources and the Environment (which was reorganized into MDEQ and MDNR during the course of the response), Michigan State Police Emergency Management Division, Calhoun County Public Health Department, Calhoun County

Sheriff, Kalamazoo County Sheriff and the City of Battle Creek (U.S. EPA, 2010a). U.S. EPA served as Incident Commander and led the Unified Command throughout the response. U.S. EPA issued multiple Administrative Orders and letters to Enbridge over the course of the response, with the last issued in March 2013 instructing Enbridge to complete additional submerged oil recovery through dredging, by December 31, 2013 (http://www.epa.gov/enbridgespill/documents.html). That deadline was not achieved; however, Enbridge completed required dredging by September 2014. MDEQ will be responsible for oversight of the long-term remediation and restoration of areas affected by the Enbridge Line 6B Oil Discharges under state law authorities.

Immediately following the start of the Enbridge Line 6B Oil Discharges in July 2010, county health agencies closed public access to 39 miles of the river system to protect public health and safety. Initially, lighter constituents of the oil, including benzene, posed a hazard to inhalation. Direct contact with the oil in the river and floodplain and hazards from the response activities were also public health and safety concerns. Eventually, on April 18, 2012, a three-mile portion was opened from Perrin Dam in Marshall to Saylor's Landing near 15 Mile Road and the Kalamazoo River. On June 21, 2012, the remainder of the river was opened for public use, although certain areas remained marked off by buoys to exclude the public from active work areas posing a safety risk. In addition, the Michigan Department of Community Health issued a Fish Consumption Advisory and a Swimming Advisory, both of which were in place until June 28, 2012. Parts of the river were closed again in the summer and fall of 2013 to exclude the public from active work areas posing a safety risk. This included a stretch of the river in Battle Creek between Paddler's Grove and the Mill Ponds that was closed from August 16, 2013 to May 23, 2014. Specific to U.S. EPA-required dredging activities, the river was closed at the 35th Street Bridge in Galesburg to Morrow Dam from July 25, 2013 through July 3, 2014. A smaller reach from the 35th Street Bridge to the E 4.0 Boat Launch remained closed until September 12, 2014. Upstream, the river was closed from the Saylor's Landing site in Marshall to the 12 Mile Road Bridge in Ceresco on July 24, 2013 to accommodate dam removal and river restoration activities and was reopened on October 7, 2014.

During the early days of the response, Enbridge and its contractors established over 30 oil containment-and-control points along 38 miles of the Kalamazoo River. The control points consisted of a variety of oil containment strategies, including underflow dams, oil booming, and sorbent booming. Vacuum trucks and oil skimmers were used to remove oil at these locations (National Transportation Safety Board, 2012). Enbridge and its contractor, Focus Wildlife, built and began operating a Wildlife Response Center with the Wildlife Branch of Operations. The USFWS led the Wildlife Branch and worked with MDNR, the U.S. Department of Agriculture's Animal and Plant Health Inspection Service (USDA APHIS), and others to survey for and capture oiled wildlife.

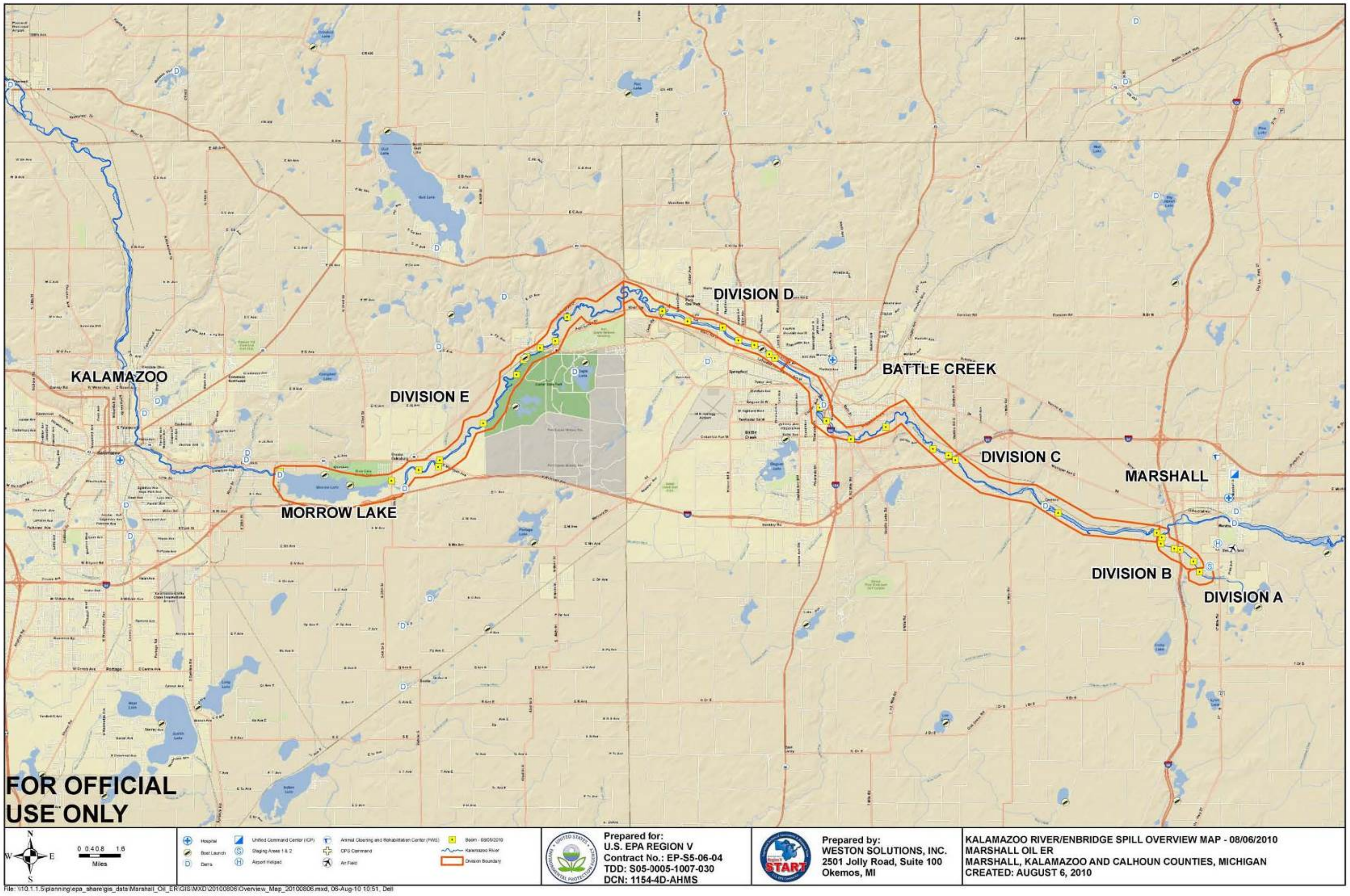
The U.S. EPA completed Situation Reports (Sitreps) for each operational period of the response. Each Sitrep contains detailed information on many different aspects of the response as it was collected from agencies, contractors and Enbridge in real time. U.S. EPA has made all of these available at http://www.epa.gov/enbridgespill/documents.html#sitreps. Information from Sitreps, as well as from other cited sources and Trustee observations, is used in the next several paragraphs to describe the response at key or representative time points.

By July 31, 2010, the spill area had been divided into five operational segments arranged from upstream to downstream (Figure 1.2): Division A (source/release area in Marshall), Division B (Talmadge Creek), Division C (confluence of Talmadge Creek with the Kalamazoo River to the Angell Street Bridge), Division D (Angell Street Bridge to the Calhoun/Kalamazoo County line), Division E (Kalamazoo County Line to Morrow Dam).

By August 8, 2010, over 1,200 personnel were on-site and 24-hour operations included operation of 37 booms (161,413' total; marked in yellow on Figure 1.2) and corresponding collection points with skimmers and vacuum trucks, excavation of the source area and the shoreline along Talmadge Creek, cutting of oiled water lilies and other aquatic vegetation, removal of oiled vegetation and debris along the Kalamazoo River shoreline, surveying by Shoreline Cleanup and Assessment Technique (SCAT) teams, sampling of water and sediment, evaluation of residences for re-occupation based on benzene concentrations in air, and daily helicopter flights (U.S. EPA, 2010a). On that day, the USFWS reported that the Wildlife Branch continued to collect oiled animals along the Kalamazoo River and operate the Wildlife Response Center with 171 animals in live care, the majority of which were Canada geese and turtles. The Wildlife Branch had also implemented deterrence tactics to attempt to keep additional wildlife from coming into contact with the oil.

By August 26, 2010, approximately 1,800 personnel were on-site. Operations continued on a 24 hour per day basis and included operation of 33 surface booms (145,118' total) and corresponding collection points, plus gabion baskets filled with oil snares and X-TEX filter curtains being operated to collect oil moving downstream in the water column and with bedload sediment transport (U.S. EPA, 2010b). In addition, crews were continuing excavation in the source area and along Talmadge Creek and backfilling excavations. Enbridge reported laying swamp mat road along Talmadge Creek and constructing berms, flumes, and mat roads. U.S. EPA had created a Submerged Oil Task Force to assess and address the problem of submerged oil. Submerged oil and sheen were observed in Morrow Lake. Over 160 boats were being operated in Division C of the Kalamazoo River (from Talmadge Creek to Battle Creek) alone, and that number was expected to increase. Crews were completely removing vegetation from islands, cleaning pools of oil from island interiors, and continuing to cut oiled vegetation along all divisions of the Kalamazoo River. SCAT surveys, sampling of air, water and sediment, and daily helicopter flights continued. On that day, the USFWS reported that the Wildlife Branch continued to collect oiled animals along the Kalamazoo River and operate the Wildlife Response Center with 229 animals in live care and a total of 335 animals that had been rehabilitated and released.

Figure 1.2. Map Showing Location of Divisions Used for Response to Enbridge Line 6B Oil Discharges



By the fall of 2010, response operations were focused on completing shoreline and overbank cleanup in quarter mile sections of the river, stabilizing excavated areas for the winter, submerged oil investigations, and planning for winter activities. Numerous cleanup completion reports were finalized in September of 2010 (See http://www.epa.gov/enbridgespill/data/index.html#collection and http://epa.gov/enbridgespill/data/scat.html for more details.) By mid-October, the leadership of the Wildlife Branch was transferred to Enbridge as the last rehabilitated birds were released and the cooling temperatures were resulting in fewer oiled turtles being active enough for capture.

In the winter of 2010-2011, Enbridge continued excavation of contaminated soils in the floodplain. They created "frost roads" across wetland areas that allowed them to access contaminated wetlands along the river while intending to minimize soil compaction. They performed work on a daily basis and worked in 17 locations (U.S. EPA, 2011a). Enbridge maintained turtles over the winter that had not been rehabilitated sufficiently to be released in the fall. As spring arrived and ice melted, Enbridge re-installed booms along the Kalamazoo River.

In the summer of 2011, U.S. EPA directed Enbridge to address more than 220 areas in the river that still were moderately to heavily contaminated with submerged oil and were resulting in sheen and flakes being released as the water warmed (U.S. EPA, 2011b). Enbridge used a variety of techniques to agitate the sediments and collect oil and sheen that came to the surface as a result. These techniques included using pumps to jet water or air into the sediments as well as using mechanical techniques like rotary tiller heads to agitate the sediments. Enbridge also continued excavation of contaminated floodplain soils. Entire islands in the river were excavated and backfilled, or in certain instances removed, to address continuing releases of oil. Networks of muskrat burrows that had accumulated significant amounts of oil contributed to the islands being continuing sources of oil to the river.

Also in 2011, Enbridge investigated and remediated impacted areas in and adjacent to Talmadge Creek. Enbridge mobilized workers to conduct a remedial investigation to evaluate the extent of soil, sediment, and groundwater contamination resulting from the Enbridge Line 6B Oil Discharges in the Talmadge Creek area. Based upon the results of the remedial investigation, Enbridge conducted remedial actions to remove affected soil and sediment and brought in clean soil of similar soil types to backfill and restore the channel bed, bank, and overbank to approximate pre-spill conditions. Enbridge then used native vegetation seed mixes and live plantings in an effort to stabilize site conditions. Enbridge collected and analyzed numerous soil and sediment samples during the removal work in an effort to verify the effectiveness of remedial actions in achieving compliance with state law.

In the winter and spring of 2011-2012, U.S. EPA assembled a group of environmental experts to form the Scientific Support Coordination Group (SSCG). Each participant provided the Scientific Support Coordinator (SSC) with their opinions evaluating the short- and long-term effects of the remaining oil balanced with potential damage to the environment of continued response work through a Net Environmental Benefits Analysis (Fitzpatrick et al., 2012). In support of this work, the SSC recommended to the FOSC that additional sediment analysis, toxicity testing of sediments in areas with submerged oil, and modeling of the expected movement of submerged oil under different flow conditions, and this work was quickly completed. In addition, the SSCG reviewed the time course of results from repeated surveys designed to detect submerged oil, estimates of recoverable oil remaining in the area, and the types of oil recovery techniques being proposed for the summer of 2012. As a result of these evaluations, the FOSC decided to shift the oil recovery tactics from the intensive sediment agitation and excavation work that had been conducted in 2011 to more passive tactics in 2012, including installation of sediment traps and sheen management, i.e. monitoring the river and dispatching boat crews to absorb sheen when it appeared. This strategy was coordinated with a program to dredge major impoundment areas to optimize recovery while minimizing ecological damage.

According to the National Transportation Safety Board (2012): “As of April 30, 2012, the EPA reported that over 17 million gallons of oil and water liquid waste had been collected, from which an estimated 1.2 million gallons of oil had been recovered by the spill response contractors. In addition, about 186,398 cubic yards of hazardous and nonhazardous soil and debris were disposed of, including river dredge spoils.” Thus, the volume of oil that had been recovered by the response by early 2012 was greater than the volume estimated to have been spilled, and additional oil remained associated with sediments in the river at that time.

On March 14, 2013, U.S. EPA ordered Enbridge to remove Line 6B oil and oil-containing sediment along parts of the Kalamazoo River where concentrations of submerged oil were continually being detected through poling techniques. Areas dredged are upstream of the Ceresco Dam, in the Mill Ponds area in Battle Creek, in Morrow Lake, Morrow Lake Delta and adjacent areas, and in two of the sediment traps. Enbridge is obligated to continue monitoring and operating traps that gather remaining contaminated sediment and submerged oil pursuant to the State Settlement.

MDEQ has been working closely with U.S. EPA and Enbridge to ensure that Enbridge’s response work will also meet requirements under state law. MDEQ is also overseeing Enbridge’s long-term cleanup and restoration efforts consistent with state law authorities, as described further in Section 1.2.2.

1.2.2 State of Michigan Authorities and Settlement

The State of Michigan has authorities for response, NRDA and mitigation under Michigan’s Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA). As a part of these authorities, the MDEQ has entered into a settlement agreement with Enbridge (State Settlement) that includes several components that will restore impacted areas and provide compensation for wetland losses, impacts to the stream channel, and lost recreational uses. Also, the State Settlement provides for monitoring of spill impacts and restoration success along with adaptive management measures to be taken if necessary. These are described further in Section 1.5.

1.3 NRDA Authority and Legal Requirements

The federal Trustees for this NRDA are the U.S. Department of the Interior (DOI), represented by USFWS, and the U.S. Department of Commerce, represented by NOAA. Each of these agencies is a designated natural resource Trustee under Section 1006 (b) of OPA, 42 U.S.C. § 2706(b), and the National Contingency Plan (NCP), 40 C.F.R. Section 300.600, for natural resources injured by the Enbridge Line 6B Oil Discharges. State Trustees for Michigan are designated by the Governor of Michigan pursuant to the NCP, 40 C.F.R. § 300.605, and include the MAG, the MDEQ, and the MDNR. The tribal Trustees are the NHBP and the Gun Lake Tribe. Federally-recognized tribes are designated as Trustees pursuant to the NCP, 40 C.F.R. § 300.610. The Trustees are working together under a Memorandum of Understanding (State of Michigan et al., 2010 and 2012). Each designated Trustee is authorized to act on behalf of the public or their tribe to assess and recover natural resource damages, and to plan and implement actions to restore natural resources and resource services injured or lost as the result of a discharge or discharges of oil.

1.3.1 Overview of Legal Requirements

A NRDA conducted pursuant to OPA and the regulations promulgated thereunder at 15 C.F.R. Part 990, consists of three phases: 1) Preassessment; 2) Restoration Planning; and 3) Restoration Implementation. OPA authorizes federal, state, and tribal natural resource trustees to initiate a damage assessment, among other requirements, when natural resources may have been injured and/or natural resource services impaired as a result of discharges of oil.

OPA regulations provide specific definitions for the following terms:

- "Injury" is "an observable or measurable adverse change in a natural resource or impairment of a natural resource service";

- "Natural resources" are "land, fish, wildlife, biota, air, ground water, drinking water supplies, and other such resources belonging to, managed by, held in trust by, appertaining to, or otherwise controlled by the United States, any state or local government or Indian tribe"; and

- "Natural resource services" are "functions performed by a natural resource for the benefit of another resource and/or the public".

During the Preassessment Phase, the Trustees determined that the provisions and determinations of OPA applied to these Discharges including: (1) one or more incidents has occurred; (2) the Discharges were not from a public vessel; (3) the Discharges were not from an onshore facility subject to the Trans-Alaska Authority Act; (4) the Discharges were not permitted under federal, state, or local law; and (5) public trust natural resources and/or services may have been injured as a result of the Discharges. On the basis of those determinations, on March 1, 2012, the Trustees issued the Notice of Intent to Conduct Restoration Planning for the NRDA case associated with the Enbridge Line 6B Oil Discharges in Marshall, Michigan. The Trustees then began the Restoration Planning Phase even as they were still finishing some preassessment activities. In the Restoration Planning phase, the Trustees evaluated and quantified the nature and extent of injuries to natural resources and services, and determined the need for, type of, and scale of appropriate restoration actions. Using the information developed during the Restoration Planning Phase, the Trustees developed a Draft DARP/EA, considered public comments on it, and then prepared this Final DARP/EA.

The first component of the Restoration Planning Phase was injury assessment. The Trustees evaluated injury to: (1) instream habitats including riverine and lake (impoundment) types; (2) floodplain habitats including many wetland types (3) upland habitats; (4) specific species groups like birds, turtles and mussels; (5) public recreational uses; and (6) tribal uses. As provided at 15 C.F.R. § 990.14(c)(1), the Trustees invited the Responsible Party (RP) to participate in the injury assessment component of the NRDA (see also Section 1.3.3). The RP, Enbridge, was involved in the design, performance, and funding of several preassessment activities to collect ephemeral data, but declined to participate cooperatively during the Restoration Planning Phase and instead performed independent restoration scaling analyses. The Trustees' assessment used data from the Trustees, Enbridge (when validated), U.S. EPA and other sources. The Trustees' assessment produced relevant information that the Trustees considered in determining the nature and extent of injuries to natural resources.

The second component of the Restoration Planning Phase is restoration selection. Considering the nature and extent of exposure and/or injuries to natural resources caused by the Enbridge Line 6B Oil Discharges, the Trustees developed a plan for restoring the injured resources and services, which is set forth in this Final DARP/EA. In it, the Trustees identify a reasonable range of restoration alternatives, evaluate those alternatives, and using the criteria at 15 C.F.R. § 990.54, determinethe selected alternatives from among them.

In finalizing their selected restoration alternatives, the Trustees considered all of the criteria outlined in the regulations as well as public comments. As a part of this process, the Trustees considered the extent to which restoration alternatives provide benefits to more than one natural resource and/or service. As described in more detail in Section 4.0 of this Final DARP/EA, many of the restoration alternatives selected by the Trustees benefit multiple resources and/or resource services. Overall, the Trustees selected the least expensive, practicable alternatives that are expected to provide the restoration benefits required by these criteria.

Natural resource Trustees may settle claims for natural resource damages under OPA at any time during the damage assessment process, provided that the settlement is:

1) adequate in the judgment of the trustees to satisfy the goals of OPA; and 2) fair, reasonable, and in the public interest, with particular consideration of the adequacy of the settlement to restore, replace, rehabilitate, or acquire the equivalent of the injured natural resources and services. Sums recovered in settlement of such claims, other than reimbursement of Trustee costs, may only be expended in accordance with a restoration plan.

1.3.2 National Environmental Policy Act Compliance

Any restoration of natural resources under OPA must comply with NEPA, as amended (42 U.S.C. 4321 et seq.), and its implementing regulations (40 C.F.R. § 1500-1508) with respect to federal actions that may significantly impact the human environment. In compliance with NEPA and its regulations, this Final DARP/EA summarizes the current environmental setting of the selected restoration to be implemented under the direction and control of the Trustees pursuant to this Final DARP/EA, describes the purpose and need for action, identifies alternative actions, assesses their applicability and environmental consequences, and summarizes public participation in the decision-making process. The DARP/EA was finalized after consideration and response to public comment. Project-specific NEPA documents may also need to be prepared as plans become more specific, and these documents will refer to this DARP/EA.

If there is a significant change to any of the restoration projects selected in this DARP, the Trustees will consider the need to develop additional environmental analysis in accordance with NEPA regulations. These regulations typically require a supplemental NEPA analysis be prepared if new information arises that would substantively impact on previous decision-making or if there is a significant change to a selected restoration project (40 C.F.R § 1502(9)(c)). The decision as to whether a change is significant considers both the context and intensity of the proposed change (40 C.F.R. § 1508.27). Project changes that are not deemed significant could be outlined in a supplemental information report for posting to the administrative record.

1.3.3 Coordination with Responsible Party

The OPA regulations require the Trustees to invite the RP to participate in the damage assessment process. Accordingly, the Trustees worked with the RP to participate in the damage assessment process. Immediately after the Enbridge Line 6B Oil Discharges began, the Trustees and Enbridge cooperatively developed and implemented certain preassessment studies. In 2011, the Trustees corresponded and met with representatives from Enbridge to discuss entering into a Funding and Participation Agreement to continue cooperative assessment activities, but consensus on language was not reached and no Agreement was executed. The Trustees formally invited Enbridge's participation on March 1, 2012, in a letter that also included the Trustees' Notice of Intent to conduct restoration planning. Following that, the Trustees developed several Interim, Partial Claims for Natural Resource Damage Assessment Costs pursuant to 33 U.S.C. § 2713 which Enbridge declined to fund, as described in Table 1.1.

Table 1.1. Summary of Interim, Partial Claims for Natural Resource Damage Assessment Costs Presented to Enbridge

Type of Claim	Amount	Date Presented	Date Enbridge Responded	Enbridge Response
Recreational Use	$636,479	April 4, 2012	June 20, 2012	Declined to participate
Vegetation Survey	$167,100	July 26, 2012	October 10, 2012	Declined to participate
Federal Trustee Assessment Costs	$980,091	February 11, 2013	None	No response within 90 day presentment period

As required by the regulations at 15 C.F.R. § 990.14 (c)(4), the Trustees retain final authority to make determinations regarding injury and restoration. As described above, the Trustees may settle claims for natural resource damages under OPA at any time during the damage assessment process. While proceeding with the assessment process, the Trustees also participated in settlement negotiations with Enbridge.

1.3.4 Public Participation

The Trustees have engaged the public in many ways since initiating this NRDA. During 2010, they made presentations at public meetings and were available at open house sessions, including four in-person press conferences, six weekly press conference calls, four presentations at public meetings, and six public availability sessions from July 26, 2010 through October, 2010. They also spoke with local landowners, other interested parties, and representatives of the Calhoun County Conservation District and the Kalamazoo River Watershed Council about potential restoration projects. In that time period, they began posting updates and documents on their website at http://www.fws.gov/midwest/oilspill/ (later linked to a new NRDA-specific website at http://www.fws.gov/midwest/es/ec/nrda/MichiganEnbridge). The website includes an Administrative Record page. On March 1, 2012, the Trustees issued a public press release announcing the initiation of restoration planning to coincide with sending a Notice of Intent to Conduct Restoration Planning to Enbridge. On March 5, 2012, the Trustees met with MDEQ's Cooperating & Assisting Agencies and made a presentation that included a discussion of their restoration criteria and an overview of what a Draft DARP would contain. The Trustees released a fact sheet on their restoration criteria in June of 2012. The Trustees continued to talk with local natural resource managers and reviewed local planning documents like the Rice Creek Watershed Project Watershed Management Plan (Calhoun County Conservation District, 2003) and the Kalamazoo River Watershed Management Plan (Kalamazoo River Watershed Council, 2011). The Trustees also spoke with local stakeholders at a meeting hosted by MDEQ on April 17, 2015.

The state and federal trustees also met with the public and organizations in the Kalamazoo River watershed as a part of an NRDA for the Allied Paper Inc./Portage Creek/ Kalamazoo River Superfund site that extends from Morrow Dam to Lake Michigan. As a part of this process, they collected information on potential restoration projects in the watershed. This included a public meeting on May 1, 2012 for the Draft Restoration Plan/ Environmental Assessment (RP/EA) for natural resource damages related to the Allied Paper facility and Portage Creek portion of the Kalamazoo River

Superfund site. Also, in February of 2014, they published a Notice of Intent to Prepare a Programmatic Environmental Impact Statement for the Riverwide Restoration Plan in the *Federal Register*.

As an integral component of the restoration planning process, and prior to the finalization of the DARP/EA, a thorough public review process was performed which was consistent with all federal laws and regulations that apply to the NRDA process, including Section 1006 of OPA, 42 U.S.C. §2706; the OPA regulations (15 C.F.R. Part 990); NEPA, as amended (42 U.S.C. §4371, et seq.); and its regulations (40 C.F.R. Parts 1500-1508). As a part of that process, the Draft DARP/EA was available for public comment from June 12, 2012 through July 27, 2015. The Trustees announced the availability of the Draft DARP/EA through a Federal Register Notice of Availability (published June 12, 2015), press releases resulting in more than 12 articles in established media outlets, publication on the Great Lakes Information Network, posting on the USFWS's webpage for this case[2] and through USFWS social media, and direct outreach to interested parties including the Kalamazoo River Watershed Council and MDEQ's Cooperating & Assisting Agencies. The Trustees also met with the MDEQ's Cooperating & Assisting Agencies in person on July 1, 2015.

The Trustees sought public comment on the Draft DARP/EA regarding the analyses used to define and quantify natural resource injuries and the methods proposed to restore injured natural resources or replace lost resource services as well as the environmental consequences of the alternatives to be implemented. Trustees sought public comment on the restoration being directed by the State of Michigan, in consultation with the Trustees, as well as the proposed additional projects to be implemented by the Trustees pursuant to this Final DARP/EA and described in Sections 4.4 – 4.8. The public had separate opportunities to comment on the implementation of certain projects being completed under the direction of the State of Michigan during the State's permitting processes. Public comments on the Draft DARP/EA and Trustee responses are included in Appendices J and K and can be found in the Adminstrative Record (See Section 1.3.5). As described in Appendix J, the Trustees carefully considered the comments from the public during the finalization of this DARP/EA.

1.3.5 Administrative Record

The Trustees have maintained records to document the information considered by the Trustees as they developed this DARP/EA. These records are compiled in an Administrative Record, which is available to the public online and at the address listed below. The Administrative Record facilitated public participation in the assessment process and will be available for use in future administrative or judicial review of Trustee actions to the extent provided by federal or state law. Additional information and documents, including public comments received on the Draft DARP/EA, and other related restoration planning documents are part of the Administrative Record. The Administrative Record for this document consists of the references cited in Chapter 8

[2] http://www.fws.gov/midwest/es/ec/nrda/MichiganEnbridge

along with theAdministrative Record for the Enbridge Line 6B NRDA case as a whole that is available for inspection online at

http://www.fws.gov/midwest/es/ec/nrda/MichiganEnbridge/adminrecord.html

or during normal business hours at:

U.S. Fish and Wildlife Service
2651 Coolidge Road, Suite 101
East Lansing, MI 48823

Arrangements should be made in advance to review the record or to obtain copies of documents in the record by contacting Lisa L. Williams, Ph.D., Contaminants Specialist, at 517-351-8324 or lisa_williams@fws.gov.

1.4 Summary of Natural Resource Injuries

The injuries from the Enbridge Line 6B Oil Discharges can be divided into the following categories: in-stream habitats, floodplain habitats, upland habitats, birds, mammals, reptiles, amphibians, fish, benthic invertebrates (including freshwater mussels), and human uses. The injuries to each category are summarized here and presented in greater detail in Chapter 3.

- In-stream Habitats: 1,560 acres of in-stream habitat were impacted, and recovery is expected to vary from five to 15 years, depending on the habitat type, degree of oiling, and types of response actions conducted.
- Floodplain Habitats: 2,887 acres of floodplain habitat were initially impacted and, of these, 299 acres had residual oil observed. Recovery is expected to vary from a week to many years, depending on the habitat type, degree of oiling, and types of response actions conducted.
- Upland Habitats: 185 acres of upland habitat were impacted because of response actions, including construction of roads and staging areas. Because most of the upland areas impacted were agricultural fields or areas of early successional habitat prior to the spill, recovery to their pre-spill condition is expected to occur within two to seven years following demobilization and site stabilization.
- Birds: 25 birds were found dead and 27 died while in care. In addition, 144 birds were captured because of being oiled and then successfully rehabilitated and released (Enbridge, 2012). An additional approximately 140 birds were observed oiled but never captured. The primary species impacted and captured were Canada goose (75%), mallard (9%), and great blue heron (5%). The one special status species impacted was trumpeter swan.
- Mammals: 40 mammals were found dead or died during rehabilitation. In addition, 23 mammals were captured because of being oiled and then successfully rehabilitated and released (Enbridge, 2012). An unknown number of mammals are assumed to have been oiled but never found or captured. The primary species impacted were muskrat (45%), raccoon (13%), and beaver (13%).
- Reptiles: 29 reptiles were found dead and 77 died during rehabilitation (Enbridge, 2012). In addition, over 3,800 turtles and 11 snakes were captured because of

being oiled or injured by response work and then rehabilitated and released. Enbridge (2012) reported that 3,923 turtles captured in 2010 and 2011 were oiled, but some of these were recaptured turtles that had been previously cleaned and released. A review of the data in 2013, including dates through July 13, 2013, revealed that 3,931 individual oiled turtles were captured at least once. Of those, 101 were either collected dead or died in care and the rest were cleaned and released. Some turtles were released, re-oiled and then recaptured, cleaned, and released again: 559 individuals were cleaned and released twice, 50 were cleaned and released three times, 10 were cleaned and released four times, and 3 turtles were cleaned and released five times. The primary species impacted were common map turtles (77%), snapping turtles (11%), painted turtles (6%), and eastern spiny softshell turtles (3%). Other species included common musk, Blanding's, and eastern box and spotted turtles. Spotted turtles are a state threatened species in Michigan, and one individual was collected oiled, cleaned, rehabilitated and released in a protected area.

- Amphibians: 73 amphibians were collected because they were oiled or suspected of being oiled. All were released alive.
- Fish: 42 fish were found dead during fish and wildlife response operations. Standardized surveys and other studies indicated that fish communities were impacted in some sections of Talmadge Creek and the Kalamazoo River following the spill.
- Crustaceans: 17 crustaceans were collected because they were oiled or suspected of being oiled. Three were either found dead or were dead on arrival at the WRC, two died in care and 12 were released.
- Benthic Invertebrates: Standardized surveys and other studies indicated that benthic invertebrate communities were impacted in some sections of Talmadge Creek and the Kalamazoo River following the Enbridge Line 6B Oil Discharges. Mussels were crushed by response actions (boat traffic) and mussel demographics may have been impacted by the Enbridge Line 6B Oil Discharges.
- Human Uses: Approximately 100,000 recreational user-days were lost, including activities like recreational fishing and boating and general shoreline park and trail use. Prior to the Enbridge Line 6B Oil Discharges, the NHBP was planning for the restoration of river wild rice for non-recreational uses within the historic range of NHBP tribal lands, which include the section of the Kalamazoo River that was impacted.

1.5 Selected Restoration Alternatives

In response to the Enbridge Line 6B Oil Discharges, the Trustees immediately initiated NRDA efforts pursuant to OPA. The Trustees and representatives for the RP cooperatively developed and implemented certain preassessment studies in 2010. The Trustees and Enbridge discussed continuing the cooperative assessment and restoration planning actions after 2010, but did not reach agreement on how to do so. As a result, the Trustees independently reviewed the results of preassessment studies to make a preliminary determination whether natural resources or natural resource services were injured and/or threatened by ongoing injury due to the Enbridge Line 6B Oil Discharges, and began planning additional assessment and restoration planning work independently from Enbridge.

The Trustees conducted additional assessment and restoration planning work and have estimated the nature and extent of the natural resources exposed to and/or injured and the lost public uses resulting from the Enbridge Line 6B Oil Discharges, as described in Chapter 3. Although additional assessment work may have assisted in confirming the extent of injuries to natural resources and natural resource services, the Trustees decided to move more expeditiously toward the goal of restoration.

The Trustees have determined that significant restoration and compensation will be achieved by the wetland and river restoration projects and monitoring that will be implemented in accordance with state law as directed by the State of Michigan, in consultation with the Trustees, and by the recreational use projects completed by Enbridge (Table 1.2).

Table 1.2

Restoration and Monitoring Projects Being Directed by the State of Michigan, in Consultation with the Trustees, and Recreational Use Projects

Resource/Service	Restoration Project	Description[3]	Paragraph within State Settlement
Floodplain Wetlands	Wetland Monitoring, Restoration, and Invasive Species Control	Enbridge is obligated to perform monitoring, restoration activities, and invasive species control within a 320 acre footprint of wetlands affected by the Enbridge Line 6B Oil Discharges. The affected area is generally adjacent to the Source Area, Talmadge Creek, and the Kalamazoo River and memorialized in approved work plans.	8.1 & 8.2
Floodplain Wetlands	Wetland Compensation	Enbridge agrees to permanently restore, create, or otherwise protect not less than 300 acres of wetland habitat in compensation for wetland resource losses attributable to the Enbridge Line 6B Oil Discharges, consistent with the State of Michigan's administrative rules on wetland mitigation.	19.2
Riverine Habitats	Talmadge Creek In-Channel Habitat Evaluation and	Enbridge is evaluating stream function within restored areas of Talmadge Creek, developing a work plan for MDEQ	9.2 & 9.3

[3] Approved work plans that will be an enforceable component of the State Settlement are available at http://www.michigan.gov/oilspill.

Table 1.2

Restoration and Monitoring Projects Being Directed by the State of Michigan, in Consultation with the Trustees, and Recreational Use Projects

	Restoration	approval, and will prepare a report detailing any necessary, additional restoration activities to be implemented to restore stream habitat diversity and function to approximate conditions present prior to the Enbridge Line 6B Oil Discharges.	
Riverine Habitats	Dam Removal and River Restoration at Ceresco	Enbridge removed the dam on the Kalamazoo River at Ceresco and implemented natural channel design principles to restore over 2.5 miles of previously impounded river channel, reconnecting the natural flow of the river to provide for increased movement of fish and other aquatic life and further provide enhanced recreational opportunities for the public. Enbridge is obligated to perform monitoring of the restored area under an approved work plan.	19.1
Riverine Habitats	Aquatic Vegetation Surveys and Reports	A survey of the aquatic plant inventory conducted in 2013 consistent with an MDEQ approved work plan, will be replicated by Enbridge in the summer of 2015, with a corresponding report prepared to detail findings from the survey and propose implementation of necessary aquatic vegetation restoration activities, including potential invasive species control.	9.4
Riverine Habitats	Erosion Control & Restoration	Enbridge is obligated to continue monitoring trips consistent with the approved Kalamazoo River Bank Erosion Assessment and Action Plan during the spring of 2015 and will implement necessary restoration activities consistent with the approved work plan.	9.5
Riverine Habitats	Restoration of Large Wood Debris	Enbridge is obligated to restore habitat and function provided by large woody debris removed from the Kalamazoo River as a consequence of the Enbridge Line 6B Oil Discharges through implementation of a	9.6

Table 1.2

Restoration and Monitoring Projects Being Directed by the State of Michigan, in Consultation with the Trustees, and Recreational Use Projects

		work plan approved by the MDEQ in consultation with the MDNR.	
Fish, Recreational Use	Fish Contaminant Monitoring	Enbridge agrees to fund one additional round of fish contaminant monitoring, as conducted by the MDEQ and Michigan Department of Community Health. Enbridge further agrees to develop and implement Corrective Action Plans, subject to MDEQ approval, in the event that monitoring results necessitate a fish consumption advisory attributable to the Enbridge Line 6B Oil Discharges.	9.7 & 9.8
Riverine Habitats	Fish and Benthic Macroinvertebrate Monitoring	Enbridge agrees to fund additional monitoring to be conducted by the MDEQ and MDNR in 2015, evaluating fish status and trends and the health of benthic macroinvertebrate communities within Talmadge Creek and the Kalamazoo River. In the event one or more adverse outcomes, attributable to Enbridge Line 6B Oil Discharges, are identified as a result of monitoring efforts, then Enbridge is obligated to develop and implement Corrective Action Plans subject to MDEQ approval.	9.9 & 9.10
Recreational Use	Recreational Access Projects & Endowment	Enbridge implemented 5 projects along the Kalamazoo River in Calhoun County intended to enhance recreational opportunities for the public and compensate the State for those recreational opportunities lost or diminished as a consequence of the Enbridge Line 6B Oil Discharges. From upstream to downstream, these are Saylor's Landing (new), Calhoun County's Historic Bridge Park (enhanced), Angler's Bend (new) and Paddler's Grove (new). In addition to completed construction activities, Enbridge has created the Kalamazoo River Community Recreational Foundation and endowed the foundation with 2.5 million	19.3 & 19.4

Table 1.2 Restoration and Monitoring Projects Being Directed by the State of Michigan, in Consultation with the Trustees, and Recreational Use Projects			
		dollars in funds to assure perpetual care of the five projects upon transfer of ownership to local units of government or organizations.	

In addition, the Trustees have selected a set of additional restoration projects to benefit the injured natural resources and which they believe will complete the process of making the public whole for lost resources and uses resulting from the Enbridge Line 6B Oil Discharges. These selected projects to be implemented by the Trustees will be located either in the impacted section of the Kalamazoo River or nearby, within the watershed. These selected projects include the following:

- three projects to improve aquatic connectivity in Pigeon Creek and Rice Creek, tributaries to the Kalamazoo River that join it near Marshall, Michigan, by replacing undersized and perched culverts and lowering a berm to connect the creek and its floodplain;
- funding to improve the fishery in at least two lakes within the Fort Custer State Recreation Area by controlling invasive species for at least 3 years;
- funding to restore 175 acres of oak savanna uplands in the Fort Custer State Recreation Area;
- a project to improve and monitor turtle reproduction in the impacted section of the Kalamazoo River by radio-tracking females and then fencing their nest areas;
- a project to restore wild rice in at least two locations in the Kalamazoo River; and
- a project to better understand and encourage the use of the river corridor by tribal members.

The habitat improvement projects selected will also provide benefits to address other types of injuries that the Trustees assessed including benthic invertebrates (including mussels), fish, reptiles, mammals and birds, as well as lost public uses that will be improved as the natural resources themselves improve.

Under the terms of a proposed NRDA settlement between the Trustees and Enbridge that will be subject to public notice and comment and to approval by a federal district court, Enbridge would pay $3,900,000 to the Trustees. The amount of this payment reflects the Trustees' estimate of the costs of planning, implementation, oversight, and monitoring of the selected projects; review and consultation on restoration actions being directed by the State under the State Settlement; and reimbursement of the Trustees' assessment costs that had not been reimbursed at the time the parties reached an agreement in principle. The title of the specific projects and the breakdown of the $3.9 million are shown in Table 1.3 below. Detailed descriptions of the restoration projects can be found in Chapter 4.

Table 1.3 Summary of the Selected Restoration Projects to be Implemented by Trustees and Associated Costs for Trustee Activities		
Resource/Service	**Selected Restoration Project**	**Cost to be Funded from NRDA Settlement with RP**
Riverine Habitats	Pigeon Creek, E Drive Crossing Replacement	$153,800
Riverine Habitats	Rice Creek, 29 Mile Road Crossing Replacement	$249,000
Riverine Habitats	Rice Creek, Vansickle Berm Lowering	$36,650
Lake Habitats	Fort Custer Lake Enhancements	$343,713
Upland Habitats	Fort Custer Oak Savanna Restoration	$75,000
Turtles	Turtle Nest Protection Program	$300,000
Non-recreational Use by Tribal Members	Wild Rice Restoration	$275,011
Non-recreational Use by Tribal Members	Non-Recreation Use Analysis and Restoration	$270,000
Total Estimated Cost of NRDA Settlement Restoration Projects		**$1,703,174**
Reimbursement of Trustee Past Costs[4]		$1,634,952
Trustee Future Costs[5]		$561,874
Total NRDA Payment by RP to Trustees		**$3,900,000**

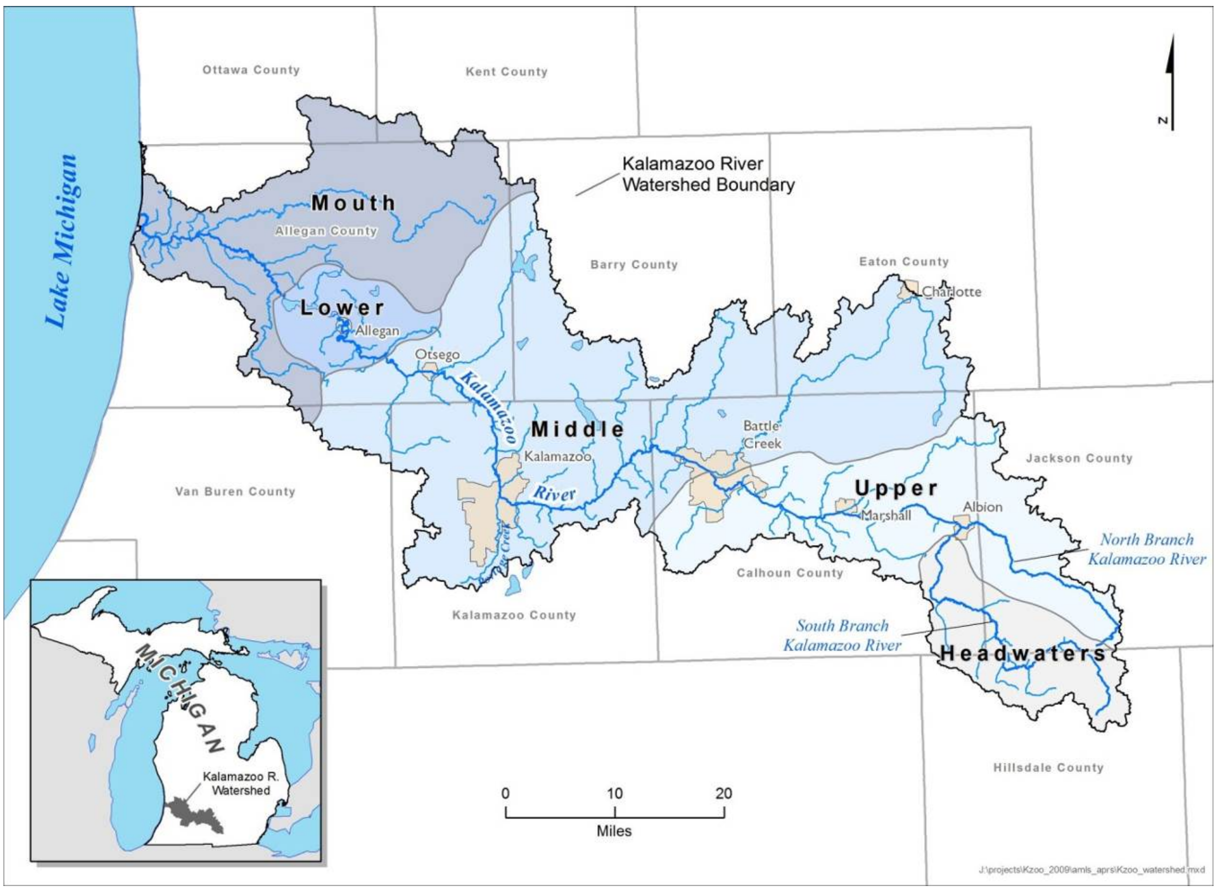
[4] Trustee past costs listed here do not include partial reimbursements that Enbridge previously made to USFWS, NOAA and the full reimbursement made to the State.
[5] Trustee future costs include federal and tribal assessment costs incurred after dates that past costs were calculated for each Trustee and estimated costs for project planning, oversight and monitoring, as well as review and consultation on restoration actions being directed by the State under the State Settlement. If the Trustees determine that additional monitoring is not necessary at some point, then the Trustees could instead use the funds for additional restoration.

2.0 AFFECTED ENVIRONMENT

2.1 Physical Environment

Restoration activities will occur in the Kalamazoo River watershed, which drains approximately 2,000 square miles of southwestern Michigan, flowing generally westward into Lake Michigan, near Saugatuck (Figure 2.1; see also MDNR, 1981). The watershed contains approximately 400 miles of stream tributaries, most notably Rice Creek, Battle Creek, Portage Creek, and the Rabbit River (MDNR, 1981; Blasland, Bouck & Lee, 1992).

Figure 2.1. Kalamazoo River Watershed



(Source: Wesley, 2005)

The climate in the Kalamazoo area is temperate, with average winter temperatures of approximately 30°F and average summer temperatures of approximately 70°F (Blasland, Bouck & Lee, 1992). Southwest Michigan receives about 35 inches of precipitation each year (National Weather Service, 2013). In the future, Michigan will likely experience higher temperatures and increased winter and spring (Kling et al., 2003; Hayhoe et al., 2010; NOAA, 2011). Summers are expected to be hotter and drier and more precipitation is likely to fall as rainfall than as snow (Hayhoe et al., 2010; NOAA, 2011).

The affected portion of the Kalamazoo River is designated as a warmwater stream that is bordered by wetland, forest, residential properties, farm land, and commercial properties. Between Marshall, MI and Battle Creek, MI, the Kalamazoo River is warm with stable flows (Wesley, 2005). Once the Kalamazoo River passes through Battle Creek, it becomes larger as it picks up a major portion of the watershed drainage and becomes cooler as groundwater flows to the river increase (Wesley, 2005). The Kalamazoo River is impounded by dams in many locations. In riffle areas, the substrate is primarily gravel and rock. In deep pools, backwaters, impoundments and other depositional areas, the substrate becomes more sandy and silty (Wesley, 2005).

MDNR has identified Talmadge Creek as a small coolwater stream before entering the Kalamazoo River based on the fish species present (Wesley, 2005). For purposes of water quality protection, however, MDEQ designates Talmadge Creek as a warmwater stream. The riparian corridor along Talmadge Creek from where the oil entered it to where the creek enters the Kalamazoo River is largely undeveloped with scattered residences. The land use in the lower watershed beyond the riparian corridor is a mixture of agriculture, residential, and undeveloped land.

Rice Creek is a large tributary that enters the Kalamazoo River at the City of Marshall. The Rice Creek watershed is 58,200 acres (about 91 square miles) in western Jackson and eastern Calhoun County. The dominant land use is agricultural followed by forest land. Rice Creek is characterized as a cool to coldwater stream. The habitat is considered "fair" due to channelization and excessive sediment loading (Calhoun County Conservation District, 2003).

Pigeon Creek is a small tributary that enters the Kalamazoo River just downstream of Ceresco, in Calhoun County upstream of Battle Creek. The dominant land use is agricultural with some undeveloped, forested, and residential areas

2.2 Biological Environment

2.2.1 Aquatic habitat

Aquatic habitat consists of surface water, sediments, overhanging brush, woody structures, pools, riffles, and runs that support all or a portion of the lifecycles of plants, benthic invertebrates, fish, other aquatic organisms, reptiles, amphibians, and birds and mammals. Benthic invertebrates are vitally important in the aquatic food chain, playing essential roles in energy and nutrient transfer from primary producers, such as algae and phytoplankton, to predatory fish, and as decomposers. Benthic invertebrates include organisms such as clams, snails, mussels, and the larval forms of some insects (e.g., dragonflies, midges, mayflies).

The fish community of Kalamazoo River consists mostly of minnows, shiners, rock bass, smallmouth bass, and suckers (Wesley, 2005). The fish community of Talmadge Creek consists mostly of mottled sculpin, blacknose dace, and blackside darter (Wesley, 2005). Fish species common in Rice Creek include white sucker and mottled sculpin, most prevalent game species are brown trout and rock bass (Wesley, 2005). Other species found in Rice Creek are blackside darter, grass pickerel, mottled sculpin, northern pike, rock bass, central mudminnow, common shiners, green sunfish, johnny darter, largemouth bass, white sucker, yellow bullhead, and yellow perch (Calhoun County Conservation District, 2003). Fish species common in Pigeon Creek include creek chub, blacknose dace, and mottled sculpin (Wesley, 2005).

A number of factors contribute to the degradation of aquatic habitat in the Kalamazoo River and its tributaries, including the release of hazardous substances, nonpoint source pollution, dams and associated impoundments, stream channelization, and urban and suburban development.

2.2.2 Riparian habitat

Riparian wetland habitat consists of emergent, shrub-scrub, forested, and rare and unique wetland types like prairie fen. Riparian wetland habitat plays an important role in protecting water quality, especially along lakes and streams because these habitat types intercept pollutants present in groundwater and surface water runoff, including nutrients and sediments. Riparian wetlands can store rain and snow melt and help to reduce the adverse effect of floods, stabilize stream flows, and protect river banks from erosion (KRWC, 2011). Riparian wetland habitat along the Kalamazoo River provides food and cover for both aquatic organisms and terrestrial organisms such as turtles, amphibians, mammals, waterfowl, and songbirds (Blasland, Bouck & Lee, 2000).

Waterfowl observed in the Kalamazoo River watershed include mallard duck, black duck, wood duck, Canada goose, blue-winged teal, American coot, snow (blue) goose, whistling swan, redhead duck, canvasback, goldeneye, American merganser, bufflehead, lesser scaup, American gallinule, Wilson’s snipe, baldpate, pintail, gadwall, and green-winged teal (MDNR, 1981). Species that were observed oiled and known to utilize riparian habitat include, but are not limited to, muskrat, raccoon, beaver, common map turtle, snapping turtle, painted turtle, Canada goose, mallard, and great blue heron (Enbridge, 2012).

Bird surveys conducted along the Kalamazoo River 1992–1994 by the Kalamazoo River Nature Center found approximately 100 species each year. A high proportion (about 60%) of birds observed were neotropical migrants, which breed in the United States or Canada and migrate to Central or South America for winter. Other species use the Kalamazoo River area as winter habitat. Resident species are also present (Adams et al., 1998).

Current threats to wetlands include filling and draining for development purposes including industrial, residential, agricultural and recreational land uses. Altered hydrology and changes to soil structure are significant threats to most wetland types.

Invasive species and polluted runoff from nearby or adjacent developments also threaten wetlands.

2.2.3 Upland habitat

The upland habitat of the Kalamazoo River watershed includes land use such as agricultural lands, residential, and industrial use (Kalamazoo River Watershed Council, 2011). Undeveloped areas include upland forests dominated by oak, hickory, hackberry, box elder, and black walnut trees (Stratus Consulting, 2013). The watershed has oak savanna and prairie remnants. The oak savannas are characterized by a grassy prairie-type ground cover underneath the trees with an open tree canopy. They are commonly found bordering prairies.

Upland habitats in the Kalamazoo River watershed support wildlife species such as red fox, fox squirrel, raccoon, striped skunk, coyote, eastern cottontail rabbit, white-tailed deer, American woodcock, ring-necked pheasant, bobwhite quail, and wild turkey (MDNR, 1981; U.S. EPA, 2000). Upland prairie habitats support breeding populations of grassland birds (e.g. Henslow’s sparrow, grasshopper sparrow), red-headed woodpecker, and Eastern box turtles (per com, Glen Palmgren, MDNR).

Current threats to upland habitat include habitat destruction for development, fragmentation, and invasive species. Prairies and oak savannas are fire-dependent systems, therefore altered fire regimes have a significant impact to these habitat types (Kalamazoo River Watershed Council, 2011).

2.3 Endangered and Threatened Species

The counties in which these selected projects will occur, Calhoun and Kalamazoo, support the following Federally-listed species: Indiana bat (endangered), eastern massasauga rattlesnake (candidate), northern copperbelly watersnake (threatened), and Mitchell's satyr butterfly (endangered).

Requests to review projects for potential impacts to endangered and threatened species protected by state law are sent to the Michigan State University Extension Service, Michigan Natural Features Inventory (MNFI). This review will be completed as part of the project-specific planning processes and selected projects will be modified as necessary to avoid adverse effects on federal and state listed species.

2.4 Historic and Cultural Resources

Humans have used the Kalamazoo River Basin for more than 11,000 years (Kalamazoo River Watershed Public Advisory Council, 1998). Artifacts dating back to approximately 10,000 BC have been found along the lower Kalamazoo River (MDNR, 1981). The Kalamazoo River watershed is rich with archaeological sites of historic and cultural significance. There are over 375 sites located in the upper and middle portions of the watershed (Wesley, 2005).

Historical records confirm that portions of the Potawatomi Nation, which lived throughout the upper Mississippi River region, used the Kalamazoo River for transportation and that a Potawatomi village was located on its banks in the vicinity of the current City of Kalamazoo (Kalamazoo Public Library, 2010). Prior to 1833, the reservation of the Match-E-Be-Nash-She-Wish Band of Pottawatomi was located on the Kalamazoo River in the present location of the City of Kalamazoo (Tanner, 1987). The Nottawaseppi Huron Band of the Potawatomi's predecessors also possessed reservation lands near the Kalamazoo River in what are now Kalamazoo, St. Joseph and Calhoun Counties (Tanner, 1987). Historic and modern records also confirm that the Potawatomi and Ottawa tribes hunted seasonally in the Kalamazoo River corridor (MDNR, 1981). Potawatomi communities have remained in Allegan and Calhoun Counties in discrete communities since the early/mid-1800s (Kalamazoo River Watershed Public Advisory Council, 2000).

The first Europeans came to the area in the late 1600s, and the area was frequented by fur traders in the late 1700s (Kalamazoo River Watershed Public Advisory Council, 2000). By the early 1800s, small communities, including Kalamazoo, were established and farming replaced fur trapping as the main industry. The river was used to ship goods downstream until a railroad was built in the 1840s. By the mid-1800s, other mill towns and commercial centers developed along the river, including Battle Creek, Parchment, Plainwell, and Otsego.

2.5 Human Use Services

The Kalamazoo River and its floodplain provide important natural resource and recreational services year-round. At the time of the Enbridge Line 6B Oil Discharges, public lands and parks along the river from Marshall to Morrow Dam included the Marshall River Walk, Historic Bridge Park, Battle Creek Linear Park, Fort Custer State Recreation Area, Galesburg Community Center Park, River Oaks County Park, the MDNR Boat Access Site on Morrow Lake, and informal access points at bridges and dams. All waters of Michigan, including the Kalamazoo River, are designated for the following uses: agriculture, navigation, industrial water supply, public water supply, warm water fishery, other indigenous aquatic life and wildlife, partial body contact recreation, and total body contact recreation during the months of May through October (MDEQ, 1994). Water-based recreation on the Kalamazoo River and its tributaries includes fishing, motor-boating, paddling, floating, swimming, and boat-based hunting and trapping. Shoreline-based activities include general recreational activities occurring at parks or other recreational areas along the shoreline such as walking, running, cycling, skiing, nature and wildlife observation, hunting, picnicking, and sightseeing. Recreational fishing in this part of the river is primarily for warmwater species including northern pike, largemouth bass, panfish, common carp, and suckers (MDNR, 1981).

The Kalamazoo River and its floodplain also provide important natural services that have been vital to tribal communities for generations and the re-vitalization of traditional ceremonies and uses of resources has been the focus of significant initiatives of the tribal Trustees. Non-recreational uses by tribal members include harvesting fish, turtles, and other animal species for subsistence or for ceremonial feasts; making traditional handicrafts (i.e. turtle shell rattles); gathering plants for food, traditional medicines or handicrafts; and religious/traditional ceremonies.

Talmadge Creek and Pigeon Creek are small streams that provide limited recreational opportunities including wildlife observation and fishing and hunting from road crossings and by riparian landowners. Rice Creek is a larger stream with similar uses along with additional public access at Ketchum Park in Marengo Township.

3.0 INJURY ASSESSMENT AND QUANTIFICATION

3.1 Introduction

The Trustees for the Enbridge Line 6B Oil Discharges initiated preassessment activities on July 26, 2010 immediately following being notified of the discharges. Preassessment activities, as defined by OPA, focused on collecting ephemeral data essential to determine whether: (1) injuries have resulted, or are likely to result, from the discharges of oil: (2) response actions have adequately addressed, or are expected to address, such injuries; and (3) feasible restoration actions exist to address the potential injuries. Trustees assessed injuries to natural resources resulting from the discharges of oil by Enbridge into Talmadge Creek, the Kalamazoo River, and adjoining floodplains.

The Trustees assessed two broad categories of injuries and losses: 1) ecological and 2) human use service losses. For both of these categories, Trustees evaluated injuries and service losses caused by the Enbridge Line 6B Oil Discharges, as well as injuries and losses as a result of response and remedial activities undertaken because of the Enbridge Line 6B Oil Discharges. Ecological injuries and service losses reviewed include floodplain habitat; in-stream habitat losses for aquatic organisms; impacts to the fluvial geomorphology of the river (e.g. erosion of shoreline, banks and river bottom); and impacts including mortality to birds, turtles, and other organisms directly affected by the Enbridge Line 6B Oil Discharges. Human use loss assessment focused on recreational service losses as a result of closure of the river to all public use as well as issuance of fish consumption and swimming advisories. Losses to non-recreational uses by tribal members were investigated through discussions with tribal elders and members.

Based on information collected since July 2010, the Trustees determined that natural resources and services have been injured and that response actions were not expected to fully address the injuries. Throughout the injury assessment and restoration planning process, the Trustees used available information, expert scientific judgment, information generated through response activities, shoreline assessments, and literature on the fate and effects of oil spills to arrive at the best estimate of the injuries caused by the Enbridge Line 6B Oil Discharges. There is, however, some uncertainty inherent in the assessment of impacts from oil spills. While in certain instances collecting more information may increase the precision of the estimate of impacts, by July of 2013 the Trustees believed that the type and scale of restoration actions would not substantially change as a result of more assessment studies. The Trustees sought to balance the additional benefits of developing more assessment information with the reality that further study would delay the implementation of the restoration projects, at the expense of the local environment and the public who use and enjoy the area's natural resources.

3.2 Impact Surveys and Studies

The Trustees conducted surveys and studies and also gathered information that was relevant to the NRDA from U.S. EPA, MDEQ, MDNR, Enbridge and others.

3.2.1 Floodplain Habitat Impact Surveys

From August 9, 2010 through September 2, 2010, the Trustees conducted on-the-ground surveys in the floodplain of the Kalamazoo River to document the extent and degree of oiling. These surveys were conducted cooperatively with Enbridge's representatives under jointly approved work plans. The Trustees and Enbridge staffed joint teams to conduct the work. The field teams walked transects that were approximately 50 meters apart from each other in floodplain habitats on both sides of the river from Talmadge Creek to Morrow Lake, a distance of approximately 25 river miles. Selected areas (e.g., islands, areas of heavy oiling of at least 50 ft^2 in the floodplain) were surveyed at a more detailed level. Field crews surveyed a total of 742 transects on both sides of the river. Field teams recorded percentages of oil present on soils and vegetation, habitat type, and some habitat features (e.g. vernal pools, downed trees). The report summarizing this work documents the presence of oil stranded in the floodplain (Appendix B).

The Trustees conducted rapid vegetation assessments in the floodplain of both the Kalamazoo River and Talmadge Creek in August of 2010 to characterize the types of habitat and vegetation present within the floodplain. The Trustees and Enbridge cooperatively developed and implemented the work plan for this rapid vegetation assessment. Although a report was not generated from the 2010 study, the results were used to inform the Trustees' comments on response related excavation plans during the winter of 2010-2011. The Trustees and Enbridge repeated the rapid vegetation assessment in the fall of 2011, and added quantitative measurements to the study protocols. The Trustees intended to repeat these cooperative surveys to monitor invasive species and determine the rate and extent to which the vegetation was recovering in the impacted area; however, 2010 and 2011 data are being used by the State and Enbridge to inform the restoration and long term monitoring of wetlands as required by the State Settlement.

U.S. EPA, the State, and Enbridge conducted SCAT surveys in 2010 to assess oiling along the riverbanks. SCAT reports characterized the degree of oiling and types of habitat and substrate present in each quarter-mile segment of the river and identified recommended cleanup techniques to be used in each segment. U.S. EPA has made all of the SCAT completion reports available to the public at http://epa.gov/enbridgespill/data/scat.html.

U.S. EPA, the State, and Enbridge conducted a Shoreline and Overbank Reassessment Technique (SORT) survey in 2011 and repeated it in 2012. Methods were based on the SCAT survey system modified to apply to a riverine environment, including assessment of overbank (i.e. floodplain) areas. Similarly as to what was done during SCAT, SORT observers also recorded the degree and type of oiling and the type of habitat and substrate present.

MDEQ worked with Enbridge to compile and reconcile these multiple datasets, including the Trustees' floodplain survey, SCAT, SORT, and various other observations collected for response and remediation purposes, into a single geographic information system database to document the extent of oiling and the nature and extent of impacts from response activities within the floodplain. The Trustees used the reconciled data to estimate that approximately 2,588 acres of wetlands were oiled only briefly as the oil floated on the floodwaters and 299 acres of wetlands were oiled significantly and subjected to response actions.

3.2.2 Aquatic Habitat Impact Surveys

U.S. EPA and Enbridge developed a poling procedure for determining the extent of submerged oil in the river. From U.S. EPA (2013b):

> Poling involves manually agitating soft sediment (river mud) using a pole with an attached disc combined with a global positioning system to record the exact location. When the sediment is agitated, submerged oil rises to the surface in the form of oil sheen and globules. A team, composed of mostly Enbridge personnel with oversight and direction from EPA and MDEQ employees, categorizes the response of the submerged oil to poling at each location as "heavy," "moderate," "light," or "none."

This procedure was used in 2010-2013, during time periods when water temperatures were warm enough to result in oil mobilization and sheening. A photo of this procedure is included in Appendix A. Enbridge mapped the poling data, and these maps were used to plan response actions for submerged oil. The Trustees used these mapped data to estimate both the extent of oiling and the timing and extent of response actions.

Enbridge was required to monitor the presence of large woody debris and the extent of bank erosion in and along the Kalamazoo River. The Trustees obtained some data from this monitoring through MDEQ and considered it when estimating in-stream habitat losses and recovery rates.

MDEQ used aerial photographs to map the extent of aquatic macrophyte beds that were impacted by the Enbridge Line 6B Oil Discharges and by spill response activities. The Trustees considered the extent of impacts to aquatic macrophyte beds in each river reach when estimating in-stream habitat losses and recovery rates.

3.2.3 Oiled Wildlife Surveys and Rehabilitation

MDNR and USFWS received the first reports of oiled wildlife on July 26, 2010, and USFWS advised Enbridge to mobilize professional rehabilitators and begin building rehabilitation facilities that evening. A wildlife hotline was established that night so that the public and responders could report sightings of oiled wildlife. Enbridge mobilized their contractor, Focus Wildlife, and they built a complete rehabilitation facility over the next several days. The USFWS developed and led the Wildlife and Environmental Assessment Branch within the Operations Section of the response. This Branch provided technical assistance to U.S. EPA on natural resource issues and field observations; led reconnaissance, capture, rehabilitation, and release of oiled animals; installed deterrence measures to try to minimize wildlife oiling and road fatalities; and provided a link between NRDA field activities and the ICS management of the overall response. The USFWS, MDNR, USDA APHIS, and contractors employed by USFWS and Enbridge performed daily reconnaissance for oiled wildlife, responded to hotline calls, and captured oiled wildlife when possible on a daily basis until mid-October of 2010 when responsibility was turned over to Enbridge and their contractors. Enbridge and Focus Wildlife led the rehabilitation functions, with Binder Park Zoo taking a major role in rehabilitation of turtles and other reptiles and amphibians. Personnel from additional zoos and volunteers also assisted in animal care and cleaning oiled wildlife (National Response Team, 2012). Wildlife releases were coordinated among USFWS, MDNR, Enbridge, and contractors.

Trustees obtained wildlife data that were collected as a part of these activities. These data identify the number, species, and locations of birds, turtles, frogs, and other biota that were found dead or oiled, as well as the number and species of biota that were rehabilitated and released, cleaned in the field and released, or died during rehabilitation. A summary of these impacted wildlife is provided above in Section 1.4 and additional details are provided in Appendix C.

3.2.4 Fish Surveys and Studies

In the first week after the Enbridge Line 6B Oil Discharges, MNDR Fisheries biologists surveyed the river for fish kills and monitored dissolved oxygen in the river. Although dissolved oxygen levels dropped as a result of the Enbridge Line 6B Oil Discharges, they recovered before reaching lethal levels for the fish species present. Wildlife response crews collected a total of 42 dead fish during the course of the response in 2010. Given the size of the impacted area and the number of observers on the river, the Trustees consider this to be a negligible number of dead fish over this time period.

As a part of the early response efforts, operators at the dam that forms Lake Allegan lowered the level of the reservoir. This drawdown resulted in the loss of some fish and mussels in Lake Allegan. MDNR collected 27 dead fish on August 5, 2010, and estimated the total number of dead fish at 168 individuals and characterized these losses as relatively minor for Lake Allegan (Appendix D).

In August of 2010, MDNR collected fish for a fish health assessment. Dr. Mohamed Faisel of the Fish Health Laboratory at Michigan State University examined the fish for a baseline health assessment following the Enbridge Line 6B Oil Discharges. Three species of fish were collected at each of three locations. Species collected included spotfin, common and sand shiners, white and golden redhorse suckers and rock bass. All fish were collected live. While the fish appeared to be in generally good health, dermal lesions were present, fin and ventral hemorrhages were "prevalent," and ocular hemorrhages were observed. Mild to moderate congestion was observed in a few livers and kidneys of common white sucker and common shiners. No other signs of disease were noted.

In August 2010, at the request of the USFWS, the U.S. Geological Survey (USGS) performed a gross pathological assessment of general fish health on fish collected from the oiled area and a reference area and calculated a Health Assessment Index (HAI) for those fish. They also collected and preserved tissue and bile samples for histological, biochemical, and chemical analyses. Fish collected from three oiled sites showed significant adverse changes in several bioindicators relative to fish collected from upstream, including reduced condition factors, greater numbers and severity of anomalies and lesions, increased mucous producing cells and cytochrome P4501A activity in the gills, and increased macrophage aggregates in the spleen (Papoulias et al., 2014, included as Appendix F). The Trustees and Enbridge also collected and preserved bile samples from fish collected by the State of Michigan in October 2010. Bile samples have not been analyzed.

The MDNR's Fisheries Division standard fish community assessment (Streams Status and Trends Program Sampling Protocol; Wills et al., 2008) was conducted on September 8, 2010 in both Talmadge Creek and several stations on the Kalamazoo River, and were repeated in the summers of 2011, 2012, and 2013. These surveys were performed in accordance with standardized procedures used by the MDNR for ordinary monitoring efforts, and as such, were performed by state personnel in 2011-2013 and by state personnel accompanied by Enbridge NRDA representatives in 2010. MDNR completed an annual report for 2010 (Appendix G), shared preliminary data from 2011, 2012 and 2013 with Trustees, and will be finalizing their full reports pending further data analysis. Preliminary results for the Kalamazoo River show a decrease in smallmouth bass density in 2010 at 15 Mile Road and 11 Mile Road sampling sites, which are within the area impacted by the discharges of oil. Overall, fish diversity and growth were variable across all years and sites on the Kalamazoo River. In Talmadge Creek, fish abundance and diversity were both reduced in 2010. Fish abundance and diversity increased in the impacted sections of Talmadge Creek in 2011, 2012 and 2013 with some changes in species composition that may have been related to changes in stream habitat type. Abundance and diversity of fish in the upstream reference reach of Talmadge Creek decreased in those years, possibly as a result of habitat changes in the impacted area downstream of the reference reach that resulted in poor connectivity between upper and lower reaches of the creek for some species.In 2011, Enbridge reported that fish were observed dying during sediment agitation in one of the areas the river. Small areas of the river were enclosed with turbidity curtains while sediment agitation was being conducted. MDNR biologist Jay Wesley instructed them to begin pumping fresh water into the enclosed area where the fish were dying. When he arrived on-site, fish in the enclosed area appeared to be recovering, but he collected the following fish that had died: two green sunfish, one largemouth bass, one johnny darter, four yellow bullheads, and three minnows.

3.2.5 Benthic Invertebrate Surveys and Studies

MDEQ conducted the State's standard benthic macroinvertebrate surveys (Procedure 51) shortly after the Enbridge Line 6B Oil Discharges in both Talmadge Creek and several stations on the Kalamazoo River, and repeated them during the summers of 2011 through 2014. Additional surveys will be conducted in 2015 and 2016 prior to the synthesis of all data into a final report. MDEQ personnel conducted these surveys using their standardized procedures and were accompanied through 2011 by Enbridge NRDA representatives. Available reports summarizing surveys conducted to date are provided as Appendix H. After showing initial impacts, the data generally indicate trends toward recovery with trends interrupted during periods when additional oil recovery efforts occurred. In August of 2010, the Trustees and Enbridge cooperatively developed work plans for the collection and chemical analysis of mussel tissue samples for oil constituents such as polycyclic aromatic hydrocarbons (PAHs) and alkylated PAHs as well as other indicator chemicals. The Trustees and Enbridge staffed joint teams to collect the samples along with co-located sediment samples from six locations, and Enbridge contracted with a laboratory for analysis. Most of the chemical concentrations were below the limits of detections and this sampling effort was not repeated. No summary report was written.

In October 2010, the Trustees and Enbridge cooperatively developed a mussel shell survey work plan to document crushed and broken shells that likely resulted from response activities in the river (Appendix I). Scientists from the Michigan Natural Features inventory led the survey with sampling teams staffed jointly with representatives from the Trustees and Enbridge. Five locations were sampled along the Kalamazoo River, including an upstream reference area. Fresh, recent, and moderately worn shells, which were indicative of mussel deaths post-spill, were most common in segments and survey sites within areas impacted by the Enbridge Line 6B Oil Discharges. These observations were atypical compared to what was observed in the reference segment. In addition, crushed shells were observed in segments impacted by the Enbridge Line 6B Oil Discharges and were not observed in the reference segment. Crushed shells were most often found in shallow water habitats downriver from boat ramps being used by spill response crews. Based on observations of boat activity made while in the field, it was concluded that these shells were damaged from being crushed by boats, or possibly by foot traffic.

As part of the SSCG investigations, sediment toxicity to benthic invertebrates was measured in 20 samples collected from the impacted reaches of the Kalamazoo River in February of 2012. Ten-day whole sediment toxicity tests using midges (*Chironomus dilutus)* and amphipods (*Hyalella azteca)* were performed by the Great Lakes Environmental Center, Inc. (GLEC), and included survival, growth and biomass as the toxicity endpoints (GLEC, 2012). The 20 samples were also analyzed for spill-related contaminants and other sediment characteristics that can influence the growth and survival of benthic invertebrates. Based on comparisons to sediment toxicity benchmarks for PAHs, some but not all heavily oiled sites were expected to pose adverse chronic risks to benthic fauna, and the toxicity testing showed reductions in growth and survival in some of the samples (Bejarano, 2012). Based on the weight of evidence approach and additional risk metrics, the author of the data analysis concluded that in 2012, residual oil from the Enbridge Line 6B Oil Discharges in 2010, particularly in heavily oiled areas, may pose some risks to benthic receptors, although other factors need to be considered (Bejarano, 2012).

During the summer of 2012, independent researchers from Central Michigan University looked at the unionid mussel assemblages at sites upstream (n=5) of Marshall, in the reach impacted by the Enbridge Line 6B Oil Discharges (n=4), and downstream (n=3) of Morrow Dam (Woolnough and Parker, 2013). They used timed, transect, and quadrat surveys to determine the assemblage, size classes, gravidity and shell deposits at all sites. Overall, fewer live species of unionids were found in the impacted spill reach as compared to the upstream and downstream regions. When standardized by area surveyed, more shells were found in the spill region compared to the upstream and downstream regions with less evidence of reproduction in the spill region.

3.2.6 Chemical Analysis of Water

In July 2010, the Trustees and Enbridge cooperatively developed work plans for the collection and chemical analysis of oil constituents such as polycyclic aromatic hydrocarbons (PAHs) and alkylated PAHs at different depths within the water column. At the time, water samples being taken as part of the response efforts were being collected from the surface of the water only and alkylated PAHs were not being measured. The Trustees and Enbridge staffed joint teams to collect the water samples during three different sampling events from July 29, 2010 through August 19, 2010. Enbridge contracted with a laboratory for analysis of the water samples. The Trustees compared the analytical results to various U.S. EPA and MDEQ water quality criteria. Most of the chemical concentrations were below criteria concentrations. The Trustees and Enbridge jointly decided that additional sampling was unnecessary. No summary report was written.

In 2011, the Trustees and Enbridge cooperatively developed a work plan to document exposure of fish to oil constituents including PAHs and alkylated PAHs at likely fish spawning locations. The purpose was to document potential exposure of these constituents to fish embryos. Surface water samples were collected from eight different locations (including upstream references) and field filtered. Samples were collected once per week for four weeks and then once every two weeks for three additional sampling periods for a total of seven sampling periods from April 12, 2011 through July 13, 2011. The Trustees compared PAH concentrations observed at the sites to literature-based effects levels and concluded that concentrations in 2011 were not great enough to adversely impact fish embryos. No summary report was written.

3.2.7 Recreational Lost Use

Nearly immediately after the Enbridge Line 6B Oil Discharges began in July 2010, county health agencies closed public access to 39 miles of the river system to protect public health and safety. On April 18, 2012, a three-mile portion was opened from Perrin Dam in Marshall to Saylor’s Landing near 15 Mile Road and the Kalamazoo River. On June 21, 2012, the remainder of the river was opened for public use, although certain areas remained buoyed to exclude the public from active work areas posing a safety risk. In addition, the Michigan Department of Community Health issued a Fish Consumption Advisory and a Swimming Advisory on July 27, 2010, both of which were lifted on June 28, 2012 (Michigan Department of Community Health, 2012).

In March of 2013, U.S. EPA ordered Enbridge to dredge several areas of the river in 2013 to remove additional submerged oil. As a result, starting on August 16, 2013, a section of the river from Historic Bridge Park to where the Battle Creek River joins the Kalamazoo River was closed in preparation for dredging near the Battle Creek Mill Ponds. This section covers about 5 miles of the river and was closed until May 23, 2014. A second section of the Kalamazoo River, from Saylor's Landing to Ceresco Dam, was closed Tuesday, July 24, 2013, to prepare for dredging and reopened on October 7, 2014. This section covers about 3 miles of the river. An additional section of river from the Galesburg Community Park Public Access to the MDNR Access on Morrow Lake was also closed from July 25, 2013 through July 3, 2014.

Within days after the Enbridge Line 6B Oil Discharges, the Trustees and Enbridge informally assessed human activity and recreational use/access locations along the impacted portion of the river. The Trustees also gathered and compiled readily available information on pre-spill recreational use along the affected portion of the river, including information on angling, park use, and shoreline use. The NHBP conducted preliminary interviews with tribal elders to evaluate whether further study of cultural use losses was warranted.

The Trustees worked with Enbridge to develop a sampling plan for telephone interviews and onsite counts and interviews of river users. Enbridge participated in the plan development, but declined to participate in sampling; thus the Trustees conducted the sampling independently. The Trustees sampled 16 sites for boating use and 22 sites for shoreline use (e.g. fishing, picnicking, exercising) from April 27, 2012 to July 31, 2012. Trustees conducted the telephone interviews from September 11, 2012 to October 31, 2012.

3.2.8 Non-Recreational Lost Use to Tribes

The Kalamazoo River is the core of the home territory of the Match-E-Be-Nash-She-Wish Band of Pottawatomi and Nottawaseppi Huron Band of the Potawatomi (the Tribes), historically both known as the Bodewadmi. The River and River Corridor are integral to the life (uses) of these two Tribes, providing them with water travel, subsistence, medicinal, economic, educational, and ceremonial services, past, present and future. The two Tribes have used such resources and lived here for thousands of years. Investigations, confidential to the Tribes, show that members of both Tribes find the area significant and important to their uses. Natural resources of significance to the Tribes' and their members include fish, mussels, turtles, mammals, birds, insects, plants, and other biological resources and water resources. The oil spill resulted in losses of tribal uses.

3.3 Injury Assessment, Methods and Results

Based on the results of the studies described in Section 3.2, the Trustees assessed both recreational use losses and ecological injuries. The ecological injuries were assessed on a habitat basis for both injuries resulting directly from the oil itself and those resulting from response actions. For the recreational use losses, the Trustees developed a site-specific recreational demand model to estimate the number of user days lost and used benefits transfer to estimate the reduction in the recreational value of the river due to the Enbridge Line 6B Oil Discharges and subsequent environmental degradation. This is described in more detail in Section 3.3.1. For the ecological losses assessed on a habitat basis, the Trustees used a Habitat Equivalency Analysis (HEA) approach to quantify injury to in-stream habitats, floodplain wetland habitats, and upland habitats. The three HEAs are described in more detail in Sections 3.3.2 and 3.3.3.

HEA is a tool commonly used in NRDA. HEA is based on the concept that habitat provides ecological services (e.g. food and shelter for organisms). Contamination and physical disturbance reduce the ecological services, but restoration of the same or similar type of habitat would replace the ecological services and thus compensate for the losses. To conduct a HEA, the Trustees quantify the duration and severity of injury in terms of the percent of the services that are lost. The injury is modeled over time, using a discount factor to bring all values into present terms. The results are measured in units of Discounted Service Acre Years (DSAYs), representing the number of acres impacted, the level of impact in terms of the percent loss of ecological services, the duration of the injury, and the discounting of all years of injury into present value terms.

3.3.1 Assessment of Recreational Losses

For the recreational use losses, the Trustees used the information developed in the surveys described in Section 3.2.7 to develop a site-specific recreational demand model to estimate the number of user days lost and used benefits transfer to estimate the reduction in the recreational value of the river due to the Enbridge Line 6B Oil Discharges and subsequent environmental degradation. Results of the sampling in 2012 produced an estimate of approximately 8,600 baseline boating trips and 64,800 baseline shoreline trips to the affected area between April and October. Closures and cleanup activities related to the Enbridge Line 6B Oil Discharges caused a 100% loss of boating trips from the date of the Enbridge Line 6B Oil Discharges through October 2011. It was assumed that as the river re-opened and the quality of the site improved, boating trips gradually returned through the summer of 2012 (losses beginning at 70% in April and ending at 30% in October). The analysis resulted in approximately 13,300 lost boating trips as a result of the Enbridge Line 6B Oil Discharges.

Shoreline use followed a similar pattern, with spill related closures and cleanup activities causing a 100% loss of shoreline trips from the date of the Enbridge Line 6B Oil Discharges and dropping to an 80% loss by October 2010. Losses throughout 2011 (April through October) were assumed to be at 75% of baseline with a modest recovery occurring in 2012 (October 2012 ending at a 7% loss). The analysis resulted in approximately 86,600 lost shoreline trips as a result of the Enbridge Line 6B Oil Discharges.

3.3.2 Assessment of Injury to In-Stream Habitats

Relying on the geographic information system produced by the MDEQ, the Trustees assessed injuries to 1,560 acres of in-stream habitats that were oiled and/or impacted by cleanup actions. In-stream habitats include the main stem of the Kalamazoo River as well as the affected portions of Morrow Lake. Poling data were used to identify areas with "heavy" and "moderate" submerged oil; these comprised 385 acres. Spill responders used "heavy" and "moderate" submerged oil to determine areas that were actionable for cleanup, thus the poling data were considered to be a good indicator of the level of oiling injury and the level of physical disturbance from cleanup work. The Trustees assumed that the remaining in-stream areas had a lesser level of oiling and cleanup activity.

The affected area of the Kalamazoo River was divided into four reaches based on geomorphic differences (e.g. channel width, straightness), differences in initial oiling, and barriers to fish passage that divide the river into different fish communities. The division points that the Trustees used were the Ceresco Dam, the downstream end of the Mill Ponds in Battle Creek, Custer Road in Kalamazoo County, and 35th Street in Kalamazoo County, upstream of Morrow Lake. Morrow Lake and the delta formed as the Kalamazoo River enters the lake are considered as a fifth reach.

The Trustees assigned injury levels and recovery rates on a reach-by-reach basis, since impacts from dredging, agitation, and sedimentation spread downstream within the reach and because fish travel throughout a reach. Also, intense boat traffic and helicopter overflights caused disturbances throughout reaches, not just in the immediate area where work was being conducted. Initial injury levels ranged from 50% in the areas with less oiling and less active remediation to 90% in areas where heavy oiling and intense and intrusive remediation activities, such as dredging, occurred. Projected recovery timeframes were approximately 15 years in sensitive habitats such as the Mill Pond (a high quality wetland with many large, diverse types of plants providing a productive fish nursery and habitat for herons and swans) and approximately 5 years in other areas. Physical disturbances of sediment and aquatic vegetation and the removal of habitat structure (e.g. removal of oiled wood snags that provide habitat) were some of the factors considered in estimating recovery times.

The HEA results indicated that 5,790 DSAYS were lost in in-stream habitats as a result of the Enbridge Line 6B Oil Discharges.

3.3.3 Assessment of Injury to Floodplain Wetlands and Uplands

Again relying on the MDEQ geographic information system, at the time of the Enbridge Line 6B Oil Discharges, 2,887 acres of floodplain wetlands and uplands were inundated because of flooding along Talmadge Creek and the Kalamazoo River. After the floodwaters receded, areas with residual oil totaled 299 acres. The Trustees assigned 70% initial injury to the areas with residual oil. This injury level was then adjusted based on the type of response action taken, as described below. Response actions may result in greater initial injury but a faster recovery time than if the oil were to be left in place. The remainder of the inundated area (i.e. areas that were exposed to oil during the flood) was assigned a temporary injury of 100% for one week following the Enbridge Line 6B Oil Discharges, because oil on the surface of the water and fumes in the air eliminated the ecological services (e.g. drinking water for wildlife, hatching area for insects, use of the water surface by air-breathing aquatic organisms). Starting one week after the Enbridge Line 6B Oil Discharges, the Trustees assigned no additional injury in areas where residual oil was not observed and response work was not conducted.

Response actions ranged from natural attenuation (no active cleanup) to excavation. In addition, some areas that were not oiled were affected by the cleanup work, e.g. construction of access roads, dredging pads, etc. Excavation causes significant physical disturbance to the habitat by removing all habitat structure and function. Soil scraping, high pressure flushing, and agitation of submerged sediment to release oil remove significant structure and function. Removal of woody debris and live vegetation has a lesser but still significant impact. Other actions such as placement of absorbent materials, vacuuming oil, and flushing with low pressure hoses all cause some impacts, such as soil compaction. Also, the presence of responders and the noise created by the response actions acted as deterrents to wildlife use of the areas. If multiple response activities took place in the same location, the Trustees assigned the higher injury level. Initial injury levels ranged from 70% to 100%.

The Trustees divided the habitat into the following types: uplands, emergent wetlands (including ponds, aquatic beds, and scrub-shrub wetlands), forested wetlands, and rare and unique wetlands. Recovery timeframes for these habitat types differ: emergent wetlands are expected to recover in three to seven years, based on the rate of plant regrowth, while forested wetlands would take five to 50 years if trees are cut down and excavation removes the hydric soils needed for wetland plants to grow. Rare and unique wetlands, such as those near Talmadge Creek, are not expected to fully recover if excavation changes the hydrology or if removal of vegetation allows invasive species to crowd out the rare and unique species.

The HEA results indicated that 2,320 DSAYS were lost in wetland and upland habitats as a result of the Enbridge Line 6B Oil Discharges.

3.4 Injury Quantification and Scaling

3.4.1 Recreational Use Quantification and Scaling

The Trustees used benefits transfer techniques to evaluate the dollar value losses resulting to recreational users as a result of the Enbridge Line 6B Oil Discharges. When recreational users of environmental resources are faced with a diminution in site quality, they often either substitute to another site, take a trip to the same site but derive less value from their trip, or cancel their trip altogether. Each of these behavioral changes results in a decrease in value. Published values of lost fishing, boating, and shoreline trips from environmental economics literature were evaluated for appropriateness of application to users of the Kalamazoo River. The Trustees used values of $23.9 and $14.4 for a lost boating and shoreline trip, respectively. As described above in Section 3.3.1, the Trustees estimated the number of lost trips at 13,300 lost boating trips and 86,600 lost shoreline trips as a result of the Enbridge Line 6B Oil Discharges. The values of these losses were discounted to present value using a 3% discount rate. Additional simulations were performed to evaluate several other scenarios, specifically supposing that 1) the estimate of baseline used was depressed due to ongoing impacts from the Enbridge Line 6B Oil Discharges, 2) losses continued into the summer of 2013, and 3) trips that took place during the spill period were trips of diminished value. The sum present value of recreational losses was estimated to be in the range of $1.7 million to $2.6 million. The Trustees believe that these losses will be addressed as the result of a combination of the public uses of the restored areas and the recreational use projects described in Table 1.2.

3.4.2 Ecological Injury Quantification and Scaling

To complete the quantification of injuries to habitats, the Trustees identified general types of habitat restoration projects and assessed the DSAYs they would provide. The total damages are given by the number of acres of those restoration projects required to match the DSAYs calculated in the injury assessment. Compensatory restoration alternatives must be scaled to ensure that the size or quantity of the project reflects the magnitude of the injuries from the discharges. The Trustees relied on the OPA regulations to select the scaling approach for compensatory restoration actions.

The Trustees considered wetland creation, benthic (riverbed) habitat creation, wild rice planting, and grassland prairie/oak savanna restoration. The Trustees assumed that each of these general restoration types would be initiated in the summer of 2014[6] and would provide increasing ecological services over time: forested wetlands would take 50 years to reach full function, emergent/scrub-shrub wetlands would take 15 years, benthic habitat would take five years, and wild rice planting would take three years.

Benthic habitat improvements, wild rice planting, and invasive species control projects in inland lakes were both scaled against the in-stream injuries identified in Section 3.3.2, and the Trustees determined that 216 acres of benthic habitat, 5 acres of wild rice planting, and 350 acres of invasive species control projects will together compensate for the injury to the in-stream habitats in Talmadge Creek, the Kalamazoo River, and Morrow Lake. The removal of Ceresco Dam and restoration of the river channel in the area of the dam, as required by the State Settlement, is connecting 199 acres of benthic habitat with the downstream stretch of river. Therefore, the Trustees sought projects that will address the difference, i.e. 5 acres of wild rice planting, 350 acres of aquatic invasive species control projects, and 17 acres of benthic habitat. The Trustees selected restoration projects on Pigeon Creek, Rice Creek, inland lakes in the Fort Custer State Recreation Area, and the Kalamazoo River that will provide the additional required ecological service improvements. These projects are described in greater detail in Chapter 4.

New wetlands were scaled against the injury identified in Section 3.3.3, and the Trustees determined that 300 acres of a combination of forested, scrub-shrub, and

[6] Based on the timing of the Final DARP/EA, projects are now expected to be initiated in 2016, but this does not significantly affect the amount of habitat restoration estimated to be necessary.

emergent wetlands must be created to compensate for the injury. This restoration is expected to be achieved with the wetland projects that Enbridge will complete under the direction of the State of Michigan, in consultation with the Trustees, as described above in Table 1.2.

The Trustees used oak savanna and adjoining woodlands restoration to scale restoration to the injury resulting from use of upland areas for response activities including construction of access roads and staging areas. Based on this analysis, the Trustees determined that three years of invasive species control on 130 acres of oak savanna and adjoining woodlands will compensate for the interim losses in the upland areas used for the response.

4.0 RESTORATION ALTERNATIVES

4.1 Restoration Strategy

The goal of restoration under OPA is to compensate the public for injuries to natural resources and services from an oil spill. OPA requires that this goal be achieved by returning injured natural resources to their baseline condition, and, if possible, by compensating for any interim losses of natural resources and services during the period of recovery to baseline.

Restoration actions under the OPA regulations are either primary or compensatory. Primary restoration is action(s) taken to return injured natural resources and services to baseline on an accelerated time frame. The OPA regulations require that the Trustees consider natural recovery under primary restoration. The Trustees may select natural recovery under three conditions: (1) if feasible, (2) if cost-effective primary restoration is not available, or (3) if injured resources will recover quickly to baseline without human intervention. Alternative primary restoration activities can range from natural recovery, to actions that prevent interference with natural recovery, to more intensive actions expected to return injured natural resources and services to baseline faster or with greater certainty as compared to natural recovery.

Compensatory restoration is action(s) taken to compensate for the interim losses of natural resources and/or services pending recovery. The type and scale of compensatory restoration may depend on the nature of the primary restoration action and the level and rate of recovery of the injured natural resources and/or services given the primary restoration action. When identifying the compensatory restoration components of the restoration alternatives, the Trustees must first consider compensatory restoration actions that provide services of the same type and quality and of comparable value to those lost. If compensatory actions of the same type and quality and of comparable value cannot provide a reasonable range of alternatives, the Trustees then consider other compensatory restoration actions that will provide services of at least comparable type and quality as those lost.

In considering restoration for injuries resulting from the Enbridge Line 6B Oil Discharges, the Trustees first evaluated possible restoration for each injury and then considered on-site work that has been or is being conducted by Enbridge under the direction of U.S. EPA and MDEQ. Based on that analysis, the Trustees determined that no additional primary restoration, other than natural recovery, was appropriate. Thus, with the exception of the natural recovery alternative, only compensatory restoration projects to be implemented under the direction and control of the Trustees pursuant to the Final DARP/EA are presented below.

Several of the restoration alternatives included in this section are based on designs that may require additional detailed engineering design work or operational plans. Therefore, details of specific projects may require additional refinements or adjustments to reflect site conditions or other factors. If a selected project becomes infeasible for some reason, the Trustees will consider substituting a similar project and evaluate whether this decision requires additional public review under OPA or NEPA.

4.2 Restoration Project Selection Criteria

NRDA regulations under OPA require consideration of six criteria when evaluating restoration options (15 C.F.R. § 990.54(a) and (b)). The Trustees are using these criteria with additional considerations that the Trustees have adopted to focus and maximize the value of restoration efforts toward recovery of natural resource injuries and service losses that occurred as a result of the Enbridge Line 6B Oil Discharges (U.S. Fish and Wildlife Service et al., 2012). Within these criteria, restoration projects and project locations that reflect the geographic area affected by the Enbridge Line 6B Oil Discharges and which address the diversity of resource injuries that resulted from it are preferred.

1. Relation to natural resource injuries and services losses
This criterion is used to judge the degree to which a project helps to return injured natural resources and services to at least baseline conditions that were present prior to the Enbridge Line 6B Oil Discharges or compensate for interim service loss. Projects should demonstrate a clear relationship to the resources and services injured. Projects located within the area affected by the Enbridge Line 6B Oil Discharges are preferred, but projects located within the Kalamazoo River watershed that provide benefit to the resources injured in the affected area will also be considered. The Trustees will aim for a diverse set of restoration projects and project locations, addressing an array of resource injuries.

2. Avoidance of Adverse Impact
Projects will be evaluated for the extent to which they prevent future injury as a result of the Enbridge Line 6B Oil Discharges and avoid collateral injury as a result of implementing the alternative. All projects shall be lawful and likely to receive any necessary permits or other approvals prior to implementation.

3. Project cost and cost effectiveness
The cost of a project, both initial cost and long term maintenance, will be considered against the relative benefits of a project to natural resources and service losses. Projects that return the greatest and longest lasting benefits for the cost will be preferred. The Trustees will also consider the time necessary before project benefits are achieved, and the sustainability of those benefits. Projects will be reviewed for their public acceptance and support, and consideration given to projects that leverage the financial resources of partner organizations.

4. Likelihood of Success
This criterion considers the technical feasibility of achieving the restoration project goals and will take into account the risk of failure or uncertainty that project goals can be met and sustained. This criterion will also consider the availability and ease of implementing corrective measures in the event that the

restoration project fails or does not initially meet its goals, to ensure project benefits are achieved. The Trustees will generally not support projects or techniques that are unproven or projects that are designed primarily to test or demonstrate unproven technology.

5. Multiple Resource and Service Benefits
Projects that provide benefits that address multiple resource injuries or service losses, or that provide ancillary benefits to other resources or resource uses are preferred. Restoration projects should not substitute for legally mandated requirements and restoration projects that would otherwise occur.

6. Public Health and Safety
This criterion is used to ensure that the project will not pose an unacceptable risk to public health and safety.

Information supporting the Trustees' selections of restoration alternatives is provided throughout the remainder of this chapter.

NEPA also applies to restoration actions taken or directed by the federal Trustees. To reduce transaction costs and avoid delays in restoration, the OPA regulations encourage the Trustees to conduct the NEPA process concurrently with the development of the restoration plan.

To comply with the requirements of NEPA, the Trustees analyzed the effects of each alternative that they would be implementing on the quality of the human environment. NEPA's implementing regulations direct federal agencies to evaluate the potential significance of proposed actions by considering both context and intensity. For most of the actions selected in this Final RP/EA, the appropriate context for considering potential significance of the actions is local, as opposed to national or worldwide. More information on the Trustee's analysis of the proposed actions relative to NEPA is provided in Chapter 5.

With respect to evaluating the intensity of the impacts of a proposed action, the NEPA regulations (40 C.F.R. 1508.27) require the consideration of ten factors:

1. Likely impacts of the proposed project.

2. Likely effects of the project on public health and safety.

3. Unique characteristics of the geographic area in which the project is to be implemented.

4. Controversial aspects of the project or its likely effects on the human environment.

5. Degree to which possible effects of implementing the project are highly uncertain or involve unknown risks.

6. Effect of the project on future actions that may significantly affect the human environment.

7. Possible significance of cumulative impacts from implementing this and other similar projects.

8. Effects of the project on National Historic Places, or likely impacts to significant cultural, scientific, or historic resources.

9. Degree to which the project may adversely affect endangered or threatened species or their critical habitat.

10. Likely violations of environmental protection laws.

Using the above criteria, the Trustees evaluated a range of restoration alternatives which would compensate the public for losses caused by the Enbridge Line 6B Oil Discharges. The Trustees reviewed existing watershed plans and other restoration planning documents for potential projects (e.g. Calhoun County Conservation District, 2003; Kalamazoo River Watershed Council, 2011; Michigan Department of Environmental Quality, 2005; Stratus Consulting, 2013). The Trustees also spoke with the public about their restoration criteria at the June 19, 2012 meeting of the Cooperating and Assisting Agencies Group convened by MDEQ and sought input in 2013 from representatives from the Calhoun County Conservation District, Kalamazoo River Watershed Council, and Fort Custer Recreation Area on potential projects. Potential restoration projects identified included culvert replacements, streambank restoration, prairie and oak savanna uplands restoration, invasive species management, shoreline softening and others. In the following sections, the selected restoration alternatives to be implemented by the Trustees under this Final DARP/EA for the affected natural resources and natural resource services and the non-preferred restoration alternatives are presented and discussed.

4.3 Evaluation of Restoration Alternative 1: No-Action/Natural Recovery

NEPA requires the Trustees to evaluate an alternative in which no actions are taken by a federal agency. Here, the no-action alternative would mean that the Trustees would take no direct action to restore injured natural resources or to compensate for lost services pending natural recovery. Instead, the Trustees would rely solely on natural recovery for the achievement of restoration goals beyond what would be achieved in the State Settlement. While the Trustees believe that natural recovery will occur over varying time scales for the resources exposed to and/or injured by the Enbridge Line 6B Oil Discharges, the interim losses suffered would not be fully compensated under a no-action alternative.

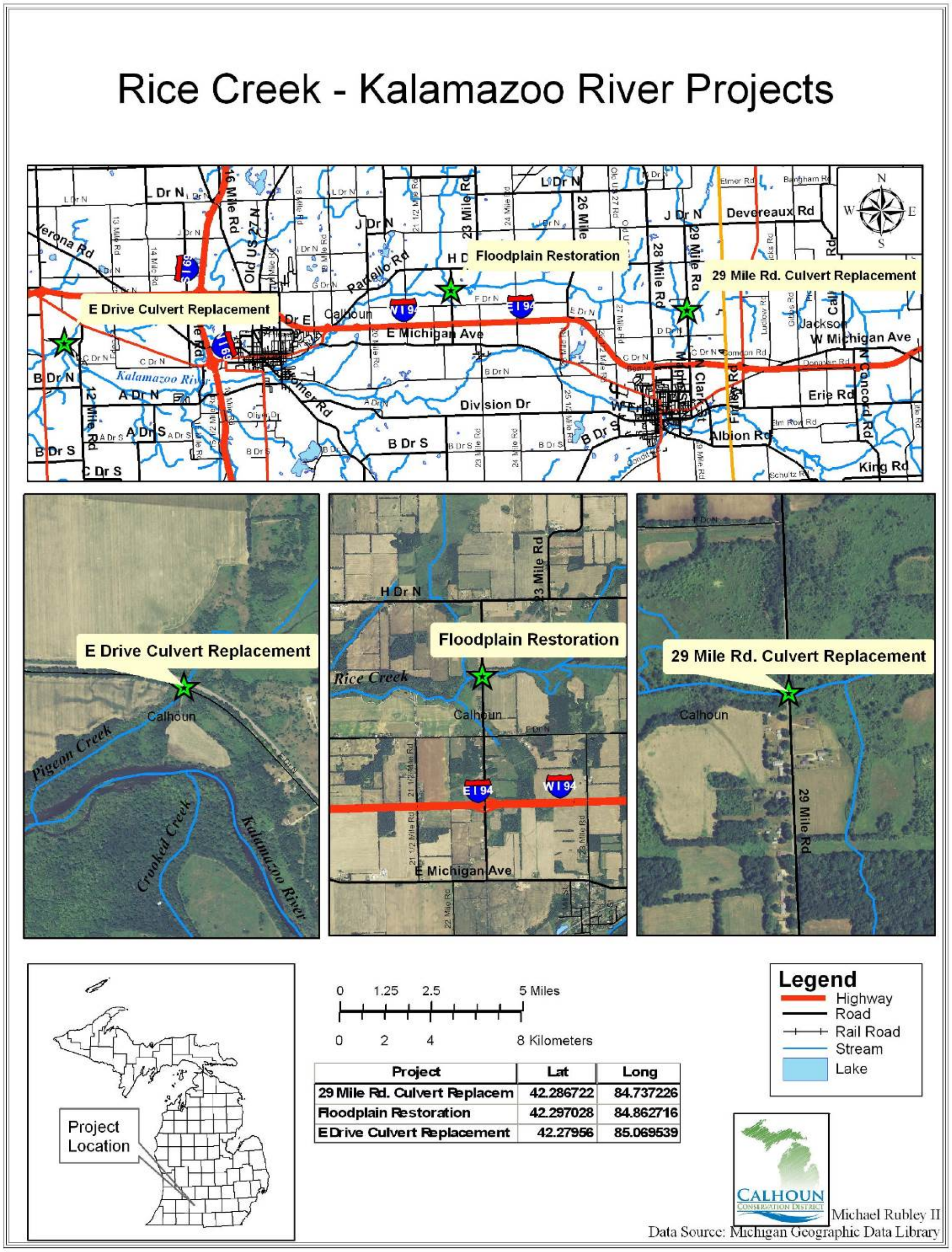
The principal advantages of this approach are the ease of implementation and lack of costs because natural processes rather than humans determine the trajectory of the system. This approach, more so than any of the others, recognizes the capacity of dynamic river systems and entire watersheds for self-healing over time and does not directly alter existing habitats.

However, OPA clearly establishes the Trustees' responsibility to seek compensation for interim losses pending recovery of the natural resources. This responsibility cannot be completely addressed through a no-action alternative. The Trustees have determined that natural recovery can be appropriate as part of primary restoration but that the no-action alternative is not sufficient for compensatory restoration. Losses were, and continue to be, suffered during the period of recovery from this spill and technically feasible and cost-effective alternatives exist to compensate for these losses beyond what is expected to be achieved by the State Settlement.

4.4 Evaluation of Restoration Alternative 2: Riverine (selected)

Several projects that benefit in-stream habitats and associated aquatic natural resources have been identified and developed by the Calhoun County Conservation District (CCCD). The Trustees selected three of these to address in-stream injuries by improving water quality, aquatic connectivity, and in-stream habitat. The three projects are located in Pigeon Creek and Rice Creek, both tributaries to the Kalamazoo River near Marshall, Michigan (Figure 4.1).

Figure 4.1. In-stream Restoration Projects



Project	Lat	Long
29 Mile Rd. Culvert Replacem	42.286722	84.737226
Floodplain Restoration	42.297028	84.862716
E Drive Culvert Replacement	42.27956	85.069539

4.4.1 Pigeon Creek, E Drive Crossing Replacement

Project Description

The E Drive road crossing on Pigeon Creek is an undersized and perched culvert system located on E Drive N in Emmett Township (Figure 4.2). A perched culvert is one in which the downstream end is significantly higher than the normal stream elevation. Because of this, the water drop may be too high for fish to jump up into the culvert, the water in the culvert may be too shallow, and the velocity in the culvert may be too great for fish to swim upstream. Mussels rely on fish of certain species to carry their young (the glochidia life stage of mussels encysts on fish gill tissue without harming the fish), so mussel reproduction and distribution is also impacted when the movement of their host fish is limited.

Pigeon Creek is a tributary to the Kalamazoo River, similar to the impacted Talmadge Creek, that enters it about one mile downstream of Ceresco Dam. The road stream crossing inventory and stream morphological assessment conducted at the crossing by the CCCD revealed concerns from sedimentation, nutrient loading, hydrologic flow, salt, road and culvert washouts, perched culverts, inadequate culvert system design, stream bed siltation, and bank undercutting. When culverts are undersized like this, excess water pressure upstream and downstream of this "pinch point" leads to erosion. As part of this erosion, soil particles and nutrients are washed into the stream. Soil particles in the stream eventually settle to the bottom as sediment, and excess sediment reduces the availability of important sand, gravel, and cobble habitats for benthic invertebrates and fish eggs and larvae. Excess nutrients entrained with soil particles can result in an overgrowth of algae in the stream.

The crossing is in an area with significant numbers of mussels and water quality in this stream also affects water quality in the Kalamazoo River downstream. The project will replace the five existing culverts with one bottomless culvert designed to accommodate flood flows from the 7.2 square mile drainage area above this crossing. (Figure 4.3; Figure 4.4)

Figure 4.2. Existing culvert system at E Drive on Pigeon Creek

Figure 4.3. Example of an open bottom structure, along with general guidance for road stream crossings (Massachusetts Department of Fish and Game, 2005)

Figure 4.4. Example of a simple open box culvert (Massachusetts Department of Fish and Game, 2005)

Restoration Objectives

This project is intended to provide compensatory restoration for the in-stream habitats and aquatic natural resources (like mussels and fish) that were injured as a result of the Enbridge Line 6B Oil Discharges by increasing the aquatic functions and values of this tributary to the Kalamazoo River. Pigeon Creek is similar to Talmadge Creek and is a tributary to the Kalamazoo River within the impacted section of the river. Completion of the project will reduce the impacts from erosion, sedimentation and nutrient loading in Pigeon Creek and downstream to the Kalamazoo River and will allow fish passage where the perched culverts currently prevent it.

Probability of Success and Monitoring

Replacing stream crossings using the technologies and design contemplated here is an established process. The Trustees believe, therefore, that this project will have a high likelihood of success. Some of the settlement funds ($4,800) will be used to manage and monitor this project for a two-year period to ensure that the appropriate hydrology has been established and that native vegetation becomes established where soils are disturbed during construction activities.

Environmental and Socio-Economic Impacts

No long-term adverse environmental or socio-economic impacts are expected from this project. It is expected that the restored stream crossing will provide improved water quality and habitat for freshwater mussels, other benthic invertebrates and fish. This will in turn provide benefits to aquatic-dependent migratory birds like green herons and mammals like muskrats, as well as provide increased opportunities for local residents that fish and observe wildlife. The new stream crossing will also reduce upstream flooding and reduce costs to maintain the road over the stream crossing. Minor short-term increases in turbidity and sedimentation would be expected to occur during construction. Turbidity will be minimized by the use of a temporary structure to divert water from the work area (e.g. coffer dam) and silt fences to control erosion until vegetation is re-established. Heavy machinery used for this project could cause minor impact to site use, noise and disruption.

Cost

The Trustees will assist in implementing this project by providing $153,800 from the settlement with the RP to the CCCD. The CCCD will assume responsibility for final design, permitting, and implementation of the project; for coordinating the work with the county road commission; and for the evaluation of the project's success.

Evaluation

The Pigeon Creek restoration site was not directly impacted by the Enbridge Line 6B Oil Discharges, but is a tributary to an impacted section of the Kalamazoo River. The project will provide improved aquatic habitat, stream connectivity and water quality for common aquatic species found in the Kalamazoo River watershed. The CCCD will coordinate the road stream crossing work with the county road commission and use the project as an example of how to use stream morphologic assessments to improve culvert sizing and further minimize impacts to stream function by the use of bottomless culverts.

Although there will be some negative short-term impacts to natural resources as a result of the construction activities, the Trustees have determined that the project's overall environmental impacts are positive. The permitting terms and conditions and other best management practices will ensure that there are minimal disturbances to the existing resources during project construction. The improved aquatic habitat and water quality will have long-term benefits for mussel, fish and wildlife species as well as local members of the public that were injured by the Enbridge Line 6B Oil Discharges.

4.4.2 Rice Creek, 29 Mile Road Crossing Replacement

Project Description

The 29 Mile Road crossing replacement on the South Branch of Rice Creek is an undersized culvert system located on 29 Mile Road approximately two miles north of Albion, Michigan, in Sheridan Township (Figure 4.5). Rice Creek is a tributary to the Kalamazoo River that enters it in Marshall, Michigan, downstream of the dam for the Marshall Impoundment and upstream of the confluence of Talmadge Creek with the Kalamazoo River. The road stream crossing inventory and stream morphological assessment conducted at the crossing by the CCCD demonstrated that the existing 14' wide culvert system is inadequate to accommodate bankfull stream flow and is responsible for flooding and erosion upstream, impaired fish passage and water quality, and stream channelization downstream of the culvert (Figure 4.6). Water quality in this stream also affects water quality in the Kalamazoo River downstream. The project will replace the existing 14' diameter culvert system with a 19'10" wide bottomless arch or box culvert able to accommodate bankfull stream flow.

Figure 4.5. Outlet of 29 Mile Road culvert (Calhoun County Conservation District)

Figure 4.6. Flooding at 30 Mile Road because of flow being impounded at 29 Mile Road crossing (Calhoun County Conservation District)

Restoration Objectives

This project is intended to provide compensatory restoration for the in-stream habitats and aquatic natural resources (like mussels and fish) that were injured as a result of the Enbridge Line 6B Oil Discharges by increasing the aquatic functions and values of this tributary to the Kalamazoo River. The South Branch of Rice Creek has a somewhat larger drainage area than Talmadge Creek and joins with the North Branch of Rice Creek prior to entering the Kalamazoo River just upstream of Talmadge Creek. Completion of the project will directly address erosion along approximately two miles of the stream as well as reduce the impacts from erosion, sedimentation, and nutrient loading in Rice Creek and downstream to the Kalamazoo River; restore fish and wildlife passage in the South Branch of Rice Creek; improve in-stream habitat; and reduce temperature increases and flooding caused when flows exceed the existing culvert capacity.

Probability of Success and Monitoring

Replacing stream crossings using the technologies and design contemplated here is an established process. CCCD has already completed a Rosgen level II geomorphic assessment to determine channel slope, lateral stream bank erosion, stream bed aggradation / degradation, stream bed material, and bankfull characteristics. They have also had soil borings analyzed and the geotechnical work completed. The Trustees believe, therefore, that this project will have a high likelihood of success. The project management budget of $28,000 includes monitoring based on the existing pre-project geomorphic assessment to ensure that the appropriate hydrology has been established and that native vegetation becomes established where bank area soil is disturbed by construction activities.

Environmental and Socio-Economic Impacts

No long-term adverse environmental or socio-economic impacts are expected from this project. It is expected that the restored stream crossing will provide improved water quality and habitat for freshwater mussels, other benthic invertebrates and fish. This will in turn provide benefits to aquatic-dependent migratory birds like green herons and mammals like muskrats, as well as provide increased opportunities for local residents that fish and observe wildlife. The new stream crossing will also reduce upstream flooding. Minor short-term increases in turbidity would be expected to occur during construction. Turbidity will be minimized by the use of a temporary structure to divert water from the work area (e.g. coffer dam) and silt fences to control erosion until vegetation is re-established. Heavy machinery used for this project could cause minor impact to site use, noise and disruption.

Cost

The Trustees will assist in implementing this project by providing $249,000 from the settlement with the RP to the CCCD. The CCCD will assume responsibility for final design, permitting and implementation of the project; for coordinating the work with partners; and for the evaluation of the project's success. This project is expected to be a partnership among the CCCD, the Calhoun County Road Commission, the Calhoun County Drain Commissioner, the Jackson County Drain Commissioner, the MDNR, the MDEQ, and landowners adjacent to the project location.

Evaluation

The Rice Creek restoration site was not directly impacted by the Enbridge Line 6B Oil Discharges, but is just upstream from an impacted section of the Kalamazoo River. The project will provide improved aquatic habitat, stream connectivity and water quality for common aquatic species found in the Kalamazoo River watershed. The CCCD will be coordinating the road stream crossing work with partners and will use the project as an example of how to use stream morphologic assessments and other aspects of modern culvert design to minimize impacts of road crossings on stream functions while ensuring long-term stability of the crossings.

Although there will be some negative short-term impacts to natural resources as a result of the construction activities, the Trustees have determined that the project's overall environmental impacts are positive. Permitting terms and conditions and other best management practices will ensure that there are minimal disturbances to the existing resources during project construction. The improved aquatic habitat and water quality will have long-term benefits for mussel, fish and wildlife species as well as the local members of the public that were injured by the Enbridge Line 6B Oil Discharges.

4.4.3 Rice Creek, Vansickle Berm Lowering

Project Description

The Vansickle berm lowering project will be located on the private property of a willing landowner adjacent to 22 ½ Mile Road along the bank and in the floodplain of Rice Creek in Marengo Township, Michigan (Figure 4.7). Rice Creek is a tributary to the Kalamazoo River that enters it in Marshall, Michigan, downstream of the dam for the Marshall Impoundment and upstream of the confluence of Talmadge Creek with the Kalamazoo River. This section of Rice Creek was dredged in the past and dredge spoils were mounded along the banks, creating long berms that disconnected the stream from its floodplain. Reconnecting the stream and floodplain allows flood flows to spread out into the floodplain. This reduces water volumes and pressures that could erode stream banks and the bed downstream and allows sediment transported during high flows to settle naturally in the floodplain. The floodplain also provides an area of lower flow rates during floods and can be used by fish and other organisms as a refuge from fast, turbulent flows in the main channel.

A previous project removed some of the berm of dredge material from the Vansickle property, but subsequent monitoring has shown that another 6" of berm should be removed to allow the stream to fully reconnect with the floodplain. Water quality in this stream also affects water quality in the Kalamazoo River downstream. This project will remove an additional 6” of berm along 470’ of Rice Creek.

Figure 4.7. Vansickle berm needs to be lower to allow spring high flows to distribute into the floodplain (Calhoun County Conservation District)

Restoration Objectives

This project is intended to provide compensatory restoration for the in-stream habitats and aquatic natural resources (like mussels and fish) that were injured as a result of the Enbridge Line 6B Oil Discharges by increasing the aquatic functions and values of this tributary to the Kalamazoo River. Rice Creek has a larger drainage area than Talmadge Creek and enters the Kalamazoo River just upstream of Talmadge Creek. Completion of the project will reduce the impacts from channelization, erosion, sedimentation, and nutrient loading in Rice Creek and downstream in the Kalamazoo River. The bermed area is upstream of high quality trout habitat that may also be enhanced by this project.

Probability of Success and Monitoring

This project will utilize the engineering work already completed for this site and will use established techniques for reconnecting the stream to its floodplain. The CCCD has already completed a Rosgen level III multi-year geomorphic assessment study to evaluate sediment loads, bank erosion rates, and understand geomorphic conditions needed to restore connectivity of the stream and its wetlands on Rice Creek. The Trustees believe, therefore, that this project will have a high likelihood of success. The project management budget of $10,500 includes monitoring based on the existing pre-project geomorphic assessment to ensure that the appropriate hydrology has been established and that native vegetation becomes established where soils are disturbed by construction activities.

Environmental and Socio-Economic Impacts

No long-term adverse environmental or socio-economic impacts are expected from this project. It is expected that the restored floodplain will reduce flooding and other impacts of stream channelization, thus providing improved water quality and habitat for freshwater mussels, other benthic invertebrates, and fish. This will in turn provide benefits to aquatic-dependent migratory birds like green herons and mammals like muskrats, as well as provide increased opportunities for local residents that fish and observe wildlife. Minor short-term increases in turbidity would be expected to occur during the physical construction work. Turbidity will be minimized by the use of silt fences and other erosion control measures to control erosion until vegetation is re-established.

Cost

The Trustees will assist in implementing this project by providing $36,650 from the settlement with the RP to the CCCD. In return, the CCCD will assume responsibility for final design, permitting, and implementation of the project; for coordinating the work with the landowner; and for the evaluation of the project's success.

Evaluation

The Rice Creek restoration site was not directly impacted by the Enbridge Line 6B Oil Discharges, but is just upstream from an impacted section of the Kalamazoo River. The project will provide improved aquatic habitat and water quality for common aquatic species found in the Kalamazoo River watershed. The CCCD will coordinate this work with the landowner and will continue to use the project as an example of the benefits of reconnecting streams with their floodplains.

Although there will be some negative short-term impacts to natural resources as a result of the construction activities, the Trustees have determined that the project's overall environmental impacts are positive. Permitting terms and conditions and other best management practices will ensure that there are minimal disturbances to the existing resources during project construction. The improved aquatic habitat and water quality will have long-term benefits for mussel, fish, and wildlife species as well as local members of the public that were injured by the Enbridge Line 6B Oil Discharges.

4.5 Evaluation of Restoration Alternative 3: Lake (selected)

4.5.1 Fort Custer Lake Enhancements

Project Description

The project site consists of three inland lakes in Fort Custer Recreation Area (FCRA) in Kalamazoo County near Augusta, Michigan: Eagle Lake (200 acres), Whitford and Lawler Lake (72 acres) and Jackson Hole Lake (62 acres). These lakes support warmwater fish species. All three are accessible to the public from the shoreline and Eagle Lake and Whitford and Lawler Lake have boat access with no boat wakes allowed. The aquatic community and fishing and boating opportunities on these lakes are impaired by aquatic invasive species, primarily Eurasian watermilfoil. Starry stonewort, Carolina fanwort and other aquatic invasive plants may also be present. This project will consist of combining control of these invasive species with aquatic herbicide and enhancing populations of the native aquatic weevil *Euhrychiopsis lecontei* with a prevention program to deter the spread of invasive plants from these lakes to others in the area and the introduction of new invasive species into these three lakes. Eurasian watermilfoil is typically treated by applying selective herbicides (e.g. 2,4-D, triclopyr), enhancing populations of the native aquatic weevil *Euhrychiopsis lecontei* (Dietz) that acts as a biological control, or some combination of the two. For this project, the Trustees will work with MDNR Fisheries, MDEQ permitting staff, and resource managers at FCRA to design an aquatic invasive plant control program optimized specifically for these lakes. The prevention program will consist of educational signage and a boat washing facility.

Restoration Objectives

This project is intended to provide compensatory restoration for the impounded areas of the Kalamazoo River that were impacted by the Enbridge Line 6B Oil Discharges by restoring the aquatic functions and values in nearby lakes. The three lakes in FCRA are currently impaired by excessive populations of invasive aquatic vegetation which limits the growth of native aquatic vegetation and the population of warm water fish species in these lakes, as well as recreational use of the lakes. This project will actively control invasive species for three years over the 334 acres of these three lakes, and benefits will continue beyond that if a self-sustaining population of aquatic weevils is established and preventative measures provided by signage and boat cleaning stations are successful.

Probability of Success and Monitoring

Controlling invasive aquatic vegetation with herbicides using the technologies and design outlined here is an established process. The Trustees believe, therefore, that this project will have a high likelihood of success over the three years of active control anticipated with the funding provided. The degree of success in the years following herbicide application is less certain based on the variability in success observed for introductions of native aquatic weevils as biocontrols for Eurasian milfoil and for boater education efforts. As part of the active control program, lake managers will monitor the success of the control efforts from previous years (e.g. percent cover of milfoil, presence of a population of aquatic weevils) when planning the treatment strategy for the upcoming year.

Environmental and Socio-Economic Impacts

No long-term adverse environmental or socio-economic impacts are expected from the lake improvement project in FCRA. The Trustees expect that this project will provide ecological benefits and improved recreational use of the lakes for swimming, boating, and fishing. The selection and application rates for herbicide use will be designed to maximize control of the invasive species and minimize harm to native vegetation, but some short-term harm to native aquatic plant species may occur. Also, the decay of the invasive plant species may cause some short-term reductions in dissolved oxygen in the water and odors on and near the lake.

Cost

The Trustees will provide $343,714 to MDNR for improvements at the three lakes in FCRA. They expect that this will provide active control of invasive aquatic plant species for at least three years, along with educational signage on invasive species and one or more boat cleaning stations or mobile boat cleaning equipment. If MDNR is able to partner with others or use some of this funding as match, additional benefits may be possible.

Evaluation

The three lakes in FCRA were not directly impacted by the Enbridge Line 6B Oil Discharges. However, the lakes are located in close proximity to Morrow Lake and the Ceresco Impoundment that have similar fisheries and recreational uses that were impacted by the Enbridge Line 6B Oil Discharges. In addition, these lakes are located in Kalamazoo County, whereas all of the recreational sites that Enbridge developed or enhanced are located in Calhoun County (see Table 1.2). Although there may be some negative short-term impacts to natural resources as a result of herbicide use, the Trustees have determined that the project's overall environmental impacts are positive. The herbicide application plan and permitting terms and conditions and other best management practices will ensure that these short-term impacts are minimized. Overall, this project will provide benefits to 334 acres of lake habitat for more than three years and thus address interim losses to similar habitats that occurred because of the Enbridge Line 6B Oil Discharges.

4.6 Evaluation of Restoration Alternative 4: Uplands (selected)

4.6.1 Fort Custer Oak Savanna Enhancement

Project Description

The project site consists of approximately 175 acres of existing oak savanna and adjoining woodland habitat within the Fort Custer Recreation Area (FCRA). This restoration project will enhance this area through the control of invasive woody plants using a combination of mechanical cutting followed by herbicide application to stumps and foliar spraying of smaller plants over three years.

Restoration Objectives

This project is intended to provide compensatory restoration for the upland habitats that were injured by the Enbridge Line 6B Oil Discharges and spill response actions by enhancing already existing oak savanna and adjoining woodland habitats that have suffered from a loss in quality because of the growth of invasive woody vegetation. The Trustees' analysis indicated that 130 acres of improved habitat over 10 years will provide sufficient compensation, but working on the 175 acre project site in FCRA is similarly cost-effective because of the scale at which the reintroduction of invasive species from adjacent parcels can occur. The objective is to enhance the ecological services provided by these specific habitats by 10% per year for the three years of active control activities with continuing benefits for seven additional years.

Probability of Success and Monitoring

The control of the woody invasive plant species present at FCRA is an established process. The Trustees believe therefore that this project will have a high likelihood of success. For monitoring, FCRA project managers will take photographs from multiple set points each year, inspecting contractor work for immediate success and any non-target damage, and assessing the success of previous treatments before starting additional treatments in subsequent years. They will do this by walking the site, noting whether woody vegetation is re-sprouting after specific treatments, and determining percent cover of different types of vegetation. They couldthen adjust their planned treatments accordingly.

Environmental and Socio-Economic Impacts

No long-term adverse environmental or socio-economic impacts are expected from these habitat enhancement activities. Impacts to non-target trees and shrubs will be minimized by applying herbicide to cut stumps and limiting foliar spraying to smaller plants. It is expected that controlling invasive plant species in this area will provide improved habitat for rare plants such as downy sunflower, false boneset, and lead plant. Wildlife species such as red-headed woodpecker should also benefit from the savanna enhancement, while forest-dwelling birds such as cerulean warbler and Eastern box turtles should benefit from invasive plant control in the oak woodlands.

Cost

The Trustees will fully fund this project, at $25,000 per year for three years, for a total amount of $75,000.

Evaluation

The oak savanna habitats at FCRA were not directly impacted by the Enbridge Line 6B Oil Discharges. However, the site is located in close proximity to the areas impacted by the Enbridge Line 6B Oil Discharges and spill response. In addition, the acreage of savanna habitat to be enhanced is similar in size and scope as the upland habitats impacted from the Enbridge Line 6B Oil Discharges.

4.7 Evaluation of Restoration Alternative 5: Turtles (selected)

4.7.1 Turtle Nest Protection Program

Project Description

The turtle nest protection program will be conducted at the Fort Custer Recreation Area (FCRA) in Kalamazoo County near Augusta, Michigan and on other properties along the Kalamazoo River between Marshall, MI, and Morrow Lake to which researchers are able to obtain access. This project will consist of capturing female turtles, using radio telemetry to track them until they dig nests and lay eggs, enclosing the nest to exclude predators, and returning to the nest to determine hatching success and release hatchlings. Because all turtles that were rehabilitated and released as part of oil spill response operations were marked with individual internal tags or shell notch patterns, researchers will be able to determine if female turtles that they capture and track were rehabilitated and be able to access details as to where and when they were captured and released and what their condition was when captured initially, cleaned, and treated for oiling. For this project, the Trustees will request detailed project proposals from qualified wildlife researchers who could combine a nest protection program with other efforts to maximize the information that could potentially be gained by examining turtle survival and reproductive success following these kind of discharges.

Restoration Objectives

This project is intended to provide benefits to turtle species that were impacted by the Enbridge Line 6B Oil Discharges by significantly improving reproductive success by eliminating predation for approximately 30 turtle clutches per year over two or possibly three years. In southern Michigan, predation, primarily by raccoons, skunks and foxes, has been shown to be responsible for the loss of 42 to 90% of Blanding's turtle nests (Congdon et al. 1983), 30 to 100% of snapping turtle nests (Congdon et al. 1987) and 22% of painted turtle nests (Tinkle et al., 1981). Human activity and landscape changes contribute to these predation losses by supporting larger populations of raccoons than would be present in less developed areas. In addition to direct nest protection, because some of the females captured are expected to be ones that were oiled, rehabilitated, and released, the observations on hatching success could provide information as to whether the rehabilitated turtles are able to reproduce successfully in the wild.

Probability of Success and Monitoring

Nest protection programs for turtles have been shown to be effective at significantly reducing nest predation and providing information for turtle conservation. A nest protection program has been made a part of the recovery plan for Blanding's turtles in Nova Scotia (Standing et al., 2000). These types of programs are less controversial than predator removal programs, and nest protection programs provide a direct measurement of their own success when hatchlings are counted and post-hatch nests excavated, as is detailed for this program.

Environmental and Socio-Economic Impacts

No adverse environmental or socio-economic impacts are expected from the turtle nest protection program. The only disturbances to the environment will be the presence of the observers and the temporary placement of fencing to exclude predators from the area in which turtles have dug their nests.

Cost

The Trustees will provide up to $300,000 to qualified wildlife researchers that submit a detailed study plan that both provides direct benefits to turtles as well as produces information that benefits turtle conservation over the longer term. Researchers will also be encouraged to work with local volunteers to educate them on turtle conservation techniques. The Trustees expect that this amount of funding will provide for two or possibly three years of direct nest protection and monitoring. This program may also provide the basis for a continuing volunteer effort to place exclosures in and monitor identified turtle nesting areas along the Kalamazoo River.

Evaluation

Overall, turtles were one of the species groups most impacted by the Enbridge Line 6B Oil Discharges, given that every turtle that surfaced to breathe during the early days of the discharges got oiled and some also appeared to have become oiled by coming into contact with submerged oil that persisted over the months and years following the initial Enbridge Line 6B Oil Discharges. Approximately 3,800 oiled turtles were captured and cleaned, and 99% of those survived to be released. This still resulted in the documented death of over 100 individual turtles, including those that were found dead and those that died during attempts to clean and rehabilitate them. The long term effects on turtles that were oiled, cleaned, and released are uncertain. While other restoration projects being performed by Enbridge will also benefit turtles by restoring their in-stream and riparian habitats, this project will provide additional benefits to turtles to offset the losses to this group of species that is particularly long-lived and has low reproductive rates.

4.8 Evaluation of Restoration Alternative 6: Tribal (selected)

4.8.1 Wild Rice Restoration

Project Description

A survey by Huron Potawatomi Staff identified several areas conducive to rice habitat restoration along the Kalamazoo River. Wild river rice (Mnomen) is a state threatened plant species and is a cultural keystone species to the Tribes, important as a subsistence food and as a way for today's members to maintain a connection to important traditional tribal activities related to the rice. The Tribes will collect Mnomen seeds from locations along the Kalamazoo River main stem and reintroduce them to areas that currently lack the species but show promise as acceptable habitat. Phase 1 will include genetic sampling of the seeds to ensure the desired species is targeted and will also identify the exact restoration site locations. Phase 2 will involve planting the rice and monitoring the locations for several years in order to evaluate the success of the project.

Environmental and Socio-Economic Impacts

No long-term adverse environmental or socio-economic impacts will be expected from this project. It is expected that the restored rice sites will provide improved habitat for native aquatic species. Minor short-term increases in turbidity would be expected to occur during the physical excavation and planting work. Turbidity impacts will be minimized by conducting excavation and planting work in accordance with all permit terms and conditions.

Cost

The Trustees will implement this project by providing $275,011 from the settlement with the Responsible Party. The estimated cost to fund this project over five years is $306,293, including one year of research and planning, three years of restoration implementation with monitoring and then a final year of monitoring. The Tribes anticipate being able to obtain matching funds to pay for the difference between the estimated budget and amount to be provided from the settlement. The Tribes will assume responsibility for final design, permitting, and implementation of the project and coordinate with Trustees to evaluate the success of the project.

Evaluation

Wild rice restoration sites identified by Huron Potawatomi Staff on the Kalamazoo River main stem were directly impacted by the Enbridge Line 6B Oil Discharges. This project will improve the habitat quality of the restoration sites and result in positive tribal service flows. The final design of the project will be developed to prevent unacceptable turbidity impacts during planting. The project plan will also include a long term monitoring plan.

Although there may be some negative short-term impacts to natural resources as a result of the construction activities, the Trustees have determined that the project's overall environmental impacts will be positive. Permitting terms and conditions and other best management practices will ensure that there will be minimal disturbances to the existing resources during project construction. The creation of a functioning wild rice habitat will have long-term benefits for a number of fish and wildlife species that were injured by the Enbridge Line 6B Oil Discharges.

4.8.2 Non-recreational Use Analysis and Restoration (selected)

Project Description

The focus of this project will be an analysis to help appropriately tailor approaches to restoration of lost services and the restoration of lost service flows to the Gun Lake Tribe and the NHBP. These federally-recognized Tribes for whom the Kalamazoo River is the core of their home territory were historically both known as the Bodewadmi. The River and River Corridor is integral to the life (uses) of these two Tribes, providing them with water travel, subsistence, medicinal, economic, educational, and ceremonial services, past, present and future. The two Tribes have used such resources and lived here for thousands of years. Natural resources are important to tribal members, both as discrete elements (i.e., specific types of natural resources), as well as for their contribution to the natural environment as a whole and, in turn, for their contribution to the identity and livelihood of tribal members. Tribal members may utilize natural resources in ways that are distinct from the general population.

This project will be undertaken using the framework outlined below in order to allow the Tribes to document ecological knowledge of the biological, water, geological, habitat, and other aspects of the River and River Corridor resource service flows, and their significance in travel, subsistence, medicinal, economic, educational, and ceremonial life, communication between generations, community building, passing on traditional knowledge, ties to native language and place names, as well as to fully understand the scope of the uses lost by their members and subsequently implement a program to improve and expand the available opportunities for traditional resource use along the river.

Bodewadmi Lost Services Analysis and Education Program Implementation:

- Develop a more detailed understanding of the ways in which both the release of oil and clean-up activities have impacted natural resources of importance to the Tribes.
- Review data on oiling and toxic effects to form a base of information for interviews, including streamlined analysis of available data on vegetation, habitat, and other resources.
- Collect existing documentary data from the two Tribes in the form of programmatic planning documents for projects truncated by the spill.

- Review recorded oral histories and other documents collected in the recent past (last 25 years) about both past River resource service flows to the Bodewadmi as well as anticipated and continued tribal use of the River and River Corridor.
- Conduct interviews with tribal staff resource specialists regarding tribally important resources and their uses and potential injuries due to the oil spill.
- Conduct small group or one-on-one interviews with tribal members, including elders practicing traditional ways, to determine how impacts to natural resources from the oil spill may have affected tribal members' current use, future use or perception of the impacted resources.
- Conduct a community survey focused on tribal use of the Kalamazoo River and Corridor to provide baseline information about service flows provided to the Tribes by natural resources prior to and following the spill.
- Based on the results of the research, interviews, and community survey, design and implement a tribal education program designed to help tribal members learn about stewarding the river and the traditional ways of using the resources found there.

Environmental and Socio-Economic Impacts

No long-term adverse environmental or socio-economic impacts would be expected from this project. It is expected that the information gathered through research, interviews, and the community survey will provide the basis for understanding historical and current traditional/cultural uses of the site and its resources, which is considered a positive social impact. Implementation of the education program addressing restoration projects and associated river activities will be expected to deliver a greater sense of stewardship of the river to tribal members, resulting in positive environmental and social impacts. Positive economic impacts will be expected during research and implementation as tribal members are hired to perform some of the necessary tasks.

Cost

The Trustees will implement this project by providing $270,000 from the settlement with the RP which is equal to the estimated cost to fund this project through research, community surveys, and implementation of the education program. The Tribes will assume responsibility for final design, planning, and implementation of the project and for the evaluation of the success of the project.

Evaluation

This project will improve the Tribes' knowledge base regarding their traditional uses of natural resources, as well as which of those uses have been curtailed because of impacts of the oil spill. There are no anticipated negative short-term or long-term impacts to natural resources as a result of this project. The Trustees have determined that the project's overall environmental impacts will be positive. The creation of an effective tribal education program is expected to have long-term benefits for the river environment, including improved stewardship of fish, turtles, freshwater mussels, wildlife, and plant species that were injured by the Enbridge Line 6B Oil Discharges.

4.9 Non-Preferred Alternatives Discussion

4.9.1 Non-Preferred Riverine Alternatives

Kalamazoo River Battle Creek Concrete Channel Restoration

In the City of Battle Creek, the Kalamazoo River flows through a concrete channel for approximately 4,000'. Restoring a more natural river corridor here would provide a significant increase in benefits to aquatic and riparian natural resources in an area that would be accessible to the urban public. However, the Trustees believe that designing and implementing the replacement of the concrete channel with a more natural river corridor would be challenging in this location and would not be the most cost-effective way to improve in-stream and riparian habitat in the Kalamazoo River. A channel and corridor 150' wide and 4,000' long would produce direct benefits in approximately 14 acres, but the drop in elevation required over this distance may still result in velocities that impair fish passage without also creating meanders or significant pool and riffle structures. Costs for land acquisition and moving existing infrastructure to allow for a more natural riparian corridor would be significant, and implementation of the project would potentially alter flooding patterns in this urban location. Shoreline softening projects in less complex situations in Michigan have cost approximately $1,000 per foot of bank. In the Draft DARP/EA, the Trustees used this unit cost estimate and a project length of 4,800 feet to estimate that this project would cost significantly more than $9,600,000 (4,800' * 2 banks * $1,000/bank foot). Based on additional information provided by the Water Resources Commissioner of Calhoun County, the project length is estimated at 4,000 feet; the project will require a full hydrology study costing an estimated $100,000 to $300,000 as part of a feasibility planning process; and the project may require $30 million to $50 million for full restoration that would likely create meanders and/or riffles and pools and instream habitat for fish use and passage. Based on this review of potential costs, risks, and benefits, compared to other available projects, this project was not selected by the Trustees for this NRDA.

Merrill Park Streambank Restoration

This project would consist of repairing and restoring approximately 700 feet of shoreline adjacent to the Kalamazoo River at Comstock Township's Merrill Park. Currently, the shoreline consists of mowed turf grass down to the waterline. The project would have repaired existing erosion and then replanted the area with a native plant buffer. Anticipated benefits would have included habitat creation and improvements in water quality. As the project location was at a park, it would have also provided natural resource based recreational benefits just downstream of the affected area. The total cost to implement this project was estimated at $100,000. The benefits of this project, when expressed as number of acres improved, were deemed to be less than those of the other riverine projects. In addition, the cost of this project was greater on a per acre basis. Therefore, this project was not selected.

4.9.2 Non-Preferred Lake Alternatives

Gull Lake Spawning Reef

This project would entail creating a spawning reef in Gull Lake in northern Kalamazoo County. The spawning reef would benefit primarily deepwater fish species and anglers that seek these species. Based on similar projects, the Trustees estimated that designing, creating, and monitoring the success of such a spawning reef would cost approximately $550,000. The fisheries benefits expected from this project would be less similar to those lost in the relatively shallow impounded areas of the Kalamazoo River than those that would be produced by enhancing fish habitat in the smaller lakes in FCRA. The smaller lakes in the FCRA are also closer to the Kalamazoo River and its anglers than Gull Lake is. In addition, recreational fishing in Gull Lake is accessible to the general public primarily through a boat ramp at the northern end of the lake that charges a fee. Fishing access at FCRA lakes is free to the public and includes angling opportunities from both boats and the shoreline.

4.9.3 Non-Preferred Upland Alternatives

The Trustees examined other restoration projects that could enhance functions and values to upland habitats to compensate for those lost from the Enbridge Line 6B Oil Discharges. The Trustees identified four non-preferred upland restoration projects, all located within the FCRA. Although these were all good projects, they were not chosen because their acreages and benefits did not match the impacted areas as well as the oak savanna habitat enhancement.

Fencerow removal

This project would entail the removal of fencerows between current agricultural fields that are in the process of being converted to native prairie. This project would have improved connectivity within about 200 acres of current and future prairie, benefiting grassland-dependent birds, such as Henslow's and grasshopper sparrows that prefer larger unfragmented blocks of grassland. It would also help achieve the FCRA's goal of restoring a significant block of the historic Coguaiak Prairie immediately east of the Kalamazoo River. The total cost to implement this project was estimated at $50,000.

Invasive plant control in recently-planted prairie

This project would entail the control of invasive plants within 147 acres of a recently-planted prairie in a mile-long corridor parallel to and east of the Kalamazoo River. This project would have benefited grassland-dependent birds, such as Henslow's and grasshopper sparrows, that historically nested in close proximity to the restored prairie. It would also help protect the plant diversity within the prairie by allowing native forbs to flourish instead of being outcompeted by invasive species. The total cost to implement this project was estimated at $45,000.

Enhancement of diversity in planted prairies

This project would consist of the collection of native, local genotype seed of a diverse array of prairie forbs (including rare species) from within the FCRA and immediate vicinity. Forbs would have been propagated to increase the number of plants that can successfully establish from a limited quantity of available seed. Finally, these forbs would have been installed into field propagation plots (to serve as a continual source for additional seed) and/or directly into recently-planted prairie to enhance the diversity of the prairie. Expected benefits from this project would have included improvements to plant diversity within the prairie by increasing the number of species and quantity of native forbs. It was estimated that up to 400 acres could be enhanced with these species over time. The cost to collect, propagate, and install the forbs was estimated at $20,000.

Prairie edge expansion and invasive plant control

This project would consist of the clearing or selective removal of invasive plants such as black locust in targeted areas around the perimeter of existing planted prairies. This would partially reconnect the Kalamazoo River floodplain to the recently-planted prairie. It was anticipated that removing the most problematic source populations of invasive plants would improve the ability to manage and maintain prairie habitats at FCRA into the future. Approximately 50 acres would have been directly restored or enhanced, which would improve the ability to manage the existing 147 acres of planted prairie. The total cost to implement this project was estimated at $70,000.

4.9.4 Non-Preferred Projects to Specifically Benefit Migratory Birds and Aquatic Mammals

The Trustees considered proposing projects that would specifically benefit migratory birds and aquatic mammals based on an assessment of mortality and lost future generations resulting from the spill. Such projects might include habitat enhancements, providing artificial nesting structures, or planting favored food plants. Because the migratory birds and aquatic mammals known to have been impacted by the spill were nearly all relatively common species in the area (e.g. mallard, Canada goose, muskrat), they will benefit from on-site restoration and compensatory wetland restoration described in Table 1.2, above as well as from the additional compensatory restoration projects referred to in Sections 4.4, 4.5 and 4.8, above. No special types of restoration are required for these species. Losses of migratory birds and aquatic mammals were thus considered in the Trustees' estimates of losses in the HEAs and the Trustees did not do a separate additional analysis for these losses because the restoration to offset them would have overlapped with other required restoration.

4.10 Summary of Selected Restoration Alternatives and Costs

The Trustees have selected compensatory restoration projects which they believe will enhance the natural recovery of resources injured by the Enbridge Line 6B Oil Discharges, and/or will provide additional resource services to compensate the public for interim losses pending response and remedial actions, restoration required by the State Settlement and natural recovery. Additional NEPA analysis of the potential impacts of the selected alternatives to be implemented by Trustees is provided in Chapter 5. The Trustees believe that the suite of selected projects and the projects from the State Settlement described in Table 1.2 will adequately address the injuries and interim service losses resulting from the Enbridge Line 6B Oil Discharges. In addition to the costs of implementing the selected restoration projects, the Trustees are also recovering the costs associated with restoration monitoring and past assessment costs not previously reimbursed by Enbridge (Table 4.1).

Table 4.1[7] Summary of the Selected Restoration Projects to be Implemented by Trustees and Associated Costs for Trustee Activities		
Resource/Service	**Selected Restoration Project**	**Cost to be Funded from NRDA Settlement with RP**
Riverine Habitats	Pigeon Creek, E Drive Crossing Replacement	$153,800
Riverine Habitats	Rice Creek, 29 Mile Road Crossing Replacement	$249,000
Riverine Habitats	Rice Creek, Vansickle Berm Lowering	$36,650
Lake Habitats	Fort Custer Lake Enhancements	$343,713
Upland Habitats	Fort Custer Oak Savanna Restoration	$75,000
Turtles	Turtle Nest Protection Program	$300,000
Non-recreational Use by Tribal Members	Wild Rice Restoration	$275,011
Non-recreational Use by Tribal Members	Non-Recreation Use Analysis and Restoration	$270,000
Total Estimated Cost of NRDA Settlement Restoration Projects		**$1,703,174**
Reimbursement of Trustee Past Costs[8]		$1,634,952
Trustee Future Costs[9]		$561,874
Total NRDA Payment by RP to Trustees		**$3,900,000**

7 This table is set forth in Chapter 1 as Table 1.3; it is repeated here for the convenience of the reader.
8 Trustee past assessment costs listed here do not include partial reimbursements that Enbridge previously made to USFWS and the full reimbursement made to the State.
9 Trustee future costs include federal and tribal assessment costs incurred after dates that past costs were calculated for each Trustee and estimated costs for project planning, oversight and monitoring, as well as review and consultation on restoration actions being directed by the State under the State Settlement. If the Trustees determine that additional monitoring is not necessary at some point, then the Trustees could instead use the funds for additional restoration.

5.0 ENVIRONMENTAL IMPACT OF UNDERTAKING THE SELECTED RESTORATION ALTERNATIVE – DETERMINATIONS UNDER THE NATIONAL ENVIRONMENTAL POLICY ACT

This section addresses the potential overall impacts and other factors to be considered under the National Environmental Policy Act (NEPA) regulations (42 U.S.C. § 4321; 40 C.F.R. Parts 1500-1508). Some of the specific potential impacts were listed within each project description above in Chapter 4, but this Chapter 5 addresses the impacts and factors systematically by category under NEPA. NEPA requires that the environmental impacts of a proposed federal action be considered before implementation. Generally, when it is uncertain whether an action would have a significant impact, federal agencies would begin the NEPA planning process by preparing an environmental assessment (EA). Federal agencies may then review public comments prior to making a final determination. Depending on whether an impact is considered significant, an environmental impact statement (EIS) or a Finding of No Significant Impact (FONSI) would be issued.

In undertaking their NEPA analysis, the Trustees evaluated the potential significance of proposed actions, considering both context and intensity. For the actions considered in this Final DARP/EA, the appropriate context for considering potential significance of the action is at the local or regional level, as opposed to national, or worldwide. This Final DARP/EA, in its entirety, is intended to accomplish NEPA compliance by summarizing the current environmental setting of the selected restoration, describing the purpose and need for restoration action, identifying alternative actions, assessing the selected actions' environmental consequences, and summarizing public participation in the decision process. This chapter focuses specifically on the Trustees' consideration of ten factors required in NEPA regulations (40 C.F.R. 1508.27) in determining significance of a proposed action before it can be selected:

1. Likely impacts of the proposed project.
2. Likely effects of the project on public health and safety.
3. Unique characteristics of the geographic area in which the project is to be implemented.
4. Controversial aspects of the project or its likely effects on the human environment.
5. Degree to which possible effects of implementing the project are highly uncertain or involve unknown risks.
6. Effect of the project on future actions that may significantly affect the human environment.
7. Possible significance of cumulative impacts from implementing this and other similar projects.
8. Effects of the project on National Historic Places, or likely impacts to significant cultural, scientific, or historic resources.
9. Degree to which the project may adversely affect endangered or threatened species or their critical habitat.
10. Likely violations of environmental protection laws.

After considering NEPA requirements, the Trustees believe that the selected projects described in this Final DARP/EA will not cause significant negative impacts to the environment, or to natural resources or the services they provide. None of the selected projects to be implemented by the Trustees is controversial, has highly uncertain impacts or risks or is likely to violate any environmental protection laws. Further, the Trustees do not believe the selected projects will adversely affect the quality of the human environment or pose any significant adverse environmental impacts. Instead, habitat restoration will benefit aquatic species by restoring natural habitat functions. Likewise, the selected restoration actions will provide positive benefits for human recreational use and non-recreational use by tribal members. As no new information was made available during the public review process that affected the evaluations made in the Draft DARP/EA, the Trustees made a Finding of No Significant Impact for the suite of selected projects described in Sections 4.4 – 4.8. A summary of the Trustees' analysis is located below.

5.1 Direct/Indirect Impacts Considered by Trustees

Overall, the selected restoration alternatives included in this Final DARP/EA will enhance the functionality of the ecosystem by improving aquatic connectivity and water quality, restoring native species, and providing protection for turtle reproduction. There could be some short-term and localized negative impacts, though not significant, from the selected restoration projects, as described below.

5.1.1 Construction, Sound and Air Pollution

Machinery and equipment used during construction and other restoration activities could generate sound that could temporarily negatively disturb wildlife and humans near the construction activity. Also, as discussed in more detail in the previous sections, there could be short-term negative impacts on fish and wildlife species as a result of construction activities. In accordance with State and Federal permit conditions, in-water work will be timed and conducted in a manner to minimize impacts to fish and other aquatic life. Impacts on mobile species (e.g., birds, mammals) are expected to be minor, consisting of short-term displacement. Overall, the construction of the aquatic habitat projects as part of the selected alternatives will provide long-term benefits to fish and wildlife species dependent on these types of habitat.

5.1.2 Federally Threatened, Endangered, and Candidate Species

According to informal consultation under the Endangered Species Act (16 U.S.C. 1531 et seq.) with the USFWS, the counties in which these selected projects will occur, Calhoun and Kalamazoo, support the following Federally-listed species: Indiana bat (endangered), northern long-eared bat (threatened), Eastern massasauga rattlesnake (candidate), Northern copperbelly watersnake (threatened), and Mitchell's satyr butterfly (endangered). The projects described in the Selected Alternatives are not likely to adversely affect these species based on the following analysis and provisions:

- For Indiana bat and northern long-eared bat, all aquatic habitat restoration work will be conducted from existing access roads, so no potential maternity roost trees will be felled. These species of bats may benefit from improvements in riparian corridor habitats and increased prey availability once restorations are completed. The upland oak savanna restoration project will include removal of early successional shrubs and small trees that would not be suitable maternity roost trees. Nonetheless, this project area will be surveyed for potential roost trees and any found will either not be cut as part of the project or will be cut during the winter when bats are not present. For Eastern massasauga rattlesnake and Northern copperbelly water snake, the restoration work along Pigeon and Rice Creeks and the wild rice restoration projects might occur within suitable habitats, but only the Van Sickle berm lowering project will be conducted with heavy equipment operating in potential habitat rather than from existing roads or manually, with workers and volunteers. The Trustees will work with the CCCD to ensure that the area of the berm lowering is surveyed for snakes prior to construction and workers and volunteers on all projects understand the value of any snakes found during the project and report any sightings to the Service. The snake species may benefit from improvements in riparian corridor habitats and increased habitat and prey availability once restorations are completed.
- Mitchell's satyr butterflies are dependent on fen habitats. Because the restoration projects do not include such areas of suitable habitat, these projects will not affect this species.

Completion of endangered and threatened species coordination with state programs will occur as part of the project-specific planning processes, including applications for permits under state regulatory processes for implementing the selected restoration alternatives.

No Essential Fish Habitats as described in 50 C.F.R. 600 have been designated in Michigan.

5.1.3 Water and Sediment Quality

There could be temporary and localized adverse impacts as a result of increases in erosion, turbidity and sedimentation related to construction activities associated with certain restoration projects. However, the use of best management practices along with other avoidance and mitigation measures required by the regulatory agencies will be employed to minimize any adverse water quality and sedimentation impacts. For example, silt fences or coffer dams will be used whenever it is determined that restoration work might increase erosion and turbidity. The selection and application rates for herbicide use for invasive species control will be designed to maximize control of the invasive species and minimize harm to native vegetation, but some short-term harm to native aquatic plant species may occur. Also, the decay of the invasive plant species may cause some short-term reductions in dissolved oxygen in the water and odors on and near the lake.

5.1.4 Visual

There may be temporary and localized adverse visual impacts during implementation of the preferred restoration projects associated with construction activities. Once the projects are completed, however, users of these areas are expected to perceive the project areas as having improved aesthetics.

5.1.5 Public Access/Recreation

Public access could be temporarily restricted during proposed construction activities, but since the selected projects are not located in heavily used recreation areas, any adverse effects will be minimal. In addition, implementation time for these projects will be relatively short and any negative impact on recreational activities will be slight and temporary. Restoration will likely not restrict future development.

5.1.6 Archaeological and Cultural Resources

Because the selected projects occur in a river or stream, do not newly disturb soils, or occur in existing road right-of-ways, the Trustees do not believe that there are any known archaeological sites or sites of cultural significance present. The Trustees will work with project managers during the permitting process to ensure that they consult with the State Office of Archeology and Historical Preservation (SHPO) to confirm that there are no known sites within the project area. If sites are discovered, the Trustees will work with the project manager to redesign projects so as to minimize or not adversely affect any known archaeological sites or sites of cultural significance, or a similar project in a different location in the watershed will be substituted. The wild rice restoration project is expected to provide additional cultural uses of the area by tribal members.

5.1.7 Other (e.g., economic, historical, land use, transportation)

No significant adverse effects are anticipated to soil, geologic conditions, energy consumption, wetlands, or floodplains. The selected restoration projects will have no adverse social or economic impacts on local neighborhoods or communities. The Trustees expect that all of these projects will provide ecological benefits and some will also improve recreational use for swimming, boating, fishing, hunting, and wildlife observation, in addition to increasing gathering of plants and other cultural uses by tribal members. The improved road stream crossings are expected to improve local transportation and locally decrease long-term road maintenance costs.

5.2 Cumulative Impacts

Cumulative environmental impacts are those combined effects on the quality of the human environment that result from the incremental impact of the alternative when added to other past, present, and reasonably foreseeable future actions (40 C.F.R. 1508.7, 1508.25(a) and 1508.25(c)). As the selected projects are intended to achieve recovery of injured natural resources, the cumulative environmental consequences will be largely beneficial for birds and wildlife habitat. All the anticipated adverse impacts will be short-term and localized, will occur during project construction, and will be minimized by using mitigation described in the Final DARP/EA. Any unanticipated negative cumulative adverse effect identified prior to project implementation will result in reconsideration of the project by the Trustees.

Overall, selected projects will result in a long-term net improvement in fish and wildlife habitat, the restoration of ecological balance in areas where human-caused disturbances have led to adverse impacts on sensitive native species, and improvement in the human use and non-use services provided by fish and wildlife in the region. The culvert removal and berm lowering projects on Pigeon and Rice Creek are far enough apart from each other that no cumulative effects of disturbance or turbidity during construction are expected. Local effects will be minimized by silt fencing and other erosion control techniques. The other projects are different enough in kind and location that no cumulative adverse effects are anticipated. The permit process required for this and similar work in streams, rivers, floodplains, and wetlands will also ensure that these projects are reviewed in the context of any similar projects that might be implemented in the area, including those by county conservation districts, drain or road commissioners, Michigan Department of Transportation, developers, or others.

Any active habitat restoration or land transactions will be conducted with willing landowners and will not displace or negatively affect any underserved, minority, or low-income populations. The overall quality of life for the surrounding communities will improve somewhat with these restoration alternatives, through increased economic and recreational opportunities, especially through improved opportunities for fishing and wildlife viewing in creek, river and lake settings in Calhoun and Kalamazoo Counties. The cumulative impact of these projects on tribal members is expected to be positive with an increase in wild rice and other natural resources as well as in knowledge and opportunities for using and enjoying these resources.

5.3 NEPA Comparison of All Restoration Alternatives Considered by Trustees

To assist with review of this document, Table 5.1 (below) is provided to outline a comparison of the direct, indirect and cumulative impacts anticipated for each of the restoration alternatives considered by the Trustees, including both the no-action alternative and the suite of selected project alternatives that would be implemented by the Trustees.

Table 5.1. Summary of Direct, Indirect and Cumulative Impacts

Alternative	Direct / Indirect Impacts	Cumulative Impacts
No Action	No immediate change in status quo, resulting in few, if any, direct and indirect impacts.	Because no work is proposed under the “no-action” alternative, the cumulative benefit would be limited.
Pigeon Creek, E Drive Crossing	Direct/Indirect impacts could include some increase in turbidity	Cumulative benefit to water quality for all aquatic

Replacement	and sedimentation, due to removal of culvert, though best management practices to control this will be put in place. Heavy machinery used for this project could cause minor impact to site use, noise and disruption. The site will be closed for public use during culvert replacement, assuring safety to passersby. Once completed, will reduce upstream flooding and costs to maintain this road crossing.	organisms in Pigeon Creek. Will allow fish to move up and downstream and reduce genetic isolation for fish and the mussels that depend on fish to serve as a host for their early lifestage as glochidia temporarily attached to fish gills. Project is too far from other projects for turbidity, noise, or disturbance across projects to be cumulative. Project will provide additional resiliency to erosion from extreme weather events that may become more frequent with climate change.
Rice Creek, 29 Mile Road Crossing Replacement	Direct/Indirect impacts could include some increase in turbidity and sedimentation, due to removal of culvert, though best management practices to control this will be put in place. Heavy machinery used for this project could cause minor impact to site use, noise and disruption. The site will be closed for public use during culvert replacement, assuring safety to passersby. Once completed, will reduce upstream flooding.	Cumulative benefit to water quality for all aquatic organisms in Rice Creek along with other habitat improvement projects recently completed and planned along it. Will allow fish to move up and downstream and reduce genetic isolation for fish and the mussels that depend on fish to serve as a host for their early lifestage as glochidia temporarily attached to fish gills. Project is too far from other projects for turbidity, noise, or disturbance across projects to be cumulative. Project will provide additional resiliency to erosion from extreme weather events that may become more frequent with climate change.
Rice Creek, Vansickle Berm Lowering	Minor short-term increases in turbidity will be expected to occur during the physical construction work, though best management practices to control this will be put in place. Turbidity will be minimized by the use of silt fences	No long-term adverse environmental or socio-economic impacts are expected from this project. It is expected that the restored floodplain will reduce flooding and other impacts of

	and other erosion control measures to control erosion until vegetation is re-established. The site is on private property, so no disruptions to public use are expected.	stream channelization, thus providing improved water quality and habitat for freshwater mussels, other benthic invertebrates and fish. Project is too far from other projects for turbidity, noise, or disturbance across projects to be cumulative. Project will provide additional resiliency to erosion from extreme weather events that may become more frequent with climate change.
Fort Custer Lake Enhancements	Some short-term harm to native aquatic plant species may occur, but the selection and application rates for herbicide use will be designed to maximize control of the invasive species and minimize harm to native vegetation. The decay of the invasive plants may cause some short-term reductions in dissolved oxygen in the water and odors on and near the lake.	Combined with other efforts by the MDNR, this project will provide ecological benefits and improved recreational use of the lakes for swimming, boating, and fishing.
Fort Custer Oak Savanna Enhancement	Some short-term disturbance will occur during tree and shrub removal. Impacts to non-target trees and shrubs will be minimized by applying herbicide to cut stumps and limiting foliar spraying to smaller plants.	Improvements in this 175 acre parcel will provide benefits to the larger landscape that is being managed for a diversity of habitat types, including oak savanna, woodlands and hardwood forest. Cumulatively, this provides habitat for birds like red-headed woodpeckers and cerulean warblers whose populations have been declining.
Turtle Nest Protection Program	The only disturbances to the environment will be the presence of the observers and the temporary placement of fencing to exclude predators from the area in which turtles have dug their nests.	Nest protection programs for turtles have been shown to be effective at significantly reducing nest predation and providing information for turtle conservation that can be applied elsewhere.
Wild Rice	Minor short-term increases in	The restored rice sites will

Restoration	turbidity will be expected to occur during the physical excavation and planting work. Turbidity impacts will be minimized by conducting excavation and planting work in accordance with all permit terms and conditions.	provide improved habitat for native aquatic species and result in cultural uses for tribal members. Project is too far from other projects for turbidity, noise, or disturbance across projects to be cumulative.
Non-recreational Use Analysis and Restoration	Positive economic impacts will be expected during research and implementation as tribal members are hired to perform some of the necessary tasks.	It is expected that the information gathered will provide the basis for understanding traditional, cultural uses of the site and its resources, which is considered a positive social impact. Implementation of the education program will be expected to deliver a greater sense of stewardship of the river to tribal members, resulting in positive environmental and social impacts.

6.0 PREPARERS, AGENCIES, AND PERSONS CONSULTED

6.1 Preparers

Lisa L. Williams, U.S. Fish and Wildlife Service, East Lansing, MI
Stephanie D. Millsap, U.S. Fish and Wildlife Service, East Lansing, MI

6.2 Agencies and Persons Consulted

Federal Agencies
U.S. Fish and Wildlife Service, East Lansing, MI
National Oceanic and Atmospheric Administration, Ann Arbor, MI
U.S. Geological Survey, Columbia, MO
U.S. Environmental Protection Agency, Traverse City, MI and Grosse Ile, MI
U.S. Coast Guard, National Pollution Fund Center, Arlington, VA

State Agencies
Michigan Department of Environmental Quality
Michigan Department of Natural Resources
Michigan Department of Attorney General

Local Agencies
Calhoun County Conservation District
Kalamazoo River Watershed Council
Kalamazoo Nature Center

Tribes
Nottawaseppi Huron Band of the Potawatomi Tribe
Match-E-Be-Nash-She-Wish Band of the Pottawatomi Indians

7.0 COMPLIANCE WITH OTHER AUTHORITIES

The following federal, state, and local laws, regulations, and policies may affect completion of the restoration projects. All project sponsors that receive natural resource damage funding will be responsible for obtaining necessary permits and complying with relevant local, state, and federal laws, policies, and ordinances.

7.1 Laws

7.1.1 Federal Laws

National Environmental Policy Act (NEPA; 42 U.S.C. § 4321 *et seq.*)

Preparation of an Environmental Assessment signifies partial compliance with NEPA. Full compliance shall be noted at the time of Finding of No Significant Impact or Record of Decision is issued. The Trustees have integrated this Damage Assessment and Restoration Plan with the NEPA process to comply, in part, with those requirements. This integrated process allows the Trustees to meet the public involvement requirements of OPA and NEPA concurrently. This Final DARP/EA accomplishes compliance by summarizing the current environmental setting, describing the purpose and need for the restoration actions, identifying alternative actions, assessing the selected actions' environmental consequences, and summarizing opportunities for public participation in the decision process.

Federal Water Pollution Control Act, 33 U.S.C. § 1251 *et seq*. (also known as the Clean Water Act or CWA)

The CWA is intended to protect surface water quality, and regulates discharges of pollutants into waters of the United States. All selected projects will comply with CWA requirements, including obtaining any necessary permits for proposed restoration actions. Restoration projects that move material in or out of waterways and wetlands, or result in alterations to a stream channel, typically require CWA Section 404 permits. Dam removal actions also require 404 permits. Project sponsors will be required to obtain the appropriate permits before restoration work begins.

As part of the Section 404 permitting process, consultation under the Fish and Wildlife Coordination Act, 16 U.S.C. § 661 *et seq*. generally occurs. This act requires that federal agencies consult with the USFWS, the National Marine Fisheries Service (NMFS), and state wildlife agencies to minimize the adverse impacts of stream modifications on fish and wildlife habitat and resources. Consultation with NMFS is not applicable to this DARP for an inland watershed in Michigan.

Compliance with the Rivers and Harbors Act, 33 U.S.C. § 401 *et seq*., generally occurs as part of the Section 404 permitting process. The Rivers and Harbors Act prohibits unauthorized obstruction or alteration of navigable waters. Any required permits under the Rivers and Harbors Act are generally included with the Section 404 permitting process.

Clean Air Act (CAA) of 1970, as amended, 42 U.S.C. § 7401 *et seq.*

The CAA regulates air emissions from stationary and mobile sources to protect human health and the environment. Any activities associated with the restoration projects that result in air emissions (such as construction projects) will be in compliance with the CAA and any local air quality ordinances.

Federal Endangered Species Act (ESA) of 1973, as amended, 16 U.S.C. §§ 1531 *et seq.*

The federal ESA was designed to protect species that are threatened with extinction. It provides for the conservation of ecosystems upon which these species depend and provides a program for identification and conservation of these species. Federal agencies are required to ensure that any actions are not likely to jeopardize the continued existence of a threatened or endangered species. Federally listed endangered, threatened, and candidate species in the counties in which these selected projects will occur, Calhoun and Kalamazoo, are listed in Section 4.10 along with a discussion of how the selected projects might affect them. Coordination with the USFWS will be completed pursuant to Section 7 of the ESA. Consultation is also incorporated into the CWA Section 404 and 401 permitting process noted above.

Fish and Wildlife Conservation Act, 16 U.S.C. § 2901 *et seq*.

The Fish and Wildlife Conservation Act authorizes financial and technical assistance to state governments to develop, revise, and implement conservation plans and programs for nongame fish and wildlife. The Trustees will seek to coordinate their restoration efforts with relevant conservation plans and programs in the State of Michigan.

Fish and Wildlife Coordination Act, 16 U.S.C. § 661 *et seq.*

The Fish and Wildlife Coordination Act authorizes the involvement of the USFWS in evaluating impacts to fish and wildlife from proposed water resource development projects. Federal agencies that construct, license, or permit water resource development projects are required to consult with the USFWS, and in some instances with NMFS, concerning the impacts of a project on fish and wildlife resources and potential measures to mitigate these impacts. The Trustees will engage in coordination if relevant to any of their projects.

Information Quality Act of 2001 (guidelines issued pursuant to Public Law 106-554)

As the lead federal natural resources Trustee for this document, USFWS confirms that this information product meets its Information Quality Act guidelines, which are consistent with those of the DOI and the Office of Management and Budget.

Magnuson-Stevens Act Fishery Conservation and Management Act, as amended, 16 U.S.C. 1801 et seq.

Coordination with the National Marine Fisheries Service and preparation of an Essential Fish Habitat (EFH) Assessment signifies compliance with the EFH provisions of the Magnuson-Stevens Act. This consultation does not apply to this Final DARP for an inland watershed in Michigan.

Marine Mammal Protection Act, 16 U.S.C. 1361-1326, 1371-1384 note, 1386-1389, 1401-1407, 1411-1418, 1421-1421h.

Activities associated with these projects will not have an adverse effect on marine mammals. This consultation does not apply to this Final DARP for an inland watershed in Michigan.

Migratory Bird Treaty Act of 1918, as amended, 16 U.S.C. §§ 703–712

The Migratory Bird Treaty Act protects all migratory birds and their eggs, nests, and feathers and prohibits the taking, killing, or possession of migratory birds. The selected restoration actions will not result in the taking, killing, or possession of any migratory birds.

Migratory Bird Conservation Act, 16 U.S.C. § 715 *et seq*.

The Migratory Bird Conservation Act established a commission and conservation fund to promote the conservation of migratory waterfowl and offset or prevent serious loss of important wetlands and other waterfowl habitat. The Migratory Bird Conservation Fund could potentially provide a source of additional funding to expand on Trustee efforts to conserve or restore migratory waterfowl habitat.

National Historic Preservation Act (NHPA) of 1966, as amended, 16 U.S.C. §§ 470 *et seq*.

NHPA is intended to preserve historical and archaeological sites. Compliance with the NHPA will be undertaken through consultation with the Michigan State Historic Preservation Office. If an eligible historic property is within the area of the selected restoration project, then an analysis will be made to determine whether the project will have an adverse effect on this historic property. If the project will have an adverse effect on historic properties, then the agency proposing the restoration project will consult with the State Historic Preservation Office to minimize the adverse effect.

Occupational Safety and Health Act (OSHA) of 1970, as amended, 29 U.S.C. §§ 651 *et seq*.

OSHA governs the health and safety of employees from exposure to recognized hazards, such as exposure to toxic chemicals, excessive noise, mechanical dangers, and unsanitary conditions. All work conducted on the selected restoration actions will comply with OSHA requirements.

Oil Pollution Act of 1990 (OPA), 33 U.S.C. 2701-2706, et. seq., 15 C.F.R. Part 990

OPA establishes a liability regime for oil spills that injure or are likely to injure natural resources and/or the services that those resources provide to the ecosystem or humans. OPA provides a framework for conducting sound natural resource damage assessments that achieve restoration. The process emphasizes both public involvement and participation by the Responsible Parties. The Trustees have conducted this assessment in accordance with OPA regulations.

Watershed Protection and Flood Prevention Act as amended, 16 U.S.C. 1001 et seq.

Floodplain impacts were considered prior to project selection and are expected to be positive. As required for permits, final project design plans will be submitted to state and federal regulators (e.g. NREPA Parts 301 and 303, below).

7.1.2 State Laws

The Natural Resources and Environmental Protection Act (NREPA), 1994, Public Act 451, as amended

Michigan's environmental protection and natural resource management authorities have been codified in NREPA. Several parts of NREPA will be applicable to restoration work undertaken by the Trustees. The most significant parts are described below. Permits, where required, are administered by the MDEQ, and permit application and review requirements will be consolidated whenever possible. All restoration actions undertaken by the Trustees will comply with relevant provisions of this Act and applicable rules promulgated under the Act.

Part 31, Water Resources Protection, requires that a permit be obtained prior to any alteration or occupation of the streambed, channel, or floodplain of a river, stream, or drain. Part 31 also governs discharges to waters of the State, including wetlands and groundwater and provides for the recovery of natural resource damages attributable to discharges that are injurious to designated uses of waters of the State.

Part 55, Air Pollution Control, provides authority to the MDEQ to engage in a variety of activities to protect air quality, including the regulation of fugitive dust sources and emissions, in accordance with the provisions of M.C.L. 324.5524.

Part 91, Soil Erosion and Sedimentation Control, requires that a permit be obtained to protect against the loss of soil to surface waters including wetlands. A permit is generally required for any Earth change that disturbs one or more acres or is within 500 feet of a lake or stream. Counties have the primary responsibility for issuing permits. In some cases, cities, villages, and townships have assumed permitting responsibility within their jurisdictions. Permit applications can be obtained from the respective county or municipal agencies.

Part 115, Solid Waste Management, regulates companies and businesses that dispose of solid waste. The solid waste program performs inspection, evaluation, permitting, and licensing of solid waste disposal areas in the state, including evaluation of groundwater monitoring data and corrective actions associated with releases from solid waste landfills.

Part 201, Environmental Remediation, provides legislative authority for Michigan's cleanup program for hazardous waste sites. The purpose of this authority is "to provide for appropriate response activity to eliminate unacceptable risks to public health, safety, or welfare, or to the environment from environmental contamination at facilities within the state" (M.C.L. 324.20102). The authority also includes "additional administrative and judicial remedies to supplement existing statutory and common law remedies" (M.C.L. 324.20102), including making claims against liable parties for "the full value of injury to, destruction of, or loss of natural resources, including the reasonable costs of assessing the injury, destruction, or loss resulting from the release" (M.C.L. 324.20126a).

Part 301, Inland Lakes and Streams, requires a permit for certain construction activities on inland lakes and streams. The Inland Lakes and Streams Program is responsible for the protection of the natural resources and public trust waters of the inland lakes and streams of the state. The program oversees the following activities: dredging, filling, constructing, or placing a structure on bottomlands; constructing or operating a marina; interfering with the natural flow of water; and connecting a ditch or canal to an inland lake or stream. Several selected projects may require permits under Part 301, but the final design plans for the projects will be developed so as to meet permit requirements.

Part 303, Wetlands Protection, requires that a person obtain a permit to perform certain activities in a wetland (Table 7.1).

Table 7.1. Examples of Types of Activities that Require a Wetlands Protection Permit

Activity	Example (partial list only)
Deposit or permit the placing of fill material	Bulldozing, grading, dumping
Dredge, remove, or permit the removal of soil or minerals	Removing tree stumps, bulldozing, digging a pond
Construct, operate, or maintain any use or development	Constructing buildings, structures, boardwalks; mining peat, treating water
Drain surface water	Diverting water to another area via ditch, pump, or drain

The programs in MDEQ that administer these parts have the objective of protecting human health and the environment in Michigan.

A joint state and federal permit process has been established between the MDEQ and the U.S. Army Corps of Engineers for projects in wetland areas that have both state and federal jurisdiction. None of the selected projects are expected to require state or federal wetland permits, but this will be reviewed again during the development of the final design plans for the projects and permit requirements will be met wherever applicable.

Part 365, Endangered Species Protection, requires that people not take or harm any endangered or threatened fish, plants or wildlife. MDNR is responsible for issuing permits and enforcement relative to the take of endangered and threatened species. Project reviews are performed by the Michigan State University Extension Service, Michigan Natural Features Inventory (MNFI). This review will be completed as part of the project-specific planning processes and projects will be modified as necessary to avoid adverse effects on state listed species.

Michigan Occupational Safety and Health Act, 1975, Public Act 154

The Michigan OSHA (Public Act 154 of 1974) is an act to prescribe and regulate working conditions, and places and conditions of employment to provide for occupational health and safety. The Departments of Labor and Public Health are responsible for implementing the provisions of this act. All activities conducted under this DARP/EA will comply with provisions of this act.

7.1.3 Local Laws

As appropriate, restoration actions will consider and comply with local plans and ordinances. Relevant local plans could include shoreline and growth management plans. Relevant ordinances could include, but not be limited to, zoning, construction, noise, and wetlands.

7.2 Policies and Directives

7.2.1 Federal Policies and Directives

The following federal policies and Presidential Executive Orders may be relevant to the selected restoration projects in the proposed alternative:

USFWS Mitigation Policy (Fish and Wildlife Service Manual, 501 FW 2)

> This policy of the USFWS seeks to ensure "no net loss" of fish and wildlife habitat as a result of USFWS actions. The Trustees do not anticipate that any of the selected projects will result in adverse impacts to habitat.

Executive Order 11514 – Protection and Enhancement of Environmental Quality, as Amended by Executive Order 11911 Relating to Protection and Enhancement of Environmental Quality

> These Executive Orders require federal agencies to monitor, evaluate, and control their activities to protect and enhance the quality of the Nation's environment. These Executive Orders also require agencies to inform the public about these activities and to share data on environmental problems or control methods, as well as to cooperate with other governmental agencies. The actions described in this RP/EA address the intent of these Executive Orders.

Executive Order 11593 - Protection and Enhancement of the Cultural Environment

Coordination with the State Historic Officer will signify compliance. Consultation is incorporated into the CWA Section 404 and 401 permitting process.

Executive Order 11988, 24 May 1977 amended by Executive Order 12148, 20 July 1979 – Floodplain Management

This Executive Order directs federal agencies to avoid the occupancy, modification, and development of floodplains, when there is a practical alternative. For all projects, the Trustees will work to ensure that any floodplain impacts are minimized. Public notice of the availability of this report or public review fulfills the requirements of Executive Order 11988, Section 2(a) (2). Consultation is incorporated into the CWA Section 404 and 401 permitting process.

Executive Order 11990 – Protection of Wetlands

This Executive Order instructs federal agencies to avoid adverse impacts associated with destruction or modification of wetlands. The Trustees will work to ensure that projects minimize any wetlands impacts. Public notice of the availability of this report for public review fulfills the requirements of Executive Order 11990, Section 2 (b). Consultation is incorporated into Sec. 404 and 401 permitting process.

Executive Order 12898 – Environmental Justice

This Executive Order instructs federal agencies to assess whether minority or low-income populations will be disproportionately impacted by agency actions. The selected projects are not expected to adversely affect the environment or human health for any environmental justice populations in the vicinity of the selected projects.

Executive Order 12962 – Aquatic Systems and Recreational Fisheries

This Executive Order requires that federal agencies, where practicable and permitted by law, work cooperatively to improve the quantity, function, sustainable productivity, and distribution of aquatic resources for increased recreational fishing opportunities. The Trustee agencies worked cooperatively to identify potential projects that will benefit aquatic resources and recreational fishing opportunities, in compliance with the intent of this Executive Order.

Executive Order 13007 - Accommodation of Sacred Sites

This Executive Order is not applicable unless on Federal lands, then agencies must accommodate access to and ceremonial use of Indian sacred sites by Indian religious practitioners, and avoid adversely affecting the physical integrity of such sacred sites.

Executive Order 13045 - Protection of Children from Environmental Health Risks and Safety Risks

The selected projects in this Final DARP will not create a disproportionate environmental health or safety risk for children.

Executive Order 13112 – Invasive Species

This Executive Order requires that federal agencies, where practicable and permitted by law, should identify any actions that may affect the status of invasive species and take actions to address the problem within their authorities and budgets. Agencies also are required not to authorize, fund, or carry out actions that they believe are likely to cause or promote the introduction or spread of invasive species, unless a determination is made that the benefits of actions outweigh potential harms and measures are taken to minimize harm. None of the selected restoration projects will promote the introduction or spread of invasive species and several will reduce invasive species.

Executive Order 13186 – Protection of Migratory Birds

This Executive Order requires federal agencies to evaluate the effects of their actions on migratory birds, to take actions to avoid or minimize the impacts of their actions on migratory birds, and to help promote conservation of migratory birds if actions are likely to have a measurable negative effect on migratory bird populations. None of the projects selected are expected to have a negative effect on migratory bird populations.

Executive Memorandum on the Analysis of Impacts on Prime or Unique Agricultural Lands in Implementing NEPA (11 August, 1980)

Not applicable since the selected projects do not involve or impact agricultural lands.

DOI Departmental Manual, Parts 517 and 609 – Pesticides and Weed Control

Implementation of any of the projects described in this RP/EA will be consistent with DOI policy to use integrated pest management strategies for control of insect and weed pests. Pesticides or herbicides will only be used after a full consideration of other control alternatives; the material selected and method of application will be the least hazardous of available options.

DOI Departmental Manual, Part 518 – Waste Management

If implementation of any alternatives generates waste, the Trustees will comply with all relevant DOI directives and policies.

DOI Departmental Manual, Part 602 – Land Acquisition, Exchange, and Disposal

If the federal government acquires any real property through implementation of these restoration projects, appropriate pre-acquisition standards – particularly the American Society for Testing and Materials standard for Environmental Site Assessments for Commercial Real Estate – will be complied with. No land acquisition is anticipated.

7.2.2 State and Local Policies

Selected restoration projects will consider and comply with other relevant state and local policies and directives.

8.0 REFERENCES

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9.0 ADMINISTRATIVE RECORD

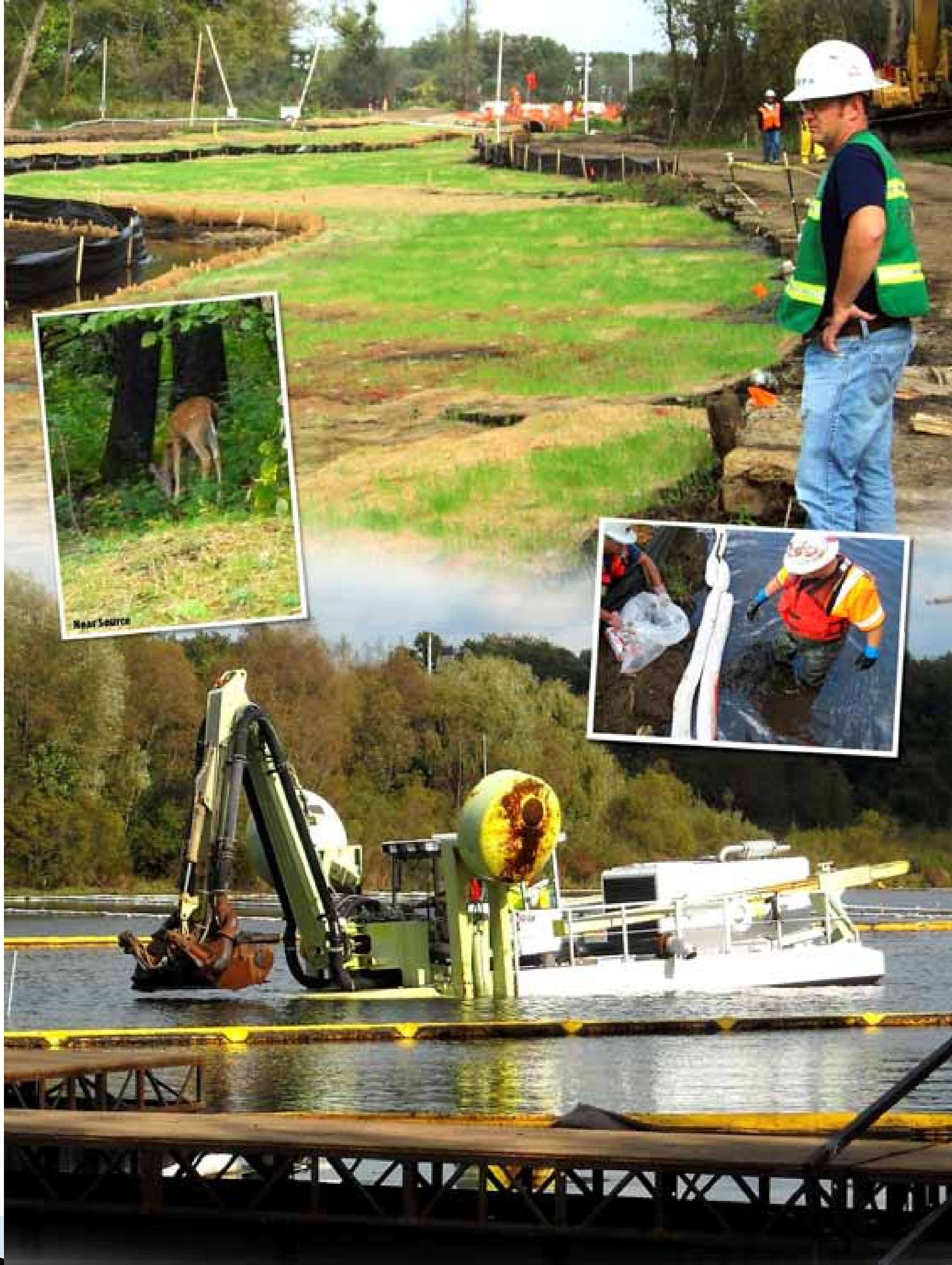
The Administrative Record for this document consists of the references cited above (Chapter 8) along with the Administrative Record for the Enbridge Line 6B NRDA case as a whole that is described in Section 1.3.5 and available at http://www.fws.gov/midwest/es/ec/nrda/MichiganEnbridge/adminrecord.html.

Appendix A: Photographs of the Areas Impacted by the Enbridge Line 6B Oil Discharges and of Response Actions from U.S. EPA presentations in 2010 and 2015

Enbridge Line 6B Incident

Public Update and Availability Session

October 14, 2010
(Day 81)



Pipeline Release Site

Division A

Oil coming out of culvert on Talmadge Creek on first day of spill, July 26, 2010.

Exposed pipeline during the first week of the oil spill response.

Initial cleanup of a 5-acre contaminated zone in the pipeline break area. Photo shows a dewatering operation.

Second week of contaminated soil cleanup near the pipeline break.

After four weeks, contaminated land located by the pipeline break was backfilled with clean soil.

Restored and re-vegetated pipeline break area on Oct. 11, 2010.

Talmadge Creek

Division B

Talmadge Creek day one: creek and floodplain completely oil-covered.

Initial containment measure in the creek includes skimmers, containment booms, and siphon dams.

Surface water was reduced to heavy sheen by the end of the response’s first week.

To access the creek in order to remove contaminated soil, swamp mat roads were established. Note white oil pads placed to absorb oil.

Talmadge Creek after soil scrapping was completed. Contaminated soil staging pads visible on the right side of the picture.

Talmadge Creek following restoration, which included soil backfilling, coconut matting, vegetation seeding, and silt fencing.

View of Talmadge Creek on Oct. 14, 2010.

Kalamazoo River

Division C, D, & E

Kalamazoo River on July 26, 2010, day one of the response: oil covered the river from bank to bank.

Within one week, presence of heavy oil reduced to a sheen.

In August 2010, most sheen production came from contaminated vegetation on the riverbanks and islands.

Example of sheening during week two and three of the response.

By mid-August, all contaminated islands were contained.

Some islands required soil removal.

Ceresco Dam

Division C

July 26, 2010, Ceresco Dam: note the oil flowing over the dam.

By the end of the first week, oil reduced to a heavy sheen.

Oil caught in backwater vegetation just upstream from Ceresco Dam.

Containment booming established to control vegetation sheening upstream of Ceresco Dam.

October 2010: submerged oil cleanup started upstream of Ceresco Dam.

Condition of stream bank just downstream of Ceresco Dam in late July 2010.

Same location, late September 2010.

Morrow Lake, October 11, 2010.

Sampling and Assessment

Containment

Contamination Recovery

Staging

Soil Removal

Disposal

Shoreline Cleanup

Floodplain Cleanup

Floodplain Cleanup

Excavation of floodplain contamination & staging of one-ton waste bags.

Decontamination

Decontamination of containment boom.

Decontamination

Decontamination of containment boom.

Submerged Oil

Dredging at Ceresco Dam

Ceresco Dam dredging operation and submerged oil aeration cells along the north bank.

Amphibex dredge used to remove approximately 18 inches of sediment from upstream of Ceresco Dam.

Geotube filter system used to capture contaminated sediment.

Ceresco Dam dredging progress as of Oct. 12, 2010: green indicates completed areas and blue shows areas in progress.

Submerged Oil

Aeration, Flushing, Agitation

Submerged oil recovery at “Mill Pond Area” in Battle Creek.

Example of submerged oil aeration, flushing, and recovery. Sediment is agitated to reintroduce oil to the surface so it can be collected.

Close-up shot of aeration activities.

Operation and Maintenance

Long Term Activity

Riverbank flushing activities.

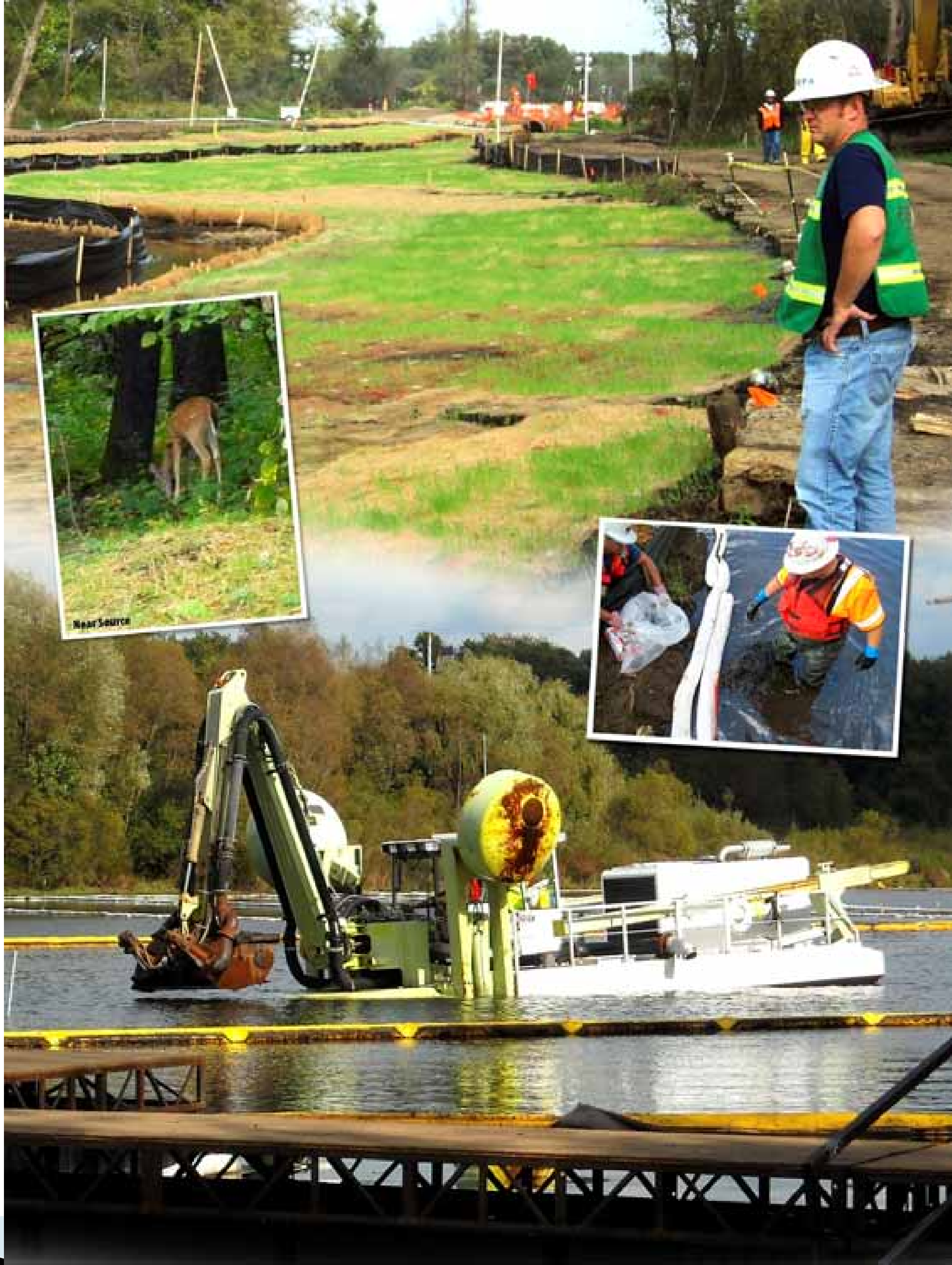
Riverbank restoration and long-term containment . Some areas on river will be monitored over time for potential contamination.

Residual contamination on islands will be monitored over time.

Stains on trees and rocks will fade over time and do not present health or environmental risks.

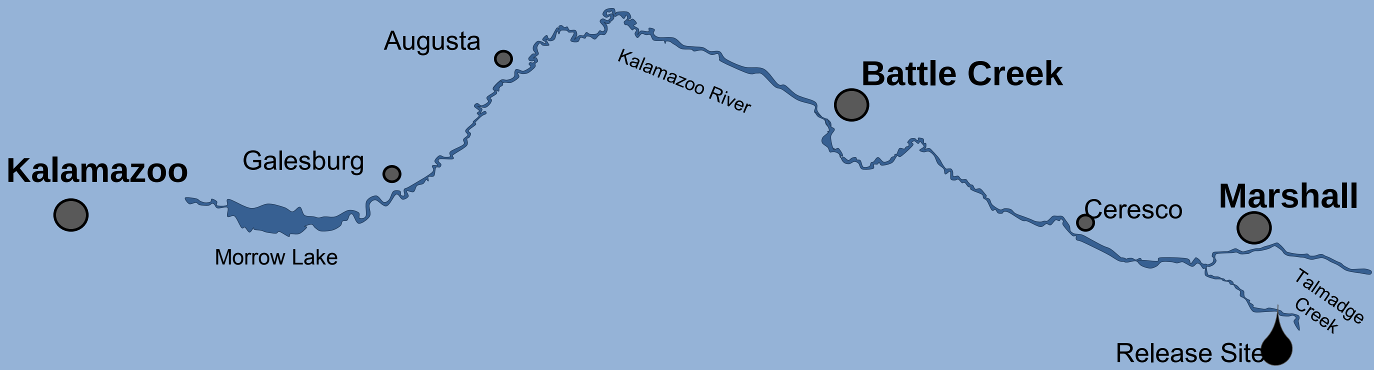
Other areas will require long-term operation and maintenance to continue to reduce contamination levels.

Thank You



U.S. EPA Presentation at No Spills Conference, January 2015

Enbridge Oil Spill



Source Area

August 4, 2010

Source Area


Battle Creek
Kalamazoo
Ceresco
Marshall
Source


2010/08/07 07:50:58

Source Area

August 5, 2010

Source Area

September 20, 2012

Source Area

September 17, 2014

Talmadge Creek

November 11, 2011

Talmadge Creek

September 17, 2014

Talmadge Creek and Kalamazoo River Confluence

March 5, 2012

Talmadge Creek and Kalamazoo River Confluence

September 17, 2014

Frac Tank City

September 17, 2014

Island A

September 17, 2014

MP 4.5 Overbank Excavation

September 17, 2014

Ceresco

September 17, 2014

Ceresco Dredge Pad

September 17, 2014

MP 11.25 Overbank Excavation

September 17, 2014

Mill Ponds

August 17, 2014

Mill Ponds Dredge Pad

September 17, 2014

MP 21.5 Sediment Trap

September 17, 2014

Morrow Lake Delta

July 17, 2014

E 3.5 Boat Launch and Staging Area

September 17, 2014

Morrow Lake Dredge Pad

September 17, 2014

Morrow Lake

September 17, 2014

EPA Metrics Project Total

Progress Under EPA Orders (as of 10/06/2014)

- Waste shipped off site
  - Haz Soil – 19,644 cubic yards
  - Non-haz Soil – 327,669 cubic yards
  - Non-Haz Soil and Debris – 64,815 cubic yards
  - Haz Debris – 12,075 cubic yards
  - Non-Haz Water – 11,934,503 gallons
  - Haz Water - 3,594,579 gallons
  - Oil (as recoverable crude) – 766,288 gallons
  - Calculated oil total from all sources – 1,201,098 gallons

Appendix B: Floodplain Oiling Report

STRATUS CONSULTING

Kalamazoo River Floodplain Oiling Survey Data Report

Prepared for:

Stephanie Millsap
U.S. Fish and Wildlife Service
and
Enbridge NRDA Trustee Council

Kalamazoo River
Floodplain Oiling Survey
Data Report

Prepared for:

Stephanie Millsap
U.S. Fish and Wildlife Service
and
Enbridge NRDA Trustee Council

Prepared by:

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January 3, 2012
Confidential Attorney/Consultant Work Product – Privileged
SC12521

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Acronyms and Abbreviations

DBH	diameter at breast height
GIS	geographic information system
GPS	global positioning system
ID	identification
MP	mile post
NRDA	natural resource damage assessment
ODA	oil delineation area
QA	quality assurance
QC	quality control
SCAT	Shoreline Cleanup and Assessment Technique
USFWS	U.S. Fish and Wildlife Service

Executive Summary

The Enbridge Oil spill occurred on July 26, 2010, near Marshall, Michigan. Soon after the spill, the state and federal natural resource Trustees and Enbridge cooperated on a floodplain survey. The purpose of the survey was to use ground surveys to document the degree and extent of oiling in the Kalamazoo River floodplain from Talmadge Creek (where the spill originated) downstream to approximately five miles upstream of Morrow Lake and to record the types of habitat and specific habitat features within this floodplain. This report describes the objectives, approach, and methods of the floodplain oiling survey, and presents the results of the survey. The report does not present any interpretation of the results in terms of natural resource injury or restoration scaling.

The survey took place from August 13, 2010, to September 2, 2010. The survey was conducted according to detailed written protocols that were developed specifically for this survey. Multiple field teams that included both trustee and Enbridge representatives conducted the survey. The written field protocols were modified during the course of the survey to adjust to field conditions and to incorporate the transition from using hardcopy forms to computer tablets for data recording. The field-collected data were tracked and managed under chain of custody procedures to ensure the integrity of the raw data.

Floodplain on both sides of the river from Talmadge Creek to Morrow Lake, a distance of approximately 25 river miles, was surveyed by field crews. The field surveys were conducted primarily along linear transects situated either perpendicular to river flow or along N-S compass lines. Transects were approximately 50 m apart from each other. Selected areas (e.g., islands, areas of heavy oiling of at least 50 ft^2 in the floodplain) were surveyed at a more detailed level. Field crews surveyed a total of 742 transects on both sides of the river.

The raw field survey data was processed to allow for data presentation in maps and tables, which are presented in this report. Any decisions that were made during data processing were carefully recorded and are presented in this report for transparency. The intent of the data processing was to be able to present and summarize the data in figure and table format in ways that accurately reflect the original raw field data as closely as possible. We intentionally minimized as much as possible any data interpretation in the data processing step.

The results of the floodplain oiling survey are presented here in tables and maps. The highest degree of oiling occurred from mile post (MP) 2.25 to MP 17.25 (Division C). In this area, 76% of surveyed transects were 1–10% oiled. All areas with heavy oiling at least 50 ft^2 in size (called "oil delineation areas," or ODAs) identified by field crews were located between MP 2.25 and MP 17.25. Downstream of MP 17.5, few observations of oil were made along transects and no ODAs were identified. The maps and tables presented here show that the predominant habitat

type identified during the survey was forested wetland. The types of habitat features observed included water features, vernal pools, downed trees, and skunk cabbage.

1. Introduction

On July 26, 2010, a discharge of heavy crude oil (Cold Lake Blend) from the Enbridge Energy Partners, L.P. (Enbridge) line 6B, located along Talmadge Creek, was discovered near the Town of Marshall in Calhoun County, Michigan. The oil traveled down Talmadge Creek approximately 2.2 miles and into the Kalamazoo River (AECOM, 2011). The line 6B discharge point is on the outskirts of Marshall (North ½ Section 2, T3S, R6W, Latitude: 42.2395273, Longitude: -84.9662018). Upon discovery of the discharge, the pipeline was shut down and isolation valves were closed, stopping the discharge of the oil. Enbridge estimates that approximately 20,082 barrels (843,444 gallons) of heavy crude oil were discharged (AECOM, 2011).

Prior to the spill event, from July 22 through 25, 2010, heavy rains had fallen in the area of and upstream of the oil spill, increasing the volume of water in the Kalamazoo River and inundating the floodplain. During this period, the Town of Ceresco (approximately 5 miles west of the spill) received an estimated 5.70 in. of rain and the Town of Albion (approximately 10 miles east of the spill) received an estimated 5.65 in. of rain (AECOM, 2011). Based on readings at the stream gauge in Marshall (gauge 4103500), at the time of the spill event, the flood stage was estimated to be between a 10- and 25-year flood event (AECOM, 2011). When the oil was discharged, it was carried with the flooding river and distributed in the inundated floodplain. Within a few days of the spill event, the water had receded from the floodplain to the main river channel.

The Trustees have engaged in preassessment activities since the occurrence of the spill. The Trustees include the Michigan Department of Environmental Quality, the Michigan Department of Natural Resources, the Michigan Department of the Attorney General, the U.S. Department of Interior acting through the U.S. Fish and Wildlife Service (USFWS) and the Bureau of Indian Affairs, the U.S. Department of Commerce acting through the National Oceanic and Atmospheric Administration, the Nottawaseppi Huron Band of the Potawatomi, and the Match-E-Be-Nash-She-Wish Band of the Potawatomi. Many of these activities have been conducted cooperatively with Enbridge.

The Trustees and Enbridge, working together as a cooperative natural resource damage assessment (NRDA) group (the NRDA group), conducted a floodplain survey soon after the oil spill occurred. The purpose of the survey was to document the spatial extent and degree of oiled habitat within the Kalamazoo floodplain, between the confluence with Talmadge Creek [defined as mile post (MP) 2] and approximately five miles upstream of Morrow Lake (MP 32.25). This report, produced by Stratus Consulting on behalf of the Trustees, describes the methods used in the field to collect data and the data management methods and geographic information system (GIS) database development. The field survey results are also presented in tables and maps.

1.1 Objectives and Scope

Based on field reconnaissance of the floodplain by the Trustees and Enbridge representatives soon after the spill (August 9–12, 2010) and reports and observations made by response personnel, it was clear that there was oil in the floodplain as a result of the incident. The NRDA group estimated that floodplain vegetation and soils were oiled at a background level of 1–10% (as defined in Owens and Sergy, 1994), interspersed with much more heavily oiled patches of varying spatial dimensions. Response activities were focused on characterizing oil within the river and along the shoreline using the Shoreline Cleanup and Assessment Technique (SCAT), which is focused on assessing shoreline areas. Based on initial floodplain reconnaissance, the NRDA group determined that there was a need to document the amount of oil present in the floodplain and designed a floodplain survey that was implemented independently of the SCAT survey. The primary study objectives of the floodplain survey were to characterize the areal extent and degree of oiling in the Kalamazoo River floodplain that resulted from the Enbridge pipeline spill and the general floodplain habitat types that were oiled. The NRDA floodplain survey results could be evaluated in conjunction with the SCAT survey results, and later response efforts to document the extent of floodplain oiling, in order to develop a more comprehensive, overall description of shoreline and floodplain oiling.

The geographical scope of the oiled floodplain study encompassed the Kalamazoo River floodplain from the confluence of Talmadge Creek and the Kalamazoo River (MP 2.0) to just upstream of Morrow Lake (MP 32.25; Figure 1). Incident Command designated Talmadge Creek and the Kalamazoo River downstream of the pipeline break into Divisions A through E. Division A encompassed the spill area on Talmadge Creek (MP 0–0.25), Division B encompassed the area just downstream of the spill to the confluence of Talmadge Creek and the Kalamazoo River (MP 0.25–2), Division C extended from the confluence of Talmadge Creek and the Kalamazoo River downstream past Battle Creek (MP 2.25–17.25), Division D extended from MP 17.5 through 23.75, and Division E extended from MP 24 to Morrow Dam at MP 40. The Kalamazoo River floodplain between MP 2 and MP 32.25 (including Divisions B, C, D, and part of E), where the NRDA group had permission to access, was surveyed. Response actions or private property restrictions precluded access to some parts of the floodplains; consequently, these parcels could not be surveyed.

The survey work was initiated in early August and completed in early September 2010. The initial reconnaissance work was undertaken between August 9 and 12. Survey work took roughly three weeks, and was conducted from August 13 to September 2, 2010.

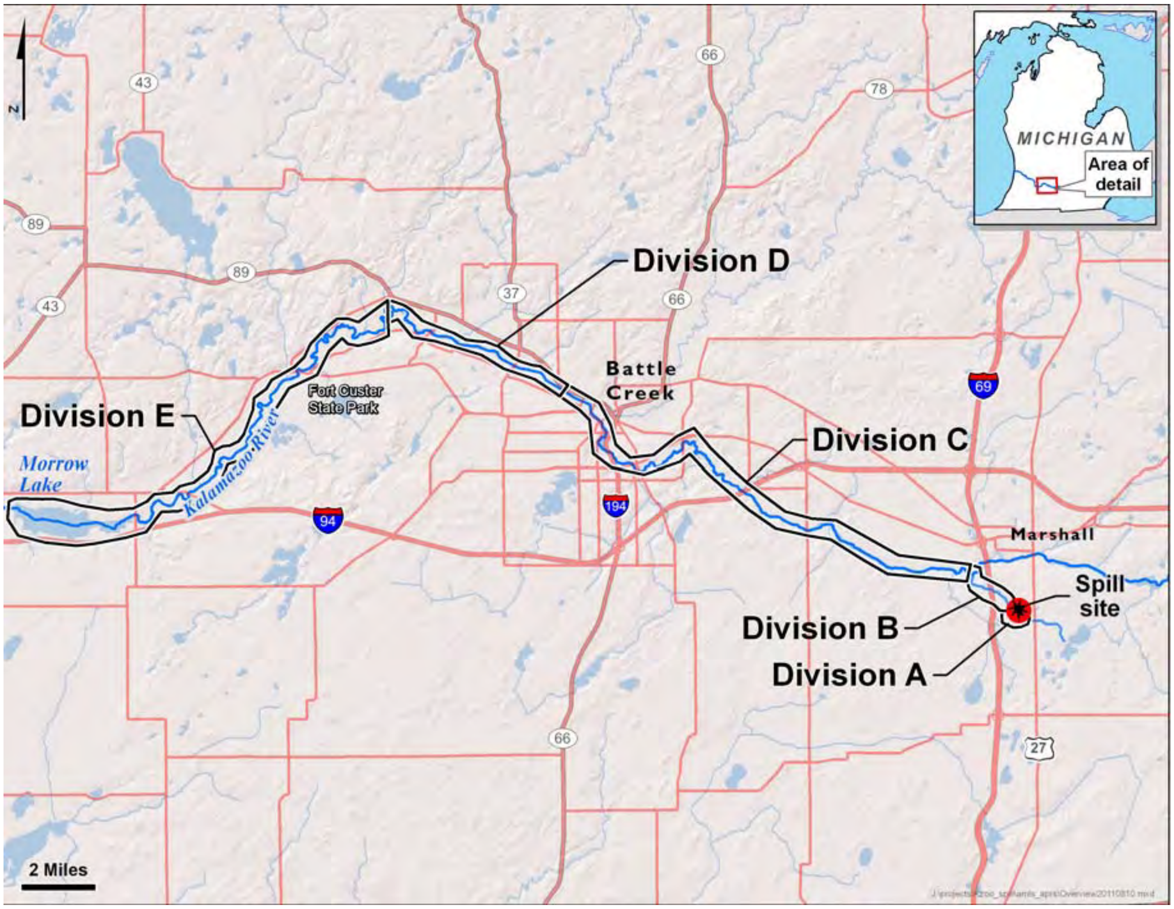

Figure 1. Overview of the study area.

The remainder of this report is organized as follows:

- Section 2 describes the field survey methods
- Section 3 describes database development and GIS mapping methods
- Section 4 presents results of the floodplain survey.

2. Field Survey Methods

Initial field reconnaissance indicated that the floodplain areas which were under water at the time of the spill were oiled at a background level of 1–10%, interspersed with much more heavily oiled patches of varying spatial dimensions. For the purposes of the floodplain survey, sporadic oiling was specifically defined as 1% (trace) to 10% oil covering floodplain surfaces including soil, vegetation, and tree trunks. Figure 2 provides an example of 1–10% oiling, and Figure 3 provides an example of heavy oiling. Additional examples are provided in the floodplain characterization protocol in Appendix A.

Figure 2. Example of 1–10% oiling.

Figure 3. Heavy oiling on emergent vegetation.

The main objectives of the survey was to characterize the areal extent and degree of oiling in the Kalamazoo River floodplain that resulted from the Enbridge pipeline spill, and to characterize the general floodplain habitat types that were oiled.

The remainder of this section is structured as follows:

- Section 2.1 describes protocol development, based on initial reconnaissance work in the field
- Section 2.2 describes the survey approach
- Section 2.3 describes field data collection methods
- Section 2.4 describes daily data management methods.

2.1 Protocol Development

Representatives of the cooperative NRDA group conducted four days (August 9–12, 2010) of reconnaissance in Division C, near MP 10 and the C3.2 boat ramp. The purpose of the reconnaissance work was to understand field conditions, including oiling and habitat, to inform the study design. The reconnaissance team found that the floodplain vegetation and soils were oiled throughout and that there were areas with heavy oiling.

After completing the initial reconnaissance investigation (August 9–12, 2010), the NRDA group developed a protocol to survey the floodplain. The protocol was tested in the field on August 13–14, 2010. The floodplain survey protocol, "Protocols for Characterizing Kalamazoo River Floodplain Oiling," is included in Appendix A, and the survey methods are summarized below.

Due to changing field conditions, observations made during the field sampling effort, and availability of data collection tools, the protocol was revised several times during the survey (the final version of the protocol is included in Appendix A). These revisions were made to improve the efficiency or methods of data collection based on field experience, address new conditions encountered in the field (e.g., areas where response occurred before the floodplain survey reached that location), and include new technology as it became available (e.g., electronic data entry tablets). Protocol modifications are described in relevant sections of this report. In addition, Table 1 summarizes all modifications made to the protocol as field work progressed.

2.2 Survey Approach: Floodplain Sections and Transects

The survey was conducted using a systematic approach in which the floodplain was split into 400-m-wide sections (sections) and each section was further divided into eight transects (transects) spaced 50 m apart. In the original protocol, the transects were oriented perpendicular to the river, with the 50-m spacing measured along the Kalamazoo River shoreline. However, that approach resulted in an uneven density of surveyed areas within sections, especially in areas where the river was more sinuous. For example, some transect lines cross and others diverge, leaving large unsurveyed areas within sections.

To address this uneven transect coverage, a revised approach was developed in which the transects were oriented parallel to each other in a N-S direction. All transect lines were generated using GIS and assigned a unique identifier. This modification became effective August 17, 2010 (Figure 4).

Table 1. Inventory of floodplain protocol changes

Section in this report	Floodplain protocol change	Protocol revision date	Reason
2.2	Orient transects N-S rather than perpendicular to the river	8/17/2010	Improve consistency, predetermine transect locations, follow general orientation of the floodplain
Implementation of use of electronic tablets			
2.3.2	Use electronic tablets to record field data	8/19/2010	Enter data directly in electronic format, integrate data in field (observations, waypoints, photographs), avoid errors related to data entry
2.3.1	Use Bluetooth global positioning system (GPS) unit to collect waypoint coordinates	8/19/2010	GPS coordinates automatically inserted into data entry form
2.3.1	Stop taking photographs of handheld GPS units	8/19/2010	GPS information integrated directly into data entry form
Implementation of revised protocol			
2.3.1	Waypoint transitions simplified to three types: start, habitat transition, end	8/28/2010	Provide increased clarity in data collection
2.3.1	For transect waypoints, do not record specific habitat features [pooled oil, water feature, vernal pool, downed tree, and skunk cabbage (*symplocarpus foetidus*)]	8/28/2010	Simplify data collection in the field, reduce the amount of information recorded at each point
2.3.1	For transect waypoints, degree of oiling is set to default of 1–10%; if oiling outside of this range is observed, record information about the percent of oiling in the notes field	8/28/2010	Simplify data collection in the field, reduce the amount of information recorded at each point
2.3.1	For oil delineation area (ODA) waypoints, identify the purpose (start, directional transition, end)	8/28/2011	Provide increased clarity ODA delineation
2.3.1	For ODAs, record specific habitat features once per ODA rather than at each ODA waypoint (pooled oil, water feature, vernal pool, downed tree, and skunk cabbage)	8/28/2010	Simplify data collection in the field, reduce the amount of information recorded at each point
2.3.1	For ODAs, record the habitat type once per ODA rather than at each ODA waypoint (forested upland, prairie, forested wetland, human managed, other)	8/28/2010	Simplify data collection in the field, reduce the amount of information recorded at each point
2.3.1	Record percent of oiling for ODA once; oiling still recorded for soil, herbs, shrubs, and trees	8/28/2010	Simplify data collection in the field, reduce the amount of information recorded at each point

Table 1. Inventory of floodplain protocol changes (cont.)

Report section	Floodplain protocol change	Date implemented	Reason
Implementation of surveys on islands and in response areas			
2.3.3	Document oil on islands	8/25/2010	Capture information about oil on islands in the Kalamazoo River
2.3.4	Document areas where cleanup actions have been completed	8/23/2010	Record areas where oil was removed from the floodplain (these areas would have been ODAs if field crews encountered them before response crews cleaned them), document areas where a substantial amount of oil had been present in the floodplain

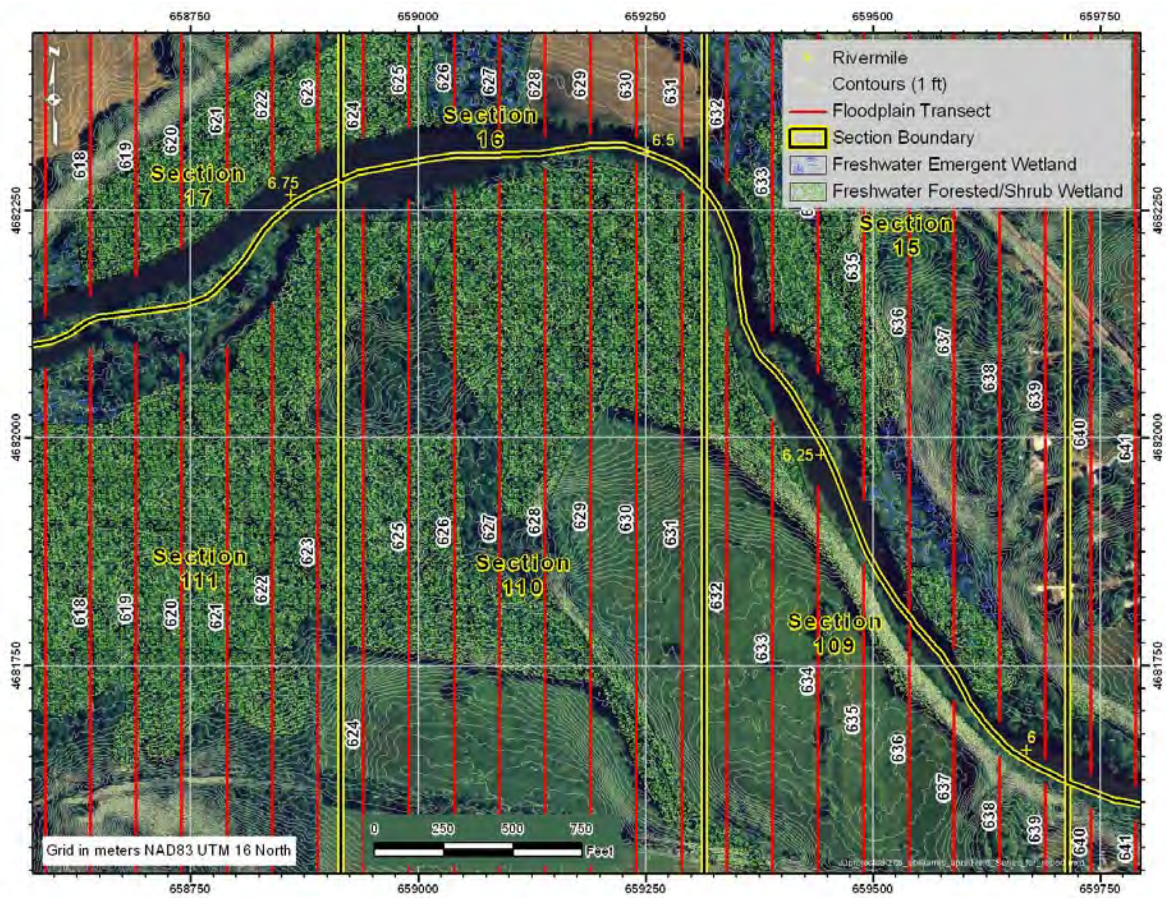

Figure 4. GIS-generated N-S transects in the Kalamazoo River floodplain.

A random sampling technique (with a random number generator) was used to select the sections to be surveyed daily. Upon implementation of the survey, it became evident that some private lands could not be accessed for surveying. Thus, accessibility dictated where work could be conducted, and sections were randomly selected within those areas where the crew had access to the floodplain. The NRDA group coordinated with Enbridge personnel daily to identify which land parcels were accessible for surveying (i.e., permission given by owners to access their land). By August 17, 2010, field work was no longer limited by access in Division C. Permission was not granted for large areas in Divisions D and E within the timeframe of the survey, but the areas where permission was granted were surveyed.

2.2.1 Transect naming conventions

When recording data, each transect was assigned a unique identification (ID). Individual floodplain transect IDs were generated using a combination of the unique transect ID and riverbank orientation when facing downriver. For example, transect number 124 located on the right riverbank was labeled 124R.

Island transects were named using a similar convention. Island transects in Division C downriver of Ceresco Dam were named sequentially, working upriver from the Mill Pond in Battle Creek (Division C and D boundaries) to Ceresco Dam starting at 900. Similarly, island transects in Division C between Ceresco Dam and the Talmadge Creek confluence were labeled sequentially from 1,000. All island transects were given a left riverbank orientation code, regardless of which side of the river they were located. For example, the fifth island located upriver from Ceresco Dam was labeled 905L.

2.3 Field Data Collection Methods

This section describes the methods used to collect data in the floodplain.

2.3.1 Survey field methods

The floodplain survey was conducted by teams of two field personnel (field crews). Each crew included one member representing the Trustees and one member representing Enbridge. On occasion, one crew consisted of two Trustee representatives or two Enbridge representatives. Most days, four crews of two field personnel each were deployed in the field.

Transects

The field crews verified the start location of each transect using a GPS unit and detailed transect maps. Once correctly positioned, the crew took three photographs marking the start of the transect: one of the GPS unit with coordinates visible, one facing north, and the other facing south. For each waypoint, the data recorder filled out the field datasheet (specific information recorded at each waypoint is described below). Field crews were instructed to note any instances where terrain or vegetation made it difficult to observe 25 m on either side of the transect. Data collection sheets included a space for recording additional relevant notes and observations (Figure 5).

Each transect was initiated with a waypoint. If there was no oil present at the first waypoint or if the habitat was physically inaccessible (e.g., a steep bank), only one waypoint was collected and the transect was ended. If the first waypoint was in an area at least sporadically oiled, and the location was physically accessible, the field crew began walking along the transect. At specific transitions, field crews marked additional waypoints and recorded data on the field datasheet. Transitions that warranted a waypoint and data collection included:

- Habitat transition
- Beginning of an ODA, defined as an area with oil coverage greater than 1–10%, covering a surface area least 50 ft^2
- End of a transect, defined as:
  - The point at which oiling is reduced to “no visible oil”
  - An area of greatly reduced habitat quality (e.g., housing development or agricultural field)
  - A point 15 ft past the edge of the floodplain (based on visual estimation).

For each transect, general information was recorded about the location of the transect, the date, field crew members, and equipment.

Floodplain Characterization Data Sheet (Version 5.0) Site ____/_____ (Sheet ___ of ___)

River Mile (tenths) ____.____ Bank Side Descending (R/L) ____ Date ___/___/2010 Data Collector/Recorder ______________________________

GPS/Photo Operator _____________ GPS Unit ID __________ GPS Photo (Y ___, #______) GPS Start Waypoint _____ Camera ID_____________

TRANSECT ID (Rivermile.transect):________________________OIL DELINEATION AREA ID (A-Z): ________ Time:______________________

Waypoint # (___) **Habitat type (FU, P, FW, M, H, O):** _______ If O, describe ____
Oiling: Soil visible? (Y__/N___) If Y % oil covered soil (___%) % oil covered herbs (____%) % oil covered shrubs (___%) % oil covered trees (____%)
Features: Pooled oil (>50ft²)?¹ (Y__/N__) Water feature (>50ft²)?² (Y__/N__) Vernal pool (>50ft²)?³ (Y__/N__) Downed tree (>4" DBH)?⁴ (Y__/N__) **Skunk**
Cabbage: Present? (Y___/N___) If present, healthy___/defoliated___/new shoots_____ (combination ok) **Photos #s** ____________________
Notes: ____

Waypoint # (___) **Habitat type (FU, P, FW, M, H, O):** _______ If O, describe ____
Oiling: Soil visible? (Y__/N___) If Y % oil covered soil (___%) % oil covered herbs (____%) % oil covered shrubs (___%) % oil covered trees (____%)
Features: Pooled oil (>50ft²)?¹ (Y__/N__) Water feature (>50ft²)?² (Y__/N__) Vernal pool (>50ft²)?³ (Y__/N__) Downed tree (>4" DBH)?⁴ (Y__/N__) **Skunk**
Cabbage: Present? (Y___/N___) If present, healthy___/defoliated___/new shoots_____ (combination ok) **Photos #s** ____________________
Notes: ____

Waypoint # (___) **Habitat type (FU, P, FW, M, H, O):** _______ If O, describe ____
Oiling: Soil visible? (Y__/N___) If Y % oil covered soil (___%) % oil covered herbs (____%) % oil covered shrubs (___%) % oil covered trees (____%)
Features: Pooled oil (>50ft²)?¹ (Y__/N__) Water feature (>50ft²)?² (Y__/N__) Vernal pool (>50ft²)?³ (Y__/N__) Downed tree (>4" DBH)?⁴ (Y__/N__) **Skunk**
Cabbage: Present? (Y___/N___) If present, healthy___/defoliated___/new shoots_____ (combination ok) **Photos #s** ____________________
Notes: ____

Waypoint # (___) **Habitat type (FU, P, FW, M, H, O):** _______ If O, describe ____
Oiling: Soil visible? (Y__/N___) If Y % oil covered soil (___%) % oil covered herbs (____%) % oil covered shrubs (___%) % oil covered trees (____%)
Features: Pooled oil (>50ft²)?¹ (Y__/N__) Water feature (>50ft²)?² (Y__/N__) Vernal pool (>50ft²)?³ (Y__/N__) Downed tree (>4" DBH)?⁴ (Y__/N__) **Skunk**
Cabbage: Present? (Y___/N___) If present, healthy___/defoliated___/new shoots_____ (combination ok) **Photos #s** ____________________
Notes: ____

Waypoint # (___) **Habitat type (FU, P, FW, M, H, O):** _______ If O, describe ____
Oiling: Soil visible? (Y__/N___) If Y % oil covered soil (___%) % oil covered herbs (____%) % oil covered shrubs (___%) % oil covered trees (____%)
Features: Pooled oil (>50ft²)?¹ (Y__/N__) Water feature (>50ft²)?² (Y__/N__) Vernal pool (>50ft²)?³ (Y__/N__) Downed tree (>4" DBH)?⁴ (Y__/N__) **Skunk**
Cabbage: Present? (Y___/N___) If present, healthy___/defoliated___/new shoots_____ (combination ok) **Photos #s** ____________________
Notes: ____

Figure 5. Example hard copy datasheet used in the field from August 13 to 18, 2010.

At each waypoint, the following information was recorded:

- Waypoint ID (number identifying the waypoint in the handheld GPS unit)
- Habitat type (these are broad categories intended only to provide documentation of the general habitat present):
  - Forested upland
  - Prairie
  - Forested wetland
  - Human managed (e.g., pasture, lawn)
  - Other (if other, field crews provided a description)
- Oiling – percent of oil present on soil and vegetation for the following specific habitat features:
  - Percent of oil-covered soil if soil visible
  - Percent of oil-covered herbs
  - Percent of oil-covered shrubs
  - Percent of oil-covered trees
- Habitat features (recorded as presence or absence):
  - Pooled oil (> 50 ft^2)
  - Water feature (> 50 ft^2)
  - Vernal pool (> 50 ft^2)
  - Downed tree [> 4-in. diameter at breast height (DBH)]
- Skunk cabbage:
  - Whether present
  - If present
    - Healthy
    - Defoliated
    - New shoots
- Photographs
- Notes – an area was left for field crews to record notes.

Some logistical modifications were made to the protocol when the tablets were introduced. First, waypoint coordinates were taken using a Bluetooth-linked GPS unit that was integrated into the data entry form (see Section 2.3.2 for more details) at each waypoint. Table 1 summarizes all protocol changes.

Oil delineation areas

ODAs were defined as areas with greater than sporadic oiling covering an area at least 50 ft^2 (Figure 3). Crews were instructed to leave the transect to inspect any suspected ODAs, such as side channels connected to the river, and return to the transect at the point where they left the transect. Every ODA encountered was delineated.

ODAs were delineated by taking waypoints at key points of direction change to make a polygon encompassing the ODA. Figure 6 shows a single, example ODA delineated in the field and associated photograph taken at one of the ODA waypoints. At each point defining an ODA the same information was recorded using the same methods and data entry forms described above for waypoints in a transect. ODA waypoints were recorded on a separate data entry form and labeled with the transect where the ODA was found and a unique ODA identifier. As with the transect waypoint data, this information was recorded, initially on field datasheets from August 13 to 18, 2010, and later in electronic format on the tablets from August 19 to September 2, 2010. If the team could not safely walk the perimeter of the oiled area, a waypoint was taken in the center of the area and dimensions were visually estimated.

On August 27, 2010, the data collected to date were reviewed. Based on this review and on an assessment of remaining available crew time to complete the survey, changes were made to the information recorded at transect waypoints and at ODAs. Figures 7 and 8 show the revised datasheets that were used to develop the revised tablet data entry form. Table 1 summarizes all protocol changes.

Specifically, the following modifications were made to the field data collection methods.

Transect waypoints

- Transitions that warranted a transect waypoint were simplified from the list provided in Section 2.3.1 to three types:
  - Start
  - Habitat transition
  - End

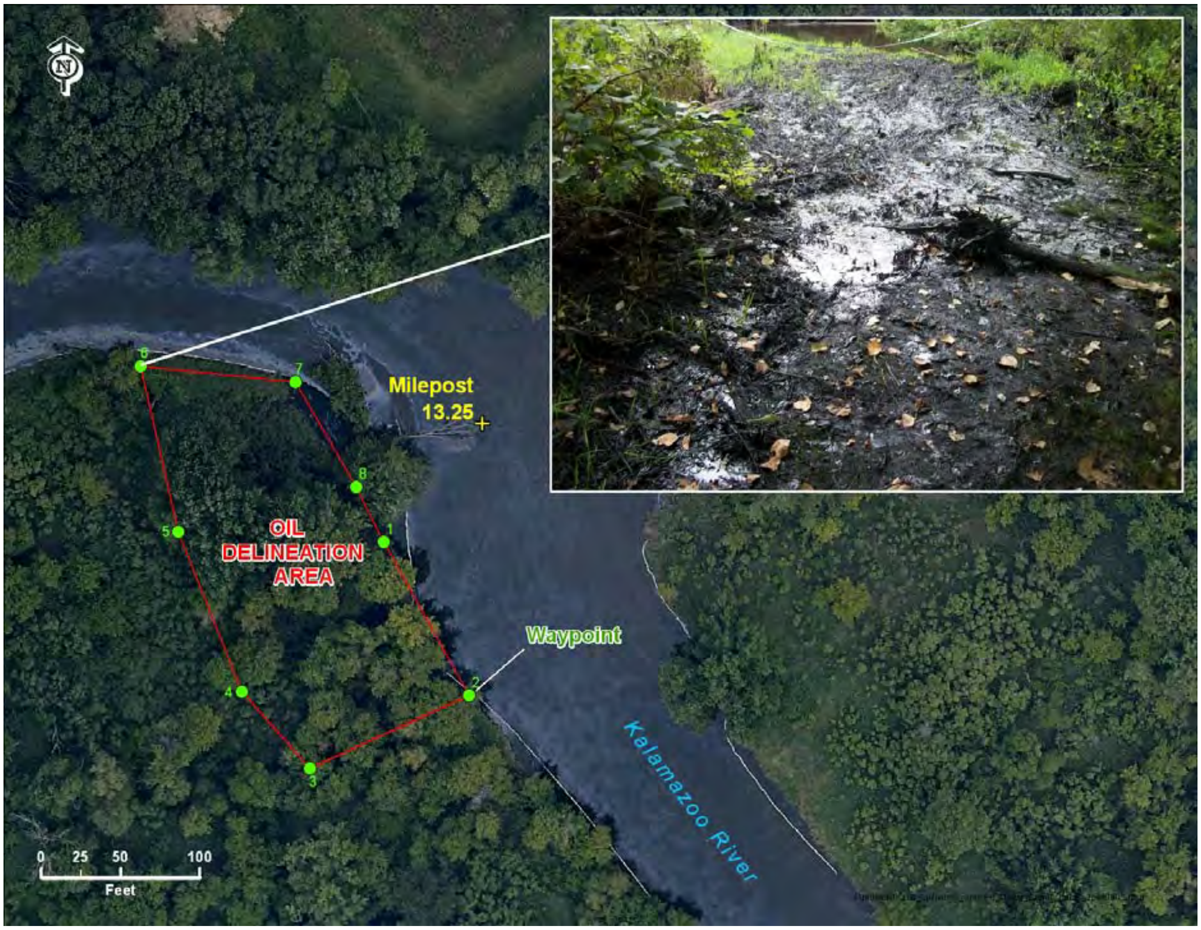

Figure 6. Example ODA delineated in the Kalamazoo River floodplain and a photograph taken during data collection at one of the ODA waypoints.

Floodplain Characterization **Transect** Data Sheet (Version 6.0) Site ____/_____ (Sheet __ of __)

River Mile ____ Bank Side Descending (R/L) ____ Date ___/___/2010 Data Collector/Recorder ______________________

GPS/Photo Operator ___________ GPS Unit ID _________ GPS Photo (Y ___, #______) GPS Start Waypoint _____ Camera ID___________

TRANSECT ID:____________________OIL DELINEATION AREA ID (A-Z): ________ Time:____________________

Waypoint # (___) Waypoint Type (S,HT,E):________Habitat type (FU, P, FW, M, H, O): _______ If O, describe ______________________
Photos #s ____
Notes: ____

Waypoint # (___) Waypoint Type (S,HT,E):________Habitat type (FU, P, FW, M, H, O): _______ If O, describe ______________________
Photos #s ____
Notes: ____

Waypoint # (___) Waypoint Type (S,HT,E):________Habitat type (FU, P, FW, M, H, O): _______ If O, describe ______________________
Photos #s ____
Notes: ____

Waypoint # (___) Waypoint Type (S,HT,E):________Habitat type (FU, P, FW, M, H, O): _______ If O, describe ______________________
Photos #s ____
Notes: ____

Waypoint # (___) Waypoint Type (S,HT,E):________Habitat type (FU, P, FW, M, H, O): _______ If O, describe ______________________
Photos #s ____
Notes: ____

Waypoint Type: S = Start, HT: Habitat Transition; E = End **Habitat types**: FU = forested upland, P = prairie, FW = forested wetland, M= marsh, H = human managed (e.g. pasture, lawn), O = other (if other, describe)

Figure 7. Revised data entry form for transects, implemented August 28, 2010.

Floodplain Characterization **Oil Polygon** Data Sheet (Version 6.0) Site ____/_____ (Sheet __ of __)

River Mile _____ Bank Side Descending (R/L) ____ Date ___/___/2010 Data Collector/Recorder ____________________

GPS/Photo Operator ____________ GPS Unit ID __________ GPS Photo (Y ___, #______) GPS Start Waypoint _____ Camera ID____________

TRANSECT ID:______________________OIL DELINEATION AREA ID (A-Z): ________ Time:______________________

Oil Polygon Waypoint # (____) , **Waypoint Type** (S, DT, E):________**Photos #s** ____________________<take GPS coordinates>

Oil Polygon Waypoint # (____) , **Waypoint Type** (S, DT, E):________**Photos #s** ____________________<take GPS coordinates>

Oil Polygon Waypoint # (____) , **Waypoint Type** (S, DT, E):________**Photos #s** ____________________<take GPS coordinates>

Oil Polygon Waypoint # (____) , **Waypoint Type** (S, DT, E):________**Photos #s** ____________________<take GPS coordinates>

Oil Polygon Waypoint # (____) , **Waypoint Type** (S, DT, E):________**Photos #s** ____________________<take GPS coordinates>

Oil Polygon Waypoint # (____) , **Waypoint Type** (S, DT, E):________**Photos #s** ____________________<take GPS coordinates>

Oil Polygon Waypoint # (____) , **Waypoint Type** (S, DT, E):________**Photos #s** ____________________<take GPS coordinates>

Oil Polygon Waypoint # (____) , **Waypoint Type** (S, DT, E):________**Photos #s** ____________________<take GPS coordinates>

Oil Polygon Waypoint # (____) , **Waypoint Type** (S, DT, E):________**Photos #s** ____________________<take GPS coordinates>

Oil Polygon Waypoint # (____) , **Waypoint Type** (S, DT, E):________**Photos #s** ____________________<take GPS coordinates>

Oil Polygon Waypoint # (____) , **Waypoint Type** (S, DT, E):________**Photos #s** ____________________<take GPS coordinates>

Oil Polygon Waypoint # (____) , **Waypoint Type** (S, DT, E):________**Photos #s** ____________________<take GPS coordinates>

Oil Polygon Habitat type (FU, P, FW, M, H, O): _______ If O, describe ____

Polygon Oiling: Soil visible? (Y___/N___) If Y % oil covered soil (____%) % oil covered herbs (____%) % oil covered shrubs (____%) % oil covered trees (____%)

Oil Polygon Features: Water feature (>50ft²)? (Y__/N__) Vernal pool (>50ft²)? (Y__/N__) Downed tree (>4" DBH)? (Y__/N__)
Skunk Cabbage: Present? (Y___/N___) If present, healthy___/defoliated____/new shoots_____ (combination ok)
Notes:

Waypoint Type: S = Start, DT = Directional Transition; E = End
Habitat types: FU = forested upland, P = prairie, FW = forested wetland, M= marsh, H = human managed (e.g. pasture, lawn), O = other (if other, describe)

Figure 8. Revised data entry form for ODAs, implemented August 28, 2010.

- The percent of oiling was not recorded for transect waypoints. The default value for all transect waypoints was 1–10%, and field crews were instructed to record information about the percent of oiling, if different from the 1–10% in the notes.

- Specific habitat features (i.e., pooled oil, water feature, vernal pool, downed tree, and skunk cabbage) were not recorded at transect waypoints.

- Marsh was added to the list of habitat types.

The habitat type (i.e., forested upland, prairie, forested wetland, human managed, other) continued to be recorded, and as with the previous format, a space was provided for notes.

Oil delineation areas

- At each ODA waypoint, the waypoint number was recorded and the waypoint was classified into one of three categories (simplified from the list of transitions provided in Section 2.3.1):

  - Start
  - Directional transition
  - End

- Oil polygon habitat type – the habitat type (i.e., forested upland, prairie, forested wetland, human managed, or other) present in the ODA was recorded once for each polygon, rather than for each individual waypoint.

- Polygon oiling – the degree of oiling observed in each polygon was recorded once for the entire ODA (rather than at each waypoint). Field crews were instructed to estimate the average degree of oiling over the ODA for the same features as the original form as follows:

  - Presence of visible soil
  - Percent of oil-covered visible soil
  - Percent of oil-covered herbs
  - Percent of oil-covered shrubs
  - Percent of oil-covered trees

- Oil polygon habitat features – the presence of habitat features [same as those described in Section 2.3.1, including pooled oil (> 50 ft^2), water feature (> 50 ft^2), vernal pool (> 50 ft^2), downed tree (> 4-in. DBH, and skunk cabbage) was recorded once for the entire ODA, instead of by waypoint.

2.3.2 Data recording methods

Field data were collected using hardcopy datasheets from August 13 to 18, 2010 (Figure 5, Section 2.3.1). Data were collected using electronic tablets from August 19 to September 2, 2010.[1] On a few occasions after August 18, some field crews used hardcopy datasheets due to computer problems (August 20) or rainy weather conditions that prevented computer use in the field (September 2).

When tablets became available on August 19, 2010, the field crews spent one day together testing the tablets. Data collection with the tablets began on August 20, 2010.

The tablets were IBM ThinkPad computers with a touch screen and stylus. The tablets were supplied and maintained by Burns and McDonnell, an Enbridge contractor.

The tablet capabilities included:

- Electronic data entry form
- Linked GPS for generating waypoints within the electronic data entry form
- Software to link photographs to waypoints.

Waypoint coordinates were recorded using the GPS unit integrated with the tablet, which had the ability to import the GPS information directly into the data entry form. Handheld GPS units were used to locate transects and help field crews orient themselves in the field. Data collection methods in the field were the same when using hardcopy datasheets and tablets, except when the use of technology led to changes in the logistics and mechanics of data collection methods. Photographs were manually linked to the waypoints at the end of each day using the software provided with the tablet computers. Field crews used the handheld GPS units to orient themselves along the proper transect, and waypoints were recorded using a remote GPS unit connected to the tablet and electronic data entry form using Bluetooth technology.

2.3.3 Surveying of islands

Island survey field data were collected from August 25 to August 29, 2010, using tablets. All islands in Divisions C and D were surveyed.

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1. The original intent was to collect data using an electronic tool throughout the survey. However, because the electronic data collection tablets were not available when the NRDA group began collecting data, the group agreed to initiate field data collection using hardcopy field sheets (Figure 5). When the electronic tablets became available on August 19, 2010, the protocol was revised to reflect changes that occurred when the tablets were deployed in the field.

Data collection on islands followed the same protocol as for floodplain data collection, with the following exceptions. One transect was walked longitudinally along the center of each island. The islands were small enough that the field crew could see the entire island from the mid-point, and the entire island was inspected for ODAs that were delineated when appropriate. When surveying islands, teams started at the most downriver end of the island, recorded a waypoint, took one photograph facing upriver toward the island, and then took another photograph downriver facing away from the island. A waypoint was recorded and photographs were taken in a similar manner at the end of each island transect.

2.3.4 Surveying areas impacted by response activities

As response activities within the floodplain and field work progressed, floodplain field crews began encountering areas that had been cleaned and cleared of vegetation and oil as part of these activities. Field crews were instructed to treat the cleaned and cleared areas as ODAs, record waypoints and take photographs, and identify the area as being cleaned. They clearly identified these areas as having been cleaned and recorded the percent of oiling that was observed at the time of the floodplain survey.

2.4 Daily Data Management Methods

Field crews returned to the Incident Command Center at the end of each day to download collected data. Data were distributed to both Trustee and Enbridge representatives each day. Daily data management and recordkeeping activities were the responsibility of a designated member of each team. The rest of this section describes the data management methods.

From August 13 to 18, 2010, and on August 20, 2010, when data were collected using hardcopy sheets, the following daily data management protocols were followed. After completion of each day’s field activities, hardcopy field datasheets were brought to the Incident Command Center. Two photocopies of each datasheet were made; the original datasheets remained with the Stratus Consulting field supervisor, one photocopy was given to a USFWS representative, and one photocopy was given to Entrix staff. Each datasheet was also scanned into a PDF document and saved to a project folder on a USB drive and a laptop hard drive. Folders were organized by date and survey name. Data were then transcribed from the hardcopy datasheets into an Excel template. All photographs, GPS coordinates, and Excel datasets were saved in the project folder according to the predetermined data date/surveyor/data type naming conventions specified in the protocol. Each day, all data were saved in folders in individual laptops and then backed up on an external hard drive dedicated to the project, to the Entrix FTP site dedicated to the project, and to jump drives.

From August 19 to September 2, 2010, when data were collected with the tablets, the following data management protocols were followed. Each day after the field work was completed, the tablet files were saved as .xml files labeled with the date and survey name information: <date>_<last name>. (On September 2, 2010, when data were collected in the field using hardcopy datasheets due to rainy weather, field crew members entered the day's data into their tablets back at the Incident Command Center and those data were then handled as if collected using the tablets.)

Floodplain assessment photographs were uploaded to the tablet hard drive at the end of each day and saved to the Floodplain_Assessment_Survey_Photos folder and named using a predetermined convention, summarized in the protocol, that included the map transect number, L/R descending side, and photograph number. Photograph file paths were inserted into respective transect-specific files on each team's tablet, linking the photographs with the waypoint at which they were taken.

At the end of each day, after saving the complete .xml file with associated photographs, the entire file was saved on an external hard drive dedicated to the project and an additional jump drive before returning the tablet to the Burns and McDonnell trailer at the Incident Command Center. Burns and McDonnell had their own daily data management protocol, which included uploading the data to their OneTouch PM site, a Google Earth-based application that was established and intended to contain all data collected as part of the response activities related to the incident.

On August 20, 2010, the thumb drive with downloaded data from that day was lost prior to uploading the data to the external hard drive. Data for that day were recovered from the Burns and McConnell OneTouch PM site.

3. Database Development and GIS Mapping Methods

Stratus Consulting incorporated the data collected as part of the floodplain sampling effort into an Access database. The data were then summarized in tables and GIS maps (the results are presented in Section 4). Section 3.1 describes the database development and Section 3.2 the GIS mapping methods used to compile the data into electronic format.

3.1 Database Development

After all field data were collected, Stratus Consulting created an Access database to compile and manage the data.

All data were preserved in their original format and structure on a write-protected hard drive before incorporation into the database. Data included all original GPS waypoint data, scanned images of hardcopy datasheets, photographs, and .xml files from the tablets. Using an Excel spreadsheet, the original data were then inventoried as follows: collection format (hard copy or tablet), date collected, field crew members, transect IDs, GPS waypoints (for waypoints collected with handheld GPS units), approximate MP and shore side (left or right), GPS unit ID (for data collected with handheld GPS units), GPX export file name and location (for handheld GPS unit data), .xml file name (for data collected using tablets), location and name of PDF scans of hardcopy field forms, location of transect and ODA data on Stratus Consulting network, and whether data were imported into the Access database.

Next, all data entered on the hardcopy datasheets (i.e., transect ID, date, field crew members, GPS unit ID, waypoint ID, camera ID, MP, habitat type, oiling, habitat features, skunk cabbage, and photograph numbers) were entered into the Access database. Although field crews entered the data into an Excel file after returning from the field each day, a quality assurance/quality control (QA/QC) comparison of the hardcopy sheets to the Excel files indicated that there were inconsistencies between the original field sheets and the data entered into the Excel templates. Additionally, the Excel files were not in a format that would allow easy incorporation into an Access database. Therefore, it was determined to be more efficient and accurate to re-enter the data into the database from the original field datasheets. Data collected using the tablets were imported into the Access database from the .xml files using an XML translator (translates files from .xml format into Access 2010 format) provided by Burns and McDonnell, the Enbridge contractor who developed and managed the tablets in the field.

Data collected on hardcopy datasheets, the original tablet form, and modified tablet entry forms were stored in separate tables within the database. Photographs were saved as separate files, electronically linked to the database, and associated with the correct waypoints.

After data were incorporated into the Access database, a 100% QA/QC was performed on data that were manually entered into the database from the hardcopy field datasheets according to the following steps:

- Stratus Consulting received the original field datasheets and scanned PDFs. The first QA/QC step was to verify that there was an electronic version of every hardcopy datasheet.
- The data were then entered into the Access database from the PDF scans of the hardcopy datasheets.
- After all the data had been entered into the Access database, a version of the database was printed. The printed Access database was compared against the original datasheets, and any errors were identified and corrected.

- The identified errors were random and consisted of:
  - Typographical errors
  - Differences in handwriting interpretation because the handwriting was sometimes difficult to read
  - Missing information.

A QA/QC of the .xml data was not required because they were not manually entered into the database. However, to ensure that the data were translated properly from .xml format to the Access database format, we performed a QA/QC by verifying that all data in the .xml files were incorporated into the Access database.

3.2 GIS Methods

The floodplain survey results are summarized in maps and tables generated in GIS. Three sets of maps were generated. The first set of maps shows the degree of oiling recorded in the floodplain during the survey and the locations of each transect, transect waypoint, and ODA. Locations encountered in the floodplain that were impacted by response actions are also shown. The second set of maps shows what habitat type (i.e., forested upland, prairie, forested wetland, human managed, or other) was recorded in the field at each waypoint. The third set of maps shows the waypoints where water features and vernal pools were observed and the degree of oiling. Data summarized in tabular format include the number of transects walked in each division and the degree of oiling, the number of miles walked and the number of waypoints recorded, the degree of oiling associated with each habitat type, observations of habitat features, and observations about skunk cabbage and skunk cabbage health.

3.2.1 Transects and oil delineation areas by percent oiling

All waypoints collected as part of the floodplain sampling effort were imported from the Access database into GIS format. Transect waypoints were then connected to form transect lines to represent the path walked by the field crews. ODA waypoints were connected to create polygons encompassing the ODA. Each ODA polygon was created in GIS by evaluating the order in which waypoints were recorded for the ODA by the field crews, and any field crew notes describing the oiled area in relation to geographic features and physical obstructions (e.g., “edge of water closes polygon”). Notes on the generation of each polygon in GIS are provided in Appendix B.

Once the transects and ODA polygons were generated in GIS, each feature (i.e., waypoint, transect, ODA) was assigned the percent of oiling from the Access database. This was done as follows:

Waypoints

In the original protocol, the percent of oiling was recorded at each waypoint for visible soil, herbs, shrubs, and trees. Waypoints were assigned as 1–10% oiling if a value between 1 and 10% was recorded at the waypoint for least one type of vegetation or soil. If all vegetation types and soil were assigned 0% oil at a waypoint, that waypoint was assigned 0% oil. If the percent of oiling for at least one type of vegetation or soil was recorded by crews as greater than 10%, the waypoint was assigned the highest percent of oiling recorded (e.g., for a waypoint with the following recorded oiling: visible soil = 0%, herbaceous vegetation = 15%, shrubs = 0%, and trees = 0%, the waypoint would be assigned an oiling of 15%). Based on visual examination of photographs, the vegetation type with the highest recorded percent of oiling at a given waypoint was often the dominant vegetation type present at that waypoint.

Transects

Transects were assigned a percent of oiling based on the oiling information recorded at the transect waypoints. The following logic was adopted for assigning the percent of oiling to transects:

- Transects between two waypoints with 0% oiling were assigned 0% oiling
- Transects between one waypoint with 0% oiling and one waypoint with 1–10% oiling (in at least one vegetation type) were assigned 1–10% oiling
- Transects between two waypoints with 1–10% oiling (in at least one vegetation type) were assigned 1–10% oiling
- Transects between two waypoints with greater than 10% oiling were assigned 1–10% oiling (it is assumed that ODAs were not delineated at these locations because the observed greater than 10% of oiling covered an area less than 50 ft^2 at the waypoints.

According to the revised protocol, a default value of 1–10% oiling was assigned to the transect waypoints, unless information in the field notes indicated a different percent of oiling. The percent of oiling was assigned to transect lines between waypoints collected using the modified protocol by following the same logic described above.

Oil delineation areas

For ODAs mapped under the original protocol, the percent of oiling for each waypoint in the ODA was recorded on soil and on vegetation layers. Review of the photographs taken at ODA waypoints indicate that the dominant vegetation layer or soil typically had the highest percent oiling at each ODA waypoint. Thus, the overall degree of oiling for ODAs was assigned by identifying the highest degree of oiling across soil and vegetation layers at each waypoint (which for the most part was either soil or the herbaceous layer), and then taking the average of these highest oiling percentages for all of the ODA waypoints. This method of assigning oiling to ODAs was used for data collected from August 13 to August 27, 2010. For data collected using the revised protocol (August 28 to September 2, 2010) in which a percent oiling was assigned to soil and each vegetation layer for the entire ODA, the highest percent of oiling across soil and vegetation types was assigned to the polygon.

Exceptions to GIS mapping methods

Waypoints and linear features with greater than 10% oiling

In some cases, the crews recorded greater than 10% of oiling at a single waypoint along a transect, but no ODA was delineated at those points presumably because the area with greater than 10% oiling was less than 50 ft^2.

There were also some instances where field crews specified an ODA but marked it with only two waypoints but did not provide an explanation in the field notes. These are shown on the maps as linear features, and the degree of oiling is assigned according to the values recorded by the field crews.

Transects with 0% oiling

If locations with no oil observed were encountered either at the start or at some point along a transect, the protocol indicated that the field crews should take a waypoint and end the transect. At some locations, field crews specifically indicated that there was no oil (0%) present at a waypoint but then continued along the transect. In these instances, the waypoints and transects were mapped as recorded by the field crews using the logic for assigning the percent of oiling to transects described above.

ODAs with less than 10% oiling

There were two instances where the percent of oiling for an ODA was recorded as less than 10%. In one case all waypoints in the polygon were assigned 5% oiling; in the other, the average oiling was 10%. It is unclear why the field crews delineated these areas as ODAs given that the degree of oiling was not greater than 10%. These polygons are shown in Figures 17, 18, and 21 in Section 4.1.

3.2.2 Habitat types

In the original protocol (August 13–27, 2010), the type of habitat was recorded at each transect and ODA waypoint. The habitat types were forested upland, prairie, forested wetland, human managed, or other (if other, field crews were instructed to provide a description). In the revised protocol (August 28–September 2, 2010), the type of habitat was recorded at each transect waypoint and for each ODA (i.e., habitat types were recorded once for each ODA and not at each ODA waypoint). From these data we generated a series of maps that identify the habitat type assigned to each waypoint or ODA and a table summarizing the same information.

3.2.3 Habitat features

Information about specific habitat features was collected for transects and ODAs during the floodplain survey. In the original protocol (August 13–27, 2010), the habitat features were recorded at each transect and ODA waypoint. The habitat features observed included pooled oil greater than 50 ft^2, water feature greater than 50 ft^2, vernal pool greater than 50 ft^2, downed tree greater than 4 in. DBH, and the presence and relative health of skunk cabbage, if present. After the protocol was revised to streamline data collection (August 28– September 2, 2010), habitat features were no longer recorded at transect waypoints, and were recorded for the entire ODA (not by ODA waypoint). This information was summarized in a table. A series of maps were generated identifying water features and vernal pools classified according to degree of oiling. Those areas for which this information was not collected due to the protocol revision are indicated on the maps.

4. Results

Section 4.1 presents the floodplain oiling results, Section 4.2 presents the habitat types, and Section 4.3 presents the habitat features.

4.1 Floodplain Oiling Results

The floodplain sampling effort was conducted between MP 2 in Division B and the most downstream section surveyed at MP 32.25 in Division E (approximately five miles upstream of the entrance to Morrow Lake). Field crews walked 744 transects throughout the floodplain.Table 2 summarizes the number of transects walked in each Kalamazoo River division. The majority of transects (79%) walked were in Division C (MP 2.25–17.25). The total length of transects walked was 25 miles. Table 3 summarizes transect miles walked by division.

Table 2. Number of transects walked by division

Division	MP[a]	Number of transects	Number of transects with at least 1–10% oiling	Number of transects with 0% oiling
A	0–0.25	0	0	0
B	0.25–2.00	3[b]	3[b]	0
C	2.25–17.25	581[b]	439[b]	142
D	17.5–23.75	94	35	59
E	24–40	64	7	57

a. MP shown as the nearest quarter mile that falls within each division.
b. One transect crosses from Division B to Division C (a two-waypoint transect with one waypoint in each division, which we assigned to Division B).

Table 3. Total floodplain miles walked by division

Division	MP[a]	Transect miles walked	Number of individual waypoints
A	0–0.25	0	0
B	0.25–2.00	< 0.01	2
C	2.25–17.25	17.5	170
D	17.5–23.75	6	51
E	24–40	1	28

a. MP shown as the nearest quarter mile that falls within each division.

Figures 9–35 show all transects where data were recorded during the floodplain survey and the percent of oiling recorded at each waypoint, transect, and ODAs. Figures 9–12 are overview maps that show the full extent of the survey. Figures 13–35 are detailed maps that show the sections where transects were walked. All ODAs (areas with greater than 10% oiling covering at least 50 ft^2) are located in Division C. The total area delineated as ODAs throughout the floodplain was 10.2 acres. The percent of oiling observed in ODAs ranged from 11 to 100%, except for two ODAs (described above) where the percent of oiling recorded by the field crews was less than 10%. The largest number of ODAs were in the 71–90% oiling category (34% of all ODA observations, not including the two ODAs with less than 10% oiling).

Field crews were unable to survey Division A due to response actions. Only two full transects were completed in Division B (Table 2), also due to limited access as a result of response actions. Areas in Divisions D and E where field crews did have access had some areas of sporadic oiling, although the degree of oiling observed in these two divisions was less than

Division C based on the number of transects with sporadic oiling (Table 2). Of the areas sampled during the floodplain survey, Division C had the most oil present throughout the floodplain, based on the proportion of transects with at least 1–10% oiling (Table 3), and the distribution of ODAs in the floodplain. Particularly heavily oiled areas in Division C were observed at MP 10 to 12 (Figures 20–22). Most of the single waypoints with greater than 10% oiling were also observed in Division C. In particular, a high concentration of single waypoints with greater than 10% oiling was identified from MP 10 to 12. It is presumed that these areas with greater than 10% oiling that were less than 50 ft^2. The field crews observed some locations in Division C that were not oiled. These areas were located primarily near MP 3.25, 6, and 10.5.

Field crews resurveyed some of the most heavily oiled areas later in the survey process to ensure that all ODAs were characterized. For this reason, the maps in Figures 9–35 show some overlapping of the ODAs. One ODA identified in the field notes was marked with a single point; this area was observed when data were collected using the hardcopy datasheets and waypoints were marked using handheld GPS units (maps 2 and 12, Figures 10 and 24). Two ODAs were delineated by the field crews as having 1–10% oiling, and it is unclear from the field notes and photographs why these were identified as ODAs if they were sporadically oiled (see Figures 17–19).

All of the 63 islands in the study area (MP 2.25 to 32.25) were surveyed. All islands in Division C up to MP 12.5 were sporadically oiled (Figures 9–35). Only two islands, one at MP 12.5 and one between MP 14.5 and 14.75, were not oiled. The island at MP 14.5–14.75 shows an ODA where response actions had been completed.

In general, a trend of decreasing oiling can be seen in the maps, and is illustrated in Table 2. In Division C, 76% of transects walked were sporadically oiled; in Division D, 37% of transects walked were sporadically oiled; and in Division E, 12% of transects walked were sporadically oiled. In particular, downstream of MP 18, 0% oiling was recorded at most transects. One exception occurs between MP 21.25 and 22.5, where sporadic oiling was observed (Figures 9–35).

4.2 Habitat Type Results

Figures 36–39 shows what type of habitat was identified for each waypoint during the floodplain survey. The predominant habitat types identified during the floodplain survey were forested wetland and forested upland. In areas where the heaviest oiling was observed, the most commonly identified habitat was forested wetland (e.g., the areas near MP 11–12). Table 4 summarizes these data.

Table 4. Oiling by habitat type

Habitat type	Total number of waypoints	Percent oiling 0	1–10	11–30	31–50	51–70	71–90	91–100	%0	%1–10	% > 10
Forested wetland	0	0	0	0	0	0	0	0			
Forested upland	0	0	0	0	0	0	0	0	NA	NA	NA
Human managed	0	0	0	0	0	0	0	0	NA	NA	NA
Marsh	1	0	1	0	0	0	0	0	0%	100%	0%
Prairie	0	0	0	0	0	0	0	0	NA	NA	NA
Other	2	0	2	0	0	0	0	0	0%	100%	0%
Not reported	0	0	0	0	0	0	0	0	NA	NA	NA
Division C – MP 2-5.75											
Forested wetland	56	21	19	13	1	1	0	1	38%	34%	29%
Forested upland	92	37	52	0	2	1	0	0	40%	57%	3%
Human managed	13	8	5	0	0	0	0	0	62%	38%	0%
Marsh	84	27	48	2	1	4	2	0	32%	57%	11%
Prairie	30	8	17	0	0	1	4	0	27%	57%	17%
Other	4	4	0	0	0	0	0	0	100%	0%	0%
Not reported	5	0	0	0	0	0	0	5	0%	0%	100%
Division C – MP 5.75–13											
Forested wetland	566	167	158	49	44	47	88	13	30%	28%	43%
Forested upland	259	132	82	20	17	5	3	0	51%	32%	17%
Human managed	23	15	6	1	1	0	0	0	65%	26%	9%
Marsh	74	34	23	10	4	0	3	0	46%	31%	23%
prairie	42	27	8	1	5	0	1	0	64%	19%	17%
Other	19	9	3	2	5	0	0	0	47%	16%	37%
Not reported	6	3	3	0	0	0	0	0	50%	50%	0%

Table 4. Oiling by habitat type (cont.)

Habitat type	Total number of waypoints	Percent oiling 0	1–10	11–30	31–50	51–70	71–90	91–100	%0	%1–10	% > 10
Division C – MP 13–15.25											
Forested wetland	89	25	46	7	4	2	5	0	28%	52%	20%
Forested upland	58	19	18	12	9	0	0	0	33%	31%	36%
Human managed	1	1	0	0	0	0	0	0	100%	0%	0%
Marsh	35	17	11	1	4	0	1	1	49%	31%	20%
Prairie	8	4	3	1	0	0	0	0	50%	38%	13%
Other	20	2	7	11	0	0	0	0	10%	35%	55%
Not reported	4	0	2	2	0	0	0	0	0%	50%	50%
Division D – MP 18–19.75											
Forested wetland	5	5	0	0	0	0	0	0	100%	0%	0%
Forested upland	8	7	1	0	0	0	0	0	88%	13%	0%
Human managed	0	0	0	0	0	0	0	0	NA	NA	NA
Marsh	0	0	0	0	0	0	0	0	NA	NA	NA
Prairie	4	4	0	0	0	0	0	0	100%	0%	0%
Other	7	6	1	0	0	0	0	0	86%	14%	0%
Not reported	0	0	0	0	0	0	0	0	NA	NA	NA
Division D – MP 20.25–22.75											
Forested wetland	66	35	31	0	0	0	0	0	53%	47%	0%
Forested upland	66	54	12	0	0	0	0	0	82%	18%	0%
Human managed	2	1	1	0	0	0	0	0	50%	50%	0%
Marsh	3	3	0	0	0	0	0	0	100%	0%	0%
Prairie	0	0	0	0	0	0	0	0	NA	NA	NA
Other	0	0	0	0	0	0	0	0	NA	NA	NA
Not reported	0	0	0	0	0	0	0	0	NA	NA	NA

Table 4. Oiling by habitat type (cont.)

Habitat type	Total number of waypoints	Percent oiling 0	1–10	11–30	31–50	51–70	71–90	91–100	%0	%1–10	% > 10
Division E – MP 23.25–24.25											
Forested wetland	3	2	1	0	0	0	0	0	67%	33%	0%
Forested upland	6	5	1	0	0	0	0	0	83%	17%	0%
Human managed	2	2	0	0	0	0	0	0	100%	0%	0%
Marsh	0	0	0	0	0	0	0	0	NA	NA	NA
Prairie	0	0	0	0	0	0	0	0	NA	NA	NA
Other	0	0	0	0	0	0	0	0	NA	NA	NA
Not reported	0	0	0	0	0	0	0	0	NA	NA	NA
Division E – MP 28.75–32.25											
Forested wetland	56	52	4	0	0	0	0	0	93%	7%	0%
Forested upland	35	35	0	0	0	0	0	0	100%	0%	0%
Human managed	0	0	0	0	0	0	0	0	NA	NA	NA
Marsh	2	1	1	0	0	0	0	0	50%	50%	0%
Prairie	0	0	0	0	0	0	0	0	NA	NA	NA
Other	0	0	0	0	0	0	0	0	NA	NA	NA
Not reported	0	0	0	0	0	0	0	0	NA	NA	NA

4.3 Habitat Feature Results

Table 5 summarizes the results of the habitat feature data collection. Because of the change in protocols, habitat feature data collected before and on August 27, 2010 may not be comparable to data collected after August 27, 2010. Table 6 summarizes the information on observations of skunk cabbage. These data were collected because the NRDA group had anecdotal evidence at the time of the survey that this species may be sensitive to oil (Chuck Getter, Research Planning Inc., Senior Ecologist, personal communication, August 18, 2010). These data show that skunk cabbage was observed at 212 locations; defoliated plants were observed at 160 locations,and plants growing new shoots were observed in 87 locations.

Table 5. Summary of habitat feature results[a]

	Number of observations				
Division (MP)[b]	**Pooled oil > 50 ft^2**	**Water feature > 50 ft^2**	**Vernal pool > 50 ft^2**	**Downed tree > 4 in. DBH**	**Skunk cabbage**
Division C (MP 2.25–17.25)					
ODA	60	60	17	81	62
Transect	15	185	36	270	141
Division D (MP 17.5–23.75)					
ODA[c]	NA	NA	NA	NA	NA
Transect	0	4	0	9	0
Division E (MP 24–40)					
ODA[c]	NA	NA	NA	NA	NA
Transect	0	50	1	42	8

a. From August 13 to 27, 2010, habitat features were recorded for all waypoints. During this time, the floodplain survey covered most areas in Division C, island habitats, and 11 transects in Division D. From August 28 to September 2, 2010 (during which time the survey covered Division E, and parts of Division D), observations of habitat features were recorded only for ODAs as a whole, and no longer for transect waypoints or for each individual waypoint in an ODA.
b. Although 2 transects were completed in Division B, the data were collected using the modified protocol and there were no ODAs delineated. Thus, no data about habitat features were recorded in Division B.
c. No ODAs were identified in Divisions D and E.

Figures 40–43 show the waypoint locations where water features or vernal pools were identified and the degree of oiling recorded at those locations for the time period that information on these habitat features was collected. The maps show the transects where this information was and was not collected.

Figures 40–43 illustrate that the highest density of water features and vernal pools were observed from MP 7–15. This is also the area where the highest degree of oiling was observed in the field.

Table 6. Presence and health of skunk cabbage

	Skunk cabbage (number of observations)			
Division (MP)[a]	**Presence**	**Healthy**	**Defoliated**	**New shoots**
Division C (MP 2.25–17.25)				
ODA	62	4	50	40
Transect	141	37	110	46
Division D (MP 17.5–23.75)				
ODA[b]	NA	NA	NA	NA
Transect	0	0	0	0
Division E (MP 24–40)				
ODA[b]	NA	NA	NA	NA
Transect	8	2	5	1

a. Although 2 transects were completed in Division B, the data were collected using the modified protocol and there were no ODAs delineated. Thus, no data about habitat features were recorded at these two transects.
b. No ODAs were identified in Divisions D and E.

References

AECOM. 2011. Enbridge Energy, Limited Partnership Line 6B Incident, Marshall, Michigan. Conceptual Site Model. Prepared May 10, 2011, approved July 8, 2011. Available: http://www.michigan.gov/deq/0,4561,7-135-3313_56784-248127--,00.html. Accessed 8/2/2011.

Owens, E.H. and G.A. Sergy. 1994 *Field Guide to the Documentation and Description of Oiled Shorelines*. Environment Canada, Edmonton, Alberta, Canada. March. ISBN 0-662-22048-X.

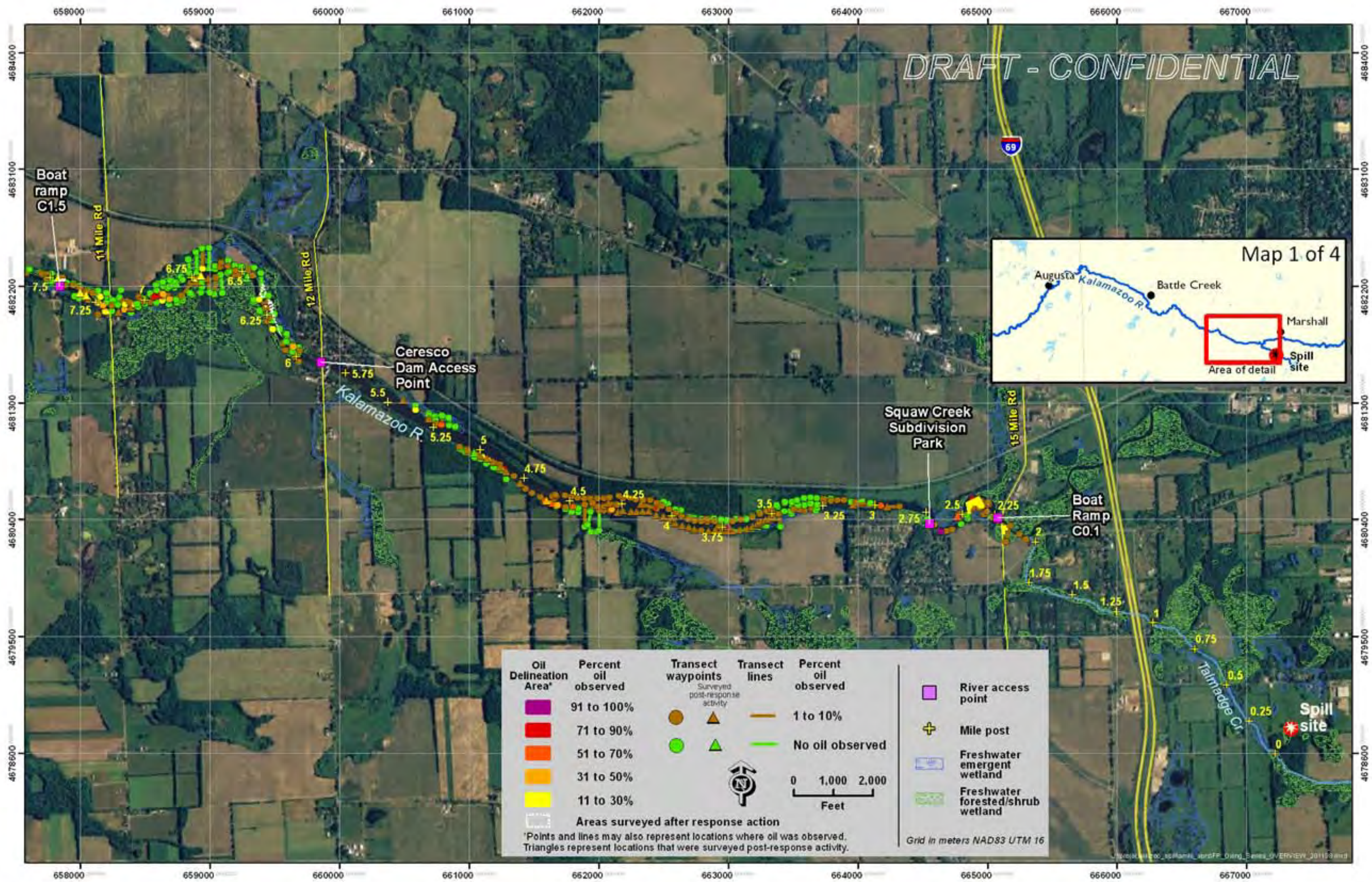

Figure 9. Overview map showing the transects and ODAs surveyed during the floodplain survey (MP 0–7.5).

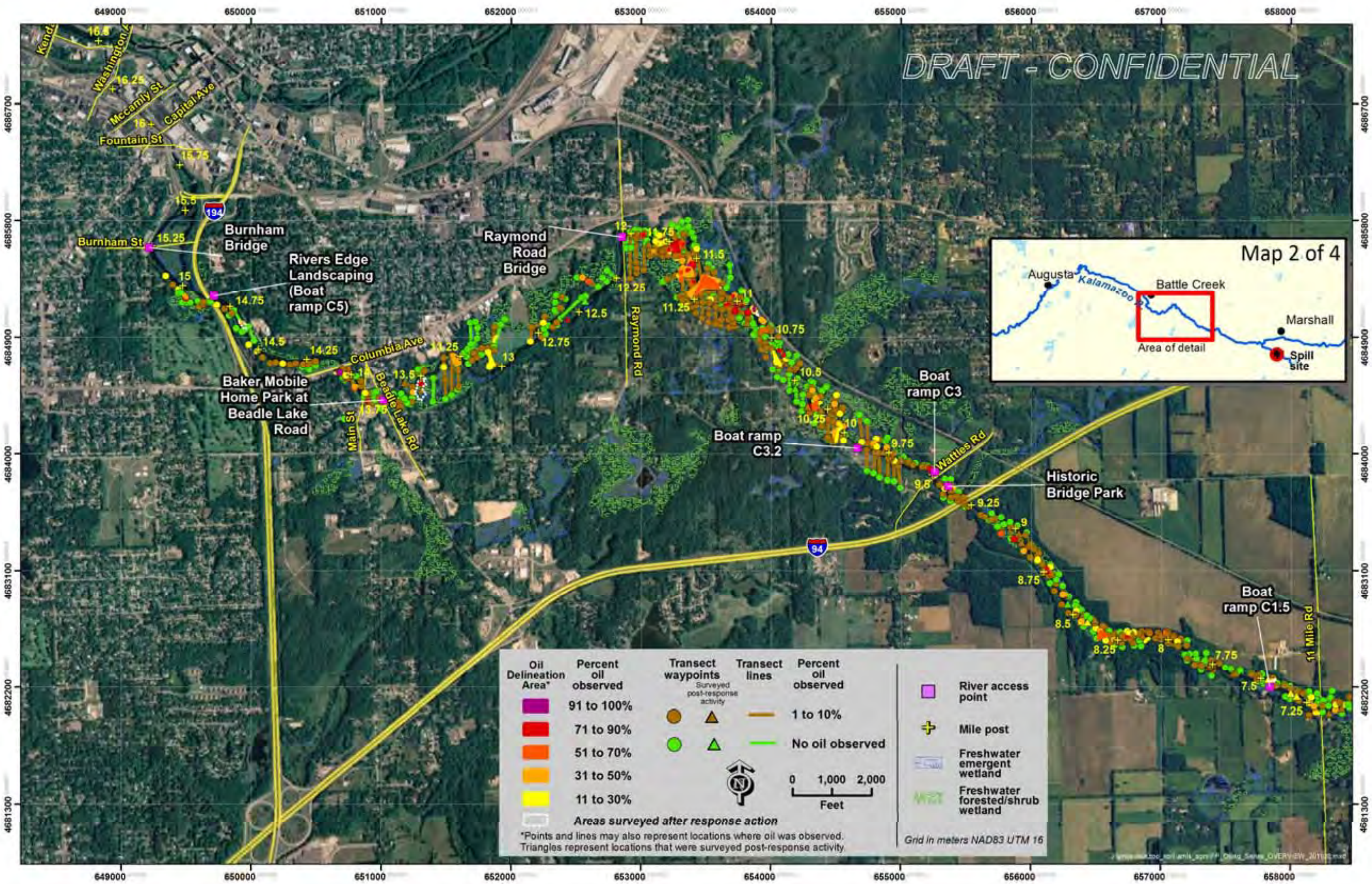

Figure 10. Overview map showing the transects and ODAs surveyed during the floodplain survey (MP 7.25–16.5).

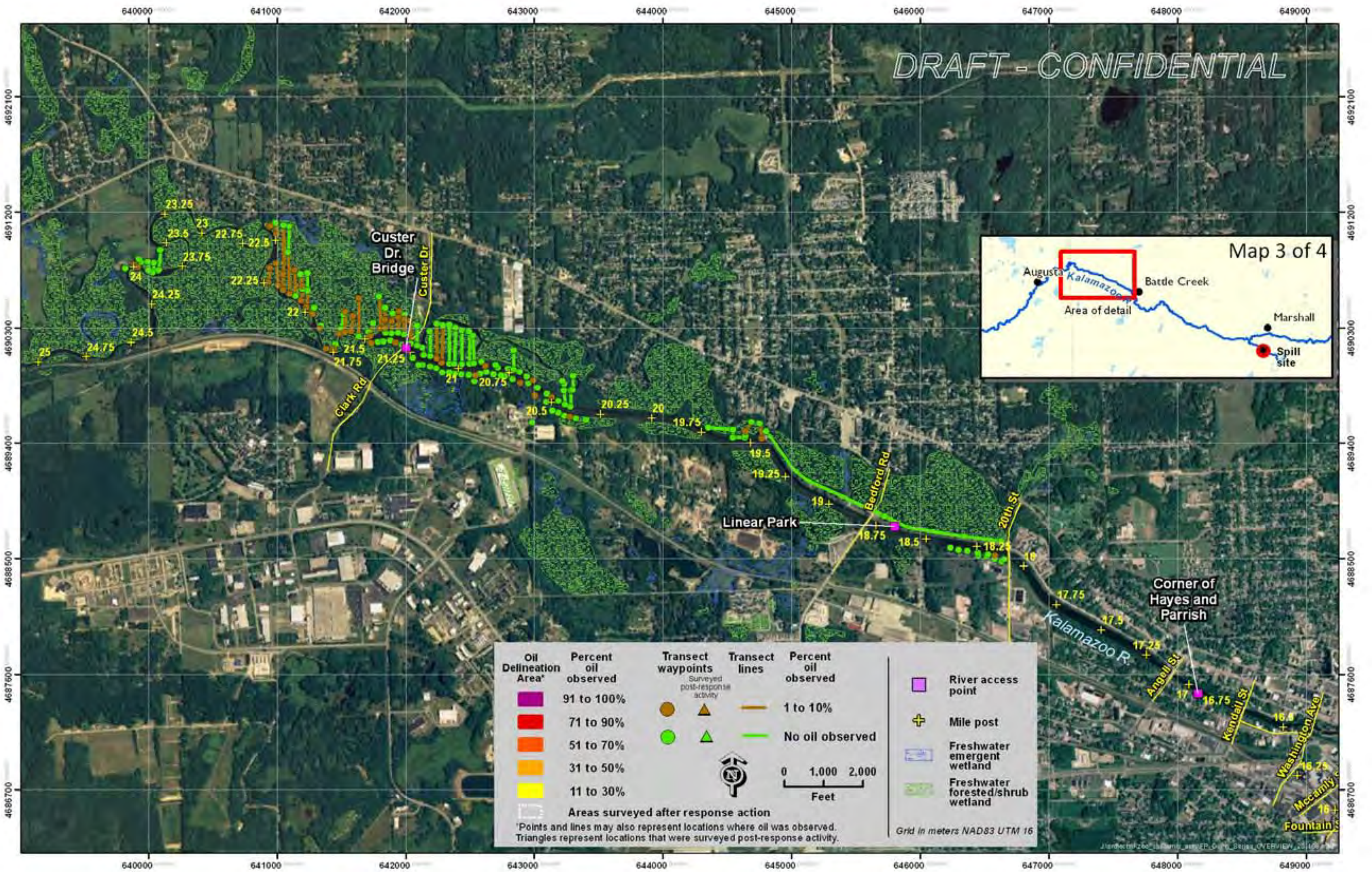

Figure 11. Overview map showing the transects and ODAs surveyed during the floodplain survey (MP 16–25).

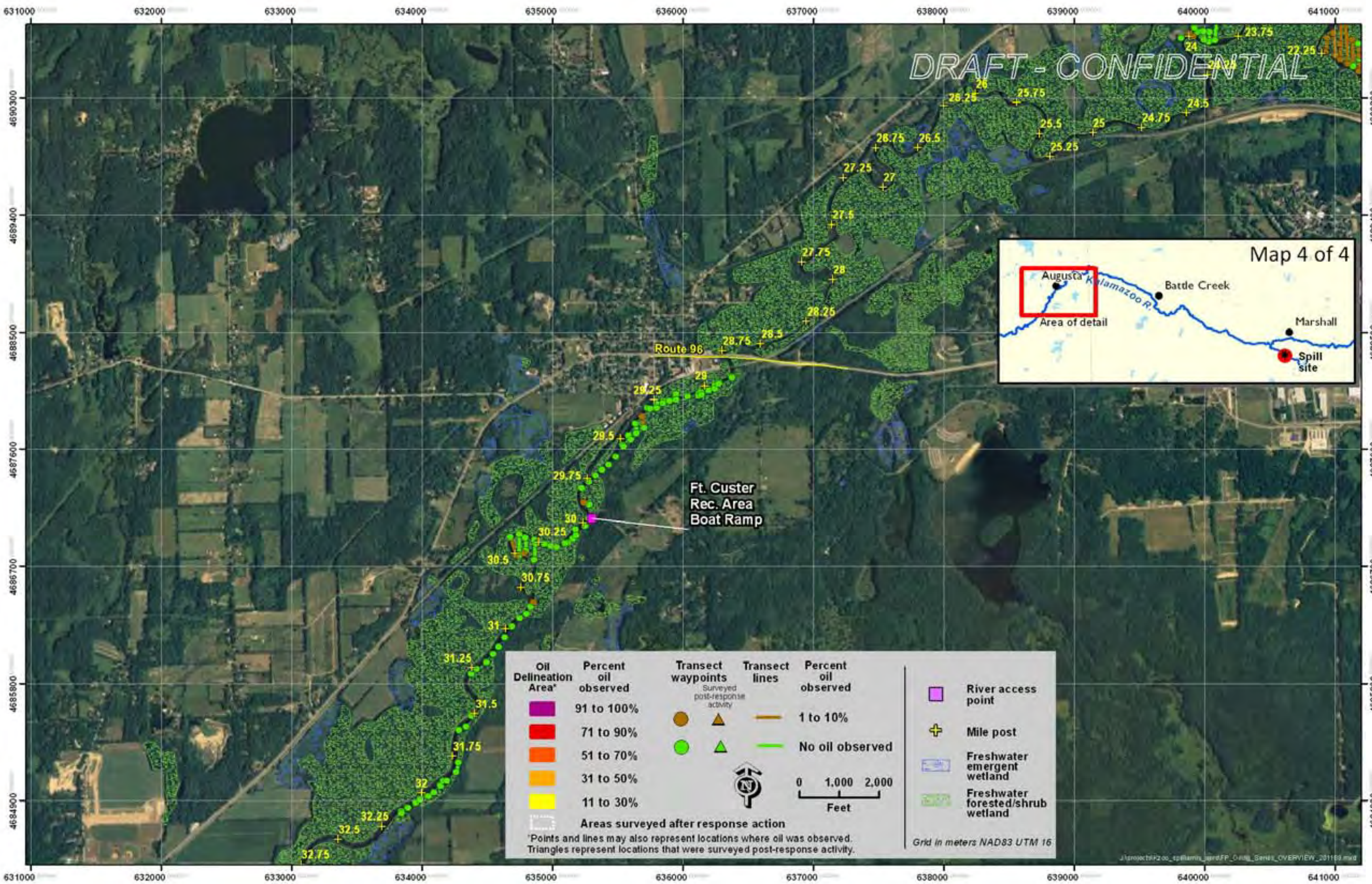

Figure 12. Overview map showing the transects and ODAs surveyed during the floodplain survey (MP 22.25–32.75).

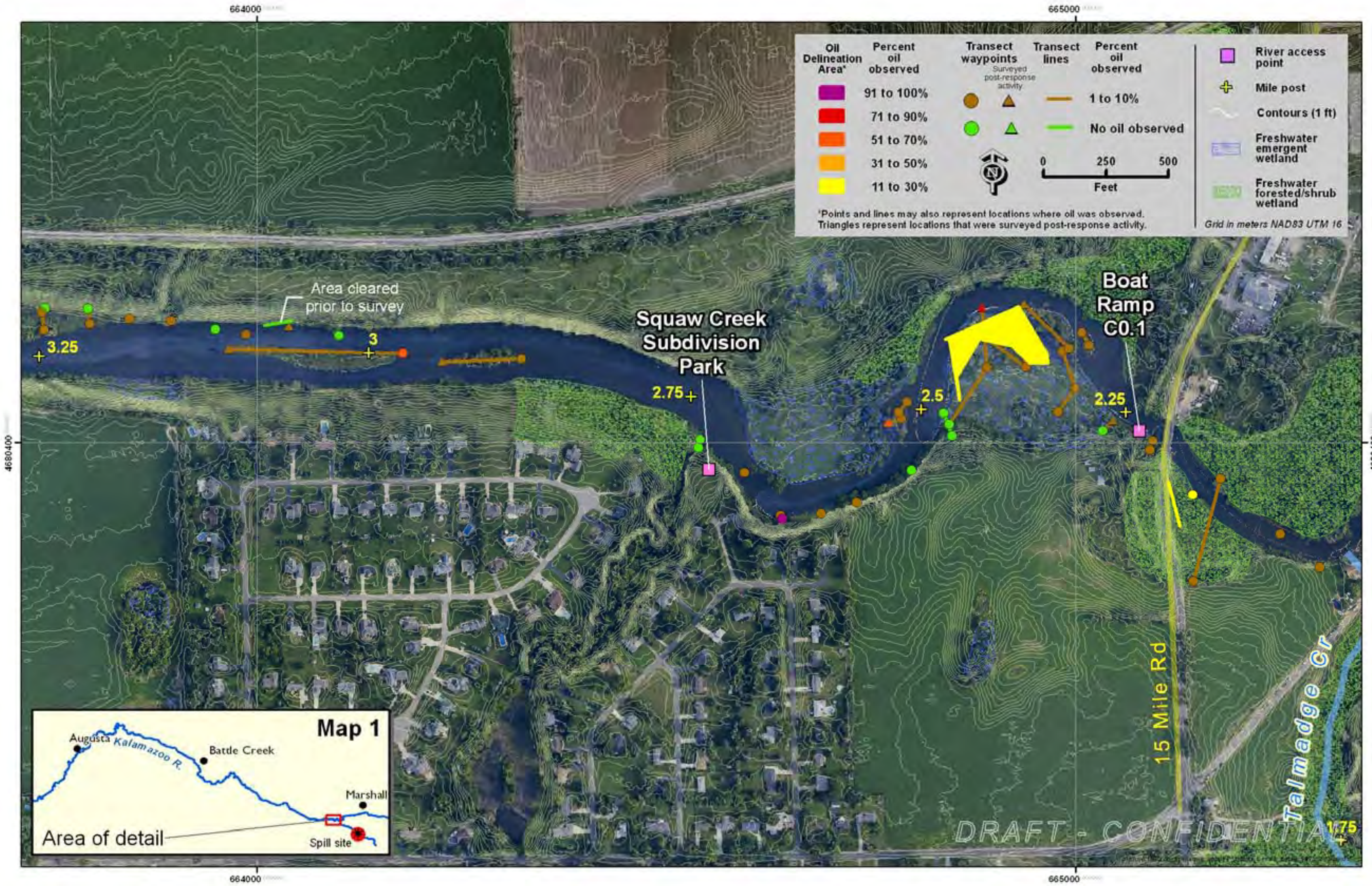

Figure 13. Detailed map showing all transects, waypoints, and ODAs surveyed during the floodplain survey (MP 2.25–3.25).

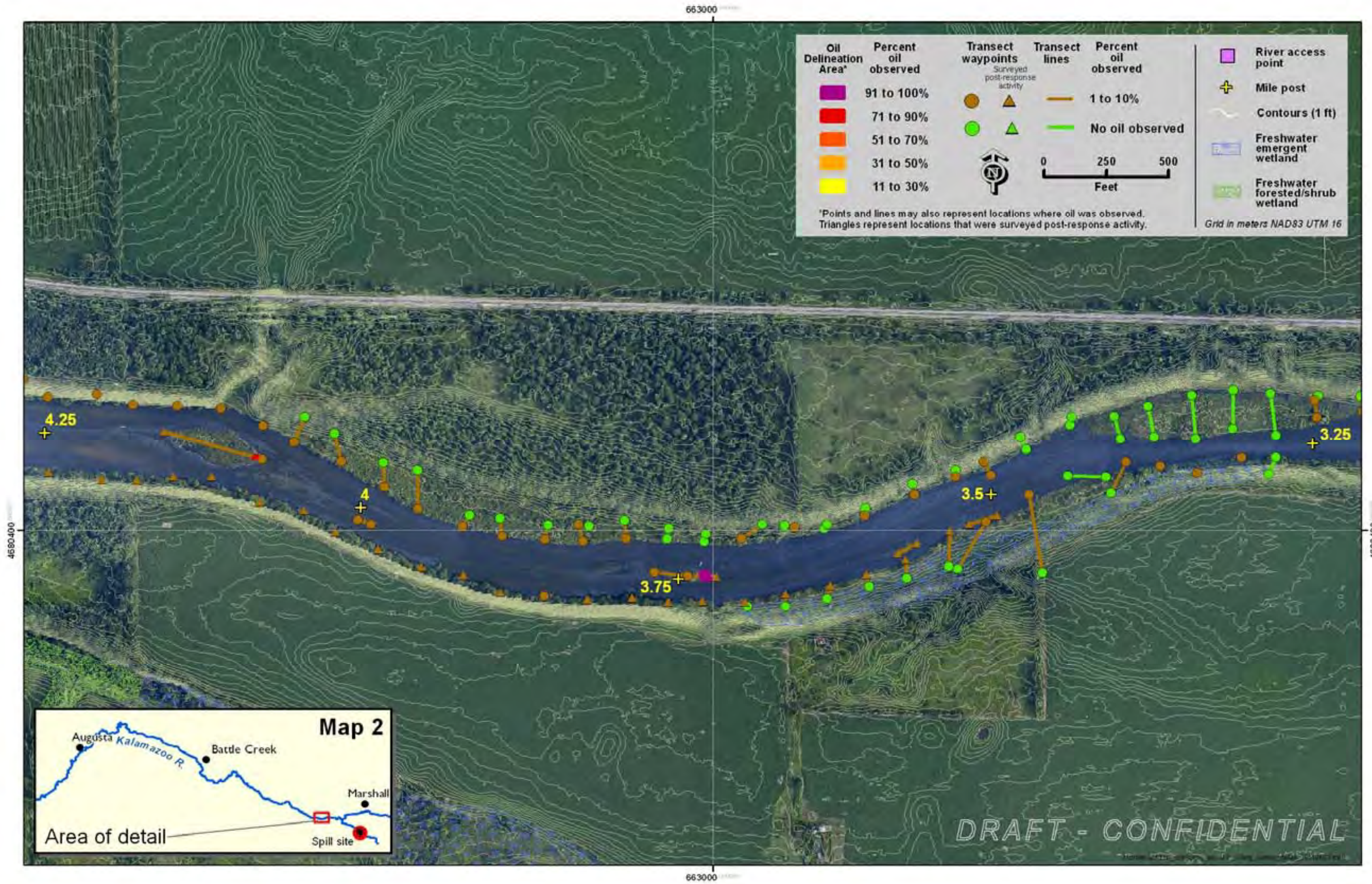

Figure 14. Detailed map showing all transects, waypoints, and ODAs surveyed during the floodplain survey (MP 3.25–4.25).

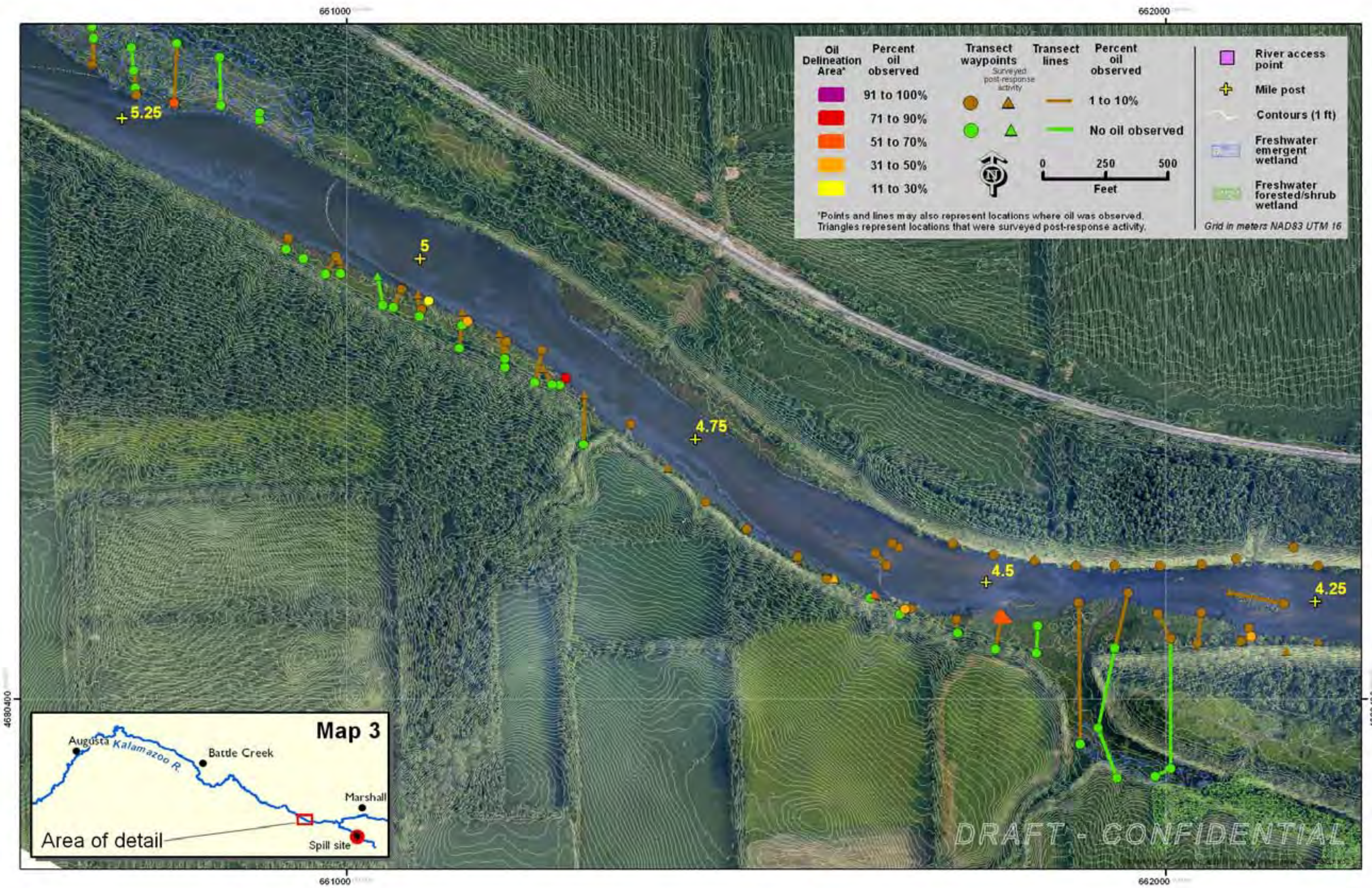

Figure 15. Detailed map showing all transects, waypoints, and ODAs surveyed during the floodplain survey (MP 4.25–5.25).

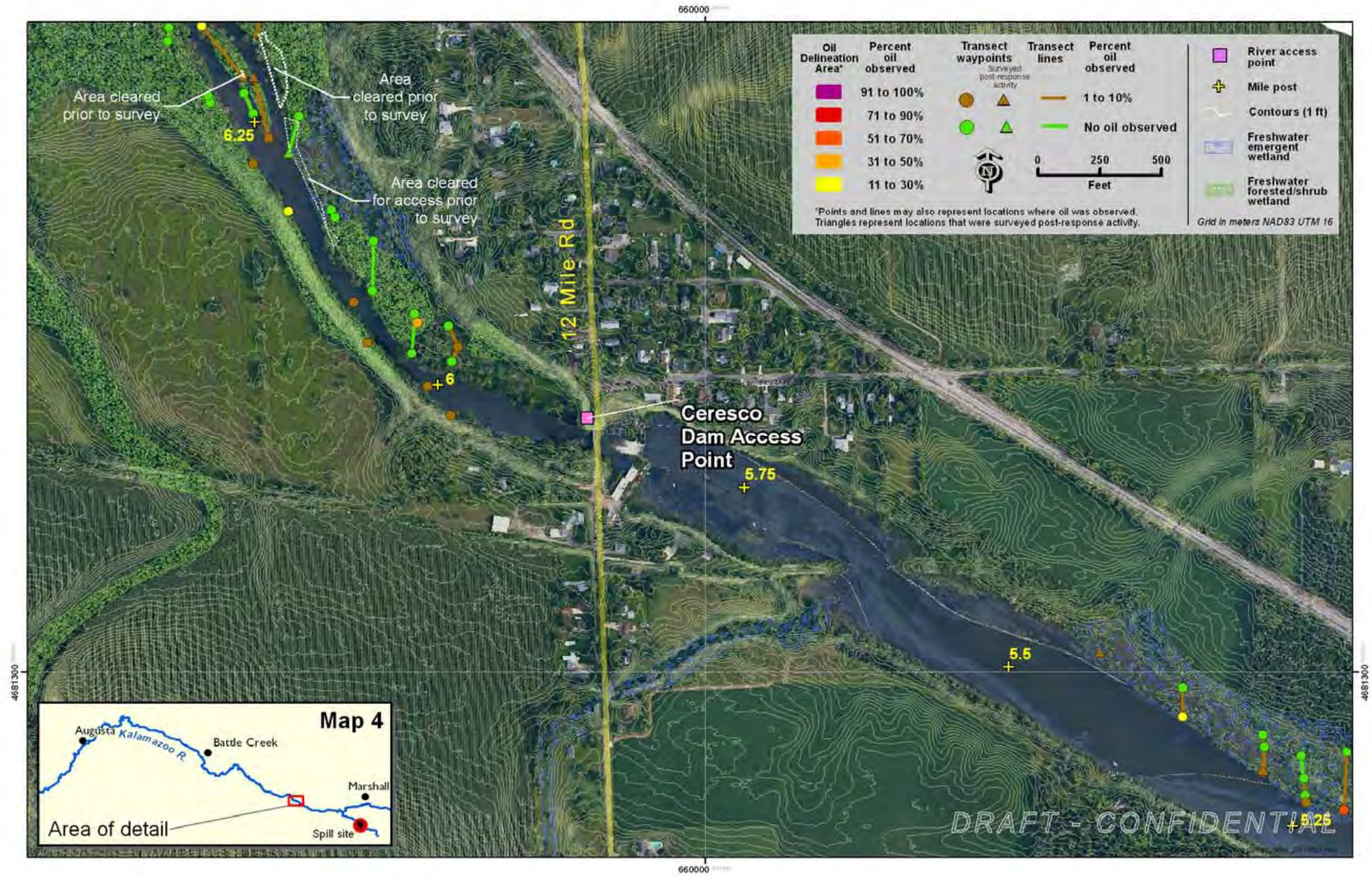

Figure 16. Detailed map showing all transects, waypoints, and ODAs surveyed during the floodplain survey (MP 5.25–6.25).

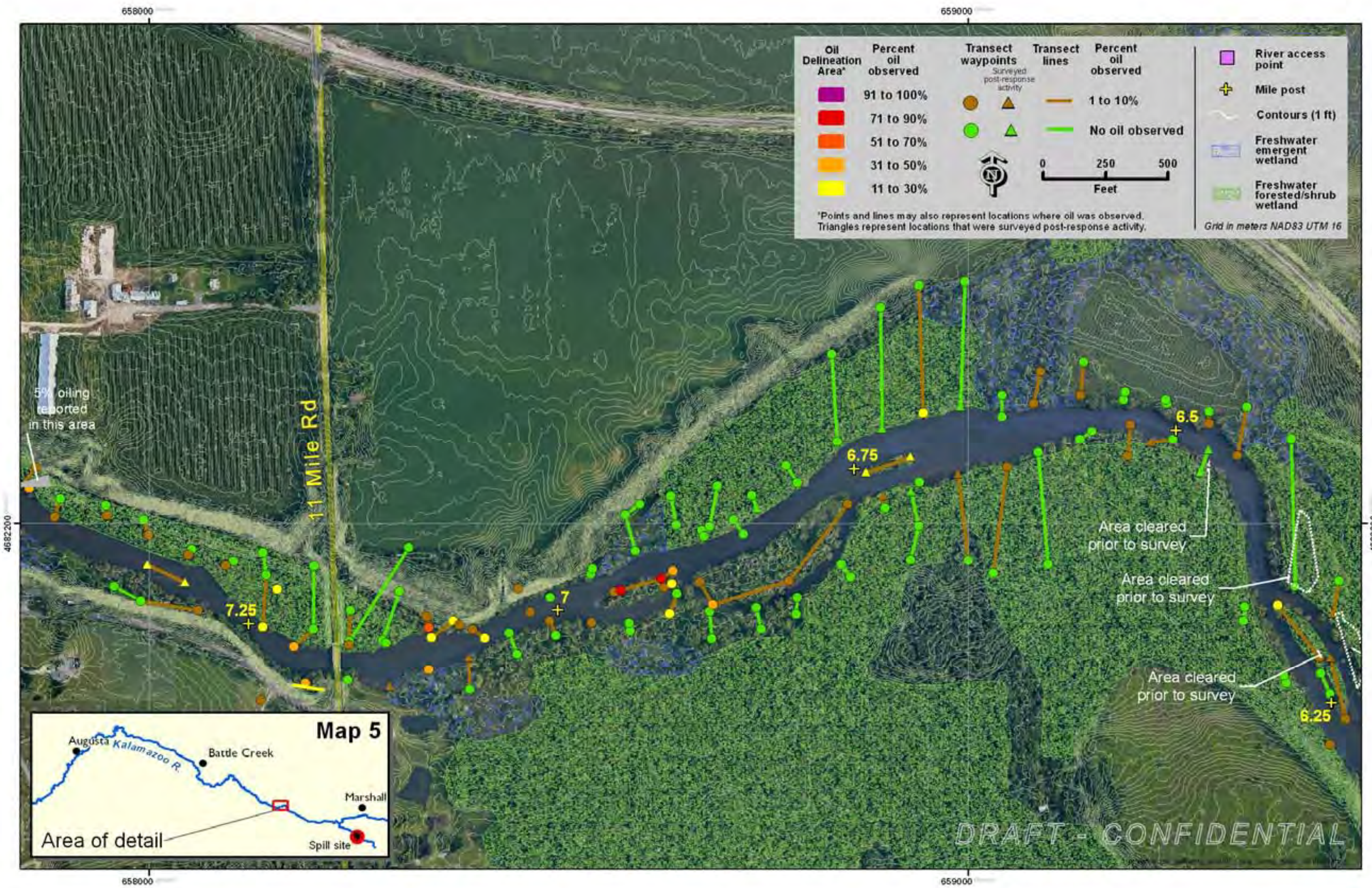

Figure 17. Detailed map showing all transects, waypoints, and ODAs surveyed during the floodplain survey (MP 6.25–7.25).

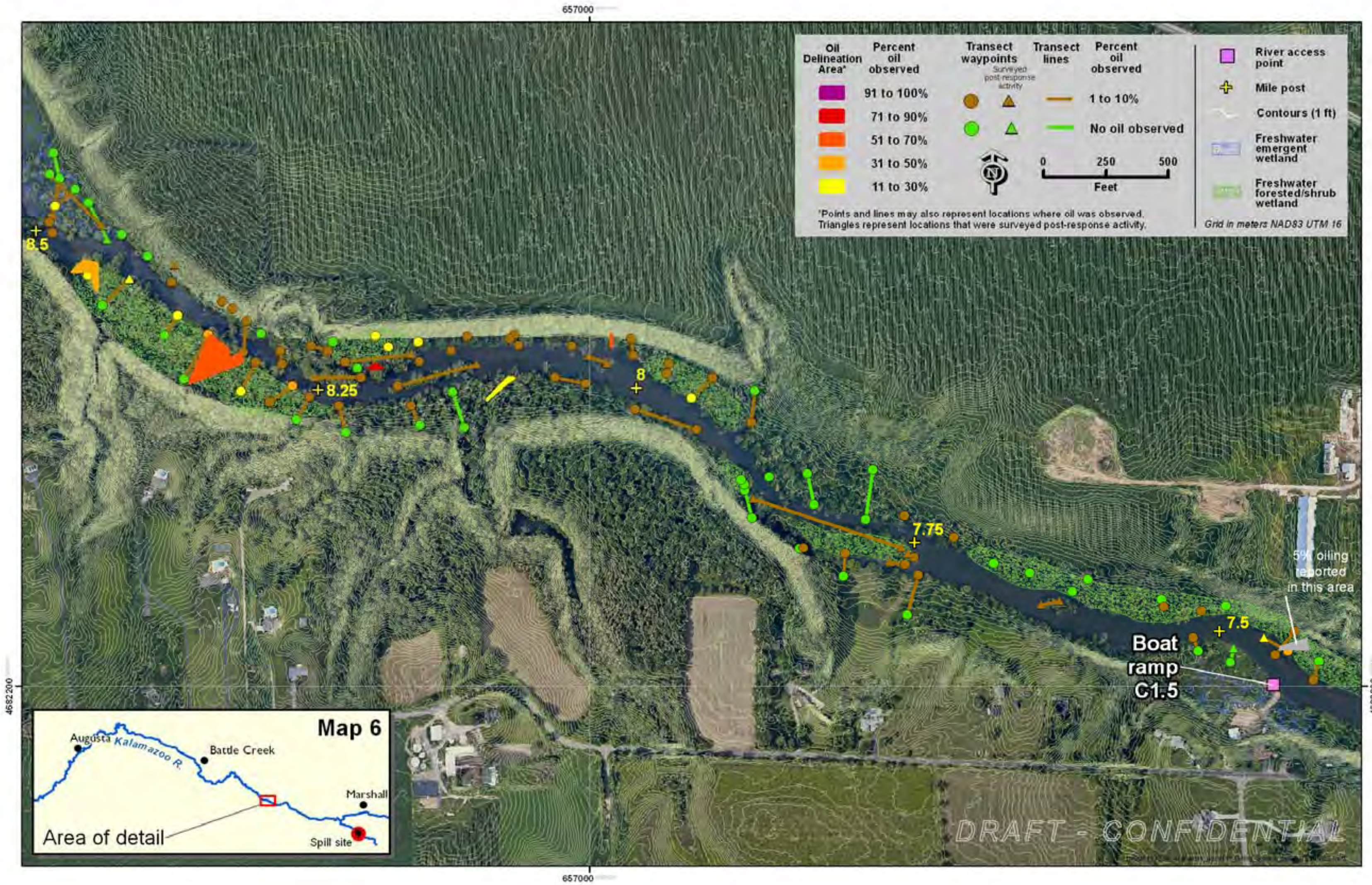

Figure 18. Detailed map showing all transects, waypoints, and ODAs surveyed during the floodplain survey (MP 7.5–8.5).

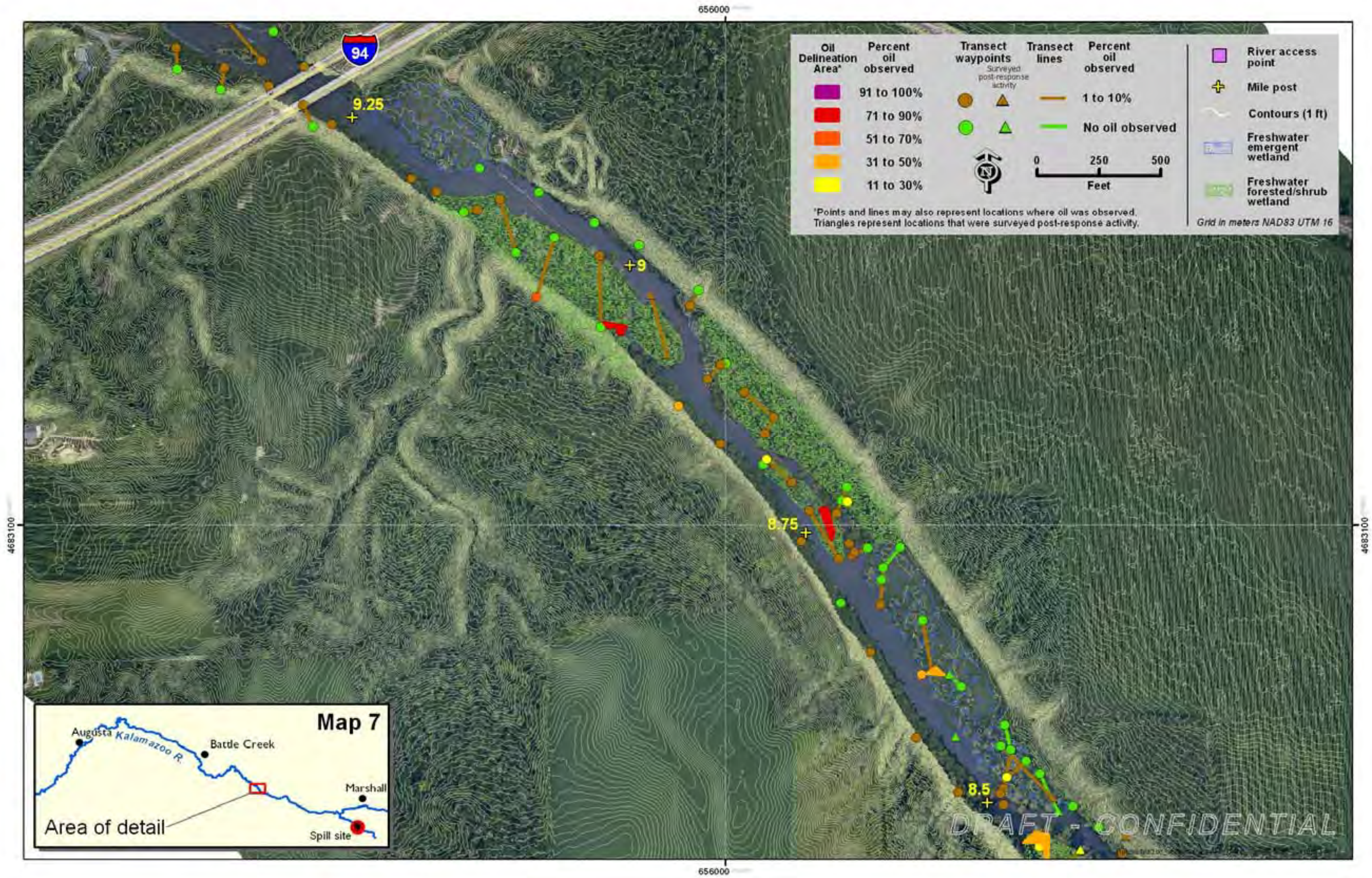

Figure 19. Detailed map showing all transects, waypoints, and ODAs surveyed during the floodplain survey (MP 8.5–9.25).

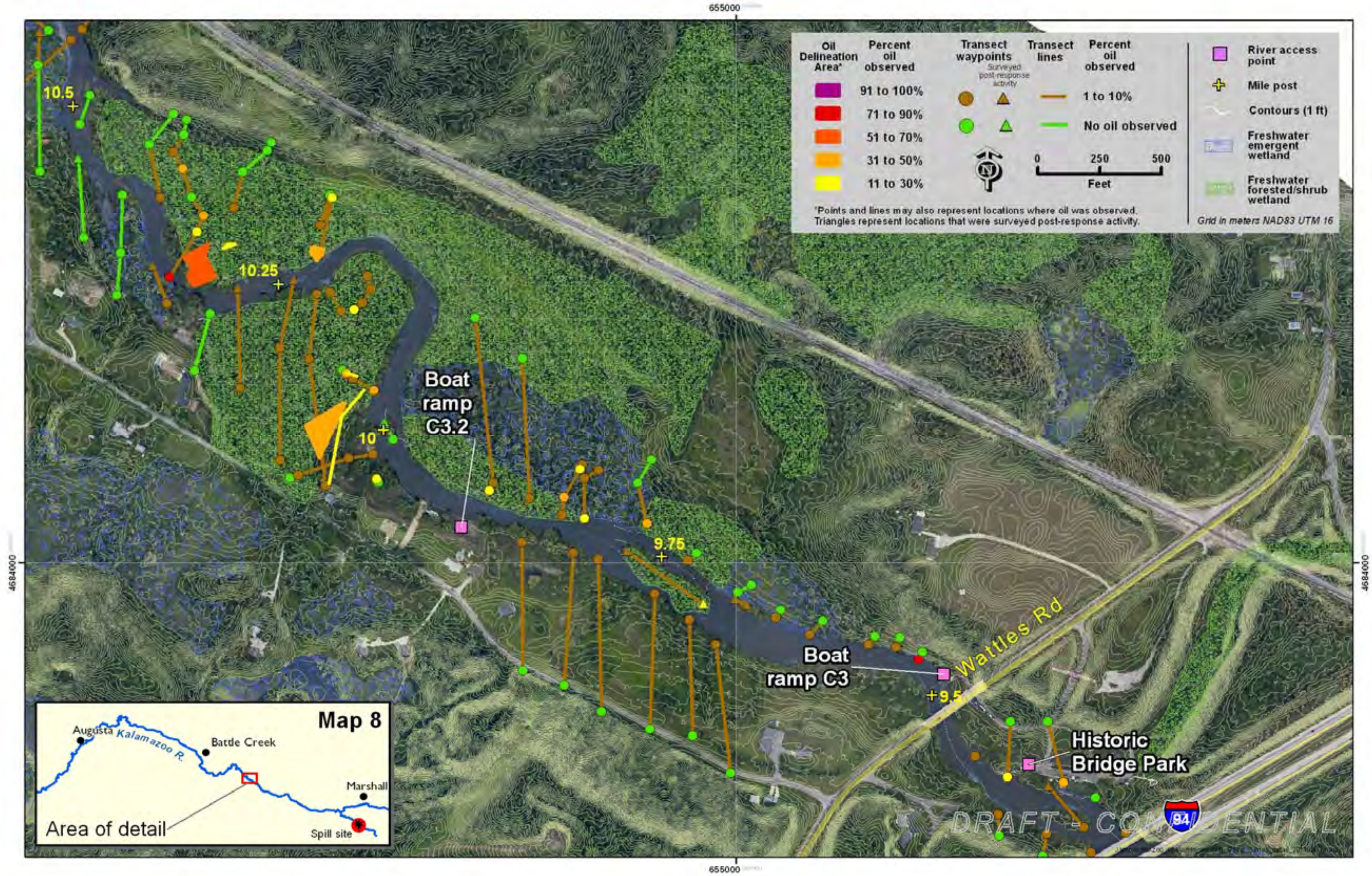

Figure 20. Detailed map showing all transects, waypoints, and ODAs surveyed during the floodplain survey (MP 9.5–10.5).

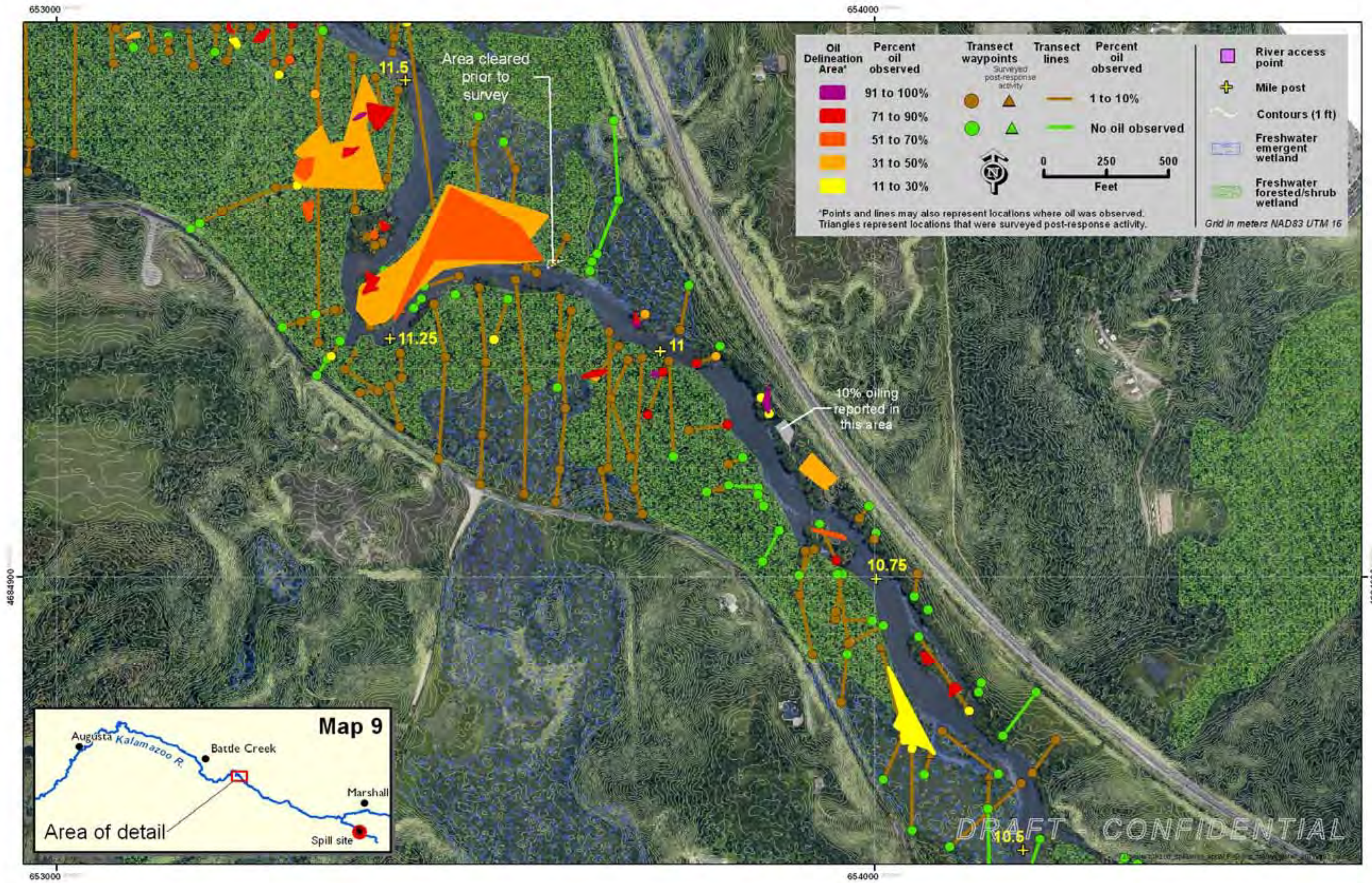

Figure 21. Detailed map showing all transects, waypoints, and ODAs surveyed during the floodplain survey (MP 10.5–11.5).

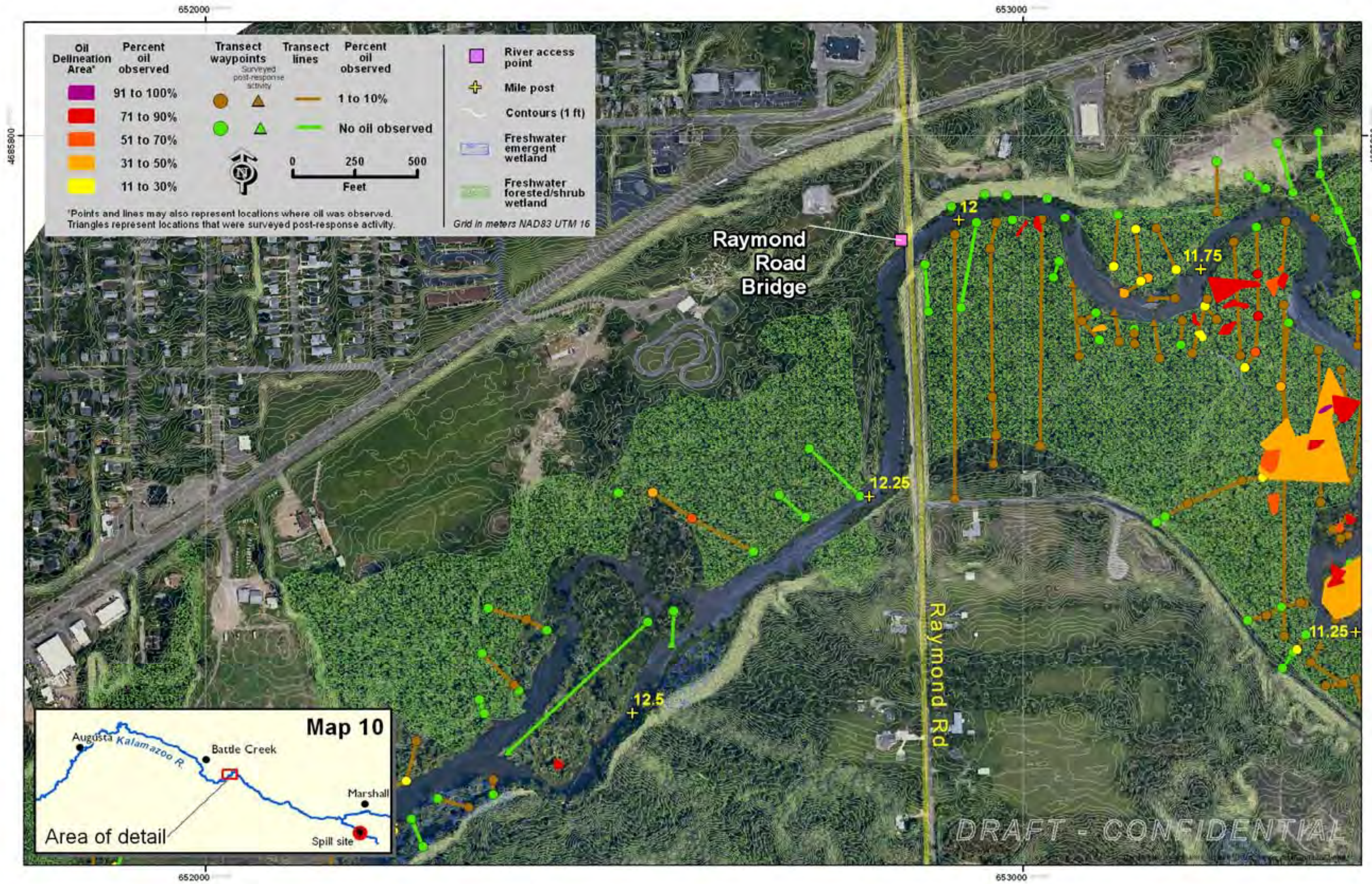

Figure 22. Detailed map showing all transects, waypoints, and ODAs surveyed during the floodplain survey (MP 11.25–12.5).

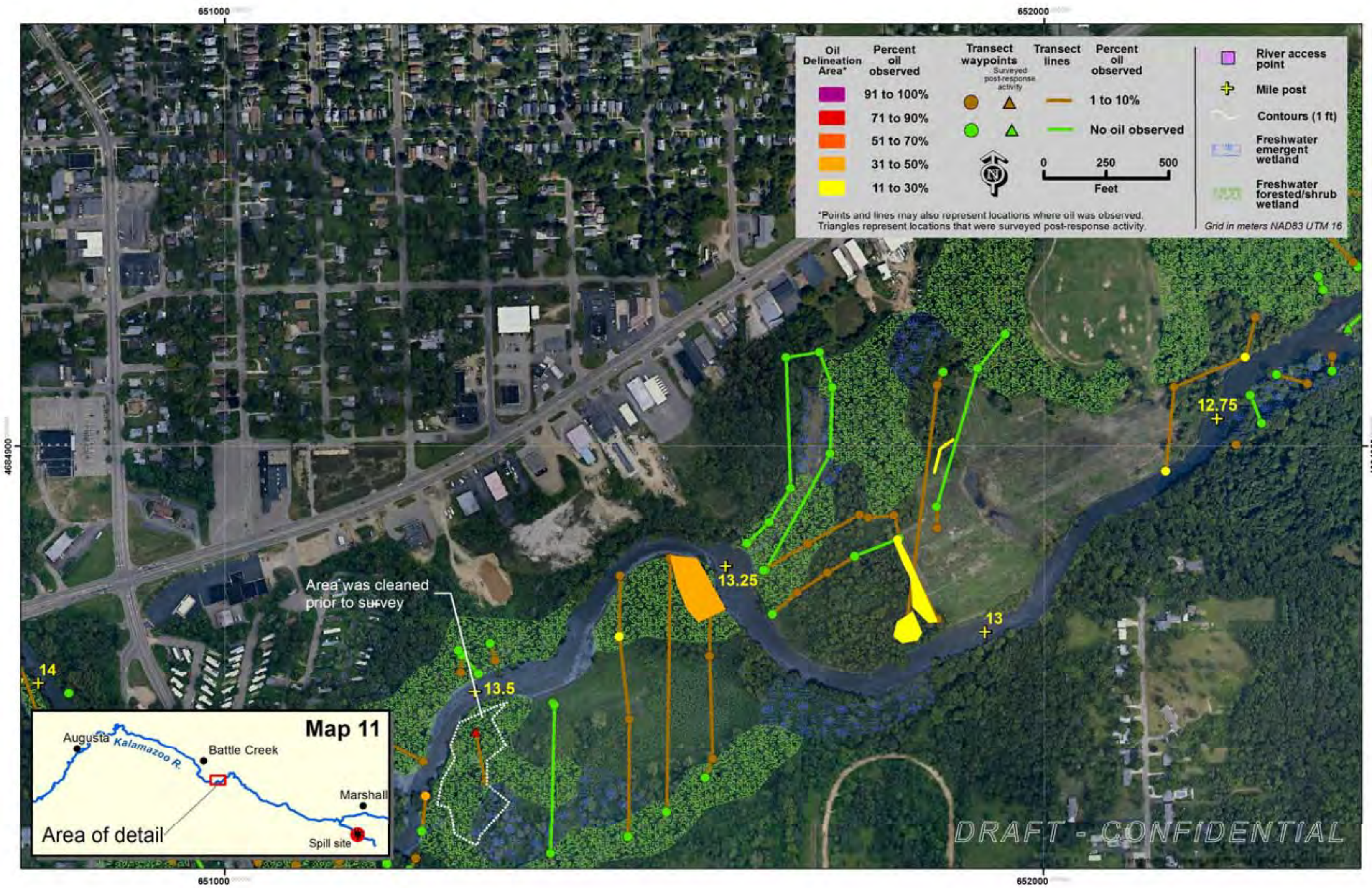

Figure 23. Detailed map showing all transects, waypoints, and ODAs surveyed during the floodplain survey (MP 12.75–14).

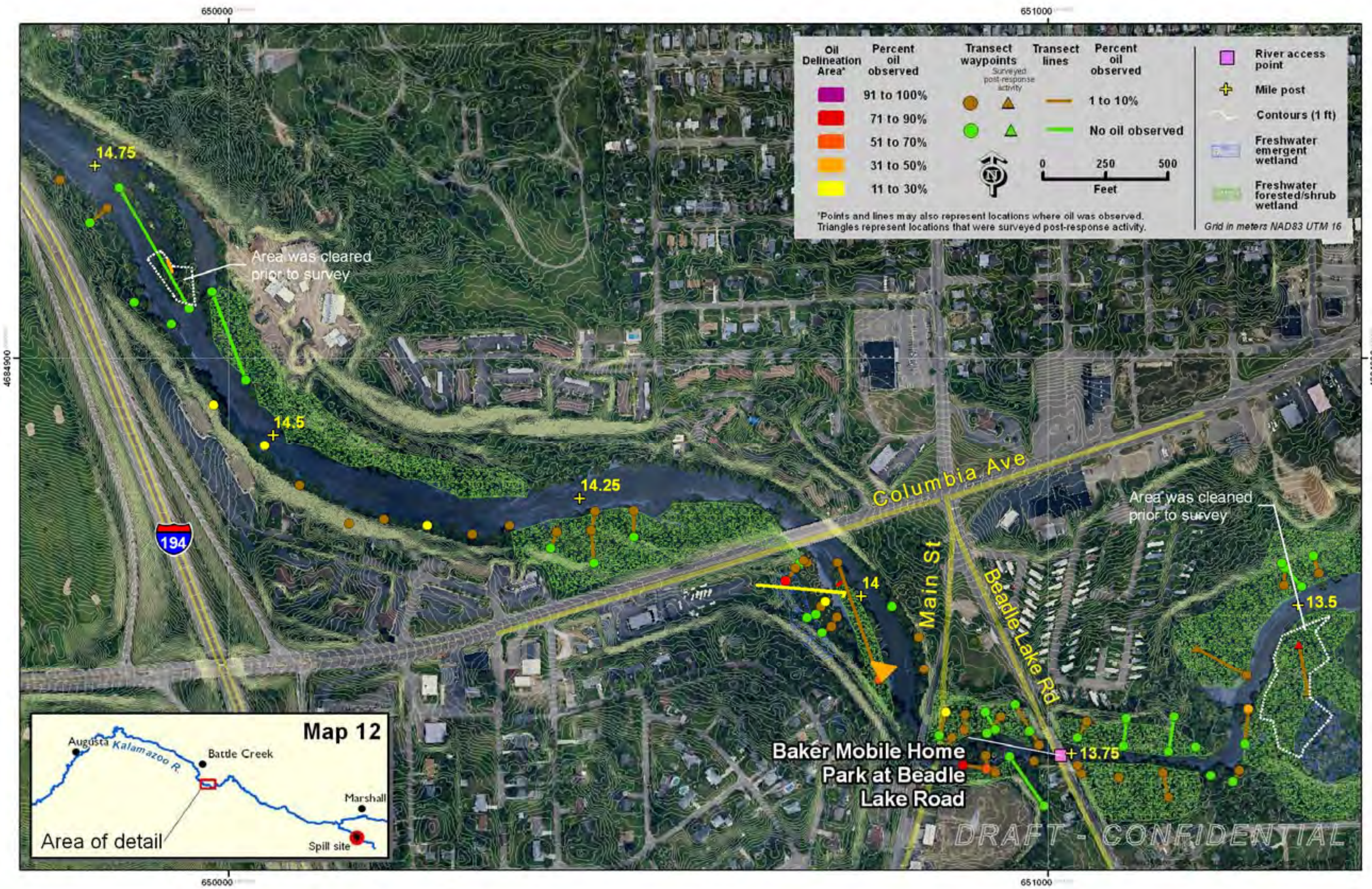

Figure 24. Detailed map showing all transects, waypoints, and ODAs surveyed during the floodplain survey (MP 13.5–14.75).

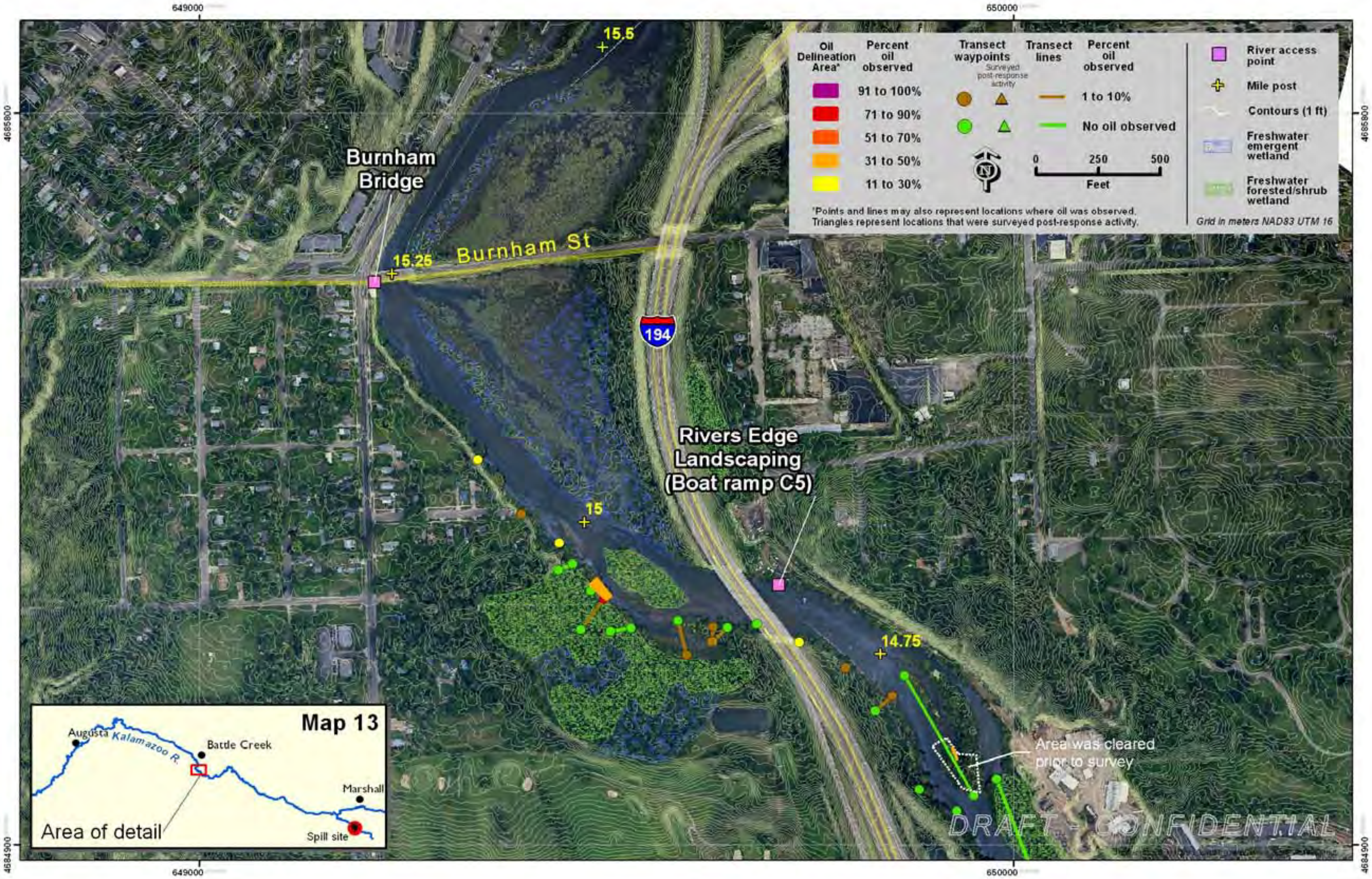

Figure 25. Detailed map showing all transects, waypoints, and ODAs surveyed during the floodplain survey (MP 14.75–15.5).

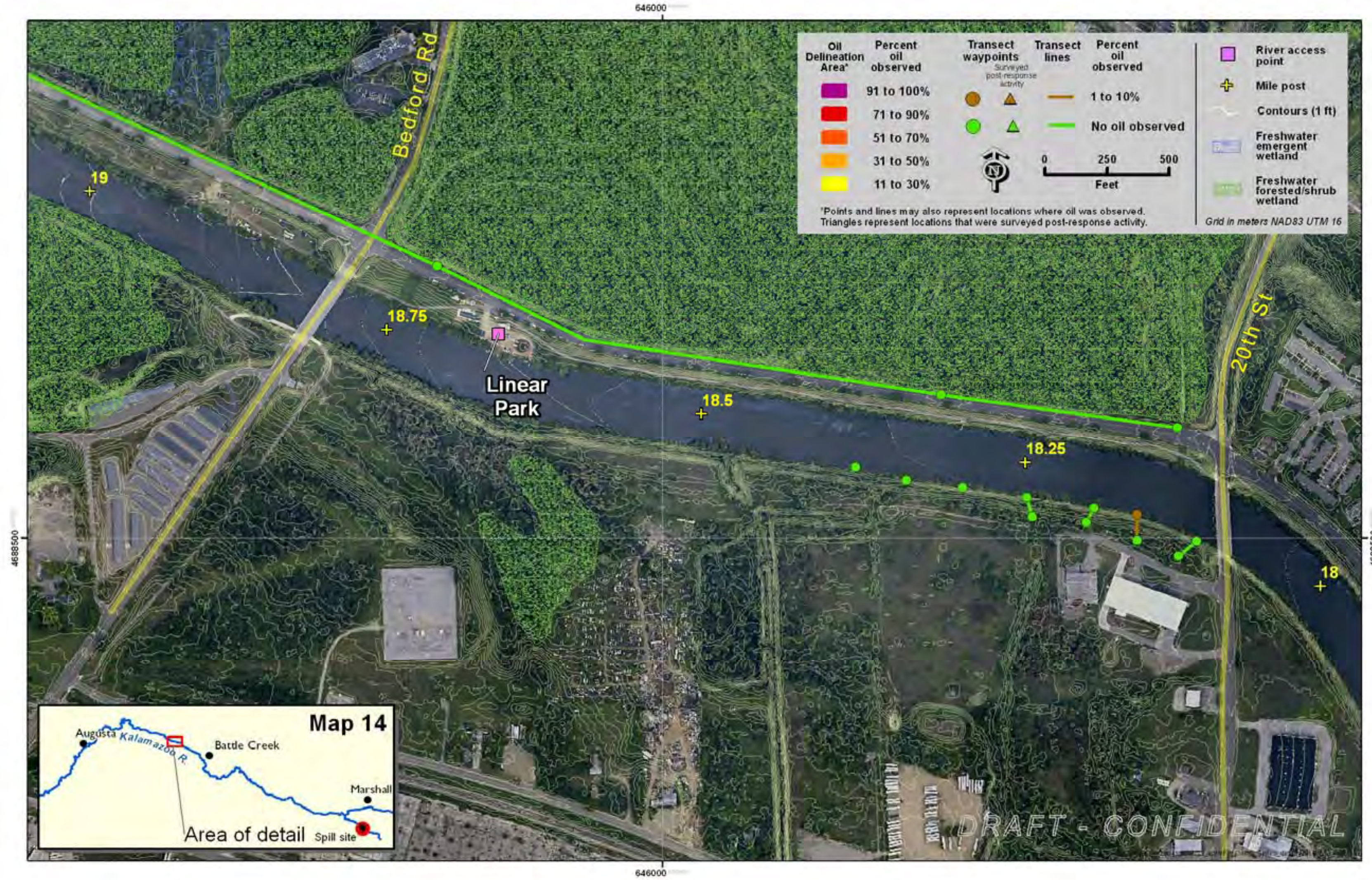

Figure 26. Detailed map showing all transects, waypoints, and ODAs surveyed during the floodplain survey (MP 18–19).

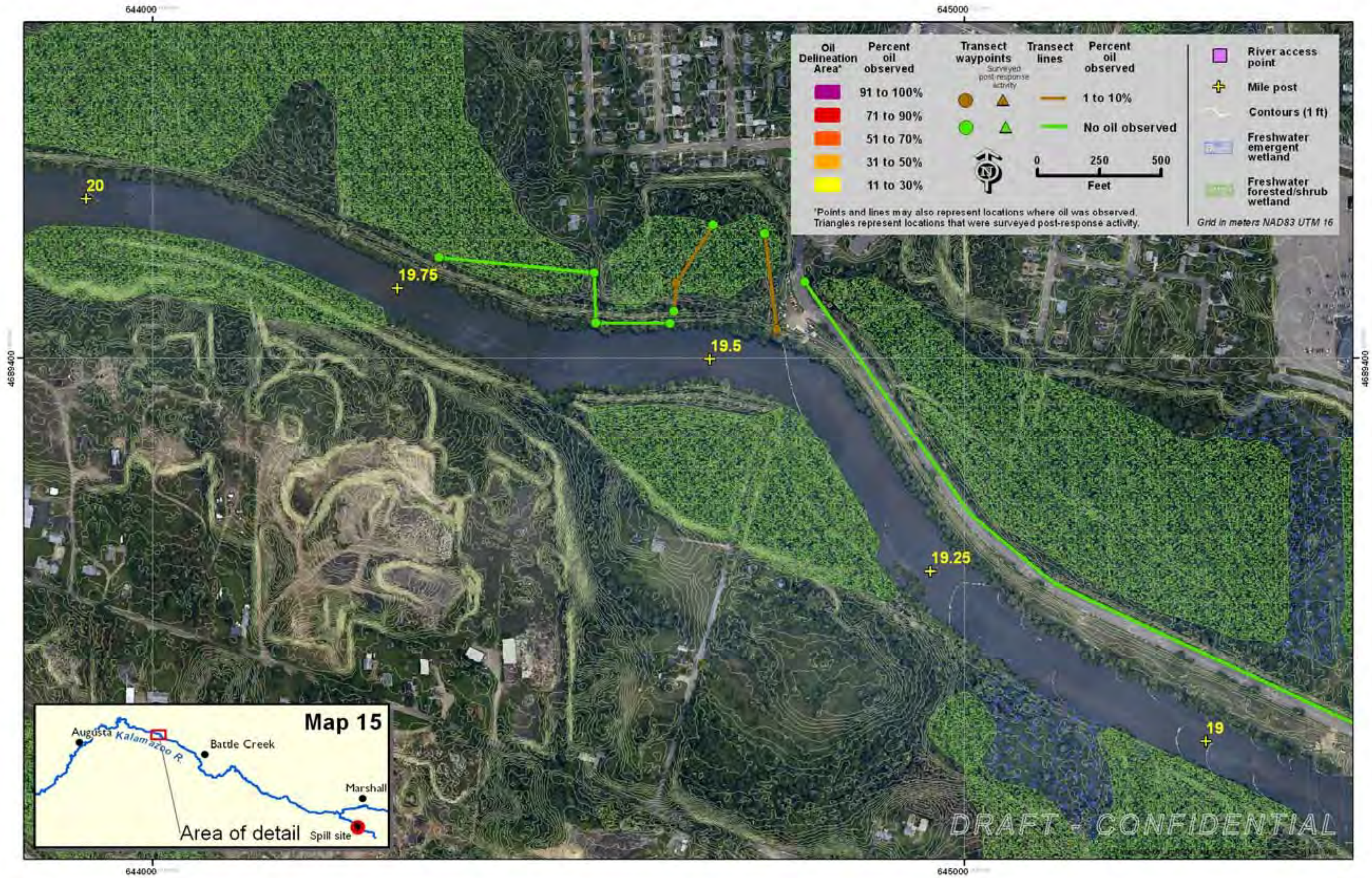

Figure 27. Detailed map showing all transects, waypoints, and ODAs surveyed during the floodplain survey (MP 19–20).

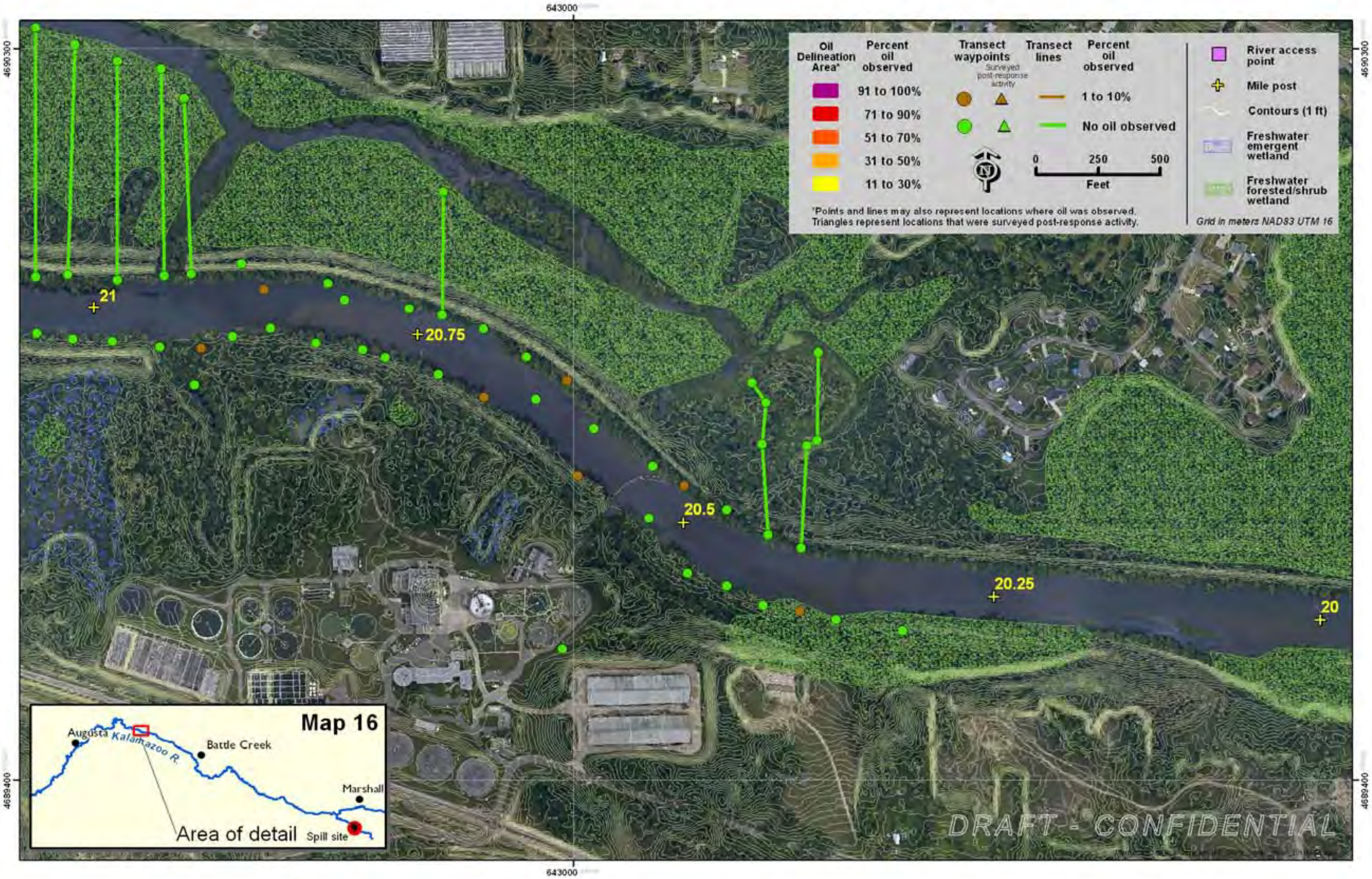

Figure 28. Detailed map showing all transects, waypoints, and ODAs surveyed during the floodplain survey (MP 20–21).

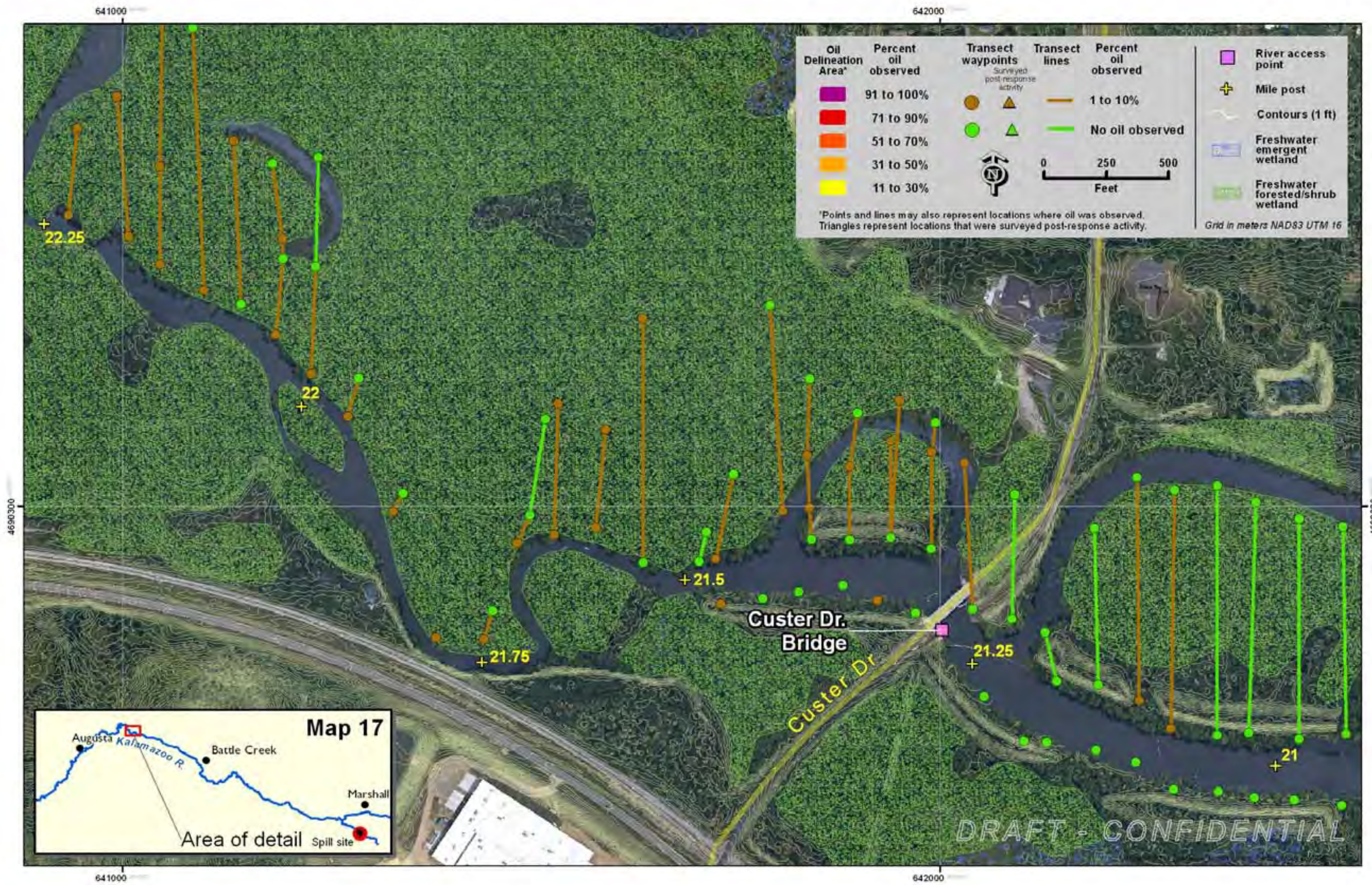

Figure 29. Detailed map showing all transects, waypoints, and ODAs surveyed during the floodplain survey (MP 21–22.25).

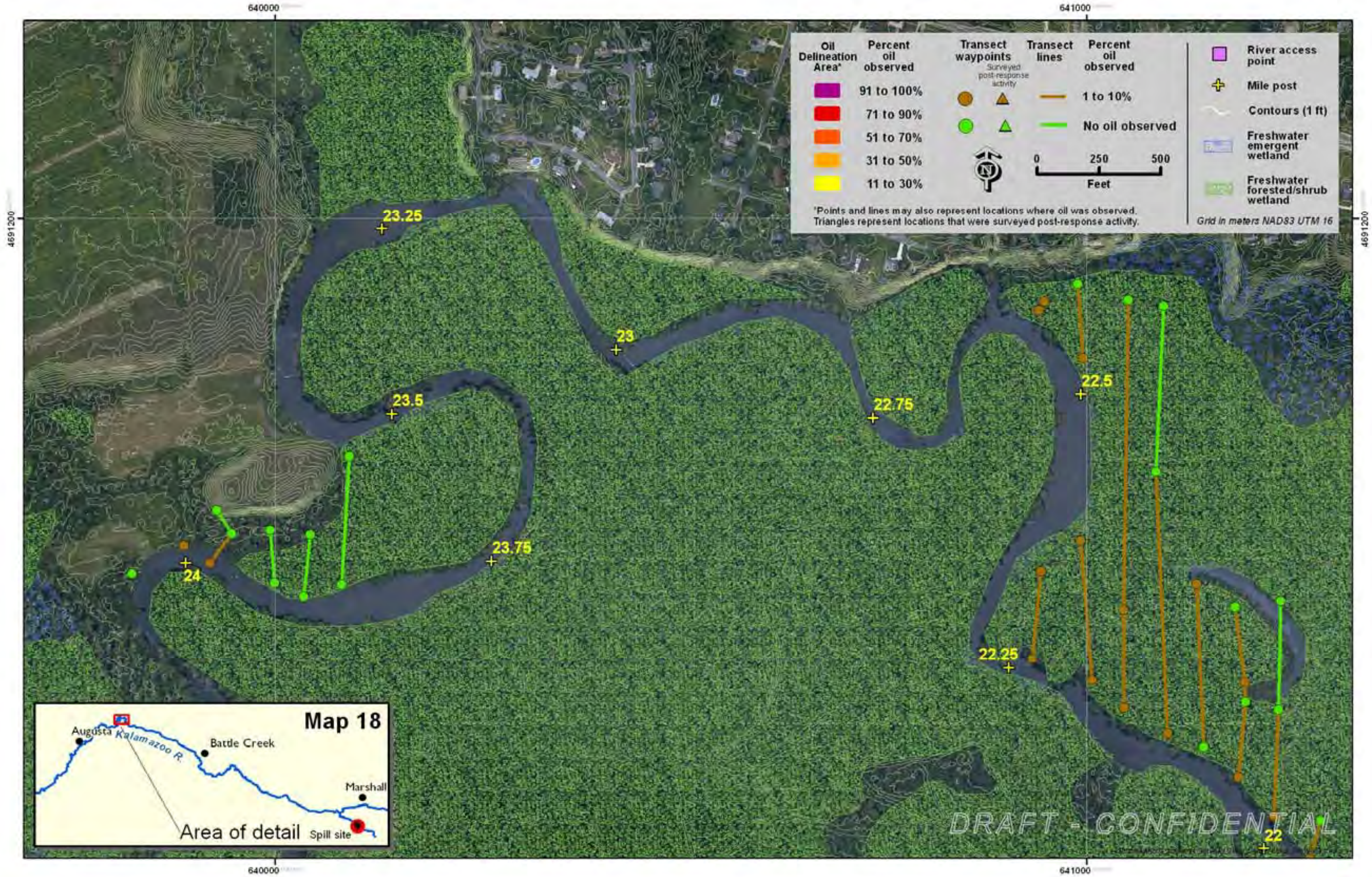

Figure 30. Detailed map showing all transects, waypoints, and ODAs surveyed during the floodplain survey (MP 22–24).

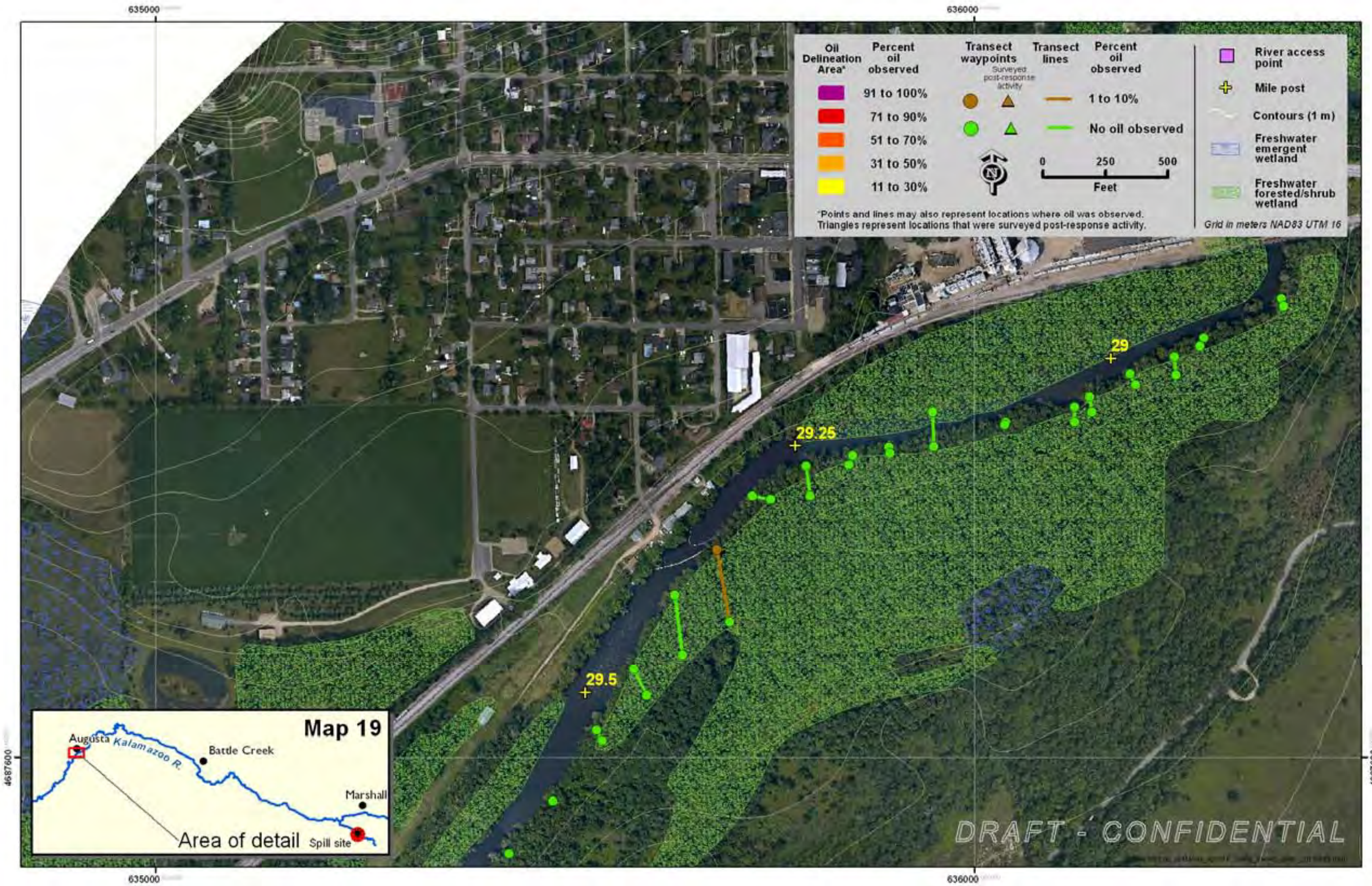

Figure 31. Detailed map showing all transects, waypoints, and ODAs surveyed during the floodplain survey (MP 29–29.5).

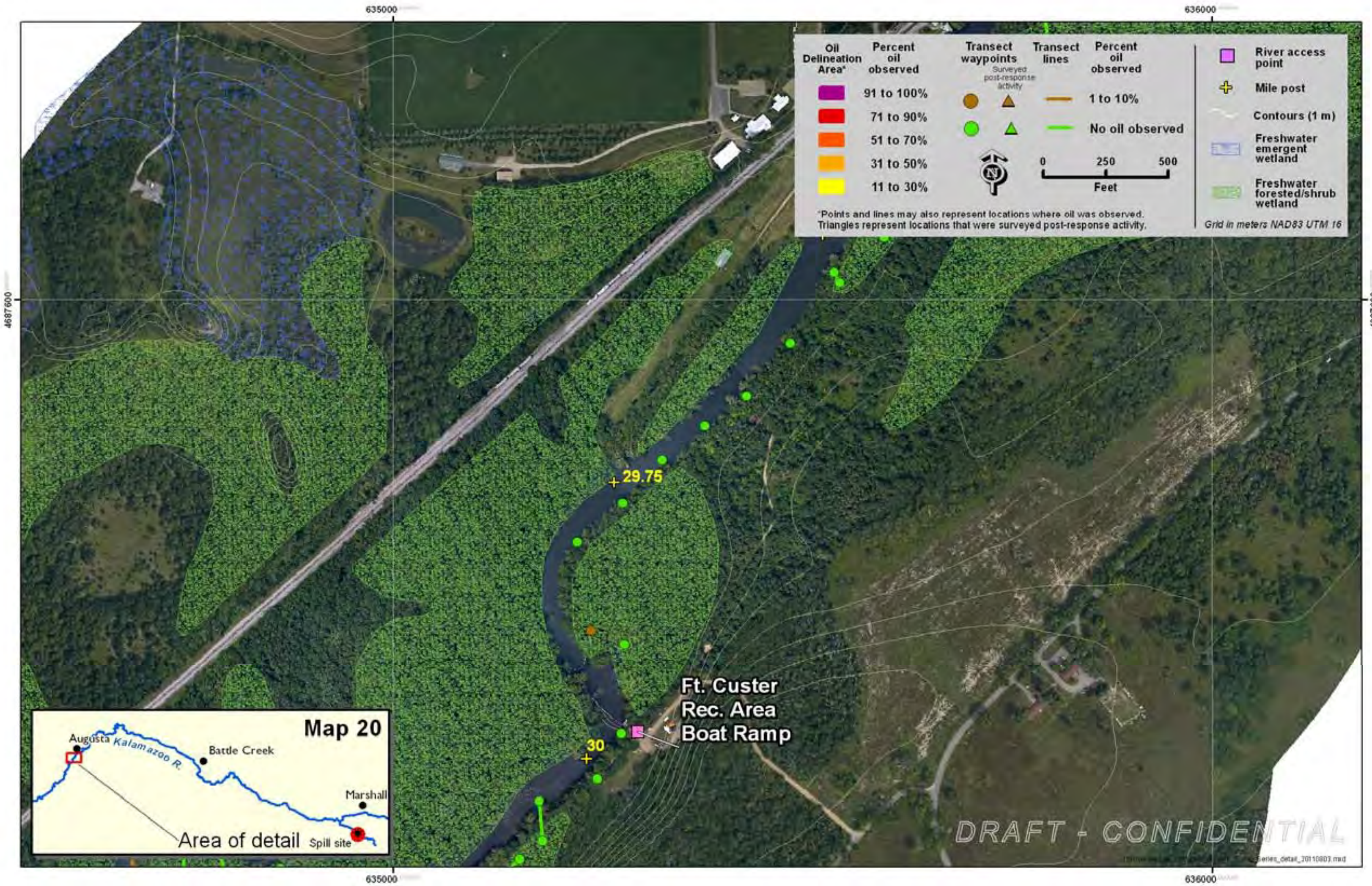

Figure 32. Detailed map showing all transects, waypoints, and ODAs surveyed during the floodplain survey (MP 29.75–30).

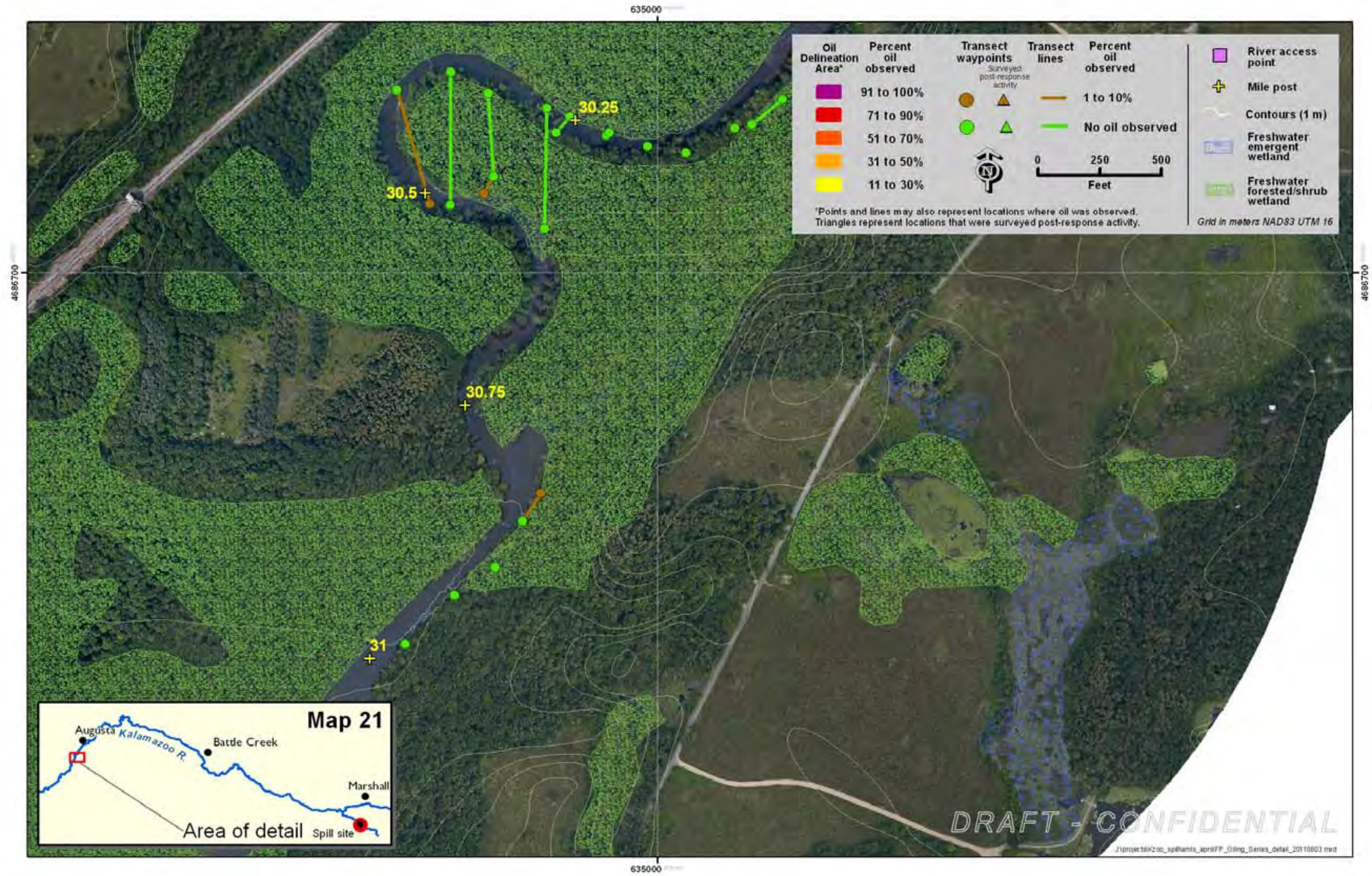

Figure 33. Detailed map showing all transects, waypoints, and ODAs surveyed during the floodplain survey (MP 30.25–31).

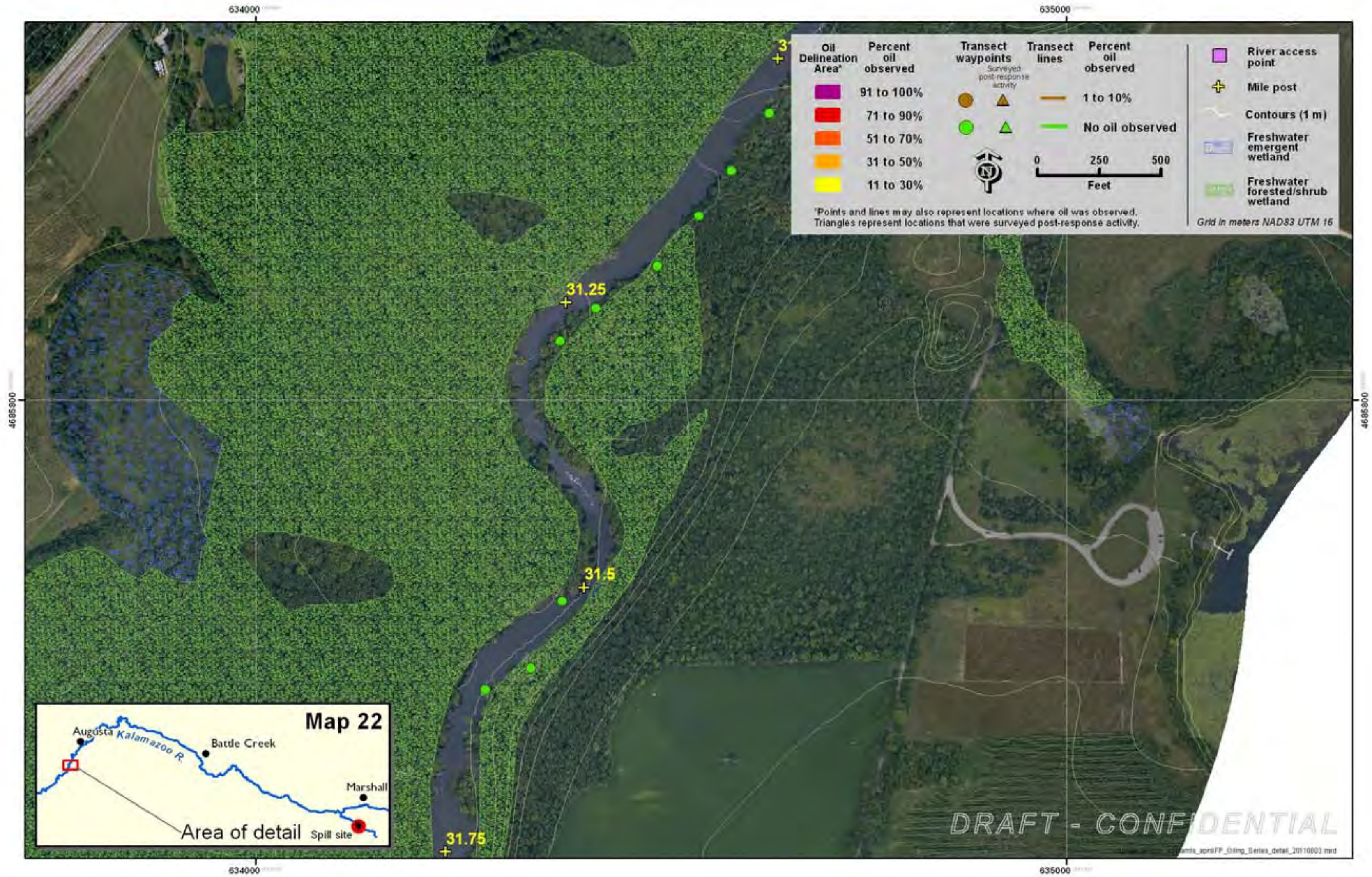

Figure 34. Detailed map showing all transects, waypoints, and ODAs surveyed during the floodplain survey (MP 31–31.75).

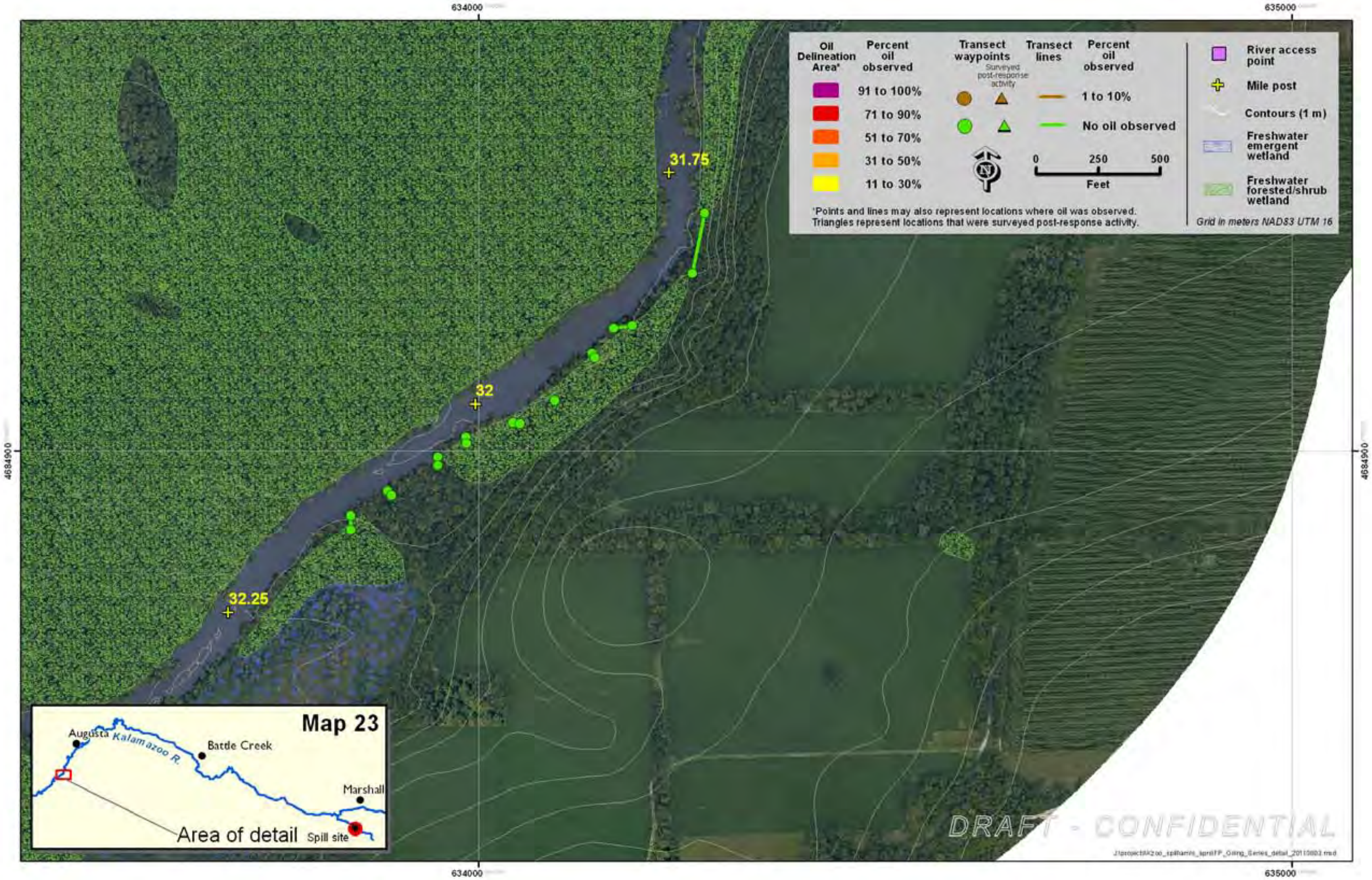

Figure 35. Detailed map showing all transects, waypoints, and ODAs surveyed during the floodplain survey (MP 31.75–32.25).

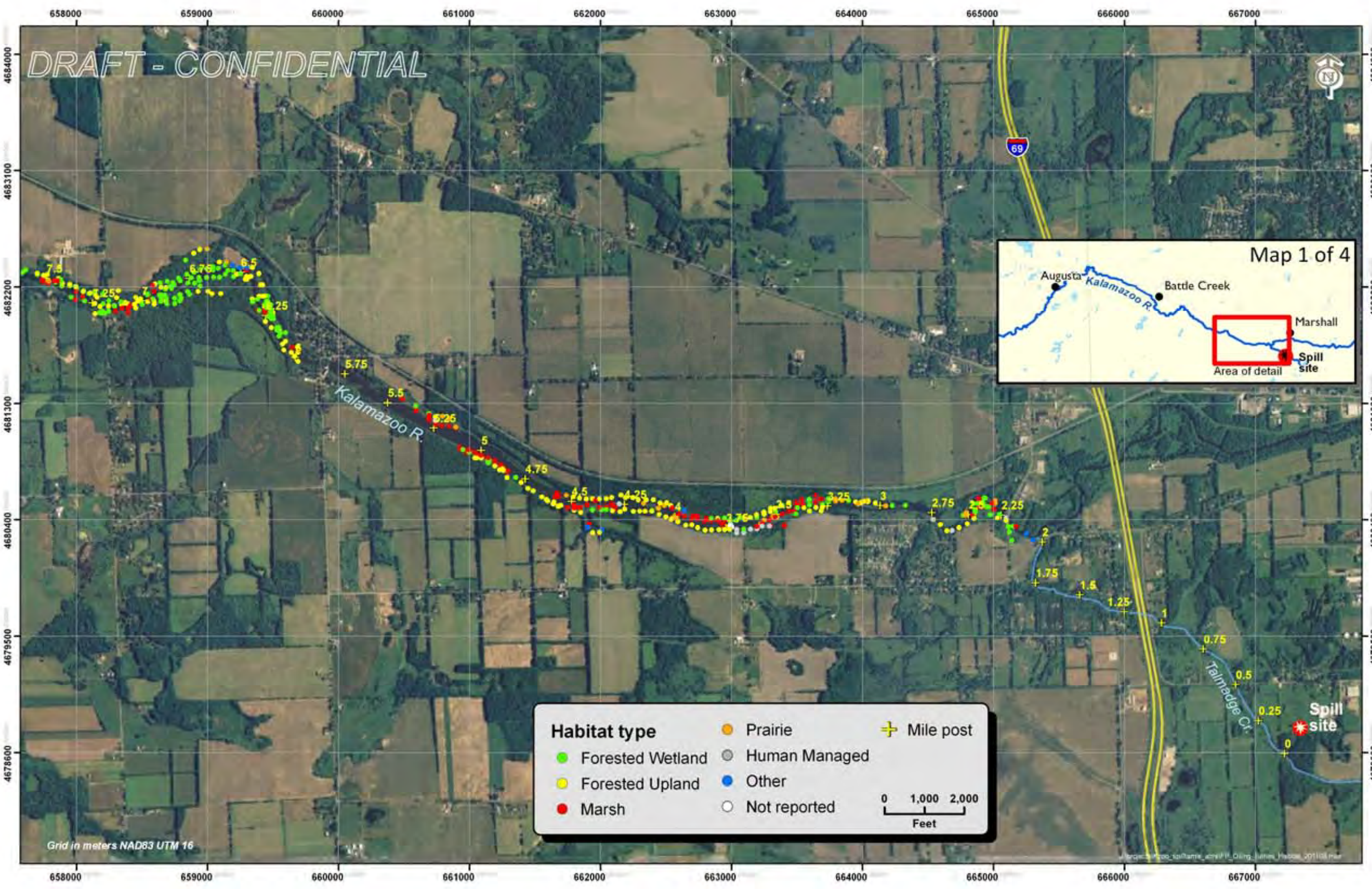

Figure 36. Map showing the habitat types identified at each waypoint during the floodplain survey (MP 0–7.5).

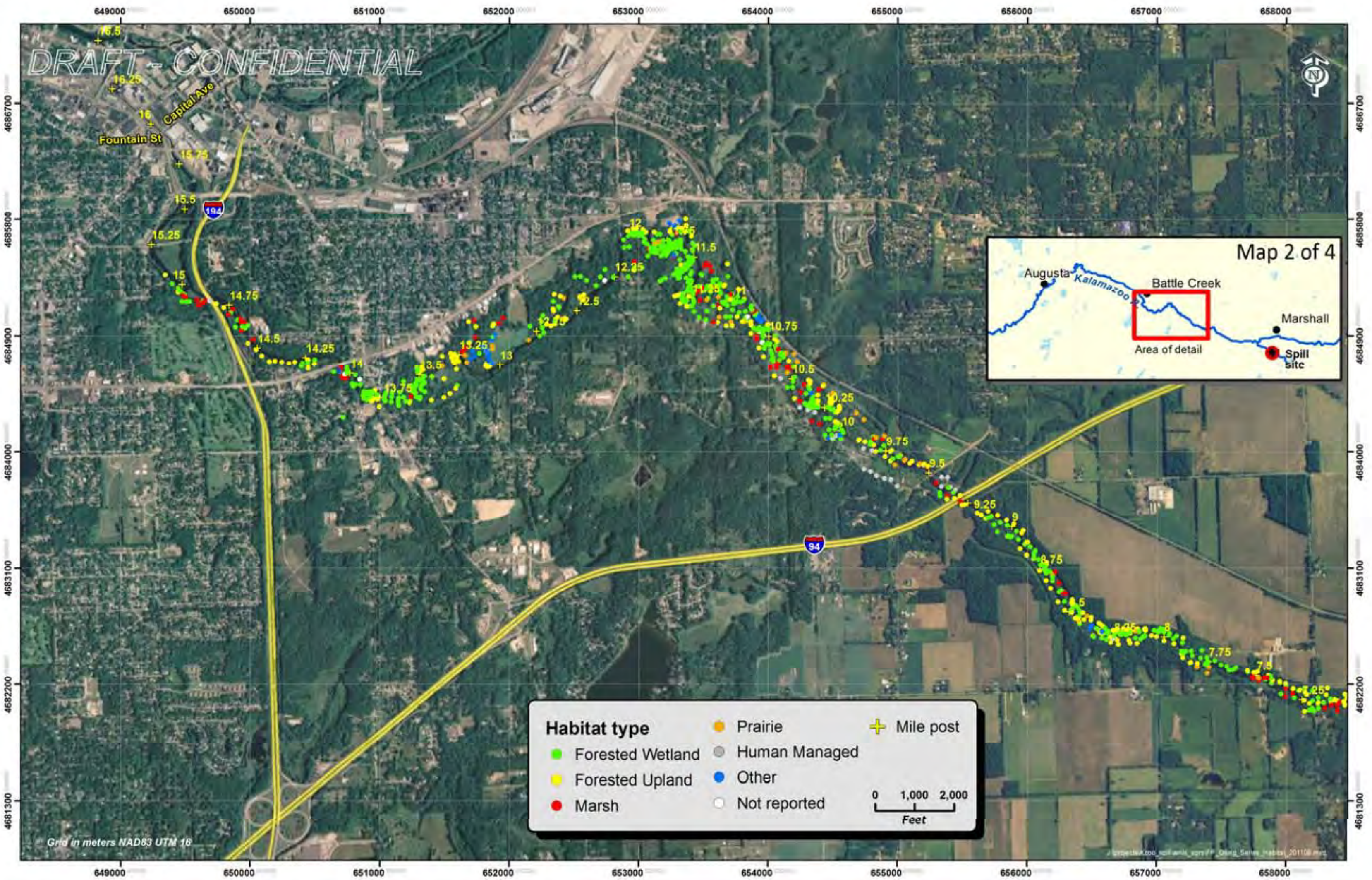

Figure 37. Map showing the habitat types identified at each waypoint during the floodplain survey (MP 7.25–16.5).

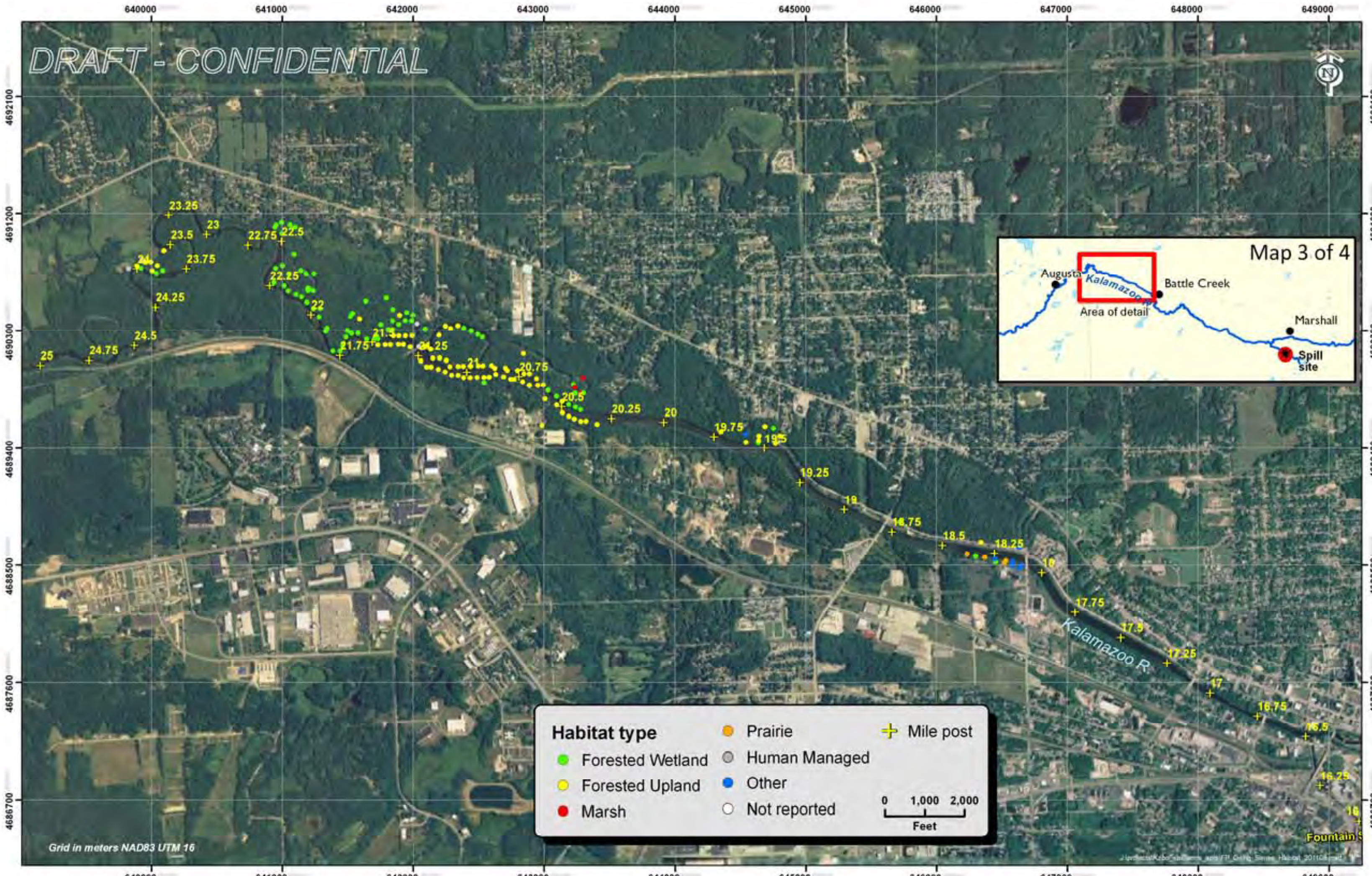

Figure 38. Map showing the habitat types identified at each waypoint during the floodplain survey (MP 16–25).

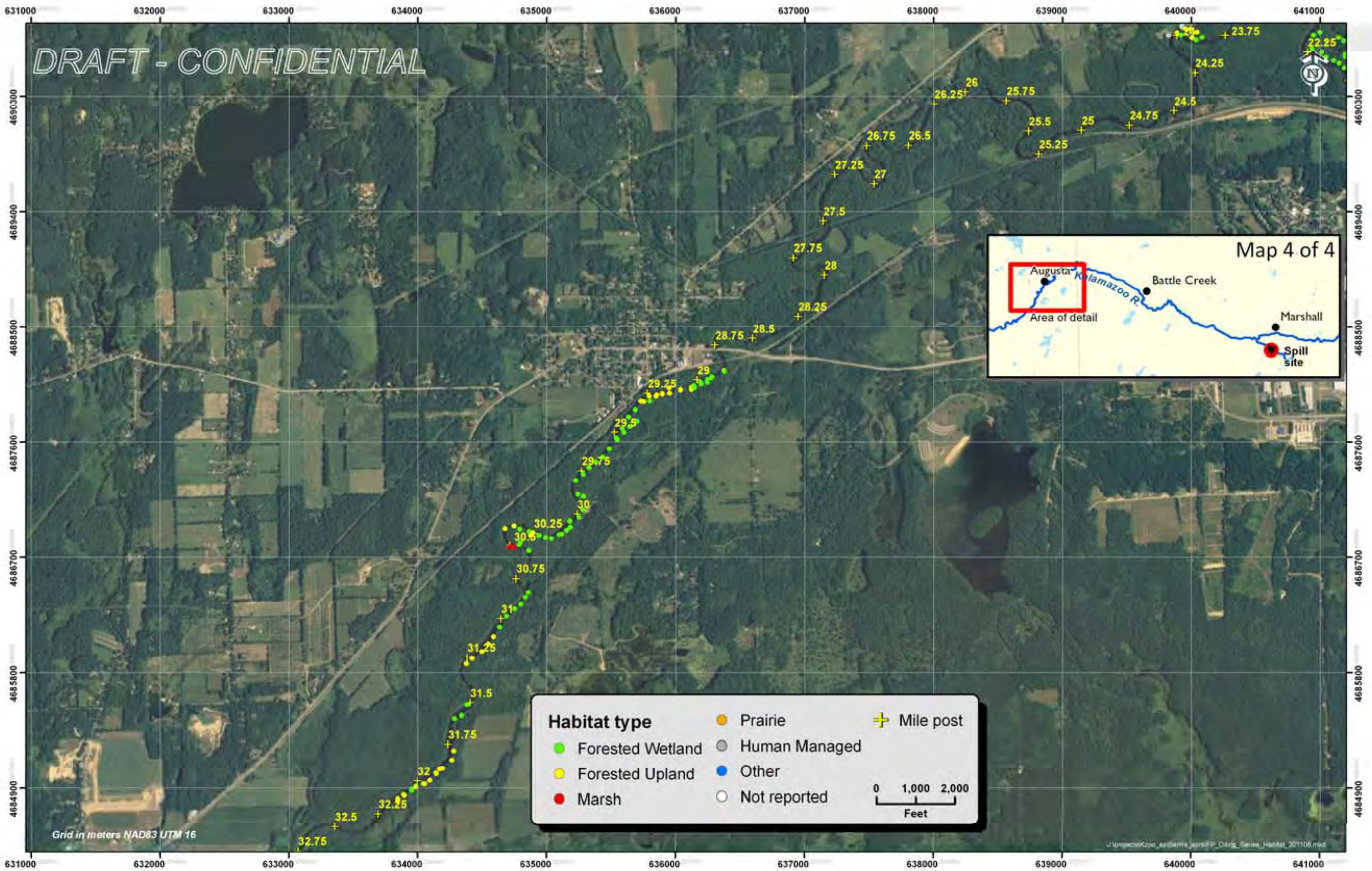

Figure 39. Map showing the habitat types identified at each waypoint during the floodplain survey (MP 22.25–32.75).

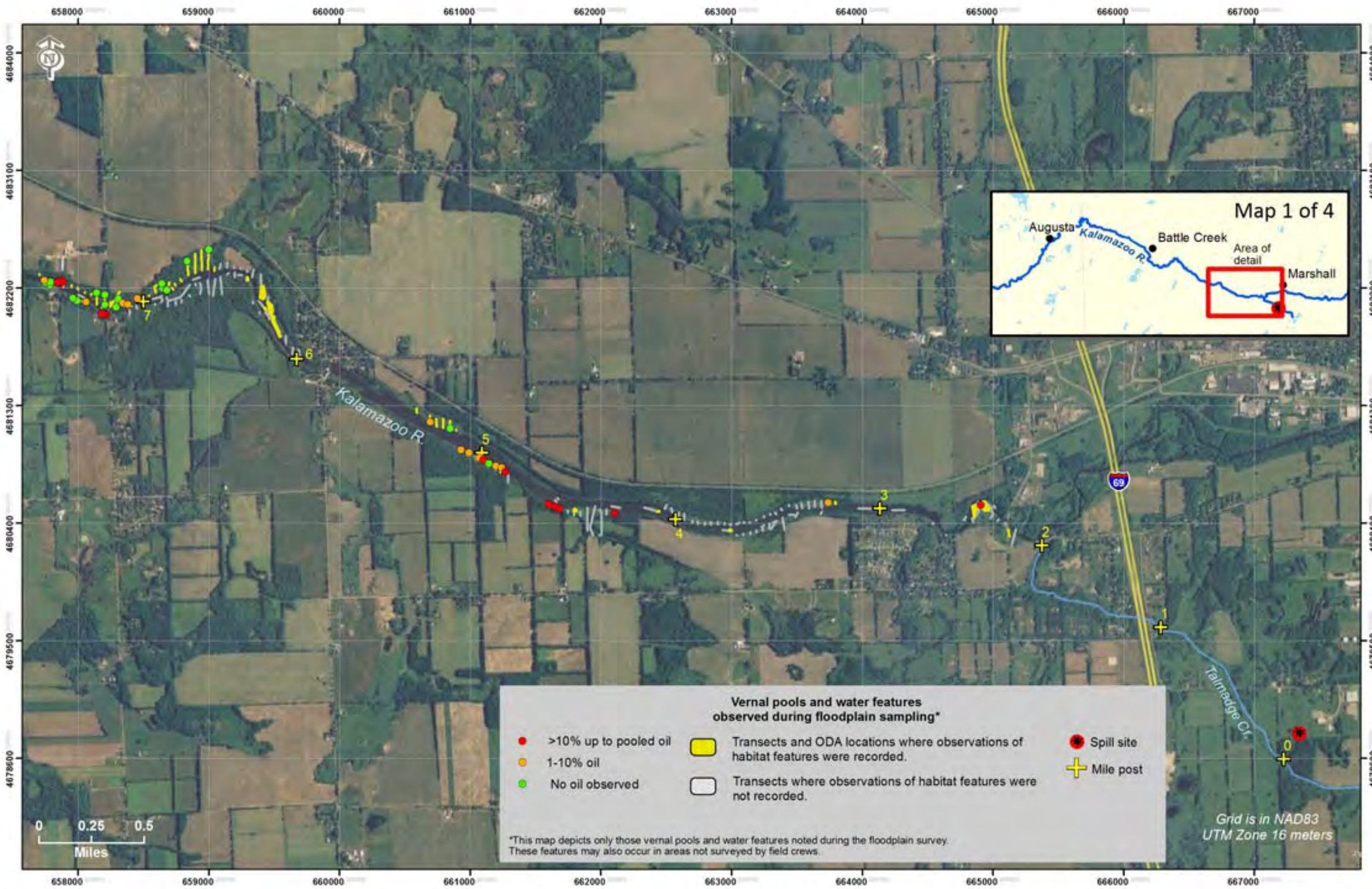

Figure 40. Map showing the waypoint locations where vernal pools and/or water features were identified and the degree of oiling recorded at the corresponding waypoint (MP 0–7.5). (Note: these data were not recorded at all waypoints during the floodplain survey and the degree of oiling was recorded for the waypoint as a whole and not the water feature or vernal pool specifically).

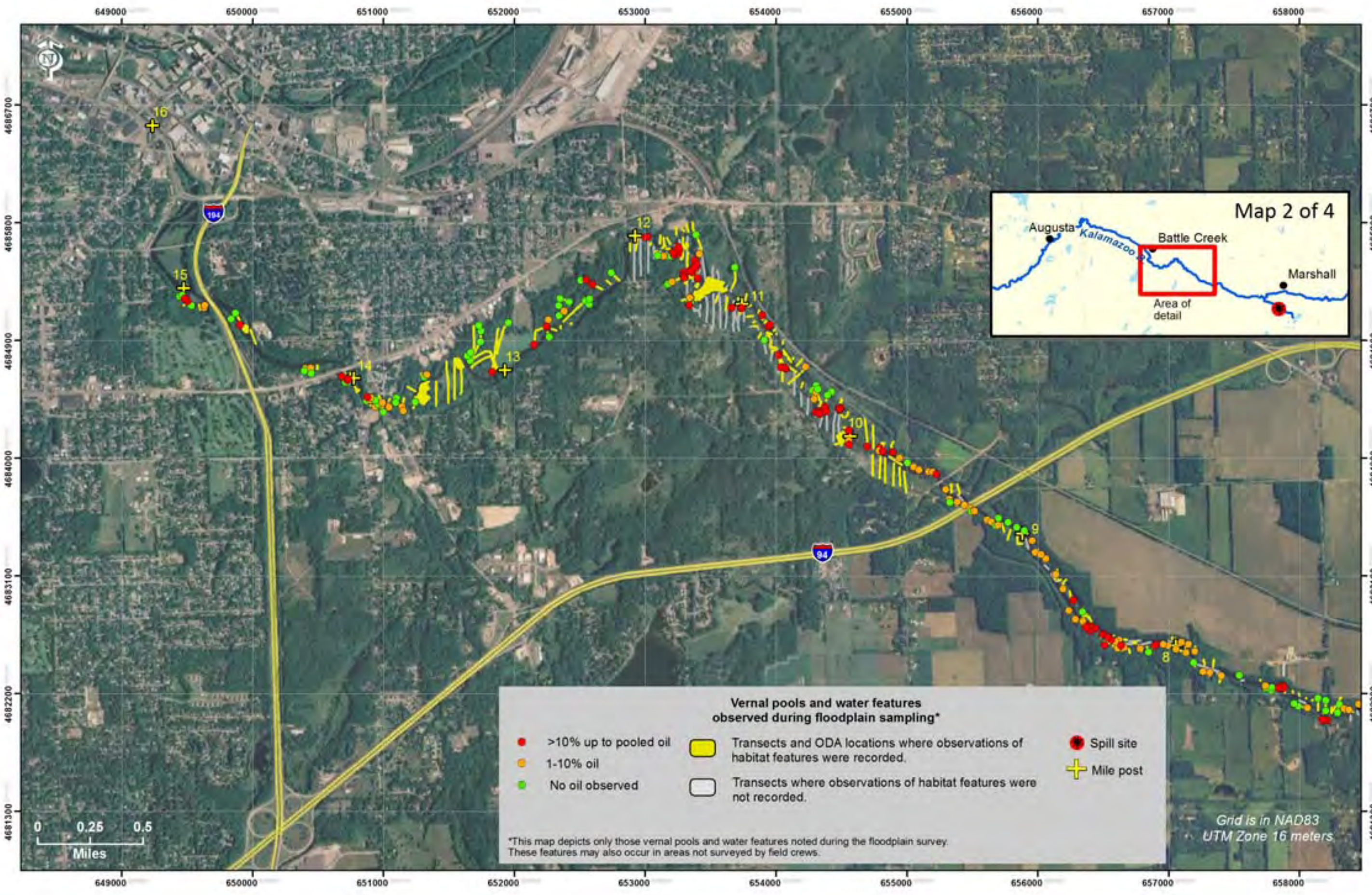

Figure 41. Map showing the waypoint locations where vernal pools and/or water features were identified and the degree of oiling recorded at the corresponding waypoint (MP 7.25–16.5). (Note: these data were not recorded at all waypoints during the floodplain survey and the degree of oiling was recorded for the waypoint as a whole and not the water feature or vernal pool specifically).

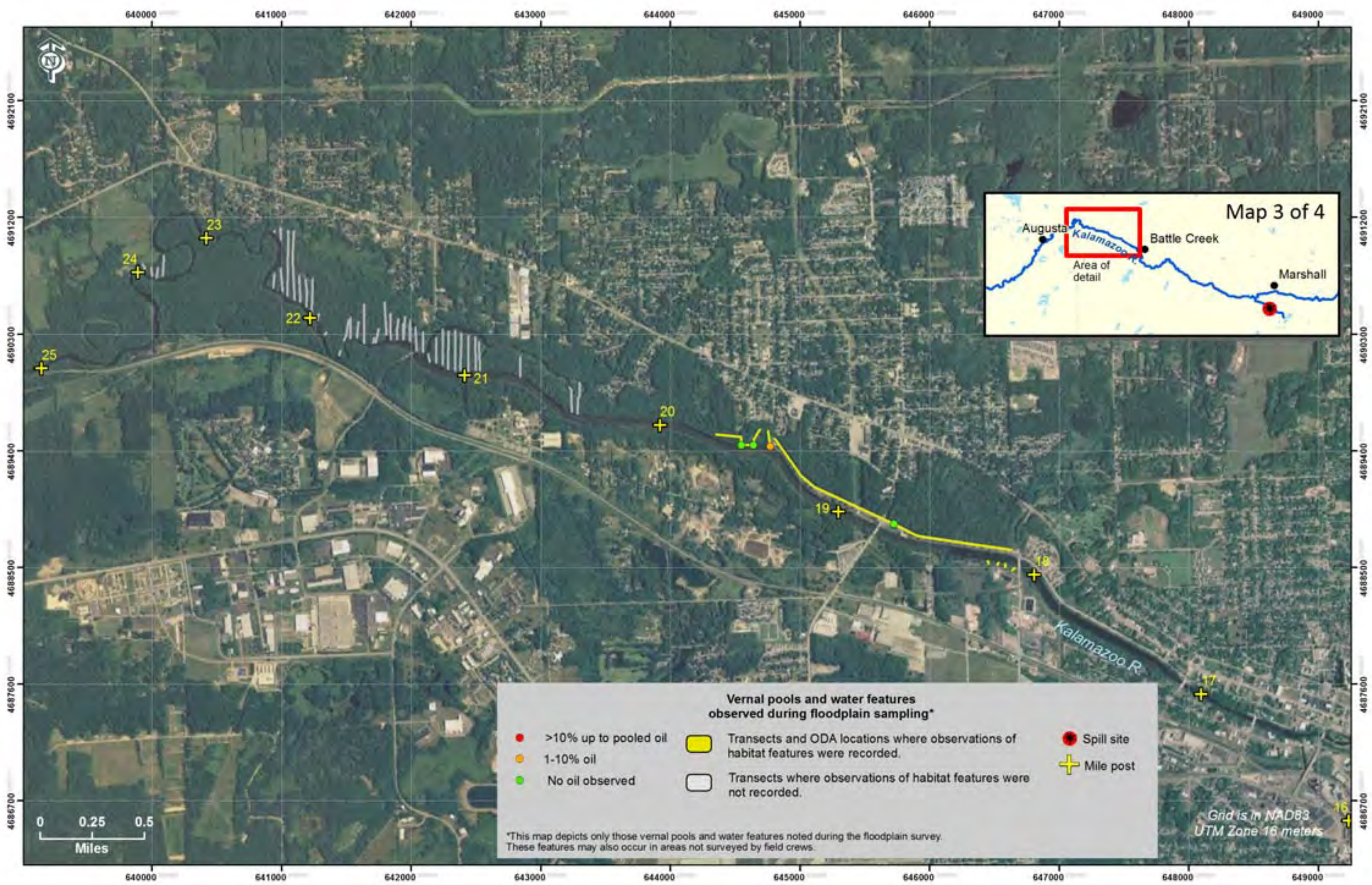

Figure 42. Map showing the waypoint locations where vernal pools and/or water features were identified and the degree of oiling recorded at the corresponding waypoint (MP 16–25). (Note: these data were not recorded at all waypoints during the floodplain survey and the degree of oiling was recorded for the waypoint as a whole and not the water feature or vernal pool specifically).

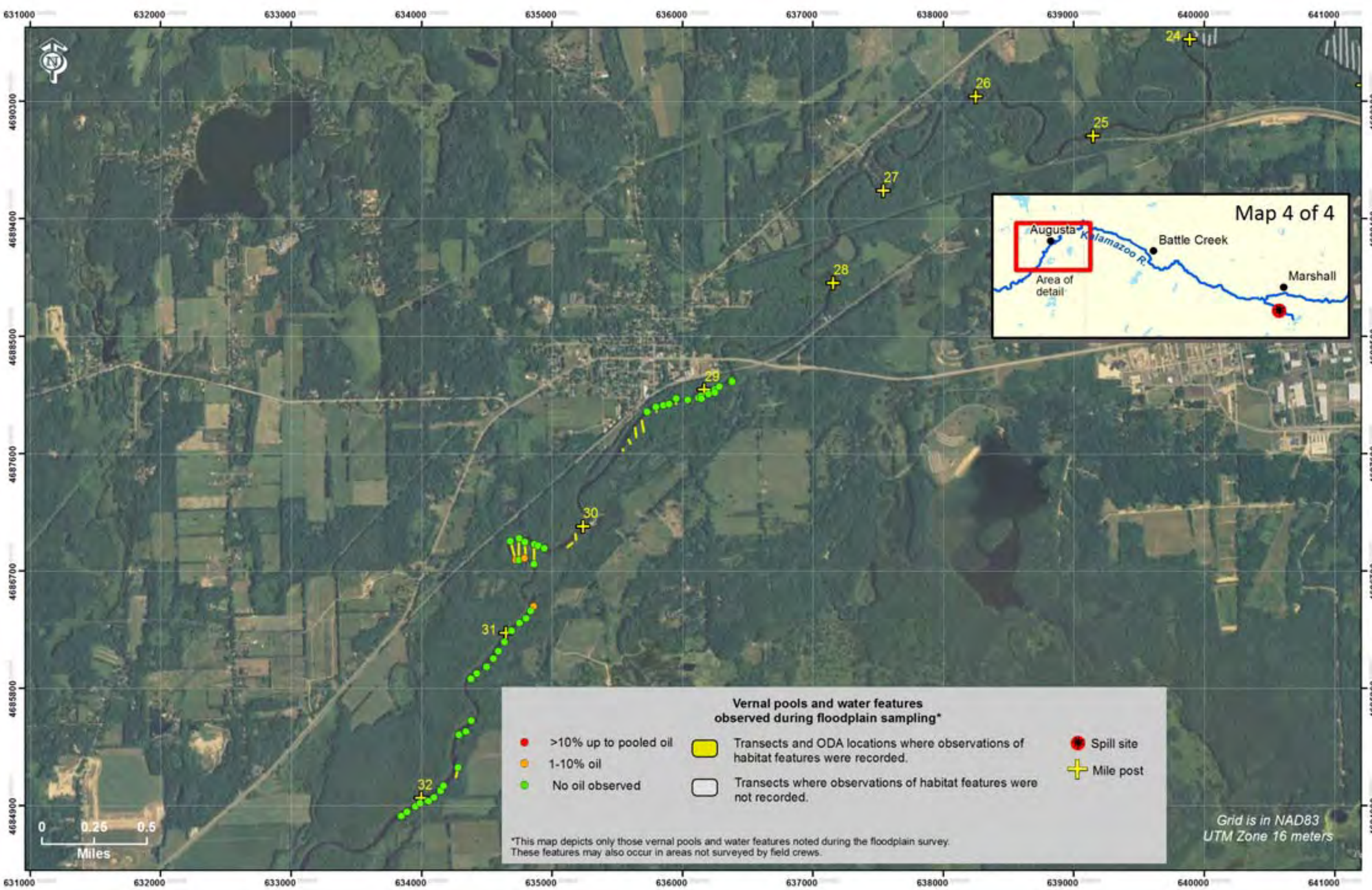

Figure 43. Map showing the waypoint locations where vernal pools and/or water features were identified and the degree of oiling recorded at the corresponding waypoint (MP 22.25–32.75). (Note: these data were not recorded at all waypoints during the floodplain survey and the degree of oiling was recorded for the waypoint as a whole and not the water feature or vernal pool specifically).

A. Floodplain Survey Work Plan

DISCUSSION DRAFT

PROTOCOLS FOR CHARACTERIZING KALAMAZOO RIVER FLOODPLAIN OILING

ENBRIDGE OIL SPILL INCIDENT

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August 18, 2010

1. Introduction

On July 26, 2010, Enbridge Energy, Limited Partnership discovered a release of heavy crude oil (Cold Lake Blend) from line 6B just west of milepost 308 in the vicinity its pump station located in Marshall, Calhoun County, Michigan. Line 6B is a 30-inch, 190,000 barrels per day (bpd) line transporting light synthetics, heavy and medium crude oil from Griffith, IN, to Sarnia, Ontario. The location of the release from Line 6B is located in an undeveloped area in the outskirts of town with coordinates of approximately North ½ Section 2, T3S, R6W, Latitude: 42.2395273 Longitude: -84.9662018. Upon discovery of the release the pipeline was shut down and isolation valves closed, stopping the source of the oil; however, initial estimates are that approximately 19,500 barrels of crude oil may have been released.

The release occurred along Tallmadge Creek approximately 1.5 miles upstream of where the creek enters the Kalamazoo River. The oil flowed down Tallmadge Creek and into the Kalamazoo River. At the time of the spill, recent rains had pushed the Kalamazoo River over its banks in many areas, and as a result the spilled oil entered into the floodplains along the river. Preliminary reconnaissance has confirmed that floodplains along the river downstream of the spill contain oil, and that the oiling is heavy in some areas. Therefore, an assessment of the locations and degree of oiling in the floodplain is required. These protocols focus on a rapid assessment of the locations and degree of oiling in the floodplains and the general floodplain habitat types where the oiling occurs. Subsequent protocols and fieldwork may address more detailed characterization of the habitat in the oiled areas for natural resource damage assessment (NRDA) purposes, if necessary.

2. Objective

The objective of these protocols is to characterize the areal extent and degree of oiling in the floodplains of the Kalamazoo River that have resulted from the Enbridge Pipeline spill and to characterize the general floodplain habitat types in the areas of the spilled oil. Discussed is a procedure that would allow us to map, characterize, and delineate both the habitat types and their extent of exposure to oil.

3. Approach

The floodplain surveys will be conducted on foot by floodplain assessment teams using protocols adapted from standard Shoreline Cleanup and Assessment Technique (SCAT) protocols. Areas requiring the on-the-ground assessment will first be identified using a combination of a previously conducted shoreline oiling survey, remote sensing data, overflight videos, GIS habitat layers, and field experience of researchers familiar with the river floodplain in this area.

4. Site Selection

The overall scope of the study is the Kalamazoo River floodplain between Talmadge Creek and Morrow Lake. Areas targeted for on-the-ground survey work will those areas that:

- Are likely to have been flooded at the time of the spill. These areas will be identified using maps, remote sensing data, the shoreline survey results, and field experience; and

- Contain at least 3 acres of floodplain habitat (based on aerial photography or GIS analysis).Smaller areas may surveyed after most large areas are surveyed.

The primary focus of the floodplain survey will be in Division C, but some surveys will be done in Division D as well. We anticipated apportioning approximately 80% of the survey level of effort (LOE) to Division C, with the balance apportioned to Division D.

Initial field reconnaissance work indicated that predicting the location and extent of oiling in the floodplain will be difficult based solely on available information (LIDAR, wetland layers from the National Wetland Inventory, shoreline oiling surveys). Initial floodplain work also indicates that surveying all floodplain within Divisions C and D may not be feasible. We are thus implementing a ‘sampling’ approach that is meant to characterize patterns of oiling across general habitat types and elevations. The ‘samples’ of river floodplain that we survey will be used to extrapolate to areas not surveyed within each of the Divisions.

Areas of river to be surveyed will be selected randomly in via GIS in Divisions C and D of the Kalamazoo River. A GIS will be used to generate randomly the areas to be sampled as follows. First, the area of interest, beginning at the confluence of Talmadge Creek and the Kalamazoo River and extending downstream to the inlet of Lake Morrow, will be divided into 400 meter wide sections that run from north to south (i.e., 400 meters across from east to west) covering the entire extent of the floodplain on both banks of the river. The 400 meter wide sections will then be identified as either right bank or left bank of the river, as delineated by the centerline of the Kalamazoo River in the National Hydrologic Database (high resolution). This will result in the entire floodplain of the Kalamazoo River in the area of interest being divided into 400 m wide (east to west) sections with borders that run straight north to south, with separate sections on the left bank and on the right bank of the river.

The left bank and right bank 400 m sections of floodplain will then be randomly assigned numbers using a random number generator. Sections for the on-the-ground survey will then be identified based on the random number assignments, starting with number 1 and proceeding up. Separate numbering will be done for the right bank sections and for the left bank sections so that an equal number of right bank and left bank sections will be sampled.

Within each 400 m wide section identified for field surveying, eight, north–south transects 50 meters apart will then be generated. GPS coordinates of where each transect intersects the riverbank will be provided to the field team. The transects will also be identified on a map that includes land ownership parcels and whether permission has been acquired to go onto the parcels. Survey areas, or individual transects within survey areas, that fall within parcels for which teams do not have permission to enter will be not be surveyed until such permission is obtained.

Field teams are to survey along each of the eight north-south transects in a 400 m wide section until, based on their judgment, they have covered all areas along the transect that likely were under water during the time of the spill. The field teams will consult wetland maps and elevation contours in making this judgment in the field.

After one week of sampling randomly selected floodplain sections with 4 field crews, the data obtained through these surveys will be evaluated to determine the degree to which floodplain oiling is predictable based on other types of information already available for the entire floodplain area (e.g., aerial photography, LIDAR elevation data, shoreline oiling survey, river bends). The evaluation of the initial floodplain oiling data from the first week of surveying in randomly selected areas will be done cooperatively between the Trustees and Enbridge. The Trustees and Enbridge will also review progress to date and determine whether the level of effort being invested in the floodplain survey is appropriate and/or needs to be changed.

5. Characterizing Habitats and Extent of Oiling

General issues:

- Safety is the first priority with all operations during this incident. The team will follow appropriate health and safety procedures related to survey activities.

- The floodplain survey will be conducted by four teams of two members each. When practically feasible, there will be one representative from the Trustees and one from the RP on each team. Teams will access the targeted floodplain habitat areas by either airboat or car. Each team will have a designated leader, who will be responsible for managing the team activities and records.

- The teams will meet with the study coordinator in the morning prior to entering the field to review safety procedures and the protocol. A morning meeting sheet will be signed by each individual.

- Each team will contact the study coordinator around mid-day to provide a quick status report and ensure the team is safe.

- The teams will meet at the end of the day with the study coordinator to download data, review the day, make any suggestions for improving the protocol, receive transect numbers to be completed the following day.

- We plan to spend three weeks intensively surveying floodplain areas. After this initial effort, the data will be reviewed to assess whether further floodplain characterization is needed. The nature and extent of any further surveying will be done at that time.

- Landowner permission for all areas to be surveyed on foot will be obtained by Enbridge prior to the teams conducting the survey in an area.

- As noted above, the primary focus of the floodplain survey will be Division C, with approximately 20% of LOE to be used to characterize Division D.

Survey Details:

- A GIS analyst will lay out north-south transects in each 400 meter survey section, at 50 meter intervals (8 transects per survey area). Coordinates of transect endpoints will be provided to field crews prior to their surveys so that their GPS units can be used to find the start and end points of transects.

- Two approaches have been developed for identifying transects; an initial approach (which will be used until we have enough information to implement the randomized approach), and a randomized approach:

    - Until we have the information available to lay out pre-determined transects, survey teams will select their own survey areas, with each team aiming to complete 250-500 m of river each day.

        - Sites will be selected based on property access (i.e., teams will go where they can).

        - Then, within a given property, areas of particular focus will include those with floodplain habitat and low banks, determined based on LIDAR and visual inspection, that are likely to have been impacted by the spill.

- — Crews will disembark the boat, noting the relevant river mile, and take a GPS waypoint to mark the point of disembarkation, and a north and south facing photograph
- — Survey teams will then mark out four to 10 different transects (depending on what is feasible, considering the number of teams present at the site, the length of river containing floodplain habitat, the amount of area for which private land owner permission has been granted, and the difficulty of terrain) on a map, spaced approximately 50 meters apart. They will then begin to conduct surveys along the transects.

- ▫ Once the randomized survey approach is implemented, teams will go to predetermined locations (400 m sections). Note that in the randomization scheme, if a randomly-selected section is located on private property that is still not accessible, it will be skipped. Skipped sections will be surveyed once access is obtained.

- At the beginning of each transect, a photograph of the GPS unit and a north-facing and south-facing photograph will be taken. If so equipped, the track log can also be turned on the hand-held GPS unit, according to the attached SOP (to be received from entrix). Note: We are investigating whether the tables can be adjusted for track logging.

- The survey team will then walk along the transect and observe the presence and degree of oiling in any areas within sight from the transect. Teams are specifically looking for any areas of at least 50 square feet that are more than 'sporadically' oiled (see photos and sheets at end of this protocol for definition). Habitat in the floodplain is assumed to be sporadically oiled unless observed to be otherwise.

- The teams should leave the transect to inspect any areas that they suspect could be oiled heavier than sporadic, such as side channels connected to the river. After inspecting these areas (and taking photographs and making appropriate records as described below if the area is more than sporadically oiled), the team will return to the transect at the point where they left it.

- The survey along the transect stops when the team reaches either:

  - ▫ the point at which oiling is reduced to 'no visible oil'
  - ▫ an area of greatly reduced habitat quality, such as a housing development or agricultural field; or
  - ▫ a point 15' past the upland edge of the floodplain area (based on visual estimation).

- GPS waypoints will be taken at the river edge, periodic waypoints along the transect to demarcate the transect path taken, the transect end point, and at habitat transitions. At each waypoint, two photographs will be taken, on north-facing, and one south-facing.

- If equipped with a GPS unit that allows it, GPS track logs can be collected in addition to discrete waypoints, for later coordination of photographs and spatial coordinates. Note: We are investigating if the tablets can be adjusted to provide track logs.

- If an area of at least 50 square feet with more than sporadic oiling is observed, the survey team will circumscribe the area by visually identifying and walking around the perimeter of the area, and taking GPS waypoints at key points of direction change. Note that hereafter, ‘oiled zone” refers to any area more than sporadically covered in oil.

    - Prior to and after delineating the oiled zone, photos of the GPS unit will be taken.
    - If equipped with GPS units that allow for it, a GPS track log will be used to circumscribe the area.
    - To characterize each oiled zone, team members will assess the degree of oiling within the oiled zone using the standard characterization charts in Appendix A.
    - If the team cannot safely walk around the perimeter of a zone, they will take a waypoint as close to the center of the area as they can reach and estimate the dimensions of the zone area visually.
    - If using back-up hardcopy sheets, separate datasheets will be used to record information about general transect waypoints (which are meant to simply show transect trajectories and habitat changes) and distinct oiled areas.

- For areas along a transect beyond which no visible occurs, only the point on the transect at which the oiling changes from sporadic to no visible oiling will be recorded, and the transect is then complete, rather than attempting to circumscribe the area of no visible oiling.

- In addition to oiling, the following habitat information will also be recorded on datasheets by the survey teams:

    - General vegetation type (forested wetland, forested upland, marsh, prairie, human managed area, etc.)
    - GPS waypoint location and approximate size of any water features of at least approximately 50 square feet, such as vernal pools or small channels
    - Presence of downed trees (that could provide habitat cover for herpetofauna and other wildlife)

- As transects are completed, field teams will note any instances where terrain or vegetation makes it difficult to observe the 25 meters on either side of the transect.
- Field teams will also note if they were impeded from completing the transect, and why (for example, if the upland edge was too steep to climb).

6. Tablets

The following rules and conventions will be followed when entering data into the tablet electronic datasheet in the field (see data management protocol for complete data management instructions):

- Transect I.D. naming convention: <map transect number>L (for left descending side) or <map transect number>R
  - e.g., 124R
- The program does not save automatically. Therefore, hit save after taking every waypoint
- USBs will be provided to each team. Conduct a save mid-day and end-of-day:
  - File that contains survey data on the tablet: C:\users\entrix\KREOS\floodplain.xml
    - Naming convention: <date>_<last name>
    - e.g., 2010_0815_Ritter.xml

7. Equipment

Transportation needs will likely vary daily, but we estimate that three to four airboats will be needed to transport four teams of two to various points along the river. One or two boats may be appropriate on given days, and some teams may be able to drive to sites, but we assume that three boats will be needed to allow maximum team mobility.

Each team will be equipped with an IBM notebook tablet, with electronic datasheets and GPS capabilities to take way points, GPS, camera, Scat Manual, PPE (Appropriate to HASP), pens, and a waterproof field notebook. Paper datasheets will also be carried in the field, as back-up to the tablets. Extra batteries, including computer batteries will be carried.

Once electronic tablets are available, they will be used to take GPS waypoints and pictures and will contain electronic version of the datasheet. Each team will still need a GPS, camera and paper data sheets as backup.

Data management and map production

Each evening cameras, GPS units, and data sheets will be turned in for downloading, and quality control. All data (hard copies of data sheets, GPS data, photos) will be shared with RP representatives by the end of the day.

Trustee and/or RP representatives will produce GIS maps showing the extent area surveyed, and, eventually, the extent of oiling in floodplain habitat will be produced after the survey is completed.

8. Data management and map production

Each evening cameras, GPS units, and data sheets will be turned in for downloading, and quality control. All data (hard copies of data sheets, GPS data, photos) will be shared with RP representatives by the end of the day.

Trustee and/or RP representatives will produce GIS maps showing the extent area surveyed, and, eventually, the extent of oiling in floodplain habitat will be produced after the survey is completed.

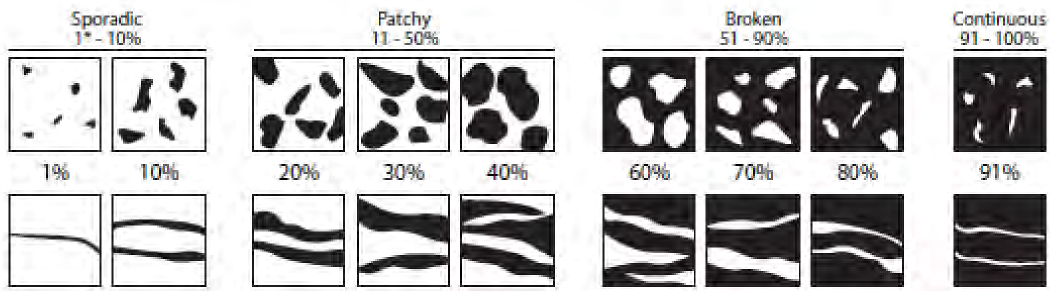
Appendix A

The extent of oiling for vegetation and sediments will be used as the standard reference.

Owens, E.H. and G.A. Sergy.Field Guide to the Documentation and Description of Oiled Shorelines. Environmental Canada, March 1994.

33 PERCENT COVER ESTIMATION CHARTS

These charts are aids to help you estimate the percent oil coverage in the area you are observing. The black shading represents oil. Do not spend time trying to get a precise measure of percent cover; the four ranges listed are usually sufficient. The chart below would prove most helpful in oil band situations; the one on the following page is best for discrete oil deposits such as tarballs.

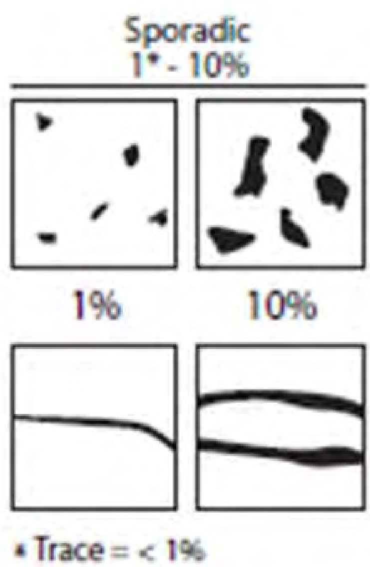


* Trace = < 1%

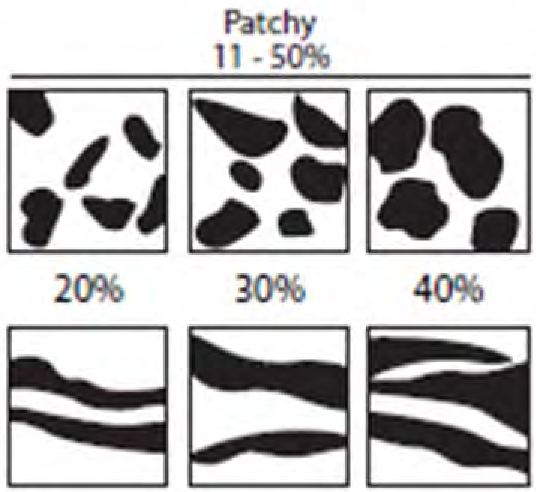
Chart source: Owens, E.H., and G.A. Sergy. Field Guide to the Documentation and Description of Oiled Shorelines. Environment Canada, Edmonton, Alberta, Canada. March 1994. ISBN 0-662-22048-X.

NO VISIBLE OIL

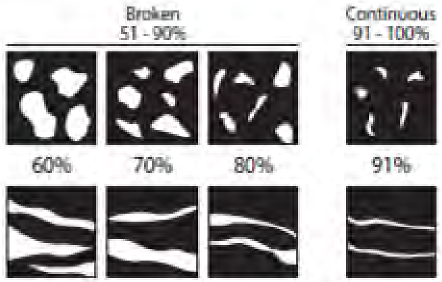
LIGHT (OR SPORADIC) OILING ON MARSH VEGETATION



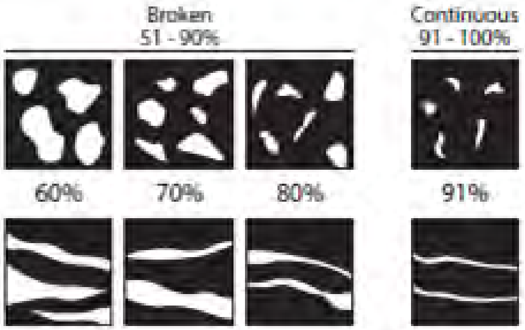
BAND OF PATCHY OIL ON EMERGANT MARSH VEGETATION



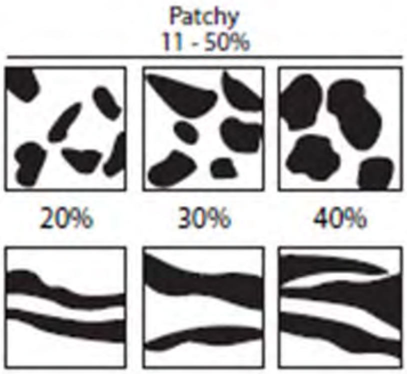
HEAVY OILING OF EMERGENT VEGETATION



HEAVY SEDIMENT OILING



MODERATE OR PATCHY OIL ON SEDIMENTS



Appendix B
Data Sheet

(In preparation)

Floodplain Characterization Data Sheet (Version 5.0) Site _____/______ (Sheet ___ of ___)

River Mile (tenths) ____.____ Bank Side Descending (R/L) ____ Date ___/___/2010 Data Collector/Recorder ________________________________

GPS/Photo Operator ______________ GPS Unit ID ___________ GPS Photo (Y ___, #_______) GPS Start Waypoint ______ Camera ID______________

TRANSECT ID (Rivermile.transect):__________________________OIL DELINEATION AREA ID (A-Z): _________ Time:_________________________

Waypoint # (____) **Habitat type (FU, P, FW, M, H, O):** ________ If O, describe ____
Oiling: Soil visible? (Y___/N___) If Y % oil covered soil (____%) % oil covered herbs (____%) % oil covered shrubs (____%) % oil covered trees (____%)
Features: Pooled oil (>50ft^2)?[1] (Y__/N__) Water feature (>50ft^2)?[2] (Y__/N__) Vernal pool (>50ft^2)?[3] (Y__/N__) Downed tree (>4" DBH)?[4] (Y__/N__) **Skunk Cabbage:** Present? (Y___/N___) If present, healthy___/defoliated____/new shoots_____ (combination ok) **Photos #s** ________________________
Notes: ____

Waypoint # (____) **Habitat type (FU, P, FW, M, H, O):** ________ If O, describe ____
Oiling: Soil visible? (Y___/N___) If Y % oil covered soil (____%) % oil covered herbs (____%) % oil covered shrubs (____%) % oil covered trees (____%)
Features: Pooled oil (>50ft^2)?[1] (Y__/N__) Water feature (>50ft^2)?[2] (Y__/N__) Vernal pool (>50ft^2)?[3] (Y__/N__) Downed tree (>4" DBH)?[4] (Y__/N__) **Skunk Cabbage:** Present? (Y___/N___) If present, healthy___/defoliated____/new shoots_____ (combination ok) **Photos #s** ________________________
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Oiling: Soil visible? (Y___/N___) If Y % oil covered soil (____%) % oil covered herbs (____%) % oil covered shrubs (____%) % oil covered trees (____%)
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Notes: ____

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Oiling: Soil visible? (Y___/N___) If Y % oil covered soil (____%) % oil covered herbs (____%) % oil covered shrubs (____%) % oil covered trees (____%)
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Notes: ____

B. Description of Closing Polygons

The ODAs delineated by the field crews required additional GIS processing in order to create closed polygons that could be visualized on a map. This appendix presents notes about how each ODA was drawn as a closed polygon on the map (Table B.1).

Each polygon was assigned a unique identification in the Access database. The ODAs are organized according to their unique identifier (see Unique ODA ID column in Table B.1).

For many ODAs, the waypoints were connected in order and the polygon was closed by connecting the first and last waypoints in the ODA. These are described as “close polygon.”

Some ODAs were delineated in the field in such a way that a closed polygon could not be drawn. These are described as “leave as line.” On the maps, these are represented as linear ODA features.

In some instances, connecting the waypoints in the order they were delineated in the field created irregular patterns or features with crossing lines. It is likely that this happened because of imprecision of the handheld GPS devices, which have an accuracy of approximately 3 m. For these cases, ODAs were drawn as closed polygons by connecting the waypoints to form a perimeter, even if the waypoints were not connected in order and a detailed description was provided.

Table B.1. Decisions for polygon delineations

Unique ODA ID	Decision	Additional notes
10.2L92_A	Close polygon	No additional notes.
10.2R286_A	Close polygon	No additional notes.
10.2R291_B	Close polygon	No additional notes.
10.2R301_C	Extend the polygon to the river – close polygon with a straight line rather than shape of the river because of unknown bank location	Because this was in a bend of the river, the polygon was created from the river edge to the next waypoint.
10.6L137_A	Close polygon	Used the adjacent transect line to complete the polygon.
12.5R59_A	Close polygon	The field notes say that the beginning of polygon is at waypoint 60, waypoint 59 is the start of the transect. Waypoint 59 was removed from the polygon and a new transect was created connecting waypoints 59–60.
12.5R71_B	Leave as line	No additional notes.
12.5R79_C	Close polygon	No additional notes.
13.3L93_A	Leave as line	No additional notes.
14.2L19_A	Extend the polygon to the river – close polygon with a straight line rather than shape of the river because of unknown bank location	No additional notes.
6.8L23_A	Leave as line	No additional notes.
8.5L43_A	Close polygon	No additional notes.
9.6L107_A	Leave as line	No additional notes.
9.6L114_B	Leave as line	No additional notes.
9.9L39_A	Close polygon	No additional notes.
8.5L39_B	Leave as point	No additional notes.
8.5L36_A		No additional notes.
474L_A	Close polygon	No additional notes.

Table B.1. Decisions for polygon delineations (cont.)

Unique ODA ID	Decision	Additional notes
477L_A	Close polygon	No additional notes.
533R_A	Close polygon	This polygon originally had 5 waypoints points. The first 4 make a nice polygon outline, but the 5th did not fit with the rest. In the field “Type” (type of waypoint) it said “End,” while others said “Oil Polygon.” The 5th point was not included as part of the polygon.
533R_B	Close polygon	No additional notes.
534R_A	Close polygon	No additional notes.
562L_A	Close polygon	No additional notes.
570R_A	Close polygon	No additional notes.
573L_A	Close polygon	No additional notes.
585R_A	Close polygon	Two of the 3 waypoints points had 0% oil recorded. However, it was noted that at this time, field crews were instructed to characterize the entire polygon with 1% oiling value, so the percent oiling was assigned to the first or last waypoint.
602R_A	Close polygon	No additional notes.
726R_A	Keep as line	Could not close the polygon.
901L_A	Close polygon	No additional notes.
901L_B	Keep as line	The field notes suggest that the pooled oil extends 15 ft north of the line; however, this is not enough information to delineate a polygon. Therefore, this ODA was left as a line.
903L_A	Close polygon	No additional notes.
903L_B	Keep as line	The field notes suggest the “Edge of water closes polygon”; however, this is not enough information to close the ODA polygon. Therefore, it was left as a line.
903L_C	Close polygon	No additional notes.
907L_A	Close polygon	The shape of this polygon was unusual; it appears that the polygon shape is irregular because of the imprecision of the GPS units. A polygon was delineated by joining the ODA waypoints in the following order: 1, 2, 4, 3, 1.

Table B.1. Decisions for polygon delineations (cont.)

Unique ODA ID	Decision	Additional notes
909L_A	Keep as line	The field notes reference a small island with oil; however, this is not enough information to create a polygon. Therefore, it was left as a line.
911L_A	Close polygon	No additional notes.
911L_B	Close polygon	The shape of this polygon was unusual; if the waypoints are connected in order, the lines form a criss-cross across a polygon. Linking waypoints 1, 2, 4, 3, 1 forms a perimeter of the points; this is how the polygon was drawn.
913L_A	Close polygon	No additional notes.
913L_B	Close polygon	This polygon overlaps with another polygon, 913L_A. These polygons were left as is.
917L_A	Close polygon	No additional notes.
919L_A	Close polygon	No additional notes.
920L_A	Close polygon	The shape of this polygon was unusual; it appears that the polygon shape is irregular because of the imprecision of the GPS units. Linking waypoints 1, 2, 4, 3, 1 forms a perimeter of the points; this is how the polygon was drawn.
921L_A	Close polygon	The shape of this polygon was unusual; linking the waypoints forms a “Z.” It appears that the field crew delineated the top of the polygon, then crossed the polygon and formed the bottom. The polygon was created by joining the waypoints that form the perimeter.
921L_B	Close polygon	No additional notes.
1003L_A	Close polygon	No additional notes.
1005L_A	Close polygon	No additional notes.
505.5L_A	Close polygon	No additional notes.
505.5L_B	Close polygon	No additional notes.
507.5 L_A	Close polygon	No additional notes.
509.5 L_A	Close polygon	No additional notes.

Table B.1. Decisions for polygon delineations (cont.)

Unique ODA ID	Decision	Additional notes
509.5 L_B	Close polygon	No additional notes.
510.5 L_A	Close polygon	Waypoints 6 and 7 cross each other. The polygon was created by connecting waypoint 5 to 6 and waypoint 6 to 8. Waypoint 7 fell within the polygon; therefore, it was not included.
510.5 L_B	Close polygon	No additional notes.
511.5L_A	Close polygon	No additional notes.
511.5L_B	Close polygon	No additional notes.
511.5L_C	Close polygon	Connecting the waypoints in order creates crossing lines; this is because of the imprecision of the GPS units. The polygon was deleted by connecting waypoints 4 and 5.
511.5L_D	Close polygon	Connecting the waypoints in order creates crossing lines between waypoints 1 and 6; this is due to the imprecision of the GPS units. The polygon was drawn by moving the lines to remove the cross.
511.5L_E	Close polygon	No additional notes.
511.5L_F	Close polygon	No additional notes.
512.5L_A	Close polygon	No additional notes.
512.5L_B	Close polygon	No additional notes.
512.5L_C	Close polygon	No additional notes.
515R_A	Close polygon	No additional notes.
518.5 L_A	Close polygon	Connecting the waypoints in order creates crossing lines. The polygon was drawn by connecting the waypoints in the following order: 2, 3, 1, 4, 5, 6.
518R_A	Close polygon	No additional notes.
535L_A	Close polygon	No additional notes.
631L_A	Close polygon	No additional notes.
633R_A	Close polygon	No additional notes.

Table B.1. Decisions for polygon delineations (cont.)

Unique ODA ID	Decision	Additional notes
634R_A	Close polygon	Connecting the waypoints in order creates crossing lines. The polygon was drawn by connecting waypoints 8 and 2; waypoint 1 falls in line between the segments.
635R_A	Close polygon	Connecting the waypoints in order creates crossing lines; this is because of the imprecision of the GPS units. The polygon was drawn by moving the vertex, which eliminated the crossing lines but kept the polygon closed.
681_A	Close polygon	No additional notes.
743L_A	Close polygon	No additional notes.
748L_A	Left as line	No additional notes.
930L_A	Close polygon	Connecting the waypoints in order creates crossing lines. The polygon was drawn by connecting the waypoints on perimeter.
934L_A	Close polygon	No additional notes.
947L_A	Close polygon	No additional notes.

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Appendix C: Wildlife Response Report

Wildlife Response Activities for

the July 25-26, 2010

Enbridge Line 6B Oil Discharges near Marshall, MI

Prepared by

Scott A. Berg and Lisa L. Williams

United States Fish and Wildlife Service

East Lansing Field Office

April 7, 2015

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Introduction and Overview

On Monday, July 26, 2010, Enbridge Energy Partners (Enbridge) reported that a 30-inch pipeline had ruptured and discharged an estimated 819,000 gallons of crude oil near Marshall, Michigan. Oil discharged from Enbridge's Lakehead Line 6B on July 25-26, 2010, entered wetlands near the rupture and then flowed through Talmadge Creek to the Kalamazoo River, where it continued to flow downstream for approximately 38 miles. Aquatic and floodplain habitats were oiled as were birds, mammals, turtles and other wildlife.

Michigan Department of Natural Resources and Environment (MDNRE) and United States Fish and Wildlife Service (USFWS) mobilized on-site and received the first reports of oiled wildlife on July 26, 2010. USFWS advised Enbridge to mobilize professional rehabilitators and begin building rehabilitation facilities that evening. A wildlife hotline was established that night so that the public and responders could report sightings of oiled wildlife. Enbridge mobilized their contractor, Focus Wildlife, overnight and they then built a complete rehabilitation facility (Wildlife Response Center or WRC) over the next several days.

The USFWS developed and led the Wildlife and Environmental Assessment Branch within the Operations Section of the Incident Command System (ICS), which was used to manage the overall response to the oil discharges. This Branch provided technical assistance to U.S. Environmental Protection Agency (USEPA) on natural resource issues and field observations; led reconnaissance, capture, rehabilitation, and release of oiled animals; installed deterrence measures to try to minimize wildlife oiling and road fatalities; and provided a link between natural resource damage assessment (NRDA) field activities and the ICS management of the overall response. The USFWS, MDNRE, U.S. Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS), and contractors employed by USFWS and Enbridge performed daily reconnaissance for oiled wildlife, responded to hotline calls, and captured oiled wildlife when possible on a daily basis until mid-October of 2010 when responsibility was turned over to Enbridge and their contractors. Enbridge and Focus Wildlife led the rehabilitation functions, with Binder Park Zoo taking a major role in rehabilitation of turtles and other reptiles and amphibians. Personnel from additional zoos and volunteers also assisted in animal care and cleaning oiled wildlife. Releases of rehabilitated animals were coordinated among USFWS, MDNRE, Enbridge, and contractors.

This report describes the operations of the Wildlife and Environmental Assessment Branch from July 26, 2010 through October of 2010.

Definitions

Administration/Finance – a person(s) responsible for day to day financial and administrative operations during the incident.

Branch Director – a position within the Incident Command System that has management responsibility of the entire branch and oversees all aspects of implementation of the incident objectives in the Incident Action Plan that are assigned to the branch. The Branch Director serves as the main contact with their respective Section Chief (e.g., Operations) and the Incident Commander or Unified Command.

Enbridge – Enbridge Energy, L.P., Enbridge Pipelines ("Lakehead") L.L.C., Enbridge Energy Partners, L.P., Enbridge Energy Management, L.L.C., Enbridge Energy Company, Inc. , Enbridge Employee Services, Inc., Enbridge Operational Services, Inc., and Enbridge Pipelines Inc.

Entrix – a private contractor hired by Enbridge to provide environmental and NRDA expertise.

Focus Wildlife – a private contractor hired by Enbridge to provide wildlife operations.

GIS Support – a person(s) assigned to provide mapping and geographical spatial data support to field operations and Incident Command.

HRM – Herpetological Resource & Management, a contractor for U.S. Fish and Wildlife Service.

IAP – Incident Action Plan, provides a concise, coherent means of capturing and communicating the overall incident priorities, objectives, and strategies in the contexts of both operational and support activities.

ICP – Incident Command Post, a centralized meeting point for Unified Command during the incident. The ICP housed representatives from each responding agency, consistent with methodology of ICS.

ICS – Incident Command System, a standardized on-scene emergency management construct specifically designed to provide an integrated organizational structure that reflects the complexity and demands of single or multiple incidents, without being hindered by jurisdictional boundaries. ICS is the combination of facilities, equipment, personnel, procedures, and communications operating within a common organizational structure, designed to aid in the management of resources during incidents. It is used for all kinds of emergencies and is applicable to small as well as large and complex incidents. ICS is used by various jurisdictions and functional agencies, both public and private, to organize field-level incident management operations.

Logistics – a person(s) designated to ensure materials, services and equipment are provided for response to the incident.

MDNRE – Michigan Department of Natural Resources and Environment.

NRDA – Natural Resource Damage Assessment as described in the National Contingency Plan and either the Comprehensive Environmental Response, Compensation, and Liability Act or the Oil Pollution Act, as applicable. In this incident, NRDA teams assessed damages to natural resources and the service they provide, including collecting ephemeral data in parallel with response activities. NRDA field team conducted surveys of impacts to surface water, sediments, soil, vegetation, benthic invertebrates, fish and wildlife and coordinated these field activities through the Wildlife/Environmental Damage Assessment Branch.

Public Information Officer (PIO) – a position within the Incident Command System that manages and disseminates information related to the incident for incident personnel, the public, and media.

Safety Officer – a position within the Incident Command System, that oversees all aspects of safety and administers corrective measures in the event of a safety breach within the branch.

Stantec – a contractor hired by Enbridge to provide herpetological expertise.

Unified Command – In incidents involving multiple jurisdictions, a single jurisdiction with multi-agency involvement, or multiple jurisdictions with multi-agency involvement, Unified Command allows agencies with different legal, geographic, and functional authorities and responsibilities to work together effectively to make decisions to coordinate the response without affecting individual agency authority, responsibility, or accountability.

USDA-APHIS-WS – United States Department of Agriculture Animal and Plant Health Inspection Service – Wildlife Services

USEPA – United States Environmental Protection Agency.

USFWS – United States Fish and Wildlife Service.

Wildlife Care – specialized teams in the animal husbandry, veterinary care and rehabilitative progress of oiled wildlife. The teams consisted of veterinarians, veterinary assistants, zoologists, rehabilitators and volunteers.

Wildlife Recovery – specialized teams in locating, observing and recovering oiled wildlife for transport to the Wildlife Response Center for rehabilitation. The teams consisted of personnel from USFWS, USDA-APHIS-WS, MDNRE, Focus Wildlife, Entrix, HRM, Stantec and volunteers.

Wildlife Response Center (WRC) – a facility located in Marshall, Michigan that housed the Wildlife/Environmental Damage Assessment Branch. The facility was developed for intake, rehabilitation and conditioning of wildlife. In addition, office space was available for wildlife response agencies. This allowed for effective communications and cooperation amongst all disciplines of the branch.

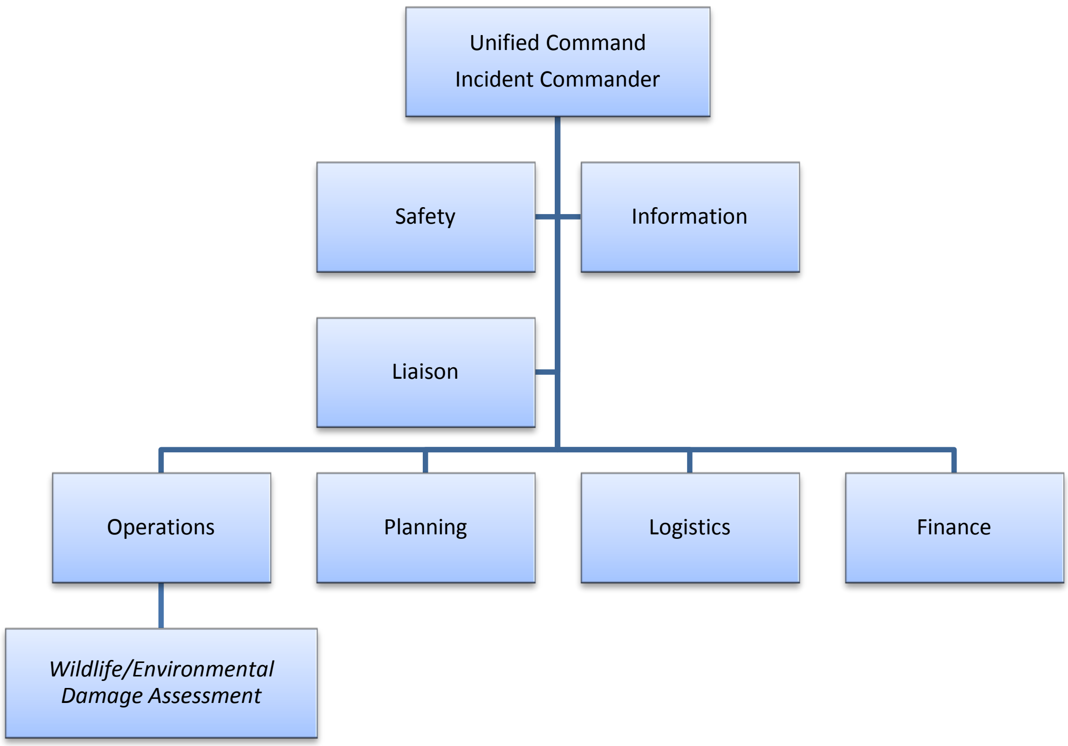
Incident Command System: Structure and Functions

ICS is a pre-determined method of response organization that clearly identifies the responsibilities, lines of communication and strategies used during any incident. ICS is designed to work across political and physical boundaries, allowing for interoperability during any emergency situation, regardless of the size.

ICS was used from the onset of the Line 6B incident, first led by Enbridge and then by a Unified Command with U.S. EPA serving as the Federal On-scene Coordinator and Incident Commander.

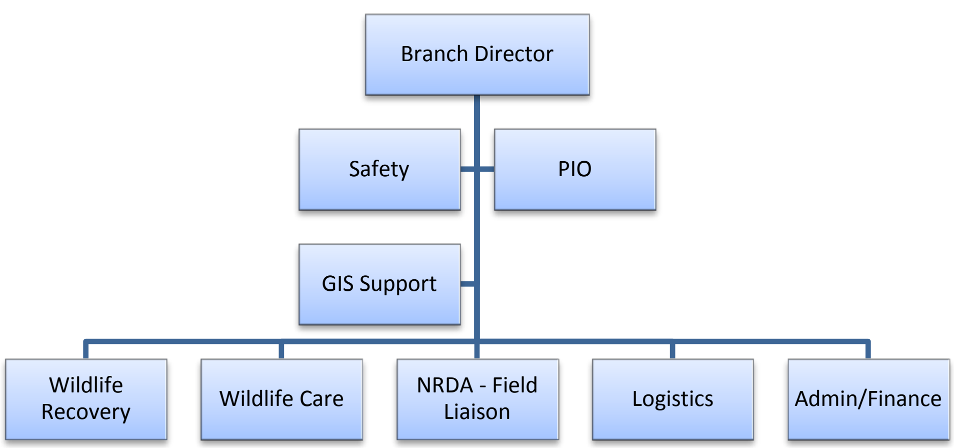
Personnel from the USFWS Fire Program assisted EPA in establishing ICS and improving its overall effectiveness, as well as being part of the leadership team for the Wildlife/Environmental Damage Assessment Branch. Within the ICS organizational structure, the Wildlife/Environmental Damage Assessment Branch was placed as one of the branches in Operations:

Incident Command



During most of the spill response, the Wildlife/Environmental Damage Assessment Branch was organized into groups and teams aligned along the following basic structure:

Wildlife/Environmental Damage Assessment Branch



The Wildlife/Environmental Damage Assessment Branch structure replicates the ICS model and is broken down into specific groups. These groups, with their descriptions, are as follows:

Branch Director

The Branch Director position was filled by USFWS personnel from the beginning of the spill through September 24, 2010, when USFWS turned over the position to Enbridge. Through most of the first three months of the response, the Branch Director was assisted by two Deputy Directors; one from USFWS and one from Enbridge. The Branch Director and Deputies were assigned oversight of all wildlife operations and reported to Unified Command through the Operations Section.

During the height of the response, the Branch Director and Deputies were assisted by Division/Group Supervisors who worked specifically with the various groups within the Branch. Division/Group Supervisors supported the groups and coordinated completion of ICS planning forms each operational period.

Safety

The Branch Safety Officer developed a Health and Safety Plan specifically for the Branch; did daily safety briefings; and, monitored working conditions, use of PPE, and waste handling for the Wildlife Response Center. Important safety concerns were exposure to oil (including volatile components like benzene), the potential for zoonotic diseases, injuries from wildlife, slip/trip/fall hazards, overheating, dehydration, and electrical hazards (especially around water in tanks, conditioning ponds, and washing areas). The Safety Officer for the Branch provided daily Safety Messages in accordance with the IAP. The Branch Safety Officer conducted continuous inspections of the WRC and took immediate corrective measures on any matters involving unsafe conditions. In addition, the Branch Safety Officer maintained a running log for all watercraft activities (float plan) and Safe Work Permits (documentation required by Enbridge). The Branch Safety Officer also helped develop and provide site-specific Hazardous Waste Operations and Emergency Response (HAZWOPER) training as needed for personnel. As the response continued, the Branch Safety Officer also wrote a Fatigue Management Plan for the Branch. No serious incidents were recorded for the Wildlife Branch.

PIO

The USFWS provided a Public Information Officer (PIO) to the Branch to address press releases and other media issues. The PIO was on-site for the first few weeks of the incident and then was located off-site for the remainder of the initial response period. The PIO also assisted with coordinating public meetings and press conferences. Originally press conferences were held daily, but then were held weekly or less often as the incident progressed.

GIS Support

MDNRE provided on-site GIS support with specialists and equipment. Mapping needs and other GIS information were channeled through this position, allowing for fast document turnaround time. GIS specialists in the WRC created maps specific to wildlife operations and managed general site maps obtained through Unified Command. GIS specialists within the branch supplied information to Unified Command on both the ongoing wildlife response and sensitive environmental areas.

Wildlife Recovery Group

Initial field teams and assignments consisted of the following teams and assignments:

- Terrestrial Teams
    - Capture/transport/survey of oiled wildlife
    - Develop alternate strategies and tactics for wildlife capture
    - Monitor/document locations/conditions where oiled birds (that could fly long distances) landed
    - Respond to Oiled Wildlife Hotline calls as needed
- Herp Teams
    - Concentrate on turtle recovery efforts
    - Coordinate with other branch/division/group operational personnel concerning turtle traps, utilizing ICS 204 (Field Assignment form) information
- Aquatic Teams
    - Survey, recover and document fish and wildlife impacted in waterways and wetland areas

As the incident progressed, additional field teams were deployed, which consisted of the following teams and assignments:

- Focus Terrestrial Team
    - Respond to Hotline calls as needed
    - Capture/transport/patrol of oiled wildlife
    - Develop alternative strategies and tactics for wildlife capture
    - Monitor/document locations/conditions where oiled birds(that could fly long distances) landed
    - Develop/provide Hazmat training as needed for necessary personnel
    - Participate in scientific support team
    - Coordinate activities using ICS 204 information
- Focus Recon Team
    - Perform reconnaissance
    - Capture/transport/patrol of oiled wildlife
    - Participate in scientific support team
    - Coordinate activities using ICS 204 information
- Beaver Trapping Team
    - Perform recon
    - Collect oiled animal locations
    - Develop/provide Hazmat training as needed for necessary personnel

    - Participate in scientific support team
    - Coordinate activities using ICS 204 information
    - Trap and recover beaver and transport back to the Wildlife Response Center
- Heron Capture Team
    - Capture/transport/patrol of oiled wildlife
    - Develop alternate strategies and tactics for heron capture
    - Respond to hotline calls as needed
    - Monitor/document locations/conditions where oiled heron land
    - Develop/provide Hazmat training as needed for necessary personnel
    - Participate in scientific support team
    - Coordinate activities using ICS 204 information
- Wildlife Data
    - Collect and process wildlife data
    - Develop/provide Hazmat training as needed for necessary personnel
    - Participate in scientific support team
    - Coordinate activities using ICS 204 information
- Stantec Herp Team Coordinator
    - Continue to concentrate on turtle recovery effort
    - Configure personnel into teams and make assignments
    - Coordinate with other branch/division/group operational personnel concerning turtle traps, utilizing ICS 204 information
    - Develop/provide Hazmat training as needed for necessary personnel
    - Participate in scientific support team
    - Coordinate activities using ICS 204 information

In addition, all teams were directed to conduct a heat stress assessment in accordance with the Health and Safety Plan for the incident. A strict work/rest schedule was enforced due to high heat and humidity levels during response. Teams also followed a lightning safety protocol for inclement weather.

<u>Wildlife Care Group</u>

The Wildlife Care Group operated primarily in the Wildlife Response Center (WRC), located in Marshall, Michigan. The Wildlife Care Group consisted of the following teams and assignments:

- Animal Area Intake Crew/Stabilization Area/Response Veterinarian
    - Document and photograph animal intake
    - Conduct initial examination and assessment of animals
    - Stabilize animals per Focus Wildlife policy
- Animal Care Manager/Release Coordinator
    - Document progress of treatment and rehabilitation
    - Oversee medical treatment and follow-up care for animals
    - Oversee and assist with animal release plans
- Facilities Coordinator
    - Ensure facilities are functioning appropriately for animal intake and rehabilitation
    - Develop and maintain intake, holding, cleaning and conditioning areas

- Turtle Area Crew
    - Assist veterinary staff with all aspects of turtle stabilization, feeding, rehabilitation and preparation for release
    - Develop techniques and methods for safe custody of wintering turtles
- Animal Kitchen Crew
    - Organize and maintain animal kitchen
    - Prepare and record food for varying animal species per veterinary guidelines
- Cleaning Area Crew
    - Organize and maintain cleaning area
    - Provide for safe cleaning environment for team members and animals
    - Clean oiled wildlife by using accepted practices and veterinary guidelines
    - Maintain equipment used for cleaning and ensure materials are in stock
- Conditioning Area Crew/Rehab Supervisor/Release Coordinator
    - Organize and maintain conditioning area
    - Provide for safe environment for animals to ensure reduced opportunity for escape and/or injury
    - Assist with conditioning and rehabilitation of animals using veterinary guidelines
    - Prepare animals for transport to release location
- Wildlife Deterrent Task Force
    - Develop wildlife deterrent techniques
    - Maintain deterrent devices (fencing, decoys, etc.)
    - Assist with other tasks as needed

All personnel were required to adhere to the Wildlife Response Center Safety Plan. Crew leaders also provided task-specific training to crews and volunteers.

<u>Natural Resource Damage Assessment (NRDA) – Field Liaison</u>

NRDA teams determined their study priorities separately from ICS, but coordinated their field activities with the rest of the response through an NRDA Field Liaison with the Wildlife/Environmental Damage Assessment Branch. The NRDA Field Liaison also ensured that all safety protocols, permit requirements, and messages from ICS reached the NRDA teams. NRDA teams conducted surveys throughout the response area to evaluate impacts to surface water, sediment, soil, vegetation, benthic invertebrates, fish and wildlife. The NRDA teams reported any of their sightings of oiled wildlife to the Branch so that dispatchers could direct wildlife response teams to the indicated locations. In addition, the Branch was able to facilitate the transfer of floodplain oiling survey information from the NRDA teams to the Planning Section.

<u>Logistics – Wildlife Support Group</u>

The Wildlife Support Group operated primarily in the Wildlife Response Center (WRC) and was comprised of the following:

- Dispatch/Volunteer Coordination
    - Provide radio and telephone communications with field teams
    - Relay hotline information for response
    - Maintain sign-in sheet for personnel and visitors to the WRC

- Coordinate and assign volunteers for wildlife operations
- Equipment/Supplies Stock
    - Ensure required materials are on-hand
    - Work with local spill donation center and Logistics Section to obtain equipment and supplies
    - Develop and maintain inventory list

<u>Administration/Finance</u>

- Administration/Purchasing
    - Provide for support in ordering materials and equipment for wildlife response and rehabilitation
    - Work with Wildlife Support Group to ensure operational readiness of WRC
- Finance
    - Ensure financial requirements for response are met
    - Monitor daily expenditures to ensure alignment with incident funds allocation
    - Assist with payroll

<u>Technical Assistance to the U.S. Environmental Protection Agency (EPA)</u>

Agency personnel within the Wildlife Branch also provided technical assistance to EPA through communications with Unified Command, Operations Section, and Planning Section:

- Reviewing and commenting on Enbridge submittals
    - Operational Health and Safety Plan
    - Sampling and Analysis Plan and Quality Assurance Project Plan
    - “Remediation” plans for source area and downstream areas
    - “Restoration” plans
- Science Team/Environmental Advisory Group
    - Cleanup recommendations
    - Submerged oil
    - Seasonal outlook
- Data for removal actions and closure approvals
    - Observations of response activities and field conditions
    - Discovery and evaluation of extent of submerged oil
    - Floodplain survey data from NRDA teams
- ICS Assistance

Oiled Goose in Flight

Wildlife Response Activities

The mission of the Wildlife/Environmental Damage Assessment Branch was to:

- Provide protection of environmentally and culturally sensitive areas including wildlife and historic properties.
- Protect threatened and endangered species & continue to recover and rehabilitate injured wildlife.

From the early hours of following notification of the oil discharges into the environment, wildlife response was a high priority within the overall response.

The first USFWS biologist arrived on scene on July 26 and began developing strategies for wildlife response. Agency involvement in wildlife reconnaissance and recovery were important for the following reasons:

- Public and wildlife safety
  - Leadership, credibility and visibility
  - Local knowledge and contacts
- Validation of number and degree of oiled wildlife
- Independent observations of impacts of oil and response activities
  - Submerged oil
  - Fen
  - Other sensitive habitats
  - Worker techniques

The operation of the Branch was under USFWS leadership, but was successful because the cooperation and work contributed by many agencies, contractors, and others, including personnel from the following:

- USFWS
- MDNRE
- USDA APHIS Wildlife Services
- Michigan Department of Agriculture, Emergency Response Unit
- Stantec
- HRM
- Focus Wildlife
- Binder Park Zoo
- Manpower
- Volunteers

The following sections describe wildlife deterrence, oiled wildlife hotline, WRC development, field teams and tactics, wildlife rehabilitation, wildlife release, volunteers and the public, training, and Branch management

Wildlife Deterrence

Efforts to prevent un-oiled wildlife from becoming oiled were implemented in the early days of the spill. Deterrence crews worked on foot to construct barriers to prevent animals from entering the river. Additional deterrence strategies included:

- Silt Fencing
- Snow Fencing
- Scare Tape
- Propane Cannons
- Predator "Scarecrows"
- Response Work
    - >1,500 workers
    - Flotillas of airboats
    - Helicopters
    - Vacuum trucks

Coyote "Scarecrow" Decoy

Deterrence Fencing and Scarecrow

Deterrence fencing was also placed along a road that was being heavily used by response vehicles in order to reduce the risk to turtles after a spotted turtle was found in the area. The spotted turtle is listed by the State of Michigan as a threatened species.

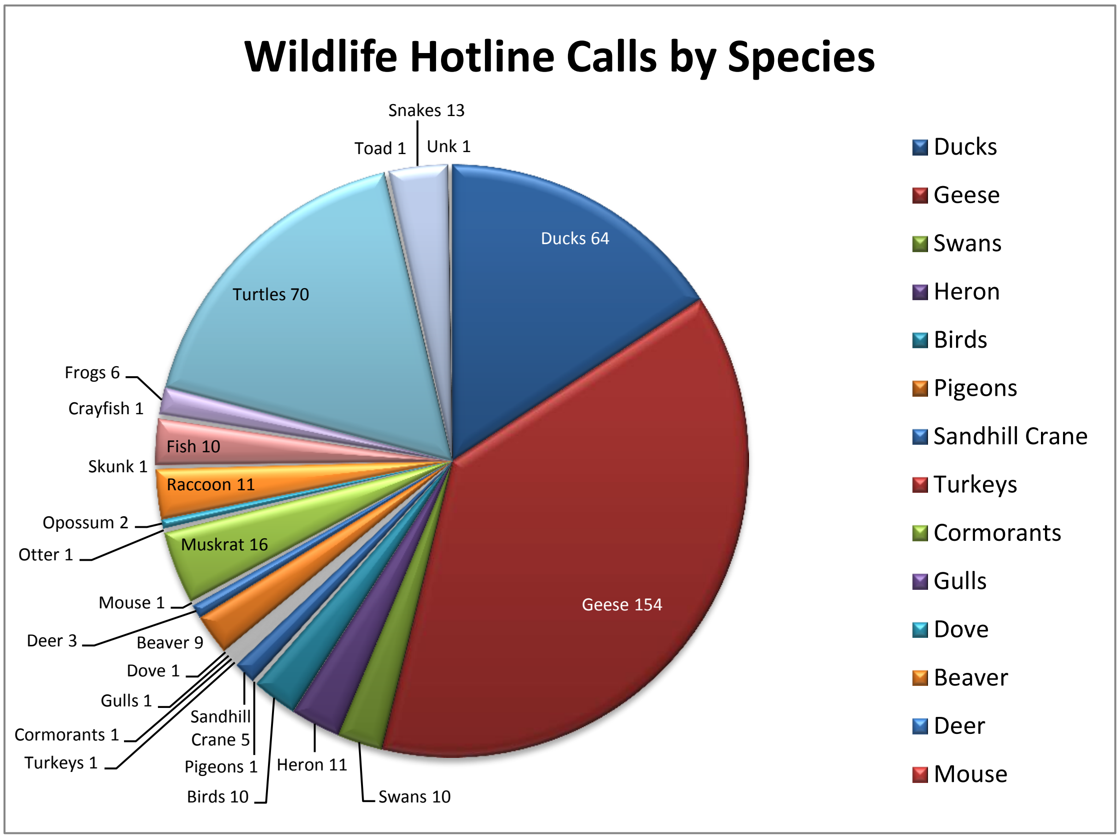
Oiled Wildlife Hotline

Enbridge developed and maintained an Oiled Wildlife Hotline that provided a single-source reporting location for members of the community and spill responders. The reports of oiled wildlife were forwarded to the Wildlife Response Center for dispatch, which allowed for timely response by wildlife field crews.

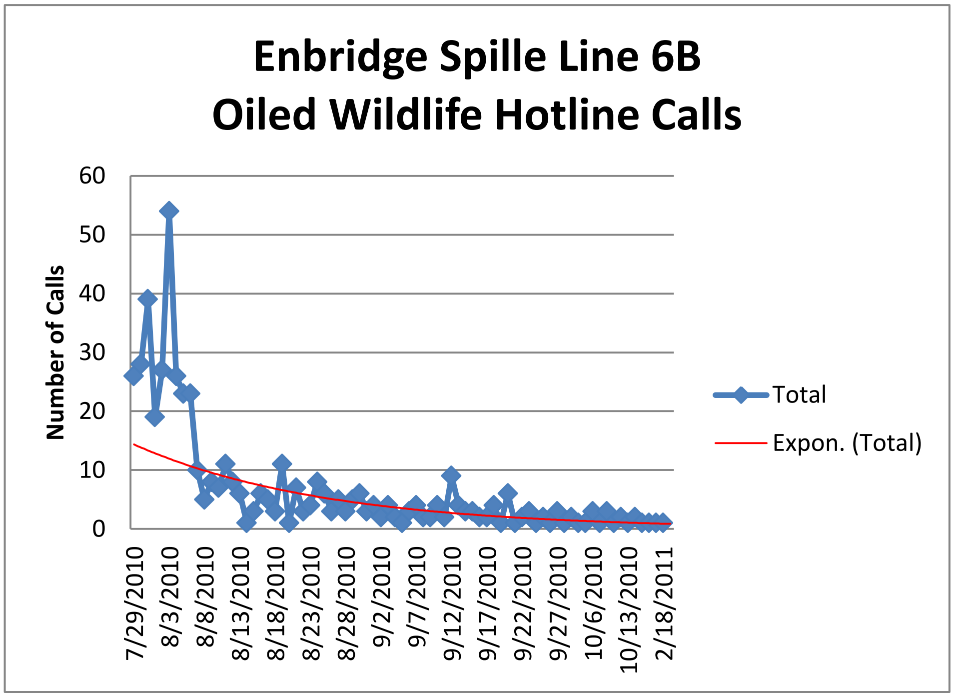
The hotline number was advertised continually, using a variety of approaches:

- Press conferences
- Press releases
- IAPs
- Flyers/Leaflets
- Business Cards
- Magnetic Door Shields
- Websites
- Wildlife Trapping Notice Signs

Heron Trapping Area



The majority of wildlife hotline calls were reports of oiled geese, turtles and ducks. Other wildlife species were also reported but with less frequency. Additionally, the hotline was used more during the first week of the spill response. Its use diminished as the incident progressed with time.



Number of Hotline Calls by Date

Waterproof business cards with the Oiled Wildlife Hotline number on its face were provided to wildlife field crews and were distributed during face to face contacts with local residents and spill responders. Several reports came in to the WRC as a result of the cards, many of which were generated by spill responders. Additionally, magnetic door shields that displayed the hotline number were provided for use on wildlife recovery vehicles. This allowed for high visibility of teams when on the road and afield and also identified responders as incident staff when stopped along roadways and near private residences.

In addition, the hotline was used for general information about the oil spill. Volunteers could use the hotline to sign up to assist at the spill. General wildlife questions could also be asked.

Wildlife Response Center Development

On Day 2 of the response, Focus Wildlife personnel arrived on-scene and began establishing the Wildlife Response Center (WRC). Enbridge and Focus Wildlife identified a facility previously used by the Firekeepers Casino in Marshall, Michigan, as having characteristics that met wildlife recovery needs. The building included office space for responding agencies and organizations and eventually was equipped with telephones and internet access. A conference room was also available and was used for daily briefings and meetings. Adequate floor space for wildlife intake, rehabilitation and conditioning allowed for flexibility in use and design. The physical structure within the building changed frequently to address the needs of wildlife care. A large parking area on-site allowed for convenient parking of personnel and response equipment. In addition, a large conditioning facility, complete with water pools, filtration and secure housing, was established close to the main building, yet far enough from the main parking lot to minimize disturbances to recovering wildlife by vehicles and other equipment. Storage was available in two large sea containers. A large, unattached garage provided additional conditioning and storage areas.

Focus Wildlife and Enbridge built systems for water supply, handling and disposal on-site and had to make adjustments to heating, cooling, and electrical systems to provide proper climate control for recovering wildlife. To get sufficient water volume and pressure, they worked with local authorities to use nearby fire hydrants to supplement the water supply to the facility. They installed on-demand water heaters and pressure controllers to provide a reliable supply of water at the narrow range of temperature and pressure required for washing large numbers of oiled animals. They also installed several large holding tanks for waste water and arranged for vacuum trucks from the overall incident response to empty them as needed.

Wildlife Response Center

Conditioning pen area

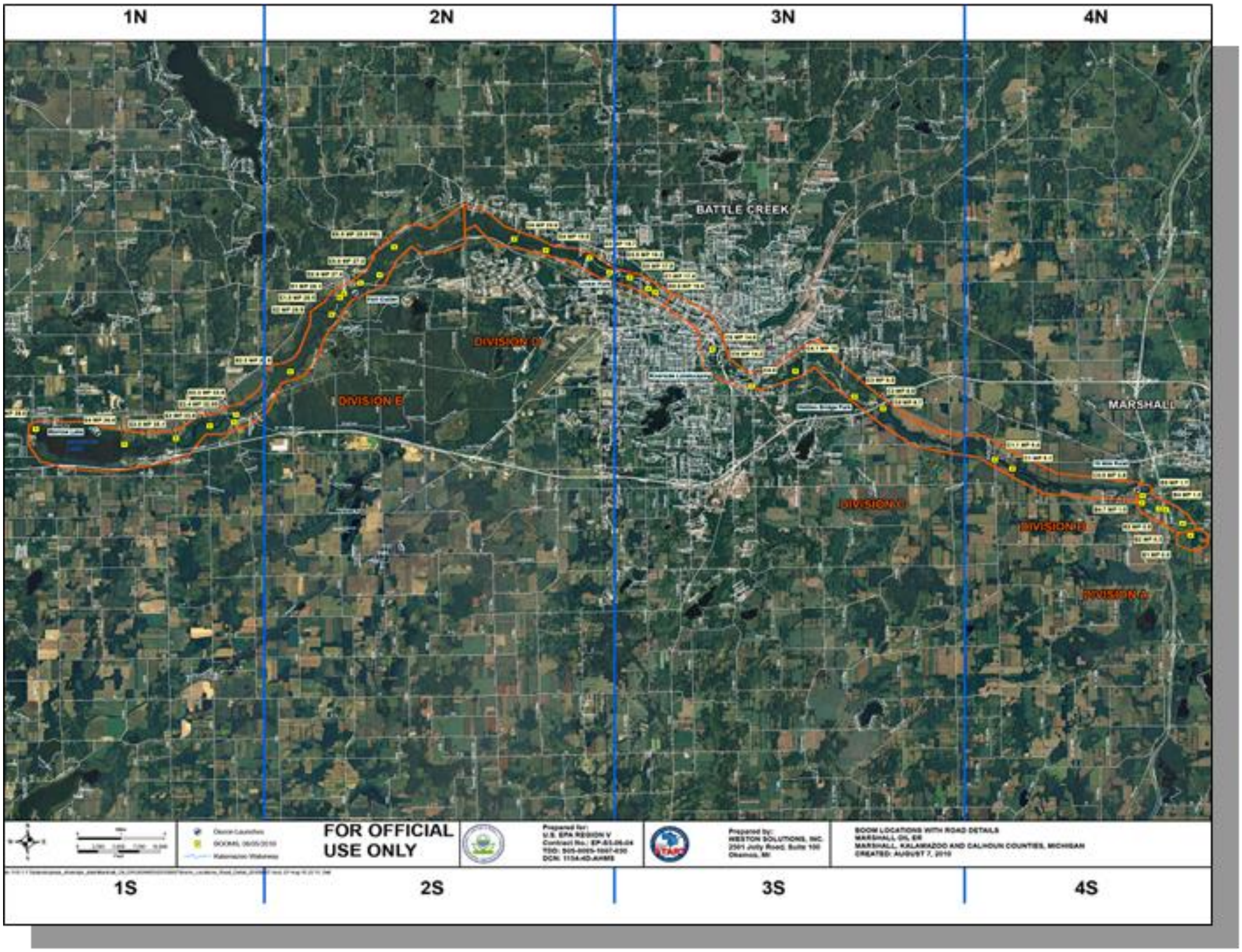
Wastewater tanks and vacuum truck

Conditioning pen

Field Teams and Tactics

Field teams were established with personnel from USFWS, USDA-APHIS-WS, MDNRE, Focus Wildlife, Stantec and a few volunteers. The teams initially located and documented oiled wildlife while the WRC was being constructed and outfitted. The teams quickly moved from observation and documentation to response and recovery once the WRC was able to accept oiled wildlife. Early in the spill, teams were accompanied by industrial hygienists to monitor concentrations of volatile compounds, particularly benzene. Later, the Branch obtained simplified meters and trained team members to use them until monitoring was no longer required by the Safety Officer.

Wildlife recovery teams used different tactics over time as the conditions changed. In the beginning of the response, the teams focused on the heavily oiled birds. Crews responded to reports from the public and response workers and were able to pick up oiled animals with hand held nets. As the most heavily oiled birds were brought in for rehabilitation, the remaining birds became wary of capture teams and crews gained more access to the river. As a result, the Branch developed geographic divisions to allow for efficient team deployment and systematic searching. In addition, specialty teams were used for targeting specific wildlife.



Geographical Response Areas

A large number of Canada Geese and other waterfowl were oiled but still able to fly. Over time, the birds appeared to learn to recognize team vehicles, to the point that certain geese would fly away upon arrival of team vehicles at potential capture sites, and to avoid certain tactics. Because of this, tactics and techniques were evaluated and new methods implemented. Original capture techniques involved teams approaching geese with large hand nets and slowly working into their locations. The teams would attempt to net the geese when they became cornered or when they would attempt to take flight. This method was ineffective for flighted birds. Tactics meetings, conducted by wildlife response personnel, identified alternative capture methods which included the following:

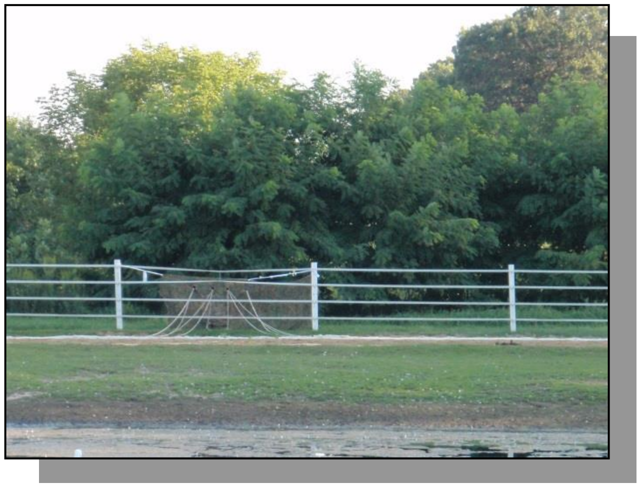
- Use of decoys and bait at cannon net stations
- Use of hand-held net deployment devices (Super Talon)
- Use of walk-in traps (waterfowl)

- Use of modified soft-catch leghold traps (Great Blue Heron and Sandhill Crane)
- Use of live traps (mammals)
- Use of box traps and commercial traps (turtles)
- Use of Alpha-chloralose on flighted geese
- Hand-feeding park geese and ducks/hand-capture

Oiled Canada Geese Watching Hand Net Operation

Use of Decoys/Bait at Cannon Net Stations (Waterfowl)

A pair of CO_2 powered cannon nets were deployed in rural areas where oiled Canada Geese repeatedly congregated. Original discussion of tactics for luring the geese into netting range included the use of goose decoys and/or bait (corn). The use of decoys was not implemented but placement of corn was used. The cannon nets were deployed successfully. Difficulty arose when trying to keep un-oiled geese from eating the bait. On several occasions the oiled geese were harassed by the un-oiled geese, causing the oiled geese to move away from the bait. During one operation at the Nottawa Painted Horse Farm trapping location, oiled geese flew into the bait before the un-oiled geese, allowing for a successful net deployment and the capture of nine birds. At the Eaton Proving Grounds trapping location, oiled geese were observed and corralled into cannon net range. Two geese were successfully captured in that attempt. Total observation and trapping effort occurred over a nine day period.

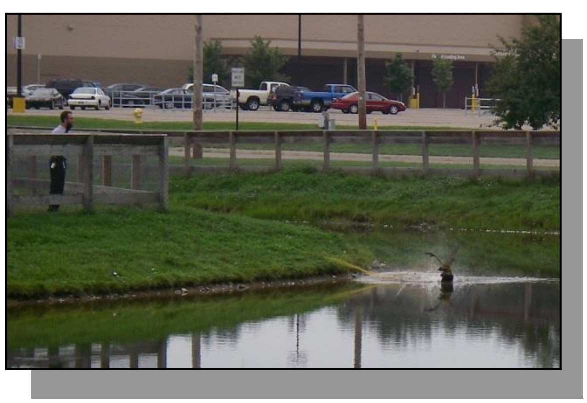


Cannon Net w/ Bait

Use of Hand-Held Net Deployment Devices (Super Talon)

Wildlife Recovery personnel made use of a hand-held net launcher called the Super Talon. The Super Talon fired a 16 foot diameter net from a hand-held launcher. Carbon dioxide (CO_2) is the propulsion source and is easily re-armed and reloaded. The net mesh comes in varying sizes, allowing for large animal or small bird capture. Additional Super Talon devices were ordered and presented to field crews. After a brief training session, the Super Talons were deployed on several capture attempts with positive results. The Super Talon's effective range varied from 5 to 10 meters.

Super Talons were fired with good overall effectiveness from stationary ground positions and from vehicles in motion. No injuries were sustained by birds captured with the devices. The devices are supplied with a relatively large mesh net that was effective for Canada geese, but mallards were able to escape. Crews experimented with a smaller net size with some success.



Super Talon Deployment

Use of Walk-in Traps (Waterfowl)

Walk-in traps were used for ducks and geese with limited success. Small walk-in traps were initially used for ducks, resulting in no captures. A large walk-in trap was constructed over time to capture Canada Geese, again with no captures. Late in the spill response, a walk-in trap was gradually constructed on a small Island that was frequented by oiled ducks on the Kalamazoo River. Bait (corn) was placed inside the trap to lure the birds inside. The trap was successfully deployed, capturing four oiled ducks. The trap's design was repeatedly modified to fit existing conditions at the trap location.

Walk-in Trap for Ducks w/ Bait

Use of Alpha-Chloralose on Flighted Geese

Alpha-chloralose, a drug that can be used to tranquilize geese, was approved for use by the MDNRE state veterinarian. APHIS personnel were able to dose individual geese by tossing treated food directly to the individual they hoped to capture. Unfortunately, geese captured this way arrived at the WRC in a stressed condition, and it was difficult to manage the timing of capture and care at intake. Working together, the agencies, Focus Wildlife, and Enbridge leaders within the Branch decided to discontinue use of alpha-chloralose for this incident.

Geese Dosed with Alpha-Chloralose

Hand-feeding Park Geese and Ducks/Hand-capture

Ducks and geese that were accustomed to hand feeding in city parks were sometimes captured by baiting them within grabbing distance. Wildlife crews would feed the birds and when close, capture the birds by hand. This method required great time in gaining confidence of the birds, but was effective in urban settings.

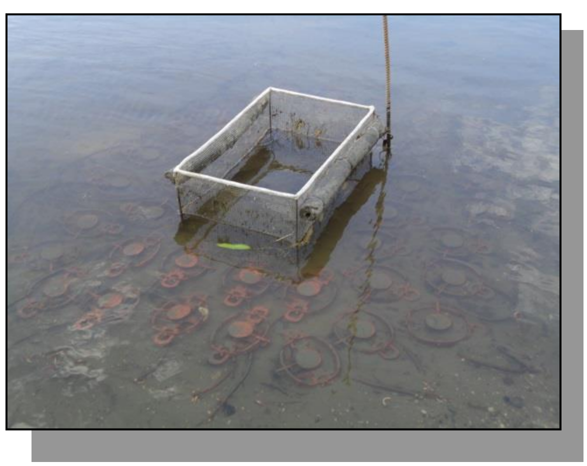
Use of Leghold Traps (Great Blue Heron and Sandhill Crane)

A significant number of oiled Great Blue Heron and a small number of oiled Sandhill Cranes were observed by field crews. A determination was made that a specialized team would need to be in place to capture these species of birds. Rita Seston from Entrix, a contractor for Enbridge, provided soft-catch leghold traps from her heron research with Michigan State University. She and Mike Nadeau, who had worked with her on her research, trained two USFWS personnel in proper capture and handling techniques. Mike Nadeau worked as a contractor with the USFWS personnel.

The team initially used bait fish purchased at a local bait shop to attract herons to the trap site. They discovered that bluegill were more attractive to the herons and so discontinued the use of purchased bait fish in favor of using locally caught small bluegills. The bait was placed in a partially-submerged bait box. Up to 60 leghold traps were placed around the outside of the bait box. The traps were secured to a staked main line, which would prevent the heron from flying away with the trap. To prevent injuries to herons, soft-catch traps were modified by lowering jaw tension and providing shock absorption within the tether that secured the trap to the main line.

The original clips for securing the traps were rusted and not fully functional. The clips were replaced with stainless steel decoy snaps that worked very effectively. The decoy snaps not only secured the traps to the main line but also aided in fast setup and takedown.

The strategy worked very effectively, accounting for the capture of nine Great Blue Herons. Because of the nomadic nature of Sandhill Cranes, the team was not able to effectively deploy traps to target them.



Great Blue Heron Trap Set

Use of Live Traps (Mammals)

Initial attempts to capture furbearing animals yielded mixed results. Baited live traps were deployed but resulted in the capture of primarily un-oiled raccoons. Snares were used to attempt beaver capture. One beaver received minor injuries due to the friction of the snare. Snaring was stopped and a contractor who specialized in animal control was hired. Dave Bowers of Bowers Wildlife Control utilized various live traps for capturing beaver, muskrat and other furbearing animals. The animals were handled according to protocols established by MDNRE and Focus Wildlife and no further injuries resulted from capture.

Live Trap with Raccoon

Turtle Trapping Techniques

HRM initially attempted to use basking traps to capture oiled turtles but had poor success rates. Turtles were able to escape from the initial trap design. Stantec deployed commercial turtle traps with much greater success rates. Basking and commercial traps were often times subject to disturbance because of the high volume of vessel traffic on the river, especially airboats. As the incident progressed into cooler months, two-person teams of a boat operator and wildlife technician became very effective at capturing oiled turtles with hand held nets.

Basking Trap

Commercial Turtle Trap

Volunteers and the Public

Using the hotline, press conferences, public meetings, and other outreach efforts, USFWS and MDNRE urged the public to report oiled wildlife, but not to pick up oiled wildlife themselves both for their own safety and to minimize handling stress on the wildlife. Nonetheless, some members of the public did pick up wildlife and attempt to clean them in the first few days of the spill. The Branch attempted to recover these animals for additional treatment or carcass disposal.

Thousands of people volunteered to help the animals impacted by the spill. Calhoun County provided staff to take calls from volunteers and compile data on potential volunteers. In addition to the spill information and wildlife reporting hotlines, people in the Calhoun County area were also directed to dial 211 or visit www.handsonbc.org to volunteer. The Wildlife Branch then used that information, as well as personal contacts with known individuals, to bring volunteers in for training and work. Within the Wildlife Branch, a Volunteer Manager position was established to screen, schedule, organize, and track volunteers. Enbridge staffed the Volunteer Manager position with a contractor. Overall, approximately 150 individual volunteers contributed over 7,000 hours of work.

Throughout the response, the volunteers were managed by Enbridge and their contractors. The volunteers were all adults, and were mostly women. Some volunteered as parts of groups or organizations and others were unaffiliated. A few had previous experience with oiled wildlife spill response, but most were trained on-site by Focus Wildlife. Some volunteers became contract employees. The volunteers were primarily used in supporting the rehabilitation efforts being managed by Enbridge and their contractors, and the task for which the largest number of volunteer hours was used was washing oiled turtles. A few volunteers participated in reconnaissance and capture crews for several days, but those volunteers did not return on subsequent days and this practice was discontinued.

Local wildlife rehabilitators who attempted to set up their own wildlife washing stations were encouraged by the USFWS and MDNRE to turn over any wildlife already in their care to the Wildlife Response Center and were invited to sign in and be trained as volunteers within the Wildlife Branch. This was eventually successful in providing efficient, state-of-the-art wildlife care, control of animal and waste handling and tracking, and ensuring the safety of everyone working with oiled wildlife.

In addition to volunteering, members of the public and local businesses donated generous amounts of supplies like towels, cleaning supplies, boxes and crates, bottled water, and snacks. The donations threatened to overwhelm staff and space at the Wildlife Response Center, and fortunately a local church set up a donation center near the Wildlife Response Center. The church and their volunteers set up a large tent and organized supplies. The donation center operated independently of the Incident Command structure, but the volunteers there implemented suggestions from the Wildlife Branch and made it possible for Wildlife Branch personnel to obtain donated materials very easily as needed.

Wildlife Rehabilitation

Focus Wildlife managed the day-to-day wildlife rehabilitation activities with oversight from USFWS and MDNRE. Initially they also were assisted by veterinarians and specialists with the Michigan Department of Agriculture's animal emergency response unit. Focus Wildlife brought in professionals experienced in working with oiled birds and mammals and also used local rehabilitators and volunteers with appropriate on-site training. Focus Wildlife used their established protocols that are consistent with the USFWS's manual *Best Practices for Migratory Bird Care During Oil Spill Response* (available at http://www.fws.gov/Contaminants/FWS_OSCP_05/FWSContingencyTOC.htm#D). The general steps in the rehabilitation process were as follows:

- Intake examination
- Stabilization with hydration, feeding, and medications as needed until the animal was healthy enough to undergo the intensive washing process
- Washing and rinsing
- Recovery
- Conditioning
- Veterinarian examination for fitness to release

HRM initiated turtle care at the WRC and then Dr. Chris Tabaka from Binder Park Zoo and his staff led the care, cleaning and rehabilitation of turtles. Eventually, Focus Wildlife and then Stantec led the care for turtles as well. Because the oil was often stiff and tacky on turtles, individual turtles were usually cleaned over several sessions, between which the turtles were allowed to rest and recover from being handled. Most turtles were cleaned by hand with pads, brushes, and cotton swabs; large snapping turtles were anesthetized by a veterinarian and cleaned with gentle pressure washing in wading pools.

In general, care was highly successful, with survival to release rates of 84% for birds and 98% for turtles. Great Blue Heron survival was lower than for other species. Approximately half of them developed skin lesions, lost weight, and either died or were euthanized because of their deteriorating condition, despite the best efforts of the veterinarians and animal care workers.

MDNRE and USFWS conducted or closely monitored intake documentation and received copies of all in-care records for individual animals. The agencies also supervised carcass documentation and storage, with USFWS law enforcement officers supervising the locked freezers for migratory birds.

Intake Examination of Great Blue Heron

Oiled Canada Geese

Pre-wash Stabilization Area for Birds and Mammals

Washing of Turtles (left) and Birds (right)

Mineral Oil Application to Loosen Oil on Canada Goose

Turtle Washing

Washing Snapping Turtle

Turtle Care and Recovery Area

Wildlife Release

Planning for release of rehabilitated wildlife was complicated by the often conflicting goals of releasing animals back to their capture locations as soon as they were fit and protecting them from additional oiling or disturbance. With an impacted corridor of nearly 40 miles, oil persisting in floodplains and submerged sediments, as well as ongoing response operations, made it difficult to find appropriate release sites for some species.

Birds were taken to locations away from the Kalamazoo River where they would be protected from disturbance when released. These sites included the Allegan State Game Area and the Kellogg Bird Sanctuary. Most birds were banded before release. Waterfowl received a special color band that indicated that this was an “oil spill bird” and gave a toll free number to call for more information.

Turtles were released in a variety of locations either upstream of the oiled areas, in tributaries to the Kalamazoo River, or in previously impacted areas that were thought to be free of oil. Turtles were marked with PIT tags or shell notches. Through subsequent re-capture of individual turtles, we learned that at least some turtles were returning to their capture locations (or had at least moved in that direction from their release point) and were becoming re-oiled.

Training

Training was provided for wildlife response personnel who did not have Hazardous Waste Operations and Emergency Response (HAZWOPER) 40-hour certification. Unified Command approved a four hour, site-specific, training program, entitled 4-Hour Safety Awareness Training for Oil Spill Workers, to familiarize response workers with oil spill hazards and operations. The training certification applied only to the Enbridge Line 6B incident location.

All USFWS personnel working on site had either the 24-hour or 40-hour HAZWOPER training, with some of them completing the 24-hour program just prior to deployment to the scene.

The state of Michigan utilizes a state-of-the-art 800 MHz trunked radio system. Wildlife response teams used the radios as part of the Wildlife Branch Communications Plan. Because of their complex features and unique operating environment, one of the Branch staff with extensive experience with the radios developed in-house training and provided it to Wildlife Branch personnel. This training program was then used as the training standard for all responders who carried radios.

Enbridge required all response personnel to receive specific safety training. The training was specific to Enbridge operations and safety protocols. Each responder was required to watch a 17 minute training video and pass a written examination. Upon successful completion of the training, a certification decal was awarded which had to be worn on the responder’s helmet or identification card.

Off-road Utility Vehicles, or UTVs, were used extensively as the spill event progressed, so a safety training program was established. All operators of UTVs were required to complete the training and carry a UTV operator card.

Branch Management

As part of ICS, the Branch had a daily cycle of regular meetings, planning, and reporting of activities. The meetings included key personnel and were used to convey important information pertaining to the Incident Action Plan (IAP), safety and other operational issues. The meeting structures were as follows:

Morning Meeting

- Review the plan
- Safety message
- Any urgent issues for groups, needs for next day
- Break into groups
- Submit changes to Incident Action Plan (IAP) for next day

Evening Meeting

- What was planned?
- What actually happened and why?
- Plan tomorrow

Meeting times varied during the spill response to address specific needs of the Wildlife Branch. Meetings were scheduled to allow field crews the ability to maximize their work efficiency while afield.

At the conclusion of the morning Branch meetings, team leaders would assemble their respective teams and provide a tail gate meeting. The purpose of the tail gate meeting was to allow team leaders to assess the team's makeup, share vital safety information and develop team unity. Teams reviewed a prepared safety briefing, which was then signed by the team leader and all team members. This briefing sheet was carried while crews were deployed and needed to be presented to safety officers upon request. In addition, the Incident Action Plan (IAP) was also carried afield and used as a daily operations plan. Team leaders also filed a Safe Work Permit, which was required by Enbridge. If a team were to deploy on watercraft, a float plan had to be filed with the branch safety officer. The teams would then embark on their assigned tasks for the day.

Unless additional work was required, most field teams were back at the WRC for the evening meetings. Some crews worked night time operations (night ops), requiring them to re-group after the meeting and prepare for deployment. Surveillance for Canada Geese was often times performed during night ops, allowing crews to observe flight patterns, feeding habits and night roosting habits.

Night Ops Surveillance

During the course of the day, the Branch Director and staff used data and information from the Branch field teams, Operations Section, Planning Section, and Unified Command to develop and write plans for the next operational period of the response (e.g. ICS forms 204 and 215 for Assignment Lists and Operational Planning Sheet, respectively). They also wrote summaries of Branch activities for the Situation Unit in the Planning Section; updated costs and personnel numbers for the Finance Section; reviewed intake and care records; reported on the number of animals captured, in care, and released; provided technical assistance to EPA by reviewing various work plans and participating on the Science Team/Environmental Advisory Group; prepared for press conferences and public meetings; and attended meetings of the Operations Section and with Unified Command and General Staff. They also managed personnel and worked with their home and regional offices to arrange for appropriate rotations of staff over time. The Branch Director also spoke at press conferences and evening public meetings in Marshall, Battle Creek, and Kalamazoo. At the height of the Branch's activities, approximately 120 people from multiple organizations and agencies were working together to find, treat, and release oiled wildlife.

Wildlife Response Chronology

July 26, 2010, Day 1:

- U.S. Fish and Wildlife Service lead person on site
- Enbridge mobilized Focus Wildlife for wildlife care and rehabilitation
- Oiled Wildlife Hotline established and maintained by Enbridge
- Rehabilitation facility planning begins
- Additional USFWS personnel requested
- Oiled wildlife observed and recorded

July 27, 2010, Day 2:

- Incident Command System (ICS) implemented, Wildlife Branch organized with USFWS, MDNRE and Law Enforcement
- Volunteer coordination began
- Sensitive natural resources maps created and analyzed for planning
- Press conference held
- Reconnaissance of oiled fish and wildlife
- Focus Wildlife arrived on scene, Wildlife Response Center (WRC) established
- Incident Command briefings occur at 6:00 am and 6:00 pm
- Teams by Response Type:
    - Recon Teams – 1 Team

July 28, 2010 – July 31, 2010, Days 3-6

- Wildlife response underway
    - Teams primarily responded to hotline calls and locations documented on previous days
- Safety was paramount
    - Training
    - Monitoring
    - Communications Plan
- Wildlife deterrence plan implemented
- Data integrity an area of priority within the WRC
- Public outreach
    - Press
    - Rehabilitators
    - Legislators
    - Governor
- Logistical issues for WRC worked out
    - Internet access
    - Supplies allocation
    - Donations distribution and storage
    - Continued construction of intake and holding areas
- Additional USFWS personnel arrived on-scene

- Wildlife Response
- Teams by Response Type:
    - Hotline Response – 2 Teams
        - Geographic Coverage
            - Marshall
            - Roaming
    - Roaming/Transport – 1 Team
        - Geographic Coverage
            - Roaming
    - Hours of Operation: Not Known

<u>August 1, 2010 – August 2, 2010, Days 7-8:</u>

- USDA APHIS Wildlife Services specialists arrived on-scene
- Tactics meetings held, new capture techniques developed and implemented
- WRC fully functional, animal intake flowing smoothly
- Record keeping streamlined and working effectively
- Communications between wildlife response teams and WRC improved
- 4-hour HAZWOPER training provided to personnel
- Enbridge safety training provided to personnel
- Teams by Response Type:
    - Hotline Response – 3 Teams
        - Geographic Coverage
            - Ceresco/Marshall
            - Battle Creek (2 Team coverage)
    - Roaming/Transport – 1 Team
        - Geographic Coverage
            - Roaming
    - Hours of Operation: Not Known

<u>August 3, 2010 – August 4, 2010, Days 9-10:</u>

- Tactics Team developed to review and implement special capture tactics outside of hand net capture of Canada Geese
- Teams by Response Type:
    - Terrestrial Teams – 2 Teams
        - Geographic Coverage
            - Battle Creek Area
            - Marshall Area
    - Tactics Team – 1 Team
        - Tactics Deployed
            - Cannon Net
            - Super Talon Net Gun (STNG)
        - Geographic Coverage

            - Marshall Area
    - Roaming/Transport – 1 Team
        - Geographic Coverage
            - Division C
    - Hours of Operation: 0700 hrs – 1900 hrs (Tactics Team until 2200 hrs)

August 5, 2010 – August 6, 2010, Days 11-12:

- Teams by Response Type:
    - Terrestrial Team – 2 Teams
        - Geographic Coverage
            - Battle Creek Area
            - Marshall Area
    - Tactics Team – 1 Team
        - Tactics Deployed
            - Cannon Net
            - Super Talon Net Gun (STNG)
        - Geographic Coverage
            - Roaming
    - Scouting/Recon Team – 4 Teams
        - Geographic Coverage
            - Battle Creek Inland
            - Battle Creek Lake
            - Marshall Inland
            - Marshall Lake
    - HRM Aquatics Team – 2 Teams
        - Geographical Coverage
            - Division C Upstream from Dam
            - Turtle Trap Deployment
    - DNRE Aquatics Team – 7 Teams
        - Geographical Coverage
            - All Divisions
            - Turtle Trap Deployment
    - Hours of Operation
        - 0700 hrs – 1900 hrs

August 7, 2010 – August 11, 2010, Days 13-17:

- Wildlife Response Geographic Zones established 8/7/10
    - Simplified tracking of effort
    - Allowed for strategic response
    - Provided systematic geographic coverage
- Teams by Response Type:
    - Terrestrial Team – 4 Teams
        - Geographic Coverage
            - 4 South, Rocket Net/Night Ops

        - 4 North
        - 3 South
        - 1 North
  - Focus Wildlife – 1 Team
    - Geographic Coverage
      - 4 South
  - HRM Aquatics Team – 2 Teams
    - Geographical Coverage
      - Division C Upstream from Dam
  - DNRE Aquatics Team – Removed from IAP
  - Hours of Operation
    - 0700 hrs – 1800 hrs

<u>August 12, 2010 – August 15, 2010, Days 18-21:</u>

- Specialized team development expanded
- Incident Division designations utilized in addition to Geographic Zones
- Teams by Response Type:
  - Terrestrial Team – 3 Teams
    - Geographic Coverage
      - Muskrat Trapping in Div. B, C, and D
      - 3 North (2 team coverage)
  - Focus Recon Team – 1 Team
    - Geographic Coverage
      - All Divisions
  - Wildlife Hotline Response – 1 Team
    - Geographic Coverage
      - All Divisions
  - HRM Aquatics Team – 2 Teams (Demobilized on 8/13/10)
    - Geographic Coverage
      - Mill Pond (C5-C6 Upstream of Ceresco Dam)
      - Division C (Ceresco Dam and Mill Pond)
  - DNRE Aquatics Team – 4 Teams
    - Geographic Coverage
      - Division C, Electro Fishing
  - Stantec Herp Team – 3 Teams
    - Geographic Coverage
      - Divisions C & E
  - Hours of Operation
    - 0700 hrs – 1800 hrs

<u>August 16, 2010 – August 20, 2010, Days 22-26:</u>

- Heron Capture Team and Focus Terrestrial Team added to operations
- Teams by Response Type:
  - Terrestrial Team – 3 Teams

        - Geographic Coverage
            - 3 South
            - 3 North (2 teams)
    - Focus Recon Team – 1 Team
        - Geographic Coverage
            - All Divisions
    - Wildlife Hotline Response Team – 1 Team
        - Geographic Coverage
            - All Divisions
    - Heron Capture Team – 1 Team
        - Geographic Coverage
            - All Divisions
    - Stantec Herp Team – 3 Teams
        - Geographic Coverage
            - Divisions C & E
    - Stantec Herp Team Coordinator position added to IAP (8/19/10)
    - Hours of Operation
        - 0700 hrs – 1800 hrs

<u>August 21, 2010 – August 28, 2010, Days 27-34:</u>

- Trapping Team added to operations
- Evening cannon net operations added
- Teams by Response Type:
    - Terrestrial Team – 1 Team
        - Geographic Coverage
            - Division B am
            - Division E pm
            - Horse Farm Net Deployment in pm
    - Focus Terrestrial Team – 1 Team
        - Geographic Coverage
            - Arbor Inn area
    - Wildlife Hotline Response
        - Geographic Coverage
            - All Divisions
            - Recon Divisions B and C
    - Heron Capture Team – 1 Team
        - Geographic Coverage
            - All Divisions
    - Trapping Team
        - Geographic Coverage
            - All Divisions
    - Stantec Herp Team
        - Geographic Coverage
            - Divisions C & E
    - Hours of Operation

        - 0700 hrs – 1800 hrs (Except for Night Ops, until 2330 hrs and Heron Capture Team, until dark)

<u>August 29, 2010 – September 23, 2010, Days 35-60:</u>

- USDA APHIS Wildlife Services staff demobilized
- Each team's geographic coverage = all Divisions
- Teams by Response Type:
    - Focus Terrestrial Team – 1 Team
    - Focus Recon Team – 1 Team
    - Heron Capture Team – 1 Team
    - Trapping Team – 1 Team
    - Hours of Operation
        - 0715 hrs – 1730 hrs (Except for Heron Capture Team, until dark)

<u>September 25, 2010 – September 29, 2010, Days 61-66:</u>

- Additional Heron Team activated
- Each team's geographic coverage = all Divisions
- Teams by Response Type
    - Focus Terrestrial Team – 1 Team
    - Focus Recon Team – 1 Team
    - Heron Capture Team 2 Teams
    - Trapping Team – 1 Team
    - Stantec Herp Team – Team Numbers Coordinated with Focus Teams and Wildlife Care Group
    - Hours of Operation
        - 0715 hrs – 1730 hrs (Except for Heron Capture Teams, until dark)

<u>September 30, 2010 – October 15, 2010, Days 67-82:</u>

- Heron Teams and Trapping Team demobilized
- Wildlife Submerged Oil Team activated
- Teams by Response Type
    - Focus Terrestrial Team – 1 Team
        - Geographic Coverage
            - All Divisions
    - Focus Recon Team – 1 Team
        - Geographic Coverage
            - All Divisions
    - Wildlife Submerged Oil Team – 1 Team
        - Geographic Coverage

            - River System
    - Hours of Operation
        - Not Known

<u>October 16, 2010 – October 19, 2010, Days 83-86:</u>

- Focus Terrestrial Team and Focus Recon Team demobilized
- Teams by Response Type
    - Wildlife Response Team – 2 Teams
        - Geographic Coverage
            - All Divisions
    - Hours of Operation
        - Not Known

<u>October 20, 2010 – October 31, 2010, Days 87-98:</u>

- Wildlife Response Teams demobilized
- Team by Response Type
    - Hotline Response
        - Geographic Coverage
            - All Divisions
    - Stantec Coordinating Wintering of Turtles with Wildlife Care Group
    - Hours of Operation
        - Not known

Appendix D: Lake Allegan Fish Kill Investigation Report

Lake Allegan Fish Kill Investigation

Field Survey Methods

Lake Allegan is a 6-mile long reservoir with a surface area of 1,550 acres at a normal water surface elevation of 615 ft (NGVD). The shoreline length of the reservoir from Allegan Dam up to M-89 is 80,678 ft including the shoreline length of two small islands in the center of the reservoir. Sampling methods for investigating the fish kill followed procedures in Southwick and Loftus (2003) and the MDNR fish kill investigations guidebook (2003). DNR- Fisheries Division staff was divided into five crews consisting of two people per crew. Lake Allegan was separated into two strata, shoreline and open water counts, for enumerating dead fish. Shoreline counts were conducted along five segments that were 2,850 ft long (Figure 1). The total number of dead fish were first estimated within each stratum and then summed together for the total estimate. The total number of dead fish within the shoreline segments was estimated by the average number of dead fish per segment multiplied by the total number of segments in the kill area. The total number of dead fish in the open water zone was estimated by area sampling. Lake Allegan was separated into five transects. Crews were instructed to sample each transect by boat following parallel transects approximately 750 ft apart that were oriented from the north shore to the south shore of the lake. Each open water zone transect began at the end of the outer edge of the shoreline segment. The total number of dead fish in the open water zone was estimated by using an expansion factor. Expansion factor = $T/(W*N)$; whereby T is the length of Lake Allegan, W is the transect width, and N is the number of sample transects.

Results of Investigation

A total of 27 dead fish were collected on August 5, 2010 by DNR staff along the shoreline segments (Table 1). No fish were collected from the sampled open water zones. An additional 12 northern pike, 3 spotfin shiners, and three largemouth bass were observed on August 4, 2010. The total estimated number of dead fish was 168 individuals. Fish losses were relatively minor as a result of the drawdown of Lake Allegan. The species observed were consistent with the composition of fish in Lake Allegan (DNR Fish Collection System Records).

Literature Cited

Michigan Department of Natural Resources. 2003. Fisheries Division fish kill investigation guide book. Lansing, Michigan.

Southwick, R. I., and A. J. Loftus, editors. 2003. Investigation and monetary values of fish and freshwater mussel kills. American Fisheries Society, Special Publication 30. Bethesda, Maryland.

Table 1. Dead fish recovered from survey segments in the shoreline segments of Lake Allegan on August 05, 2010.

species	Segment 1	Segment 2	Segment 3	Segment 4	Segment 5
Common carp		2		1	1
Black crappie	1				
Bluegill		1			
Bluntnose minnow	3	1			
Largemouth bass		1			
Yellow bullhead				2	14

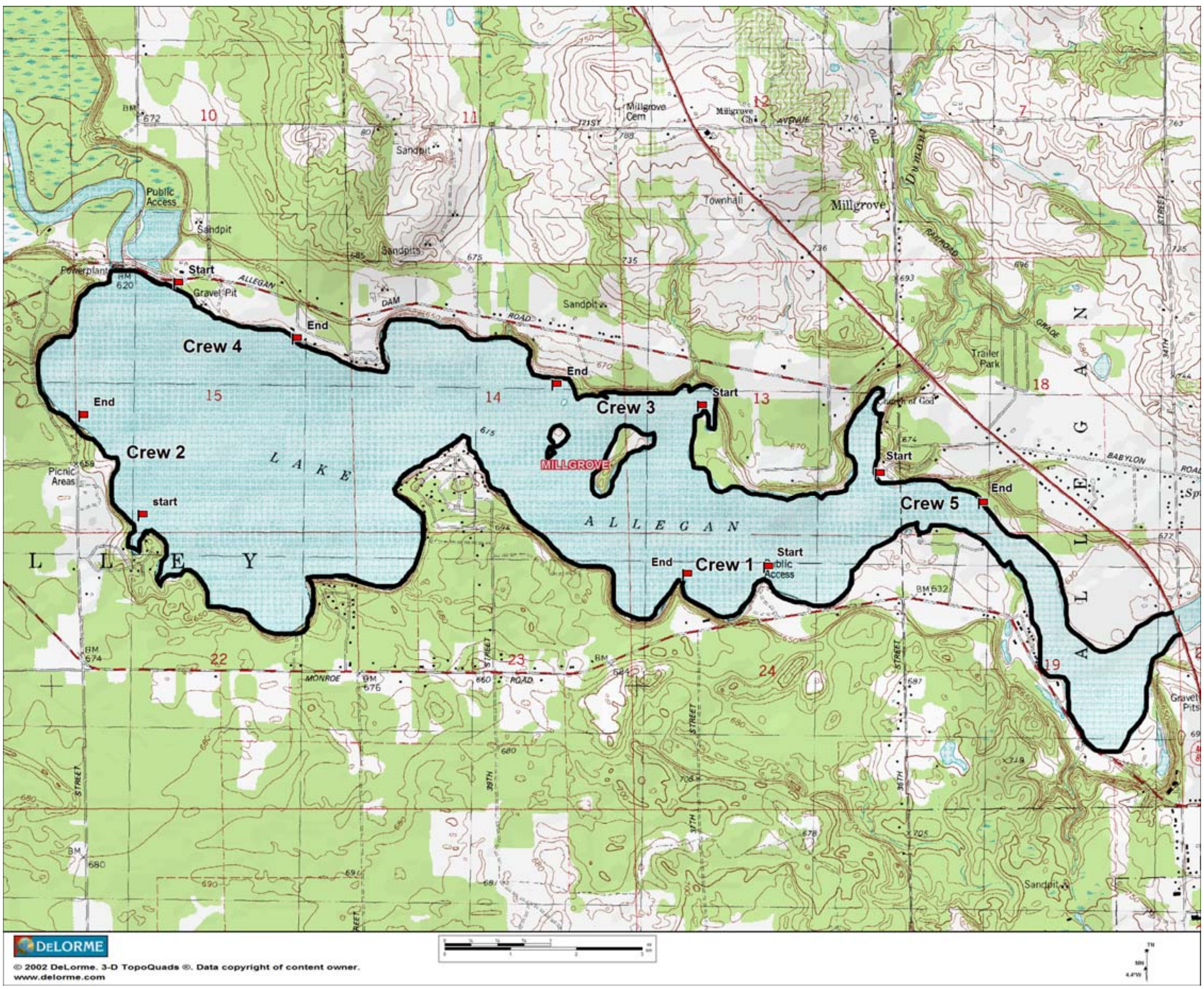


Figure 1. Lake Allegan Reservoir illustrating surveyed shoreline segments.

Lake Allegan Fish Kill Investigation
Enbridge Line 6b Incident

Submitted by:
Kregg Smith
Fisheries Biologist
Southern Lake Michigan Management Unit
MDNR Plainwell

August 9, 2010

Appendix E: Fish Health Assessment Report

Michigan Department of
Natural Resources

Fisheries Division

Fish Health Laboratory
Laboratory Report

To: Martha Wolgamood
Wolf Lake State Fish Hatchery

Report date: 1/17/10

Necropsy date: 8/3/10, 8/12/10, 8/19/10

MSU-AAHL No.: 100802-(1-3)-D-SLM
100812-(1-3)-D-SLM
100819-(2-4)-D-SLM

Host: 44 common white sucker, *Catostomus commersonii*
60 common shiner, *Luxilus cornutus*
60 golden redhorse sucker, *Moxostoma erythrurum*
60 golden redhorse sucker, *Moxostoma erythrurum*
60 spotfin shiner, *Notropis spilopterus*
60 sand shiner, *Notropis stramineus*
60 golden redhorse sucker, *Moxostoma erythrurum*
60 common shiner, *Luxilus cornutus*
60 rock bass, *Ambloplites rupestris*

Locality: Kalamazoo River

Collector: MDNRE

Date collected: 8/2/10, 8/11/10, 8/18/10

Purpose of examination: for baseline health assessment of fish following recent oil spill

Condition of fish submitted: Three species of fish were collected from three different sampling locations, totaling nine case submissions. 1) From the Marshal Impoundment in Calhoun County, upstream of the Marshall Dam, 44 common white sucker, 60 common shiner, and 60 golden redhorse sucker were collected on 8/2/10. 2) From Shady Ben Campground in Kalamazoo County, 60 golden redhorse sucker, 60 spotfin sucker, and 60 sand shiner were collected on 8/11/10. 3) From Wattles Rd. Bridge, downstream of Historic Bridge Park in Calhoun County, 60 golden redhorse sucker, 60 common shiner, and 60 rock bass were collected on 8/18/10. All fish were live at the time of collection and submitted to the laboratory dead on ice.

Testing results/Diagnosis:

- Fish generally appeared to be in good health.
- External gross examination of the dead fish revealed multifocal dermal lesions and generalized erythema on the common white sucker collected 8/2/10. Fin and ventral hemorrhages were prevalent on golden redhorse sucker and sand shiners submitted on 8/11/10. Ocular hemorrhages were observed on the majority of spotfin shiners.
- Internal examination revealed mild to moderate congestion in few livers and kidneys of common white sucker and common shiner collected 8/2/10. No other signs of disease were noted in dead fish.
- Samples of the kidney, spleen, and heart were submitted for virologic testing on epithelioma papulosum cyprini (EPC) and fathead minnow (FHM) cell lines. Inoculated cell lines were incubated at 15° and 25° C in accordance with the guidelines of the American Fisheries Society Fish Health Section Bluebook (2010). After two passages on all cell lines for a total of 28 days, there was no cytopathic effect noted and therefore declared <u>negative</u> for viruses detectable by the aforementioned cell lines.
- Fish were submitted dead, and therefore bacterial cultures were not taken.
- Gills were mildly autolyzed in the submitted fish. Gill and skin scrapings from the freshly dead fish collected on 8/2/10 revealed mild to moderate amounts of *Trichodina* sp., monogeneans, and larval

trematodes. No other parasites were noted. Skin and gill scrapings were not performed on dead fish from other collection dates.

Recommendations:

- No overt signs of disease were noted in all fish that were submitted.
- Repeated sampling may provide an opportunity to evaluate the long term effects of the oil spill on the health of these populations of fish.

Prepared by: Mohamed Faisal, D.V.M., Ph.D

cc: Gary Whelan

Appendix F: Health Assessment and Histopathologic Analyses of Fish Collected from the Kalamazoo River, Michigan, Following Discharges of Diluted Bitumen Crude Oil from the Enbridge Line 6B

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Health Assessment and Histopathologic Analyses of Fish Collected from the Kalamazoo River, Michigan, Following Discharges of Diluted Bituman Crude Oil from the Enbridge Line 6B

By Diana M. Papoulias, Vanessa Veléz, Diane K. Nicks, and Donald E. Tillitt

Administrative Report 2014

U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of the Interior
SALLY JEWELL, Secretary

U.S. Geological Survey
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U.S. Geological Survey, Reston, Virginia: 2014

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Acknowledgments

Funding for this study was provided by the US Fish and Wildlife Service (FWS), East Lansing Field Office, East Lansing, Michigan. We were assisted in the field and with logistics by personnel from the FWS (Edward Karecki and Stephanie Millsap), Michigan Department of Natural Resources (Olen Gannon, Matt Smith, Mike Wilson, Ed Pearce, Scott Hanshue, Jay Wesley, and Kregg Smith), and Enbridge contractor (John Hess). Lisa Williams (FWS) and Jessica Winters (National Oceanic and Atmospheric Administration) provided valuable comments on an early draft.

We were assisted in the laboratory by personnel from the Columbia Environmental Research Center (CERC), Biochemistry and Physiology Branch (Mandy Annis, Rachel Claunch, Claire McMenamy, and Ashley White). Fish biologists (CERC) Christopher Schmitt and Aida Farag provided valuable comments on an early draft.

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Conversion Factors

Multiply	By	To obtain
	Length	
millimeter (mm)	0.03937	inch (in.)
inch (in.)	25.4	millimeter (mm)
mile (mi)	1.609	kilometer (km)
	Volume	
cubic millimeter (mm^3)	3.3814×10^{-5}	ounce
deciiliter (dL)	0.02642	gallon (gal)
	Mass	
gram (gr)	0.03527	ounce, avoirdupois (oz)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:
$°F=(1.8\times°C)+32$

Abbreviations

AFS American Fisheries Society (AIFRB)

AIFRB American Institute of Fishery Research Biologists

ANOVA analysis of variance

ASIH American Society of Ichthyologist and Herpetologists

BEST Biomonitoring of Environmental Status and Trends

CERC Columbia Environmental Research Center

CF condition factor

CYP1A cytochrome P450 1A

EROD ethoxyresorufin-O-deethylase

FWS U.S. Fish and Wildlife Service

g gravitational

G:L ratio granulocytes to lymphocytes

GRH golden redhorse sucker

H&E hematoxylin and eosin

HAI health assessment index

Hb hemoglobin

HB Historic Bridge

HSI hepatosomatic index

LR Legacy Ranch

MA macrophage aggregates

MI Marshall Impoundment

NBF neutral buffered formalin

NOAA National Oceanic and Atmospheric Administration *p* probability

PAH polyaromatic hydrocarbon

PHAH planar halogenated aromatic hydrocarbons

PROC GLM general linear model procedure

SB Shady Bend

SMB smallmouth bass

USGS U.S. Geological Survey

Health Assessment and Histopathologic Analyses of Fish Collected from the Kalamazoo River, Michigan, Following Discharges of Diluted Bituman Crude Oil from the Enbridge Line 6B

By Diana M. Papoulias, Vanessa Veléz, Diane K. Nicks, and Donald E. Tillitt

Abstract

On July 25, 2010, a 30-inch diameter pipeline ruptured near Marshall, Michigan, and began discharging diluted bituman crude oil that flowed for approximately 38 miles down the Kalamazoo River. The U.S. Fish and Wildlife Service requested assistance from the U.S. Geological Survey Columbia Environmental Research Center in assessing the adverse health effects of this accident on fish at various locations in the Kalamazoo River downstream from the oil discharge. The objective was to compare fish collected from three oiled sites against fish collected from a reference site for a suite of biological indicators (bioindicators). The bioindicators of adverse health effects were selected to target multiple levels of biological organization and included an evaluation of condition, tissue histopathology, immunotoxicity, induction of CYP1A, and a necropsy-based assessment of health. The results for these bioindicators were overall similar for both species and among the three oiled sites. Most of the bioindicator results for fish from the oiled sites contrasted with and were different from the bioindicator results obtained for fish collected from a reference site above and unaffected by the oil discharge. Moreover, results from this evaluation are consistent with both laboratory studies of polyaromatic

hydrocarbon (PAH) toxicity to fish and field assessments of catastrophic oil spills or chronic PAH contamination from multiple anthropogenic sources.

Introduction

On July 25, 2010, at Enbridge Line 6B, a 30-inch diameter pipeline owned by Enbridge Energy ruptured near Marshall, Michigan, and began discharging diluted bitumen crude oil into a wetland adjacent to Talmadge Creek. The oil flowed through Talmadge Creek into the Kalamazoo River, a Lake Michigan tributary. The Kalamazoo River was in flood stage at the time of the discharge and the oil flowed into its flood plain and down the river for approximately 38 miles to Morrow Lake. The U.S. Fish and Wildlife Service (FWS) requested that the U.S. Geological Survey (USGS) Columbia Environmental Research Center (CERC) conduct a necropsy-based evaluation to aid their assessment of the adverse health effects on fish at various locations in the Kalamazoo River downstream from the oil discharge site.

The objective of this evaluation was to compare fish from these oiled sites against fish from a site that was not oiled for a suite of biological indicators (bioindicators). There is wide acceptance for the use of bioindicators to evaluate biological harm to aquatic organisms resulting from catastrophic oil spills (Martinez-Gomez and others, 2010; Law and others, 2011). The sublethal indicators of adverse effects on fish were selected based on their known association with degraded environments or polycyclic aromatic hydrocarbon (PAH) exposure. Golden redhorse (*Moxostoma erythrurum*), a benthic feeder, and smallmouth bass (*Micropterus dolomieu*), a piscivore, were the fish species chosen for collection. These fish species were collected because they represent different trophic levels and are commonly found in the affected areas of the Kalamazoo River as well as upstream and downstream from the affected area. Additionally, sucker and bass species have been commonly studied at sites used for biological monitoring, including PAH-impacted sites (Schmitt and others, 1993).

The bioindicators selected for this assessment target multiple levels of biological organization: the individual, tissue, cell, and biochemical levels. Bioindicators at the level of the individual fish included in this assessment are the biomarkers: condition, the relation of the liver weight to the body weight (hepatosomatic index [HSI]), and the calculation of a fish health index. Fish condition is commonly assessed using weight and length measurements (Blackwell and others, 2000). Variation from an expected weight for a given length may be due to nutrition, environmental quality, or stage of reproductive maturity. Abnormally small HSI values may reflect depleted energy reserves and may indicate poor fish health. Abnormally large HSI values may be associated with increased production of xenobiotic metabolizing enzymes, an increased parasite load, or other pathological changes (Schmitt and others, 1999). Health indices integrate observations of gross abnormalities during the necropsy into a single numerical value that can be scaled and used to assess general fish health (Schmitt and others, 1999).

Polycyclic aromatic hydrocarbons have been reported to suppress the immune system and therefore spleen, head kidney, and blood were examined (Hart and others, 1998; Reynaud and Deschaux, 2006; Reynaud and others, 2008; Uribe and others, 2011). In addition to spleen and head kidney histopathology, macrophage aggregates were quantified. Macrophage aggregates are collections of phagocytic macrophages containing cellular debris collected in the body and are found in fish spleen and head kidney (Fournie and others, 2001). Macrophage aggregates typically contain pigments such as hemosiderin, lipofuscin, ceroid, and melanin according to the type of degraded material engulfed. Macrophage number and size are used as biomarkers because these measurements have been determined to be associated with a number of environmental stressors including exposure to polycyclic aromatic hydrocarbons (Wolke, 1992; Agius and Roberts, 2003). Hematological biomarkers diagnostic of immune system dysfunction included leukocyte counts. Leukocyte profiles provide a prognostic evaluation of the level of stress an organism is experiencing (Davis and others, 2008). Hemoglobin was also measured; low hemoglobin is an indicator of anemia and has been associated with exposure to PAHs (Martinez and others, 2008).

Gills serve important respiratory and excretory functions that require a highly vascular and large surface area. The gill tissues are in direct contact with the surrounding water and therefore a primary site of contaminant contact and uptake. Mucus cells on gill lamellae proliferate when stimulated by irritants and a number of gill histopathologies are induced by exposure to polycyclic aromatic hydrocarbons (Martinez and others, 2008). Production of cytochrome P450 1A (CYP1A) is a well-known response to exposure to PAHs and has been determined to be produced in gills of PAH-exposed fish (Stegeman and Lech, 1991; Moore and others, 2003). In gills, the CYP1A biomarker can be detected with immunohistochemistry.

This report details the results of work by the CERC for the following:

- collection and preservation of gill, spleen, head kidney, liver, bile, and plasma from 110 fish;
- preparation of whole blood smears and conduct of differential analysis of leukocytes;
- calculation of a health assessment index;
- identification of histopathologic lesions in gill, spleen, and head kidney; and
- preservation and storage of samples for possible future analysis.

Methods

A biologist from the CERC Biochemistry and Physiology Branch was onsite August 19 and 20, 2010, to conduct necropsies and collect tissues. Michigan Department of National Resources, FWS, and Enbridge personnel collected fish using boat electrofishing, and used net pens to hold the captured fish in the river until necropsy.

Ten to 15 individuals of two fish species, a mid-water piscivore species, smallmouth bass (SMB), and a benthic sucker species, golden redhorse (GRH), were targeted for collection at four sites on the Kalamazoo River. The size of GRH targeted were 10 inches (in.) to 15 in. and the size of SMB targeted were greater than or equal to 14 in. Sites were selected to ensure a fish collection from each of the three different river divisions as segmented by Incident Command, which roughly corresponded to the degree of observed river oiling. An upstream reference fish collection was also selected. The Historic Bridge (Division C), Legacy Ranch (Division D), and Shady Bend (Division E) sites were downstream (9 miles, 22 miles, and 27 miles, respectively) from the oil discharge. The Marshall Impoundment location was upstream of the oil discharge location and served as a reference site (fig. 1).

Necropsy

Field necropsy procedures generally followed those used by USGS in the Biomonitoring of Environmental Status and Trends (BEST) program (Schmitt and others, 1999). A blood sample was obtained from the posterior caudal vein using a previously prepared heparinized needle (20 gauge) and syringe kept cold on wet ice. A part of the collected whole blood was used for blood smear slides and hemoglobin measurements. An additional part of the whole blood used for hormone and protein analyses was decanted from the syringe barrel into a heparinized vacutainer and held on wet ice. After blood collection, the fish was euthanized with a sharp blow to the head, weighed (grams [gr]), and the total length was measured (in millimeters [mm]). Visual observations were made of external features and grossly visible tissue anomalies were recorded; some abnormal tissues were dissected and preserved in 10-percent neutral buffered formalin (NBF) for histopathologic analysis. A gill arch, generally the second arch of the left gill, of each fish was removed, placed in a histo-cassette, and preserved in 10-percent NBF. The liver of each SMB was carefully removed with the gall bladder intact. The gall bladder was dissected from the liver, bile collected in a clean cryovial, and the entire liver was weighed. The gall bladders of GRH were dissected directly and bile collected. Because GRH have a diffuse liver that is difficult to accurately weigh, liver weight could not be obtained. Duplicate subsamples of the liver tissue from each fish were collected and flash frozen in a dry ice/ethanol slurry for ethoxyresorufin-O-deethylase (EROD) analysis. Liver, spleen, gonad, head kidney, and hind kidney were examined for abnormalities. A single piece of the spleen and head kidney were removed, placed in separate histo-cassettes and preserved in 10-percent neutral buffered formalin. Upon completion of the internal examination, the fish carcass and pieces of organs were wrapped in aluminum foil for proper and secure disposal. Work surfaces and instruments were cleaned with 70-percent ethanol followed with an acetone rinsing. Chilled blood samples were centrifuged at 3,000 g (gravitational force) for 15 minutes and plasma was aspirated into duplicate cryovials and flash frozen in a dry ice/ethanol slurry. Samples were stored in a secured location under appropriate preservation conditions until shipment. All samples were shipped to CERC at the end of the field sampling period and stored in a secure location under appropriate preservation conditions until analysis.

All field data were recorded on datasheets. Originals were digitally scanned at CERC, copies were sent to FWS East Lansing Field Office, and originals were archived at CERC (appendix 1). Samples collected in the field were transferred to CERC with chain-of-custody documentation (appendix 2).

Condition Factor and Hepatosomatic Index

Fulton's condition factor was calculated as the body weight (grams) x $10^5 \div$ (body length (mm))^3 (Thompson (1917). Hepatosomatic Index (HSI) was calculated as the liver weight (grams) ÷ body weight (grams) x 100. Hepatosomatic Index was calculated only for SMB.

Health Assessment Index

Numerical values were assigned to internal and external observations of lesions recorded in the field, and a necropsy-based fish health assessment index (HAI) score was calculated for each fish by summing the values for all organs (Schmitt and others, 1999). The HAI score ranges from 1 (healthy) to 220 (unhealthy). The suite of gross abnormalities selected for this assessment was chosen to be consistent with abnormalities commonly assessed in fish health monitoring programs (Fournie and others, 1996). Examples of abnormalities assessed included grossly visible disorders of the eye (exophthalmia, hemorrhage, opacity, emboli, missing), opercles (shortening, deformities, parasites), body and fin surfaces (ulcers, parasites, discolored areas or raised growths), and disorders of the gills and skeleton.

Hematology

Triplicate drops of whole blood were used to make three fresh-preparation blood smear slides. Slides were air-dried then immersed in 100-percent methanol for 10 minutes for preservation. One blood smear slide was stained and viewed for each fish to evaluate the leukocyte (white blood cell) population. Cells were stained using the three-step Quick-Dip 3 differential stain (Mercedes Medical, Sarasota, Florida). Leukocytes (lymphocytes, monocytes, and granulocytes) and thrombocytes were counted using a Nikon 90i® and NIS-Elements® digital imaging software (v 4.10; Nikon Instruments Inc., Melville, New York) at 600x or 1,000x magnification. Cell counting continued until an approximate total of 200 leukocyte and thrombocyte cells had been counted and categorized.

Hemoglobin measurements were made following manufacturer's instructions by placing a droplet of blood onto a HemoCue® cassette and inserting the cassette into a HemoCue 201+ analyzer (Brea, California).

Histopathology

Gill, spleen, and head kidney were preserved in 10-percent neutral buffered formalin. Before tissue processing, tissues were rinsed twice in HEPES (4-(2-hydroxyethyl)-1-piperazineethanesulfonic acid) buffer, once in 50-percent ethanol, and then transferred to 70-percent ethanol. Gills were decalcified with Cal-Ex II™ (Thermo Fisher Scientific, Waltham, Massachusetts) for 45 minutes. Tissues were processed and infiltrated with paraffin using a Shandon Excelsior® Tissue Processor through a typical xylene and ethanol series (Thermo Fisher Scientific). Infiltrated tissues were embedded in paraffin using a Microm® EC350-2 (Thermo Fisher Scientific) embedding center. Sections were cut at 7 microns on a Leica RM 2235 microtome (Leica Microsystems, Wetzlar, Germany). All microscopy was accomplished using a Nikon 90i with digital imaging capability. NIS Elements software was used to process and analyze digital images. The examiner made evaluations and counts without knowing from which site the fish were collected, except for the viewing of organs of a few individuals of each species from the reference site, which were used to orient and educate the examiner unfamiliar with the histomorphology of these species.

Two slides were made of each spleen of each fish. One slide was stained with hematoxylin and eosin (H&E), a general nuclear stain, and the other slide was stained with Pearl's stain (Luna, 1968) for macrophage aggregates. Macrophage aggregates for each fish were quantified by area and number in five fields of view at 20x and reported as a fraction of the total area of tissue viewed and as the average area of an individual macrophage aggregate (MA). Pigments associated with MAs and whether MAs were loose or clustered into centers were noted. Spleens were evaluated for presence or absence of lipid deposits, necrosis, fibrosis, and parasites; identification of parasites was not attempted. The prominence of lymphoid tissue was scored from 1 to 3 with 1 being low, 2 being moderate, and 3 being high prevalence; scores of individual fish were averaged to obtain a site score for each species.

Head kidney tissue sections were stained with H&E (Luna, 1968). Head kidney was evaluated for (1) presence or absence of parasites; (2) MAs; (3) enlarged blood vessels; (4) increased leukocytes; (5) interrenal cell hyperplasia, pyknosis, and vacuolation; and (6) chromaffin cell proliferation and vacuolation. Five individuals of each species from each site were evaluated.

Gills were evaluated for lesions, mucus cells, and for immunohistochemical staining of cytochrome P450 1A. Sections for evaluation of lesions were stained with H&E (Luna, 1968). Lesions were scored for occurrence and severity as follows: 0 equals none, 1 equals low, 2 equals moderate, 3 equals high. Scores were summed for each fish species and lesion type and percent of fish with a lesion was reported. Mucus cells were specifically stained with periodic acid Schiff and alcian blue (pH 2.5) and counted on five secondary lamellae (Alvarado and others, 2006). Numbers of mucocytes were normalized to total length along lamellae on which cells were counted. Gill sections were semiquantified for CYP1A staining. Paraffin sections of gill tissue for CYP1A were deparaffinized and rehydrated before heat-induced antigen epitope retrieval following the citrate buffer method (http://www.ihcworld.com/_protocols/epitope_retrieval/citrate_buffer.htm). A mouse anti-cod CYP1A antibody (Biosense Laboratories, Bergen, Norway), previously demonstrated to be broadly cross-reactive among fish species, was applied following the vendor's suggestions for use in immunohistochemistry (Ueng and others, 1992). Gill showing positive CYP1A staining was semiquantified by counting the areas of positive staining on five primary lamellae for five fish from each species from each site. In cases where more than five lamellae were attached to the gill arch and present on the slide, all were counted and a correction factor applied.

Additional Samples

Additional samples, collected but not analyzed, are being stored at CERC. Liver samples collected for EROD, blood samples collected for hormone or protein analysis, and bile samples for biomarkers of PAH exposure were stored at -80 degrees Celsius (^{o}C) at CERC. An additional 19 bile samples collected by FWS were included for storage with the samples CERC collected.

Statistics

All measurements were tested for significant differences among sites by one-way (site as fixed effect) Analysis-of-Variance (ANOVA) using a general linear model procedure (PROC GLM) in SAS v.9.3 (SAS Institute, Inc., Cary, North Carolina). Significance level used to judge statistical significance was p=0.05. When no sex-related differences (Student's t-test) were detected for a measurement, data from both sexes were combined. Percent thrombocytes and leukocytes were log-transformed for statistical analyses. Condition factor, HSI, and ratio of leukocytes were arcsine transformed. If measurements did not meet assumptions of normality and homogeneity of variance after transformation, a Kruskal-Wallis rank test was used. The percentages of fish with spleen parasites or with a specific splenic or gill lesion were analyzed for differences between the reference site and the sites downstream from the oil discharge by computing an odds ratio with a chi-square statistic. No statistics were provided on gill scores. Significance level used to judge statistical significance was p=0.05. Only summary descriptive statistics are provided for CYP1A immunohistochemistry in gill tissue because staining conditions were not optimal. This endpoint was added late in the study and after tissues had been field-collected. For optimal staining, preservation of gills should have followed a different procedure than was followed in this study. Results indicate presence or absence of CYP1A induction and relative intensity among sites.

All research was conducted in accordance with the procedures described by the American Society of Ichthyologist and Herpetologists (ASIH), American Fisheries Society (AFS), and American Institute of Fishery Research Biologists (AIFRB), "Guidelines for Use of Fishes in Field Research" (American Fisheries Society and others, 2004); and with all CERC guidelines for the humane treatment of test organisms during culture and experimentation.

Results

A total of 110 fish were collected for necropsy: 64 adult females, 45 adult males, and one juvenile. The targeted number of fish for each species (15) was collected at every site except Shady Bend where only 10 fish of each species were collected because of field sampling time constraints (table 1). Greater numbers of females than males of both species were collected at all sites except Legacy Ranch, although ratios of males to females were close to one except at Marshall Impoundment for both species and at Shady Bend for golden redhorse (table 1). No site-specific significant differences were observed in lengths of males and of females of both species or weights of smallmouth bass (table 1); however, site-specific differences in weights of GRH females were observed. Female GRH were heaviest at Historic Bridge and Marshall Impoundment and weighed the least at Shady Bend (table 1).

Condition Factor

Condition factors (CF) did not differ between the sexes in either species at any site. Overall, fish from the oiled sites, Legacy Ranch and Shady Bend, had significantly smaller CFs than those from the reference site, Marshall Impoundment (table 2). Condition factors for SMB, but not GRH, from Historic Bridge were also less than at Marshall Impoundment (table 2).

Hepatosomatic Index

There were no significant differences in HSI between male and female SMB; therefore, the data were combined. Hepatosomatic index was greatest for SMB from Historic Bridge and least for those at Marshall Impoundment the reference site (table 3).

Health Assessment Index

Fish from the oiled sites generally had more anomalies and lesions, and thus greater HAI scores, than those from the reference area. Marshall Impoundment was the only site at which there were significant sex-related differences, in both species, of the health assessment index (table 4). This statistical difference between the sexes may be because fewer males than females, of each species, were captured and available for evaluation at Marshall Impoundment in contrast to the other sites (except GRH at Shady Bend) which had equal numbers of males and females. To be consistent among sites, HAI scores were calculated for each site and species with the sexes combined. Marshall Impoundment fish had the lowest HAI scores compared to the other sites (table 4). Scores tended to be numerically higher in GRH than smallmouth bass. The few anomalies observed on fish from Marshall Impoundment included those associated with the eyes, body surface, and fins. During visual assessment, the fish from sites downstream from the oil discharge had relatively more lesions on these same areas of the body and, in addition, had lesions on their gills.

Hematology

Hemoglobin

Mean hemoglobin values ranged from 2.7 to 6.2 gr/dL (grams/deciliter) in both species and sexes, collectively. Golden redhorse from Historic Bridge had the smallest hemoglobin values. Hemoglobin values for SMB did not differ significantly among sites. Hemoglobin concentrations in male and female GRH from Historic Bridge were lower than at other sites; however, a statistically significant difference was found only with females from Marshall Impoundment and with females from Legacy Ranch (table 5).

Leukocytes and thrombocytes

Significant differences in leukocytes, but not thrombocytes, were found between the fish collected at sites below the oil discharge and those collected from the reference site. Percent lymphocytes of GRH from Historic Bridge and Legacy Ranch, the two sites closest to the oil discharge, were statistically, but likely not biologically, smaller than for fish from Marshall Impoundment, whereas lymphocytes of GRH from Shady Bend were greater (table 6). Granulocytes and monocytes of GRH were not significantly different between Marshall Impoundment and the affected sites (table 6). In contrast to GRH, more lymphocytes and fewer granulocytes were counted in blood of SMB from Historic Bridge and Legacy Ranch compared to SMB from Marshall Impoundment (table 6). Monocytes were slightly and significantly elevated in SMB from Shady Bend relative to those from Marshall Impoundment (table 6). The ratio of granulocytes to lymphocytes was different between the two species but similar between the sexes within a species at most sites (table 6). Ratios for GRH were significantly larger at Legacy Ranch and smaller at Shady Bend compared to Marshall Impoundment (table 6). Ratios for SMB were significantly smaller at all sites for both sexes except for females at Shady Bend.

Head Kidney

Lesions in head kidney were minor and not remarkable across species and sites. Histopathology of head kidneys of fish from the reference site was similar to that observed in head kidneys of fish from the oiled sites.

Spleen

Numbers or sizes of MAs in spleen tissue of fish from sites downstream from the discharged oil were larger than those for MAs of fish from the reference site, Marshall Impoundment. Macrophage aggregates in spleen tissues of SMB were significantly larger in size in fish from Historic Bridge and Shady Bend than those fish from Marshall Impoundment and Legacy Ranch (table 7); however, average

MA size in spleen tissues did not differ significantly among sites for GRH (table 8). Total MA area as a fraction of the area of spleen examined was greater in GRH, but not SMB, from Historic Bridge compared to fish from Marshall Impoundment (tables 7 and 8). Additionally, both species from Shady Bend had a greater total MA area than those from Marshall Impoundment (tables 7 and 8). Numerically, fish from oiled sites had more MAs than did fish from the Marshall Impoundment unaffected by the oil discharge; however, this relation was only significant for GRH with Historic Bridge and Legacy Ranch sites (tables 7 and 8).

Macrophage aggregates in all fish contained varying amounts (not quantified) of hemosiderin and lipofuscin/ceroid pigments. The most commonly observed pigment was hemosiderin. Macrophage aggregates from Historic Bridge fish contained melanin, but melanin was not observed in fish from any other site. Qualitatively, the density of pigments in MAs for both species followed a high to low pattern as follows: Historic Bridge > (greater than) Legacy Ranch > Shady Bend >Marshall Impoundment. Most of the MAs in all fish were present as encapsulated centers, although greater than 30 percent of GRH from Historic Bridge and Legacy Ranch also had many loose macrophage aggregates. Loose MAs are more typical of the type of MA found in soft-rayed fishes (that is, GRH) than in spiny-rayed fish (that is, SMB). Loose MAs may also indicate a more recent appearance of an MA before formation of an encapsulated center.

Splenic parasite numbers were variable between species and among sites downstream from the oil discharge relative to the reference site. Parasites were commonly found in SMB spleens but were uncommon in golden redhorse. Smallmouth bass from Shady Bend had more parasites than bass from Marshall Impoundment but fewer parasites were found in SMB from Historic Bridge compared to Marshall Impoundment (figs. 2 and 3). No parasites were observed in GRH from Marshall Impoundment and occurred in 10 percent or less of GRH from the other sites (fig. 2).

Scores for prominence of lymphoid tissue were lower for fish from oiled sites compared to those from Marshall Impoundment for both species but significantly different only for the golden redhorse (figs. 4 and 5).

Splenic lesions were more numerous in fish from sites downstream from the oil discharge than in fish from the reference site. No fibrosis or necrosis and a low incidence of lipid deposits were observed in Marshall Impoundment fish in contrast to fish from oiled sites. Lipid deposits were not observed in GRH from Marshall Impoundment but this splenic lesion was observed in a few SMB at this site. The incidence of lipid deposits, necrosis, and fibrosis varied between fish species from oiled sites and among oiled sites but overall were significantly greater in both species at all oiled sites relative to the reference site. Relative to other lesions, lipid deposits in SMB and fibrosis in GRH were the more prominent lesions (figs. 6, 7, 8, 9).

Gill

Sites downstream from where oil was discharged had more fish with gill lesions than did the reference site where fish were not exposed to oil. Overall, seven types of gill lesions were observed: aneurisms, blood congestion, epithelial cell hyperplasia, epithelial lifting, curling of secondary lamellae, fusion of secondary lamellae, and parasites. At no site were all fish completely lesion-free, and one or more fish of each species at a site was observed to have at least one of these lesions (table 9). No gill lesions were found in 7 of 30 fish from Marshall Impoundment, 1 of 30 fish from Historic Bridge, and 4 of 30 fish from Legacy Ranch. Only 1 of the 20 fish from Shady Bend had no gill lesions (table 9). Epithelial lifting and hyperplasia, aneurisms, congestion, and parasites were significantly more prevalent in gills of GRH from the oiled sites than in those from the reference site, and these effects were more severe in fish from the oiled sites than for fish from the reference site (table 9). Gill aneurisms, blood congestion, curling, and fusion were significantly more prevalent in SMB, at some but not all oiled sites, than those at the reference site (table 9).

Mucous producing cells and cells producing the CYP1A protein were more numerous on gills of fish at the sites downstream from the oil discharge than at the reference site. Significantly fewer mucocytes were measured at the reference site, Marshall Impoundment, than at the three oiled sites for both species (figs. 10 and 11). CYP1A produced by gill cells, as detected by immunohistochemistry staining, was observed in fewer GRH individuals, fewer cells were stained in fish of both species, and staining was overall much lighter in fish from Marshall Impoundment as compared to fish from the oiled sites (table 10). Two individuals of each species from Historic Bridge had extensive areas of CYP1A-positive staining that was unlike any other fish examined.

Discussion

Three weeks after the Enbridge Line 6B discharged oil into Talmadge Creek and the Kalamazoo River, two species of fish were collected from three locations downstream from the spill and from an upstream reference site. The objective of these collections was to compare fish from oiled sites to fish from a site that was not oiled for a suite of bioindicators. These indicators of adverse effects on fish were selected based on their known association with degraded environments or reported association with PAH exposure.

Interpretation of some bioindicators (for example, condition) can be affected by large differences in size, maturity, and age. There were no species-specific length differences among sites although GRH females from Legacy Ranch and Shady Bend tended to weigh less than GRH from Historic Bridge or Marshall Impoundment. Fish were collected after the reproductive season, and as a result during field necropsy, gonads of all individual fish were determined to be at an intermediate stage between ripe and spent. Age was not determined for these fish, but an estimate of age of SMB based on local data of the relation between length and age was made (Jay Wesley, Michigan Department of Natural Resources, oral commun., December 2012). Estimated age of SMB was variable at all sites, but on average females were younger (3–5 years old) than males (5–6 years old) (table 11). No age-length data were available to make a comparable estimate of age for golden redhorse. The HAI scores from Marshall Impoundment indicate that the reference site provided sufficiently healthy fish and therefore bioindicator results at this site could be reliably used as benchmarks of normal when evaluating results from sites downstream from the oil discharge.

Timing and location of fish collections in relation to when and where the oil was discharged may have affected the severity of the bioindicator response. Polycyclic aromatic hydrocarbons are also common in aquatic environments found near human activity. Therefore, a background level of response is to be expected. Fish for this health assessment were collected 3 weeks after the pipeline break and between 9 and 27 miles below the point of oil discharge. Total extractable hydrocarbon (TEH) concentrations measured in Kalamazoo River surface water were elevated downstream from the oil discharge point relative to concentrations upstream from the discharge (Stephanie Millsap, US Fish and Wildlife Service, oral commun., December 2012). Concentrations of TEH in surface water decreased during the 3 weeks before fish collections but remained elevated compared to upstream concentrations at the time of fish collections. Consistently, surface water at Historic Bridge, 9 miles below the discharge, contained slightly greater concentrations of TEHs than Legacy Ranch and Shady Bend, which were another 13–18 miles downstream (Stephanie Millsap, FWS, oral commun., December, 2012). Heavier fractions of the diluted bitumen from this spill sank to the bottom of the river and became associated with sediments. At the time that the fish were collected, the submerged oil was likely acting as a source of polycyclic aromatic hydrocarbons (PAHs) to benthic invertebrates, the overlying water, and aquatic organisms in this stretch of river. Because of the discharge of oil, the Kalamazoo River was closed to the public, but the oil spill response resulted in heavy boat traffic from john boats with small outboard motors and from airboats, every day until well after fish were sampled for this study.

General health metrics (CF, HSI, HAI score) consistently indicated poorer health of fish from sites downstream from the oil discharge relative to fish from the reference site. Moreover, these results were comparable to other studies that used these same biomarkers to assess fish health after exposure to PAHs. Lower condition factors were reported for flatfishes from a location near an oil refinery terminal and for sea bass exposed in the laboratory to crude oil (Kahn, 2003; Kerambrun and others, 2012). The flatfish in Kahn's (2003) evaluation also had heavier livers and therefore increased HSI values and an increased incidence of epidermal lesions especially on skin, gills, and fins compared to flatfish from a reference site. Increased numbers of fish with fin and gill lesions and the severity of those lesions were the variables that most strongly affected the high HAI scores in Kalamazoo River fish downstream from the oil discharge site. Nevertheless, the degree to which habitat differences between the impoundment, where the reference fish were collected, and the more freely flowing river reaches where the oiled fish were collected cannot be evaluated solely from the data obtained in this study. Condition, weight, and length data from SMB and GRH fish surveys on the Kalamazoo River before the Enbridge oil discharge incident may provide useful comparative information for example.

Organ-related differences were similar across species and across sites, and are consistent with literature reports of PAH effects. Macrophage aggregates were either larger or more numerous in fish from oiled sites than fish from the reference site. This same response of MAs has been reported for fish collected from chronically oiled locations (Haensly and others, 1982; Marty and others, 1999; Kahn, 2003). Macrophage aggregates are a good indicator of the general stress of a fish, which may or may not be due to contaminant exposure. In this study, the fish were exposed to contaminants and may also have been experiencing stress from the disturbance of the response activities. Marty and others (1999) attributed increased MAs to the old age of Pacific herring (*Clupea pallasii*) caught in the vicinity of the Exxon Valdez oil spill. Throughout the life of a fish, MAs collect and isolate debris that cannot be metabolized and eliminated; therefore, older fish would tend to accumulate higher concentrations of debris and MAs (Fournie and others, 2001). In the present assessment, age estimated from length (only for SMB) was similar across sites and linear regression analyses did not support a relation between MAs and age (data not shown).

Spleen lesions, gill lesions, and mucocytes on gill lamellae were all more prevalent in fish from sites downstream from the oil discharge compared to reference fish. Gill lesions, aneurisms, and blood congestion were consistently elevated in fish from sites downstream from the oil discharge and these same types of lesions were observed in fish exposed to water-soluble diesel oil (Simonato and others, 2008). Kahn (2003) found flatfishes from marine areas contaminated with oil had severe gill epithelial cell hypertrophy and fusion, lesions which were observed infrequently or less severely in Kalamazoo River fish perhaps because of the shorter period of exposure. In contrast, gill mucocytes were elevated in both the present study and Kahn (2003) and also Haensly and others (1982) perhaps because these cells are a first line of defense against irritants.

The biomarker CYP1A was clearly identified in gills of both species of fish from all Kalamazoo River sites; however, the response was strongest at sites downstream from the oil discharge site. Cytochrome P450 1A expression is the classic biomarker for chemicals that work through the aryl hydrocarbon receptor biochemical pathway (Whyte and others, 2000). These chemicals include PAHs as well as planar halogenated aromatic hydrocarbons (PHAH). The CYP1A protein is produced primarily in fish hepatocytes and to a lesser extent in kidney and gill (Tuvikene, 1995). Immunohistochemistry of fish gills using antibodies to CYP1A has been successfully used to identify field exposure of fishes to polycyclic aromatic hydrocarbons (Moore and others, 2003). Most recently, it was used to demonstrate a graded exposure response over time to oil spilled during the Deepwater Horizon accident (Dubansky and others, 2013). The low intensity of CYP1A expression at the reference site is not unexpected because of the prevalence and stochastic widespread distribution of PAHs in aquatic habitats.

The blood diagnostic indicators in the present assessment were somewhat inconsistent between species and among sites. This is perhaps explained by taxonomic differences in fish physiology and species-specific habitat and trophic characteristics. Hemoglobin concentrations within normal ranges are diagnostic of general health and the values measured in this study are consistent with values reported in the literature for seemingly healthy fish (Powers and others, 1939; Schmitt and others, 1993). Anemia is indicated by abnormally low hemoglobin concentrations but the etiology of this condition varies (Heath, 1995). A few reports associate lowered hemoglobin concentrations in fish with exposure to crude oil or water-soluble diesel oil (Alkindi and others, 1996; Kahn, 2003; Simonato and others, 2008; Hedayati and Jahanbakhshi, 2012). In contrast, fish collected in a petroleum-contaminated area by Kahn (1998) did not have lowered hemoglobin concentrations, but did have increased levels of hemosiderin compared to reference fish. Exposure of fish to oil is postulated to cause lysis of blood cells and thus the release of hemosiderin, a pigment commonly found in macrophage aggregates (Alkindi and others, 1996). The qualitative MA pigment observations in the present study are consistent with this effect. Although hemoglobin concentrations from the site closest to the oil discharge were statistically less than those from the reference site only for GRH females, together the hemoglobin concentrations and hemosiderin biomarkers support an exposure to oil in the present evaluation.

Parasite infestation was also somewhat inconsistent among species and sites. The effect of environmental stressors on parasitism in fish can be variable and complex in part because the stressor may increase the fishes' vulnerability to parasitic infection and have adverse effects directly on the parasite at some stage in its lifecycle. Moreover, ectoparasites are thought to increase and endoparasites to decrease in fish exposed to chemical contaminants (Kahn, 2003 and references therein). In the present fish health evaluation, macroscopically visible ectoparasites were infrequent on both species; however, fin erosion, which was frequently noted in fish from sites downstream from the oil discharge, may have been due to microscopic ectoparasites that would not have been seen during necropsy. Also, gill parasites were not noted during necropsy but were observed during histopathology evaluations and were increased in GRH at Historic Bridge, the site closest to the oil discharge. Compared to fish from the reference site, splenic endoparasites in SMB were lowest at the two sites closest to the oil discharge and greatest at the site farthest from the oil whereas, in GRH, splenic parasites were sparse in fish from oiled sites and absent in reference fish. These results can be interpreted as a general response to stress given the limited macroscopic evaluation of parasite infestation of the collected fish from the Kalamazoo River, the relatively brief time the fish would have been exposed to the discharged oil, and potential habitat differences between the free-flowing stretch of the river and the impounded reservoir where the reference fish were caught. Another factor to be considered is that the presence of significant boat traffic as part of the oil spill response may have also stressed fish in the areas downstream from the discharge.

Polycyclic aromatic hydrocarbons are generally expected to suppress the fish immune system. The characteristic leukocyte profile reported for fish exposed to PAHs includes a decrease in lymphocytes (Kahn, 2003; Hedayati and Jahanbakhshi, 2012; McNeil and others, 2012); however, there is an incomplete understanding of the mechanisms of immunotoxicity and species-specific effects (Reynaud and Deschaux, 2006). Immunosuppression can hinder fish from fighting bacterial and viral infections, and this can lead to lesions on the external surfaces such as the frayed fins and gill hyperplasia observed in fish from some of the Kalamazoo River oiled sites (McNeil and others, 2012). The spleen is a primary immune system organ in fish and the location of lymphocyte production. On average, spleen lymphoid tissue appeared reduced in fish from Kalamazoo River sites downstream from the oil discharge. A similar observation was made for anterior kidney of fish exposed to select PAH compounds (Hart and others, 1998; Holladay and others, 1998); however, Reynaud and Deschaux (2006) presented contradictory results wherein PAHs stimulated and suppressed lymphocyte proliferation depending on chemical, dose, and species. Counts and ratios of circulating leukocytes in the blood are also common measurements for assessing general environmental stress effects on fish (Davis and others, 2008). A popular diagnostic of general stress is the ratio of circulating granulocytes to lymphocytes wherein granulocytes increase and lymphocytes decrease. In contrast to PAH-induced immunosuppression, general stress-related lymphopenia is usually accompanied by an increase in granulocytes (Davis and others, 2008). The immune system response patterns observed in fish from the Kalamazoo River study are mixed. Circulating lymphocytes were only slightly depressed in GRH at the Historic Bridge site and granulocytes and the granulocyte-to-lymphocyte (G:L) ratio were not different when compared to GRH from the reference site. Golden redhorse from Legacy Ranch did show the general stress pattern in G:L ratio relative to GRH from Marshall Impoundment. In comparison to the reference site, Shady Bend (the site farthest from the discharge; fig. 1) GRH had a slight increase in lymphocytes, no difference in granulocytes, and a resulting decrease in the G:L ratio. Golden redhorse monocytes were few and not significantly different among sites, suggesting that the fish were not likely diseased. In contrast to the blood results, splenic lymphoid tissue was significantly reduced in all GRH from Kalamazoo River oiled sites. Together, GRH immune system suppression attributed to PAH exposure is suggested by the qualitatively observed lower lymphocyte production in the spleen but at the time of sampling was not reflected by the distribution of leukocyte types in the blood.

Results for SMB are even more difficult to interpret. In contrast to GRH, circulating lymphocytes in SMB from the two sites closest to the oil discharge tended to be greater compared to lymphocyte levels in SMB from the reference site. Granulocytes were fewer in SMB at the two sites closest to the discharge and G:L ratios less, excepting that for the female from Shady Bend, compared to the SMB from the reference site. Monocytes, which phagocytize foreign particles, were elevated only in SMB at Shady Bend and this is consistent with the elevated splenic parasites observed for SMB at this site. Assuming the leukocyte profile in fish from Marshall Impoundment is representative of normal, it seems that PAH effects an increase in SMB lymphocytes. The fact that splenic lymphoid tissue was not statistically reduced in SMB at oiled sites as it was for GRH may be related to these leukocyte results. Although differences in blood leukocyte patterns exist between the oiled fish and the reference fish, a lack of information on the normal and stressed profiles in SMB and GRH hinders a clear interpretation of these immunological endpoints.

A number of health parameters, from the biochemical level to the individual fish level were evaluated in fish collected in the Kalamazoo River downstream from the Enbridge Line 6B discharge point. The results for these bioindicators were overall similar for both species and among the three oiled sites. Most of the bioindicator results for fish from the oiled sites contrasted with and were significantly different from the bioindicator results obtained for fish collected from a reference site above and unaffected by the oil discharge. Moreover, results from this evaluation are consistent with both laboratory studies of PAH toxicity to fish and field assessments of catastrophic oil spills or chronic PAH contamination from multiple anthropogenic sources. The present fish health evaluation has demonstrated that fish at sites as far as 27 miles downstream from the Enbridge Line 6B pipeline discharge point were less healthy than fish from above the discharge point, showed signs of generalized stress, and showed effects in specific endpoints that were consistent with the adverse effects expected from exposure to crude oil.

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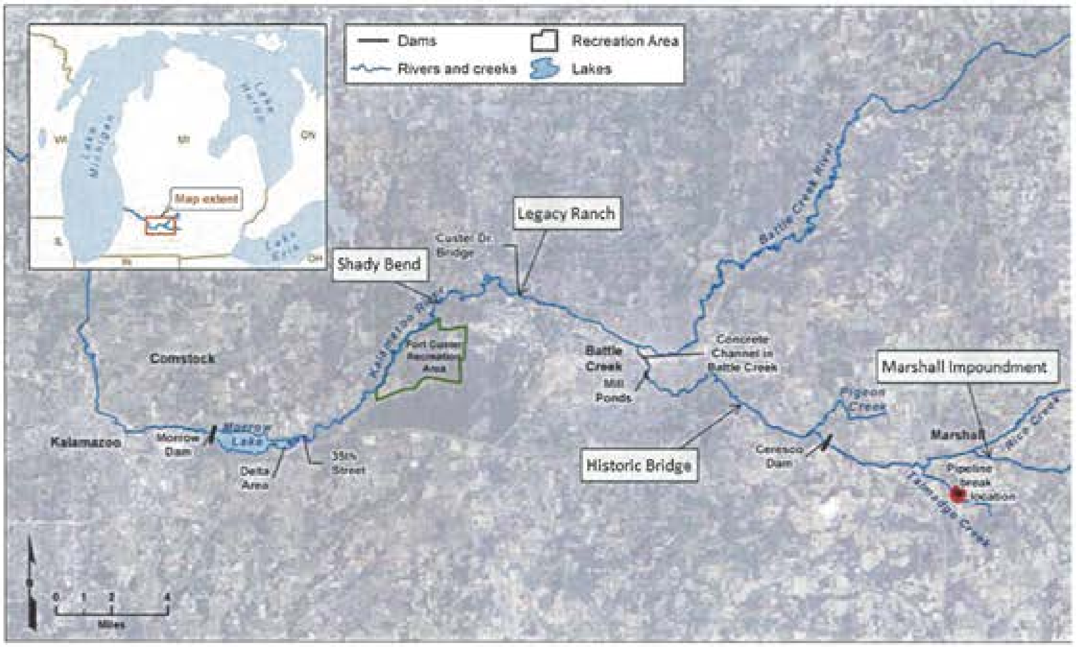

Figure 1. Approximate location of sample sites along the Kalamazoo River in Michigan. The Enbridge Line 6B pipeline break occurred near Talmadge Creek, which enters the Kalamazoo River downstream from Marshall, Michigan. The upstream reference area is in the Marshall Impoundment (MI), and the sampling sites within the Kalamazoo River downstream from the oil discharges are Historic Bridge (HB) Legacy Ranch (LR), and Shady Bend (SB).

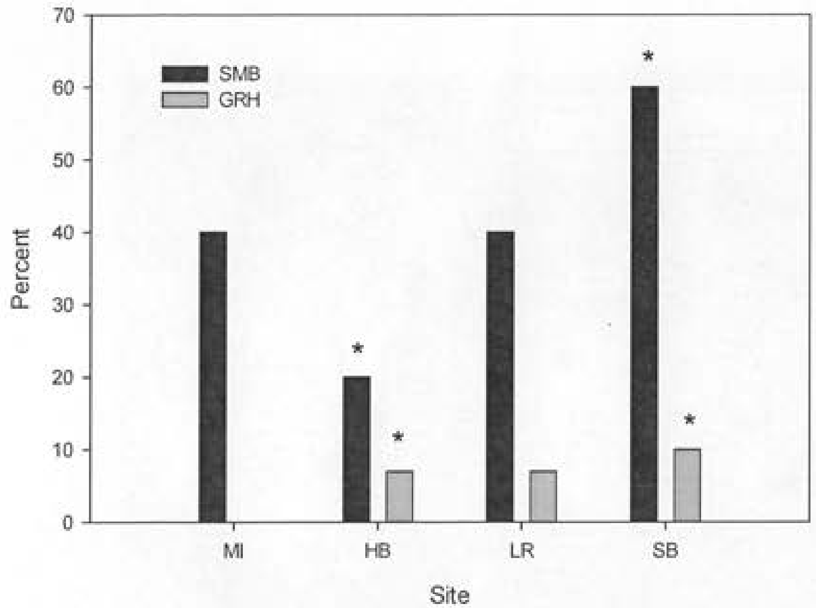

Figure 2. Percent of smallmouth bass (SMB) and golden redhorse (GRH) with splenic parasites from Historic Bridge (HB), Legacy Ranch (LR), Shady Bend (SB) and a reference site, Marshall Impoundment (MI). An asterisk above a bar indicates a significant difference ($p \leq 0.05$) between fish of a given species at the oiled site and at the reference site. [$\leq$ is less than or equal to]

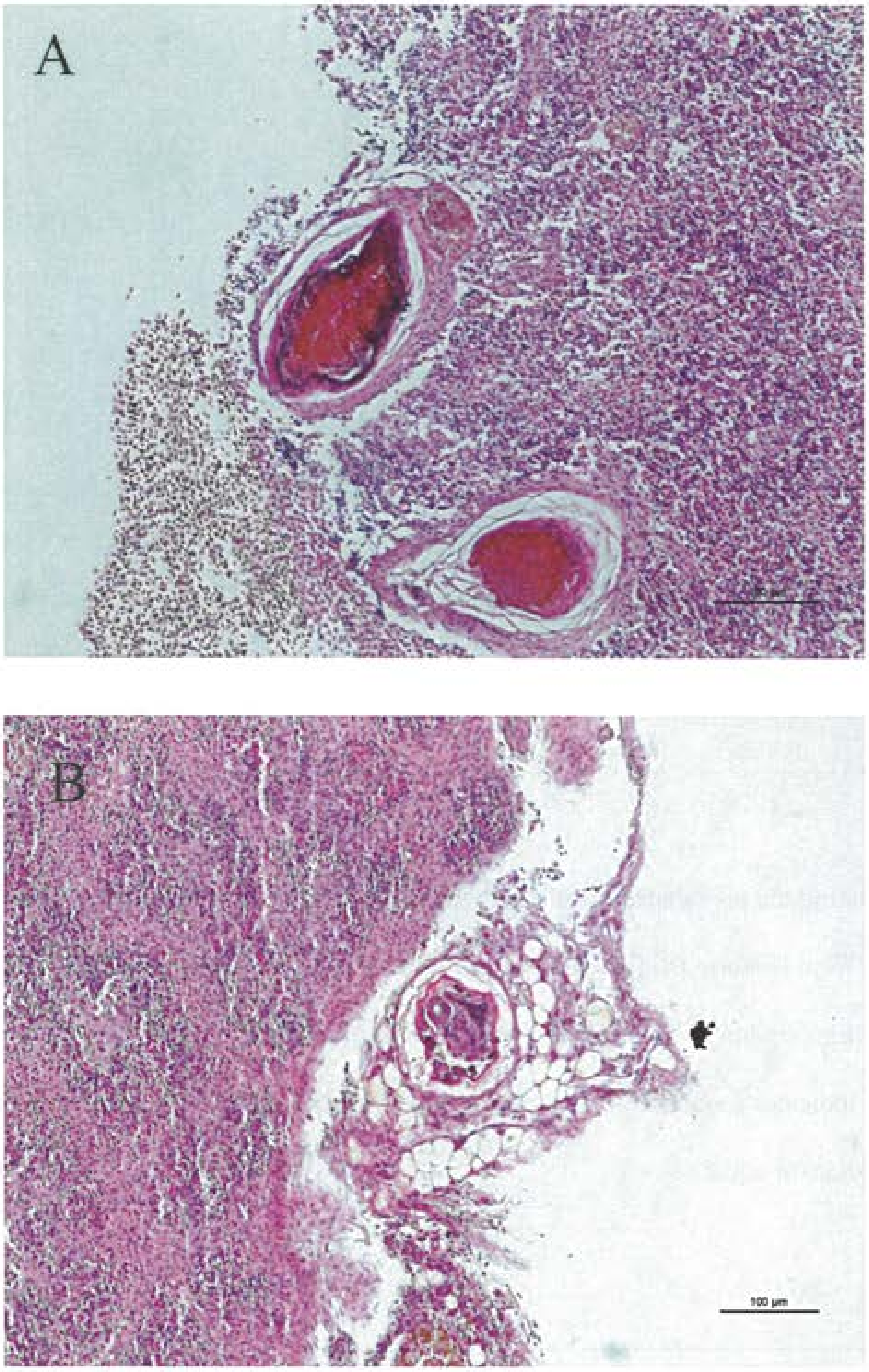

Figure 3. Example of parasites found in histological sections of smallmouth bass spleen from *A*, Marshall Impoundment and *B*, Shady Bend. Scale bar represents 100 microns.

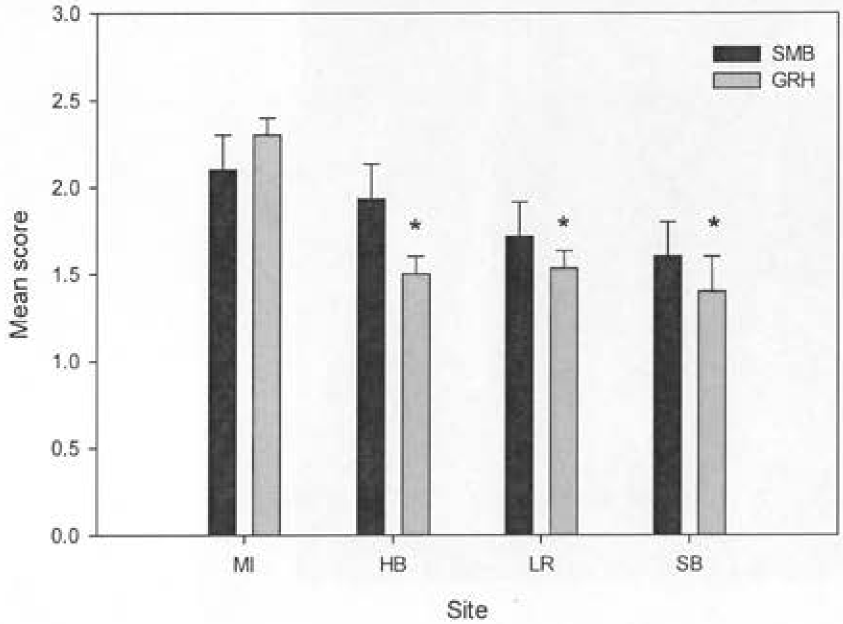

Figure 4. Mean score indicating the prevalence of splenic lymphoid tissue for smallmouth bass (SMB) and golden redhorse (GRH) from Historic Bridge (HB), Legacy Ranch (LR), Shady Bend (SB), and a reference site, Marshall Impoundment (MI). Error bar represents one standard error (SE) of the mean. An asterisk above a bar indicates a significant difference ($p \leq 0.05$) between the respective species and the reference site.[$\leq$ is less than or equal to]

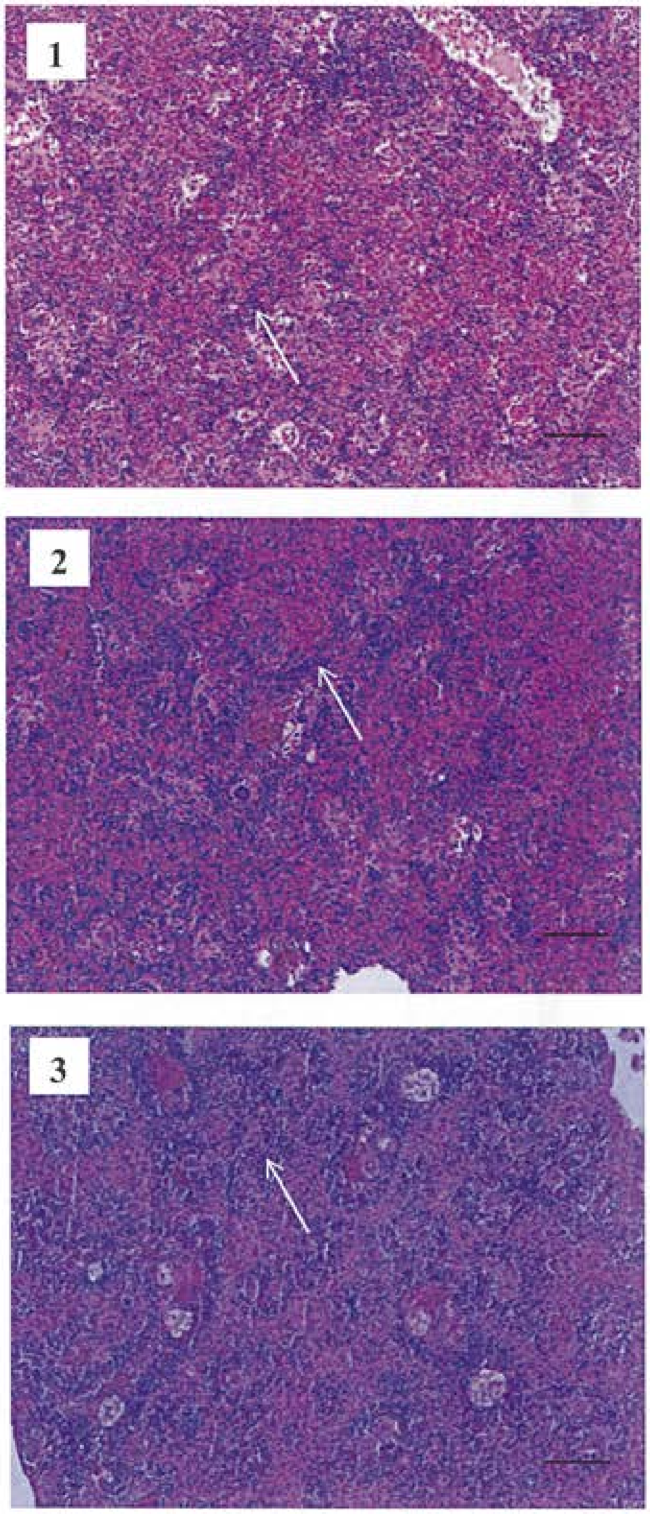

Figure 5. Histological sections of golden redhorse sucker spleen. Spleens were classified 1–3 according to the amount of lymphoid tissue (arrows) present. Scale bar represents 100 microns.

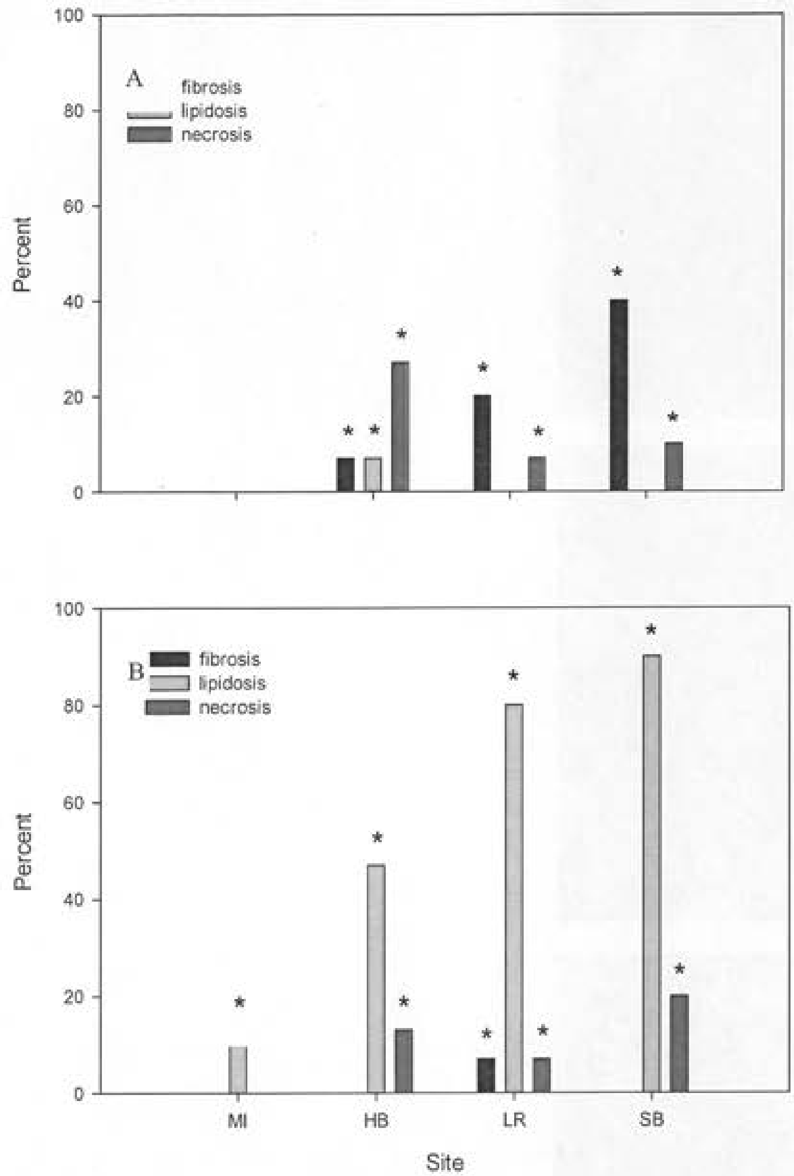

Figure 6. Percent of *A*, golden redhorse sucker and *B*, smallmouth bass with fibrosis, lipid deposits, or necrosis in spleens from three sites Historic Bridge (HB), Legacy Ranch (LR), and Shady Bend (SB) affected by the Enbridge Line 6B oil discharge and a reference site, Marshall Impoundment (MI). An asterisk above a bar indicates a significant difference ($p \leq 0.05$) between the oiled site and the reference site. [$\leq$ is less than or equal to]

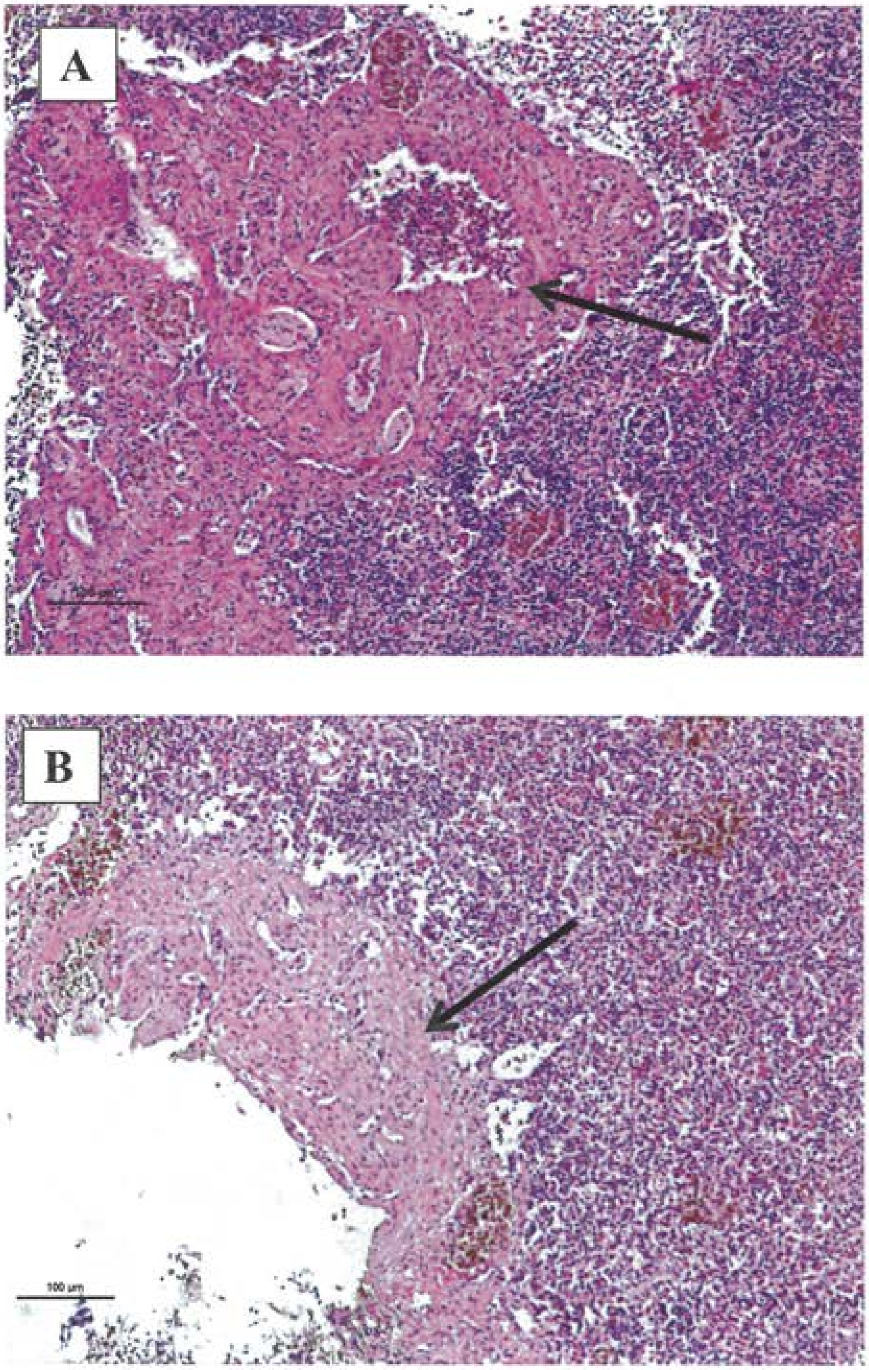

Figure 7. Example of fibrosis (arrow) in histological section of spleen of golden redhorse sucker from *A*, Shady Bend, and *B*, Historic Bridge. Scale bar represents 100 microns.

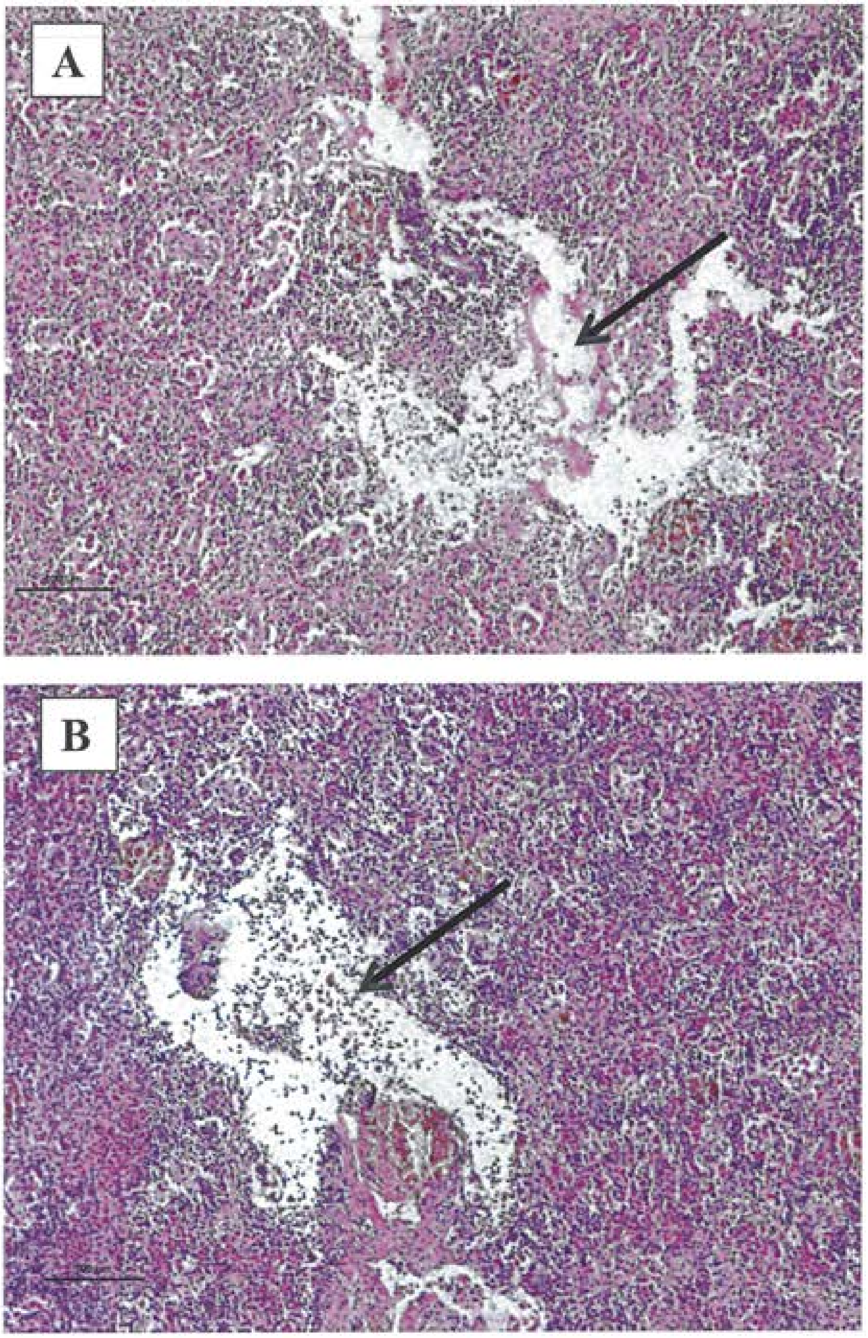

Figure 8. Example of necrosis (arrow) in histological section of spleen of golden redhorse sucker from *A*, Legacy Ranch and *B*, Historic Bridge. Scale bar represents 100 microns.

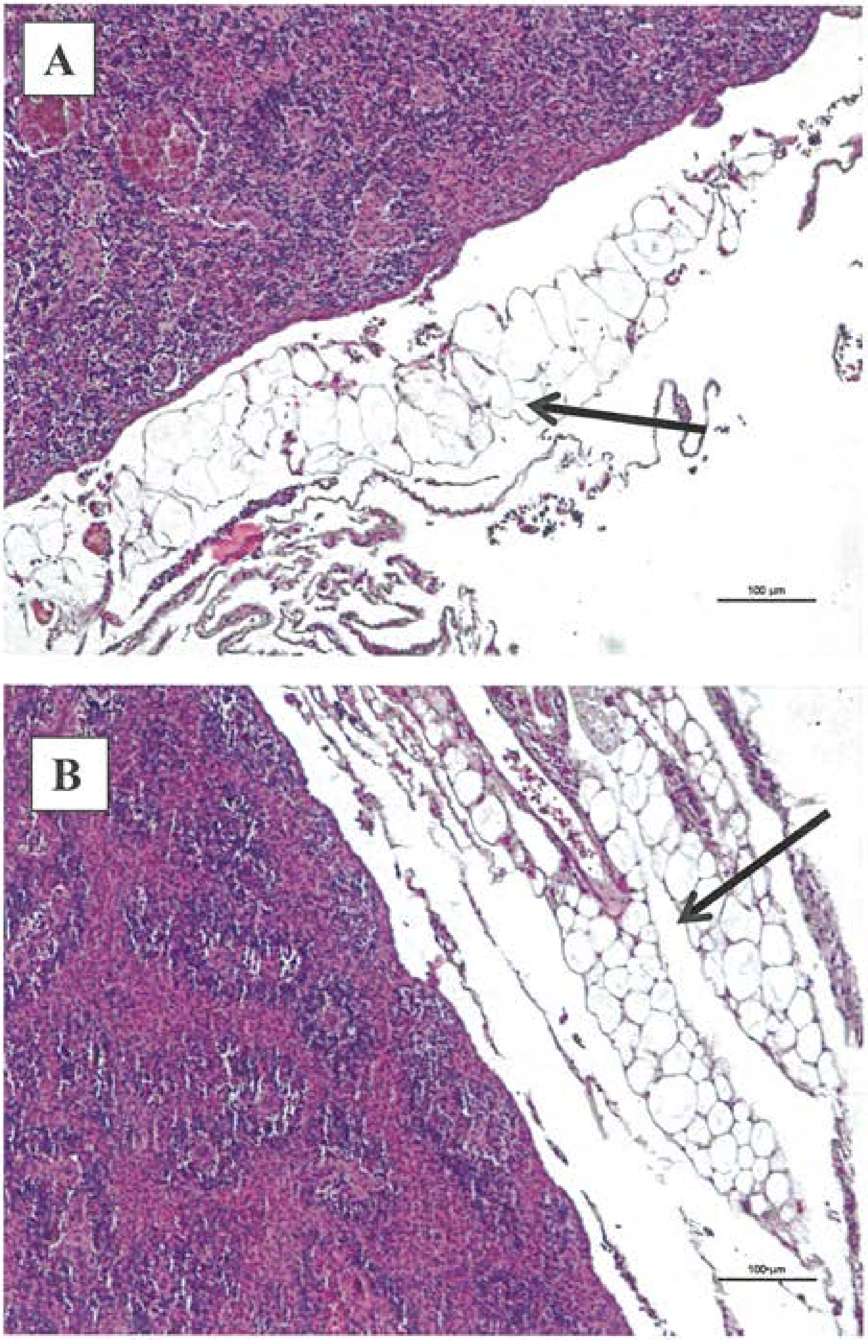

Figure 9. Example of lipid (arrow) encapsulating spleen in histological section from golden redhorse sucker from *A*, Marshall Impoundment and *B*, Shady Bend. Scale bar represents 100 microns.

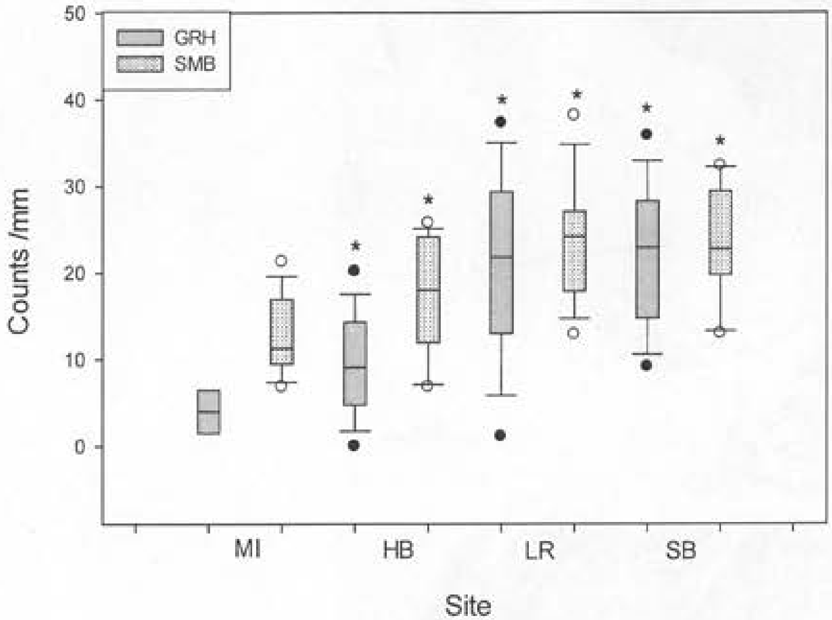

Figure 10. Mucus cell counts per millimeter gill filament in golden redhorse sucker (GRH) and smallmouth bass (SMB) from Historic Bridge (HB), Legacy Ranch (LR), Shady Bend (SB), and a reference site, Marshall Impoundment (MI). The boundary of the box closest to zero indicates the 25th percentile, a line within the box marks the median, and the boundary of the box farthest from zero indicates the 75th percentile. Whiskers (error bars) above and below the box indicate the 90th and 10th percentiles, and symbols outside the box indicate outlying points. An asterisk above a bar indicates a significant difference ($p \leq 0.05$) between the respective species and the reference site. [≤ is less than or equal to]

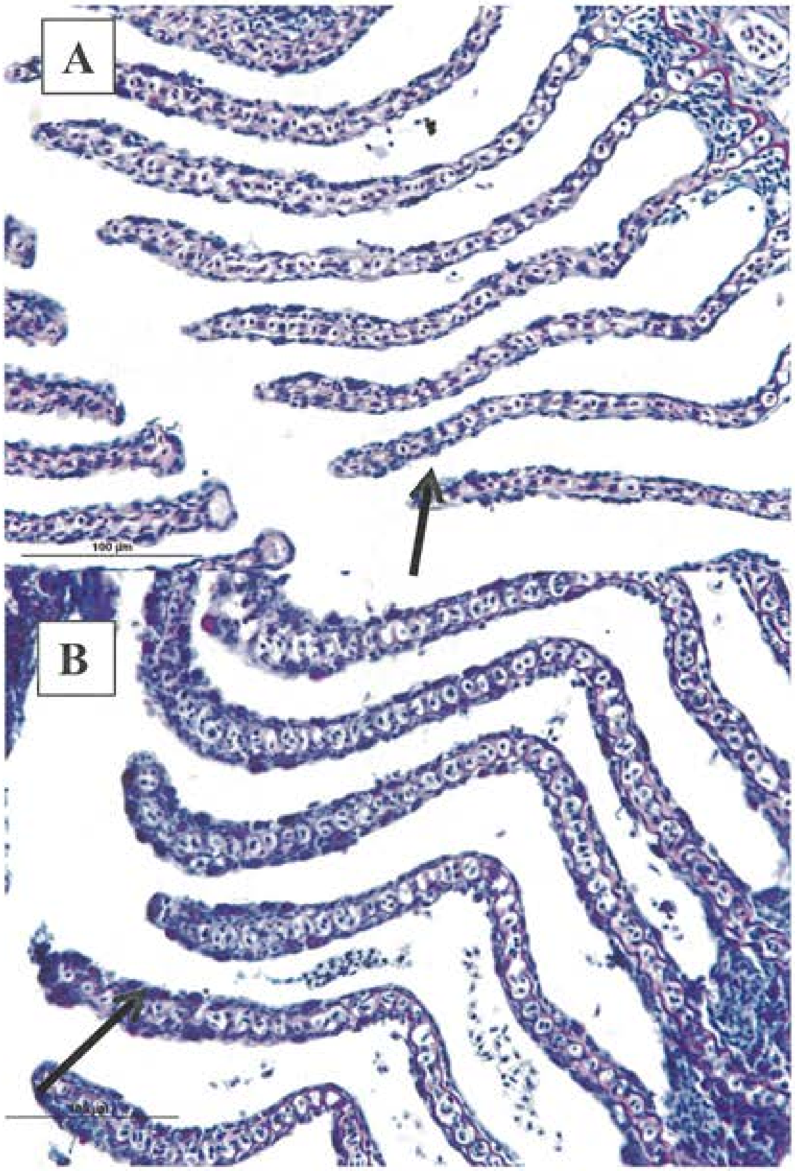

Figure 11. Example of mucus cells (arrows) on secondary lamellae in histological sections of gills from golden redhorse sucker collected from *A*, Marshall Impoundment and *B*, Historic Bridge. Scale bar represents 100 microns.

Table 1. Mean size of smallmouth bass (SMB) and golden redhorse sucker (GRH) from Marshall Impoundment (reference site) and three sites affected by the Enbridge Line 6B oil discharge. [millimeter = mm; number = N; grams = gr; standard deviation = SD]

Site	Species	Sex	N	Length (mm) mean (SD)	Weight (gr) mean (SD)	Significant differences[1]
Marshall Impoundment	SMB	M	5	339 (50)	602 (264)	
	SMB	F	10	315 (62)	475 (260)	
	GRH	M	3	391 (28)	634 (102)	
	GRH	F	12	427 (23)	827 (177)	AC
Historic Bridge	SMB	M	7	364 (71)	706 (364)	
	SMB	F[2]	7	283 (53)	261 (122)	
	GRH	M	7	371 (67)	570 (263)	
	GRH	F	8	440 (50)	933 (262)	A
Legacy Ranch	SMB	M	8	318 (63)	401 (185)	
	SMB	F	7	267 (43)	263 (118)	
	GRH	M	8	370 (26)	486 (94)	
	GRH	F	7	412 (27)	686 (166)	BC
Shady Bend	SMB	M	5	345 (61)	690 (297)	
	SMB	F	5	398 (78)	514 (398)	
	GRH	M	2	377 (28)	410 (85)	
	GRH	F	8	324 (29)	635 (134)	B

[1] Males and females were significantly different ($p \leq 0.05$) in length and weight and were therefore analyzed separately. The only site-related effects were for weight of GRH females. The same letter indicates no significant site differences ($p > 0.05$) among weights of GRH females.
[2] An eighth female was captured but not included because it was juvenile.

Table 2. Mean condition factor (CF) of smallmouth bass (SMB) and golden redhorse sucker (GRH) from Marshall Impoundment (reference site) and three sites affected by the Enbridge Line 6B oil discharge. [number = N; standard deviation = SD]

Site	Species	Sex	N	CF mean (SD)	Significant differences[1]
Marshall Impoundment	SMB	M	5	1.46 (0.17)	A
	SMB	F	10	1.40 (0.07)	
	GRH	M	3	1.06 (0.06)	A
	GRH	F	12	1.05 (0.07)	
Historic Bridge	SMB	M	7	1.36 (0.09)	B
	SMB	F	7	1.15 (0.33)	
	GRH	M	7	1.05 (0.04)	A
	GRH	F	8	1.06 (0.07)	
Legacy Ranch	SMB	M	8	1.22 (0.25)	B
	SMB	F	7	1.32 (0.12)	
	GRH	M	8	0.95 (0.05)	B
	GRH	F	7	0.97 (0.12)	
Shady Bend	SMB	M	5	1.21 (0.09)	B
	SMB	F	5	1.27 (0.12)	
	GRH	M	2	0.99	B
	GRH	F	8	0.99 (0.03)	

[1] Sexes were not significantly different ($p>0.05$) and were combined within a species for significance testing among sites. The same letter within a species indicates no significant differences ($p>0.05$).

Table 3. Mean hepatosomatic index (HSI) for smallmouth bass (SMB) from Marshall Impoundment (reference site) and three sites affected by the Enbridge Line 6B oil discharge. [number = N; standard deviation = SD]

Site	Species	Sex	N	HSI mean (SD)	Significant differences[1]
Marshall Impoundment	SMB	M	5	0.54 (0.06)	A
	SMB	F	10	0.53 (0.09)	
Historic Bridge	SMB	M	7	0.75 (0.09)	B
	SMB	F	7	1.19 (1.02)	
Legacy Ranch	SMB	M	8	0.75 (0.54)	AC
	SMB	F	7	0.57 (0.07)	
Shady Bend	SMB	M	5	0.63 (0.07)	C
	SMB	F	5	0.57 (0.11)	

[1] Sexes were not significantly different and were combined for significance testing among sites. The same letter indicates no significant difference (p>0.05).

Table 4. Mean scores for the Health Assessment Index (HAI) for smallmouth bass (SMB) and golden redhorse sucker (GRH) from Marshall Impoundment (reference site) and three sites affected by the Enbridge Line 6B oil discharge. [(number = N; standard deviation = SD].

Site	Species	Sex	N	HAI mean (SD)	Significant differences[1]
Marshall Impoundment	SMB	M	5	0 (0)	A
	SMB	F	10	1 (3)	
	GRH	M	3	23 (23)	A
	GRH	F	12	6 (9)	
Historic Bridge	SMB	M	7	26 (11)	B
	SMB	F	7	30 (0)	
	GRH	M	7	59 (17)	B
	GRH	F	8	60 (11)	
Legacy Ranch	SMB	M	8	36 (11)	C
	SMB	F	7	33 (5)	
	GRH	M	8	43 (10)	C
	GRH	F	7	44 (21)	
Shady Bend	SMB	M	5	48 (22)	C
	SMB	F	5	36 (5)	
	GRH	M	2	25 (7)	C
	GRH	F	8	45 (18)	

[1]Sexes (except fish from Marshall Impoundment) were not significantly different ($p>0.05$) and were combined within a species for significance testing among sites. The same letter within a species indicates no significant difference ($p>0.05$).

Table 5. Mean hemoglobin (Hb) for smallmouth bass (SMB) and golden redhorse sucker (GRH) from Marshall Impoundment (reference site) and three sites affected by the Enbridge Line 6B oil discharge. [grams/deciliter = gr/dL; number = N; standard deviation = SD]

Site	Species	Sex	N	Hb[1] (gr/dL) mean (SD)	Significant differences[2]
Marshall Impoundment	SMB	M	5	5.8 (0.5)	
	SMB	F	10	5.4 (0.8)	
	GRH	M	3	3.7 (0.8)	
	GRH	F	11	5.0 (0.6)	A
Historic Bridge	SMB	M	7	6.2 (1.4)	
	SMB	F	7	5.6 (1.4)	
	GRH	M	6	2.7 (0.9)	
	GRH	F	8	3.0 (1.7)	B
Legacy Ranch	SMB	M	8	6.0 (1.3)	
	SMB	F	7	4.7 (1.8)	
	GRH	M	7	4.4 (1.3)	
	GRH	F	7	5.2 (1.1)	A
Shady Bend	SMB	M	5	6.2 (1.2)	
	SMB	F	4	5.2 (0.8)	
	GRH	M	2	4.4	
	GRH	F	7	4.3 (0.9)	AB

[1]Hemoglobin values were corrected following Clark and others (2008).
[2]Sexes were not significantly different ($p>0.05$) for both species and all stations except GRH from Marshall Impoundment and SMB from Legacy Ranch. Sexes were analyzed separately within a species for significance testing among sites. Significant differences ($p\leq0.05$), found only among GRH females, are indicated by different letters.

Table 6. Thrombocytes, leukocytes, and the ratio of granulocytes (G) to lymphocytes (L) in blood smears of smallmouth bass (SMB) and golden redhorse sucker (GRH) from a Marshall Impoundment (reference site) and three sites associated with the Enbridge Line 6B oil discharge. Monocytes, granulocytes, and lymphocytes are reported as a percent of total leukocytes. Thrombocytes are reported as a percent of total thrombocytes plus leukocytes. [number = N; stand deviation = SD].

				Leukocytes[1]			
Site	Species Sex	N	Thrombocytes[1] mean (SD)	Monocytes mean (SD)	Lymphocytes mean (SD)	Granulocytes mean (SD)	G:L Ratio[2]
Marshall Impoundment	SMB F	10	3 (4)	3 (4)	72 (12)	26 (11)	0.32
	SMB M	5					0.53
	GRH F	12	15 (8)	1 (1)	93 (8)	6 (7)	0.07
	GRH M	3					
Historic Bridge	SMB F	7	2 (2)	1 (1)	94 (4)*	4 (4)*	0.05 *
	SMB M	7					0.05 *
	GRH F	8	16 (13)	1 (1)	91 (5)*	7 (5)	0.08
	GRH M	7					
Legacy Ranch	SMB F	7	1 (2)	1 (1)	96 (3)*	3 (3)*	0.03 *
	SMB M	8					0.04 *
	GRH F	7	24 (16)	1 (1)	86 (10)*	13 (9)	0.16 *
	GRH M	8					
Shady Bend	SMB F	5	3 (2)	5 (7)*	81 (17)	14 (12)	0.36
	SMB M	5					0.07 *
	GRH F	8	17 (11)	2 (2)	97 (3)*	2 (2)	0.02 *
	GRH M	2					

[1]Sexes were not significantly different ($p>0.05$) and were combined within a species for significance testing among sites. Within a column, means with an asterisk are significantly different ($p<0.05$) from respective species from Marshall Impoundment.

[2]Sexes were only significantly different ($p\leq0.05$) for SMB. Smallmouth bass sexes were analyzed separately for significance testing among sites whereas, GRH were combined for the analysis. Means with an asterisk are significantly different ($p<0.05$) from respective species and sex from Marshall Impoundment.

Table 7. Macrophage aggregates (MA) in spleens of smallmouth bass from a reference site (Marshall Impoundment) and three sites affected by the Enbridge Line 6B oil discharge. Within a column, means with the same letter are not significantly different ($p>0.05$). [square microns = µm2; number = N; standard deviation = SD, > is greater than]

Site	N	Total MA Area / μm^2 mean ± SD (range)		Size of MA (μm^2) mean ± SD (range)		Number MAs / μm^2 mean ± SD (range)	
Marshall Impoundment	15	0.008±0.008 (0–0.03)	A	1106±895 (0–3044)	A	$4.9 \times 10^{-6} \pm 4.5 \times 10^{-6}$ (0–1.3×10^{-5})	A
Historic Bridge	14	0.02±0.01 (0–0.05)	AB	2523±1529 (834–6695)	B	$5.6 \times 10^{-6} \pm 2.5 \times 10^{-6}$ (1.90×10^{-6}–1.0×10^{-5})	A
Legacy Ranch	15	0.01±0.008 (0–0.02)	AB	1505±845 (0–3946)	A	$7.2 \times 10^{-6} \pm 5.3 \times 10^{-6}$ (0–2.3×10^{-5})	A
Shady Bend	10	0.02±0.01 (0.01–0.05)	B	3190±1484 (1222–6059)	B	$7.7 \times 10^{-6} \pm 2.6 \times 10^{-6}$ (3.3×10^{-6}–1.1×10^{-5})	A

Table 8. Macrophage aggregates (MA) in spleens of golden redhorse sucker from a reference site (Marshall Impoundment) and three sites affected by the Enbridge Line 6B oil discharge. Within a column, means with the same letter are not significantly different (p>0.05). [square microns = μm2; number = N; standard deviation = SD, > is greater than]

Site	N	Total MA Area / μm^2 mean ± SD (range)	Size of MA (μm^2) mean ± SD (range)	Number MAs / μm^2 mean ± SD (range)
Marshall Impoundment	15	0.02±0.01 A (0–0.04)	1232±567 A (0–2202)	$1.1\times10^{-5}\pm6.9\times10^{-6}$ B (0–2.5×10^{-5})
Historic Bridge	15	0.05±0.06 BC (0–0.28)	2788±3674 A (365–16120)	$1.7\times10^{-5}\pm6.2\times10^{-6}$ A (4.0×10^{-6}–2.5×10^{-5})
Legacy Ranch	15	0.02±0.01 AC (0.01–0.06)	1330±379 A (764–2127)	$1.9\times10^{-5}\pm1.0\times10^{-5}$ A (8.8×10^{-6}–4.2×10^{-5})
Shady Bend	10	0.03±0.02 BC (0–0.07)	1714±1197 A (0–4809)	1.7×10^{-5} 8.9×10^{-6} AB (0–3.6×10^{-5})

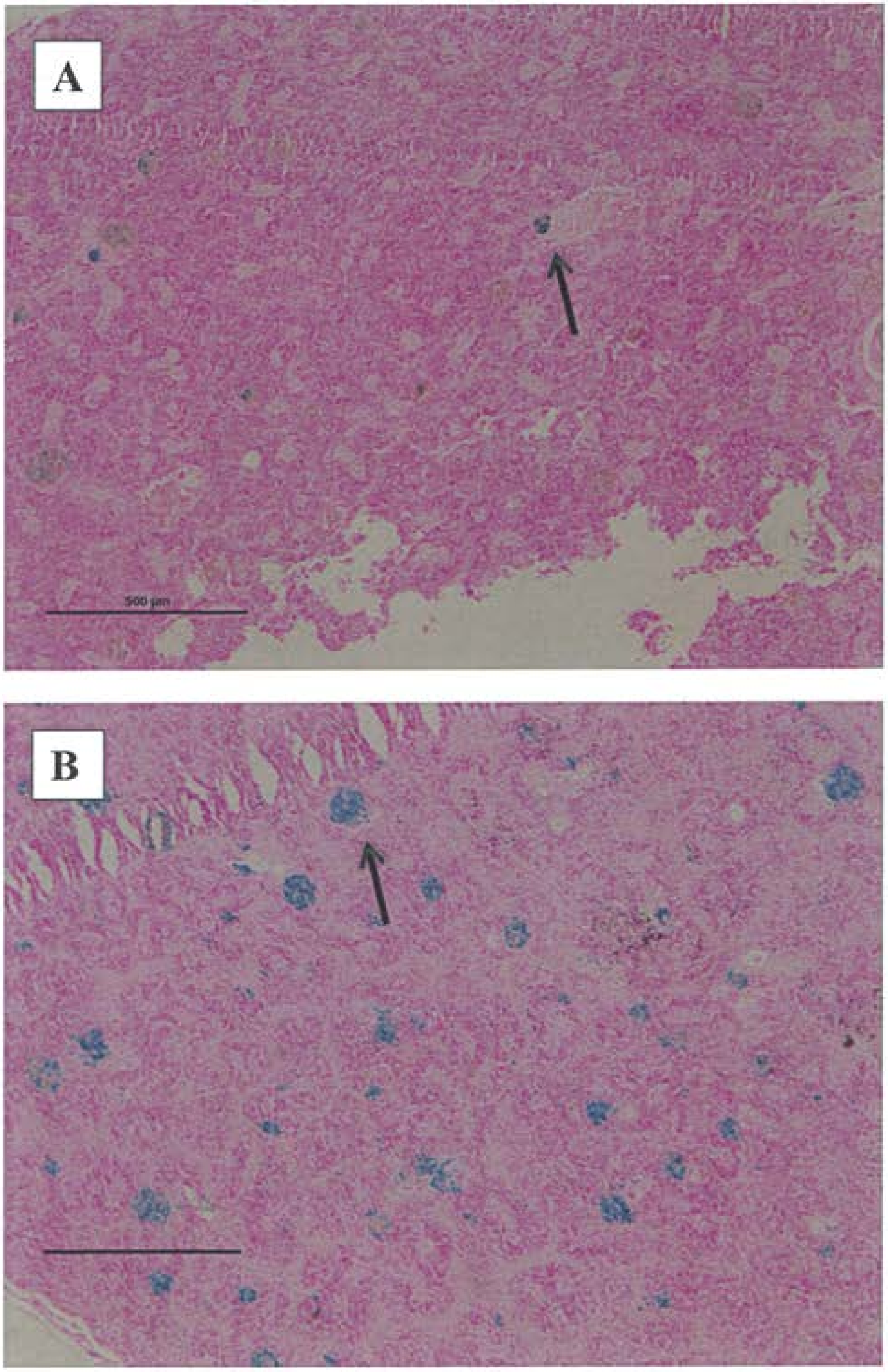

Figure 12. Example of macrophage aggregates (arrow) in histological section of spleen from smallmouth bass from *A*, Marshall Impoundment and *B*, Shady Bend. Scale bar represents 500 microns.

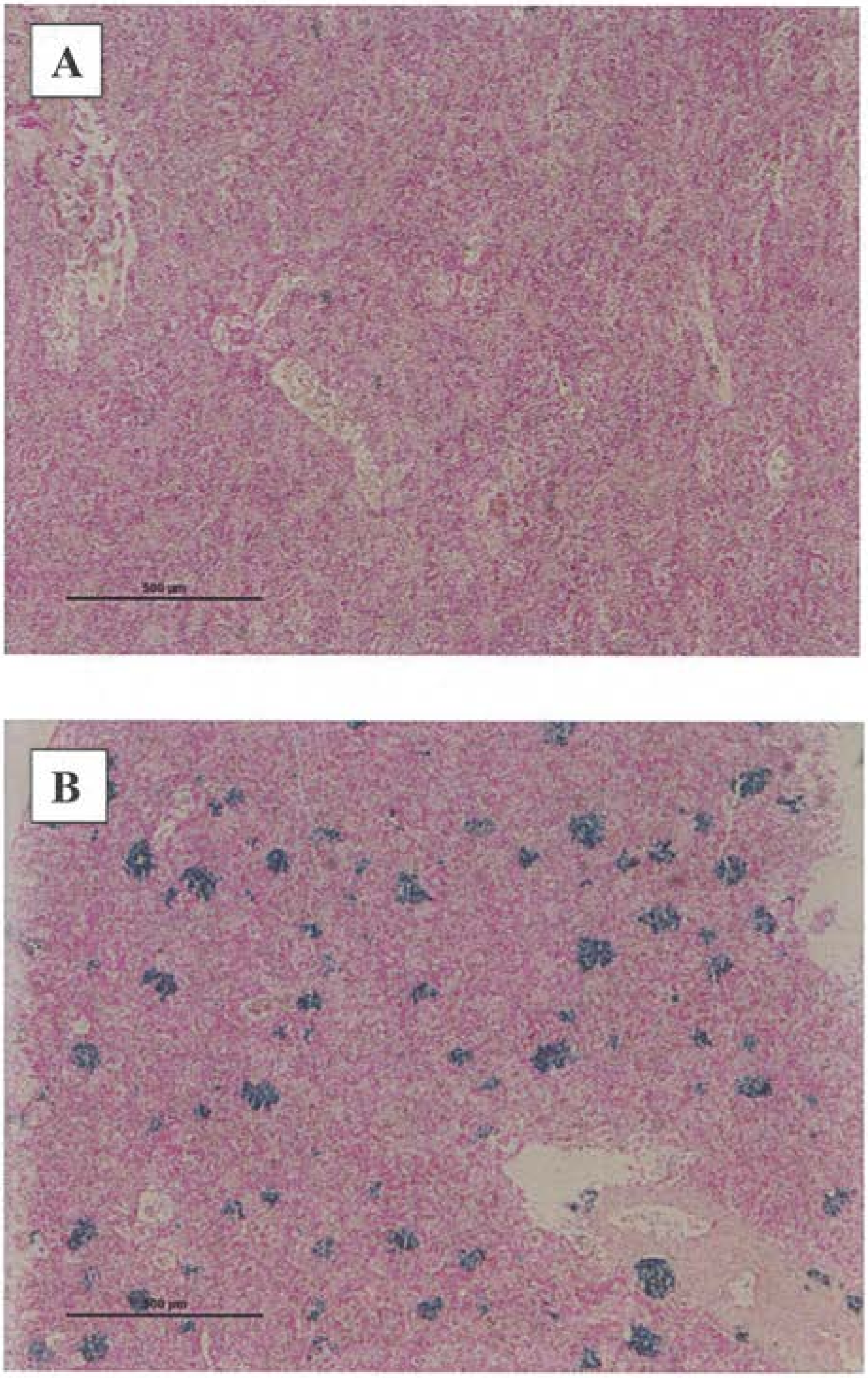

Figure 13. Example of macrophage aggregates (arrow) in histological section of spleen from golden redhorse from *A*, Marshall Impoundment and *B*, Historic Bridge. Scale bar represents 500 microns.

Table 9. Gill lesions in fish from Marshall Impoundment (**MI**), Historic Bridge (HB), Legacy Ranch (LR), and Shady Bend (SB) as percent of fish with a lesion (Percent) and severity score (Score; see text for explanation; maximum score is 45 and a higher number indicates lesion is more severe). Percent fish from oiled sites within brackets [ ] are significantly different ($p \leq 0.05$) from the reference site, Marshall Impoundment. [≤ is less than or equal to]

	Golden redhorse sucker		Smallmouth bass	
Lesion	Percent (**MI**-HB-LR-SB)	Score (**MI**-HB-LR-SB)	Percent (**MI**-HB-LR-SB)	Score (**MI**-HB-LR-SB)
Epithelial Lifting	**13**-[27-47-50]	**2**-11-12-12	**20**-20-[33]-10	**3**-3-5-2
Epithelial hyperplasia	**47**-[67]-53-0	**8**-19-12-0	**60**-53-60-40	**11**-11-12-9
Aneurism	**33**-[60-60-70]	**10**-19-16-17	**27**-[60]-27-20	**6**-19-4-5
Curling	**40**-33-40-40	**9**-5-7-8	**7**-13-0-[20]	**1**-2-0-1
Congestion	**33**-40-[53-50]	**6**-12-12-11	**13**-[27-27-50]	**3**-5-4-9
Parasites	**7**-[20-0-0]	**1**-4-0-0	**0**-0-0-0	**0**-0-0-0
Fusion secondary lamellae	**13**-7-7-[0]	**2**-1-2-0	**7**-[20]-7-[0]	**1**-4-1-0

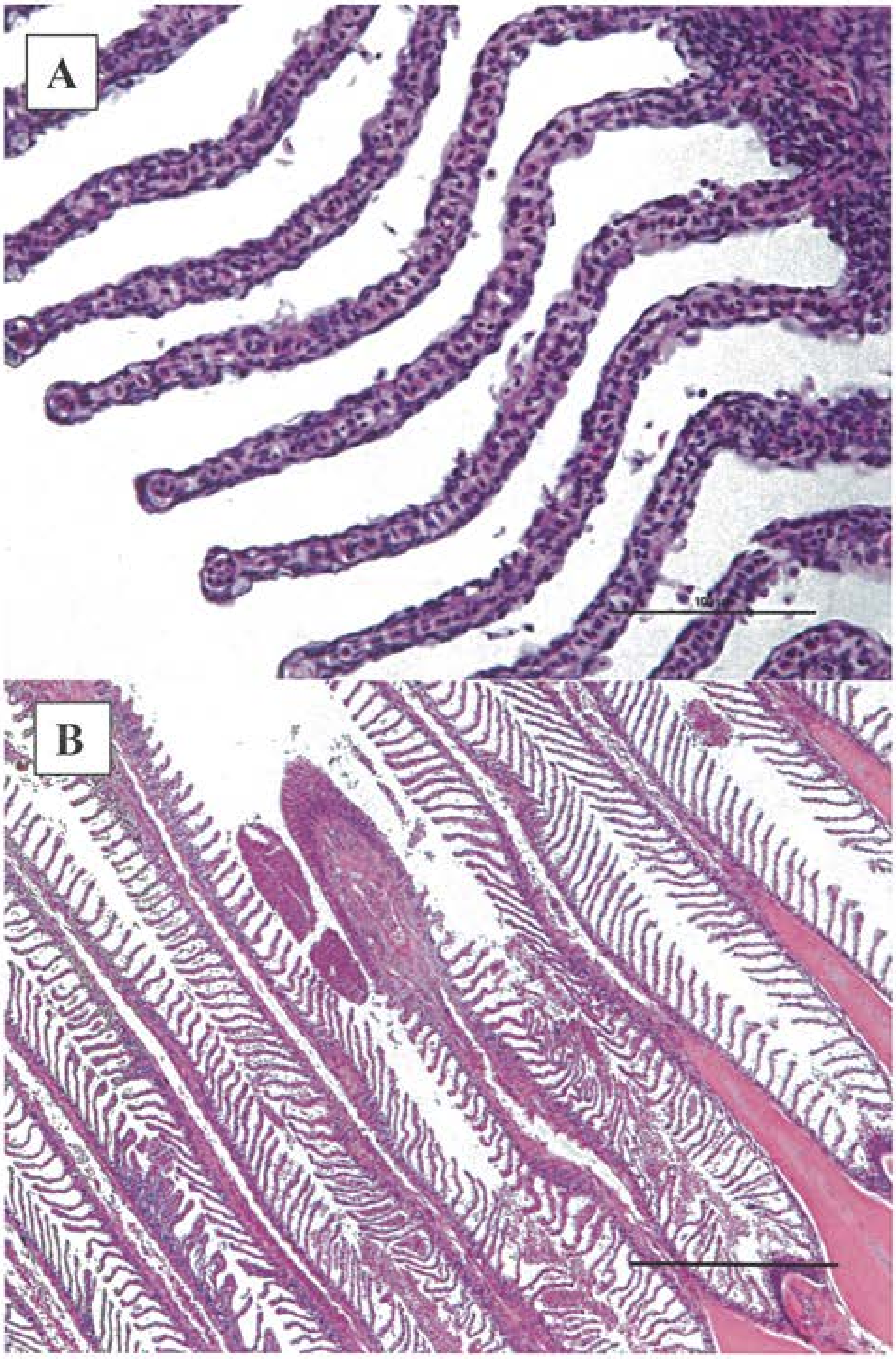

Figure 14. Example of histological section of *A*, normal gill secondary lamellae and a section *B*, showing many primary lamellae one of which is shortened. Scale bar in top panel represents 100 microns and scale bar in bottom panel represents 500 microns.

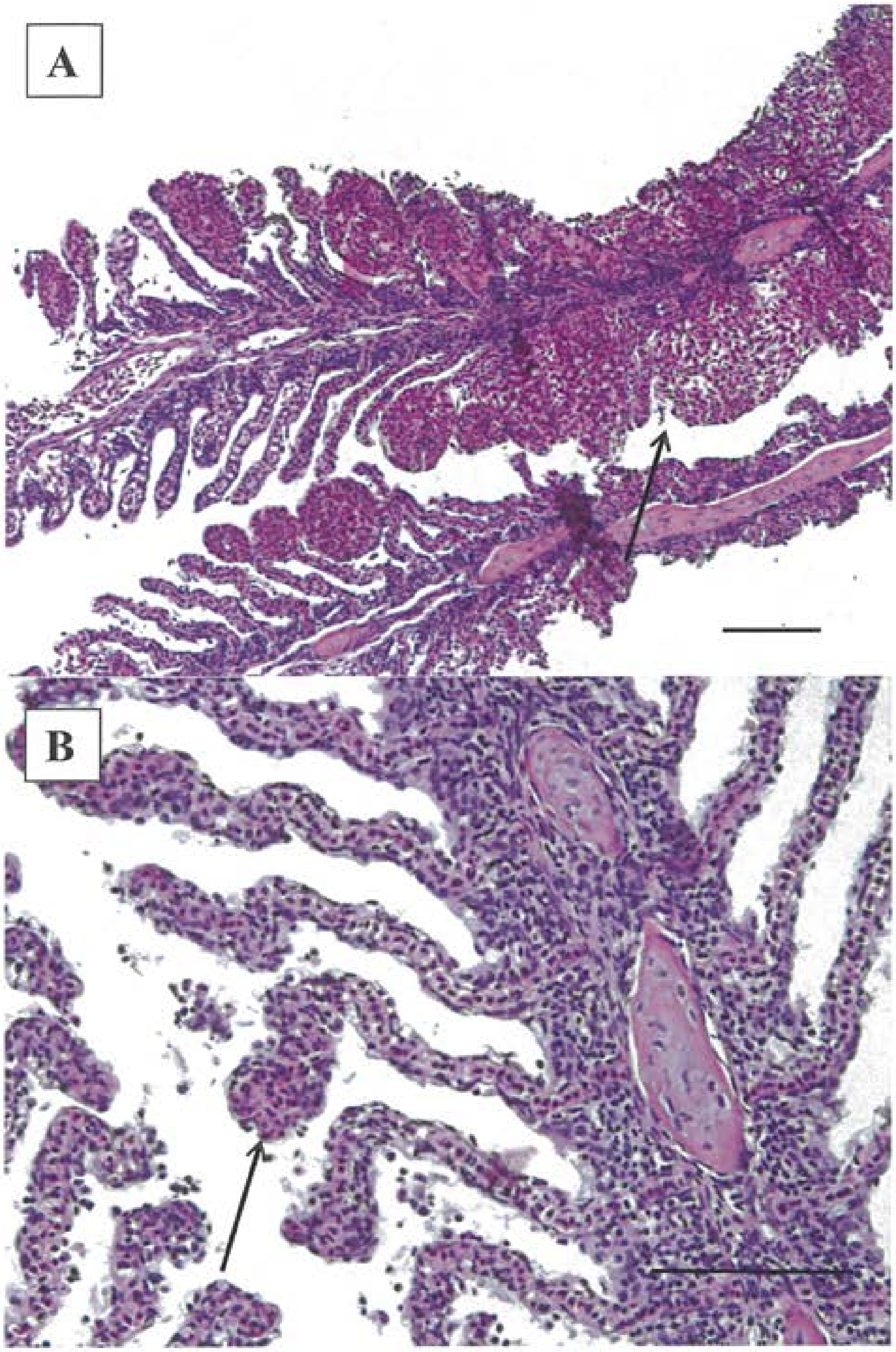

Figure 15. Example of aneurism (arrow) in secondary lamellae of an *A*, histological gill section and *B*, blood congestion (arrow) in secondary lamellae. Scale bars represent 100 microns.

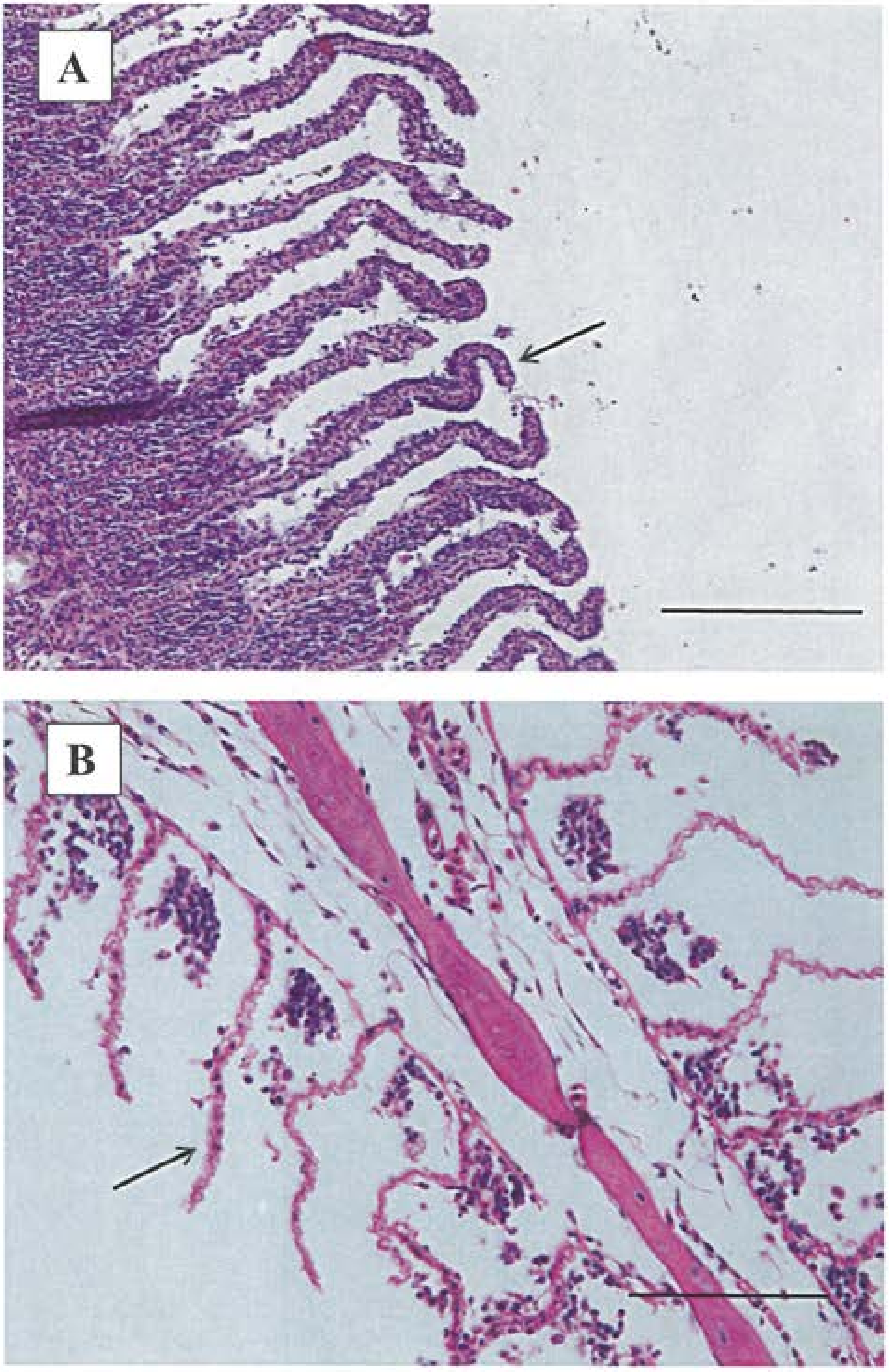

Figure 16. Example of histological section of gill showing *A*, curling at ends of secondary lamellae (arrow) and *B*, degenerated secondary lamellae stripped of epithelial cells (arrow). Scale bar represents 100 microns.

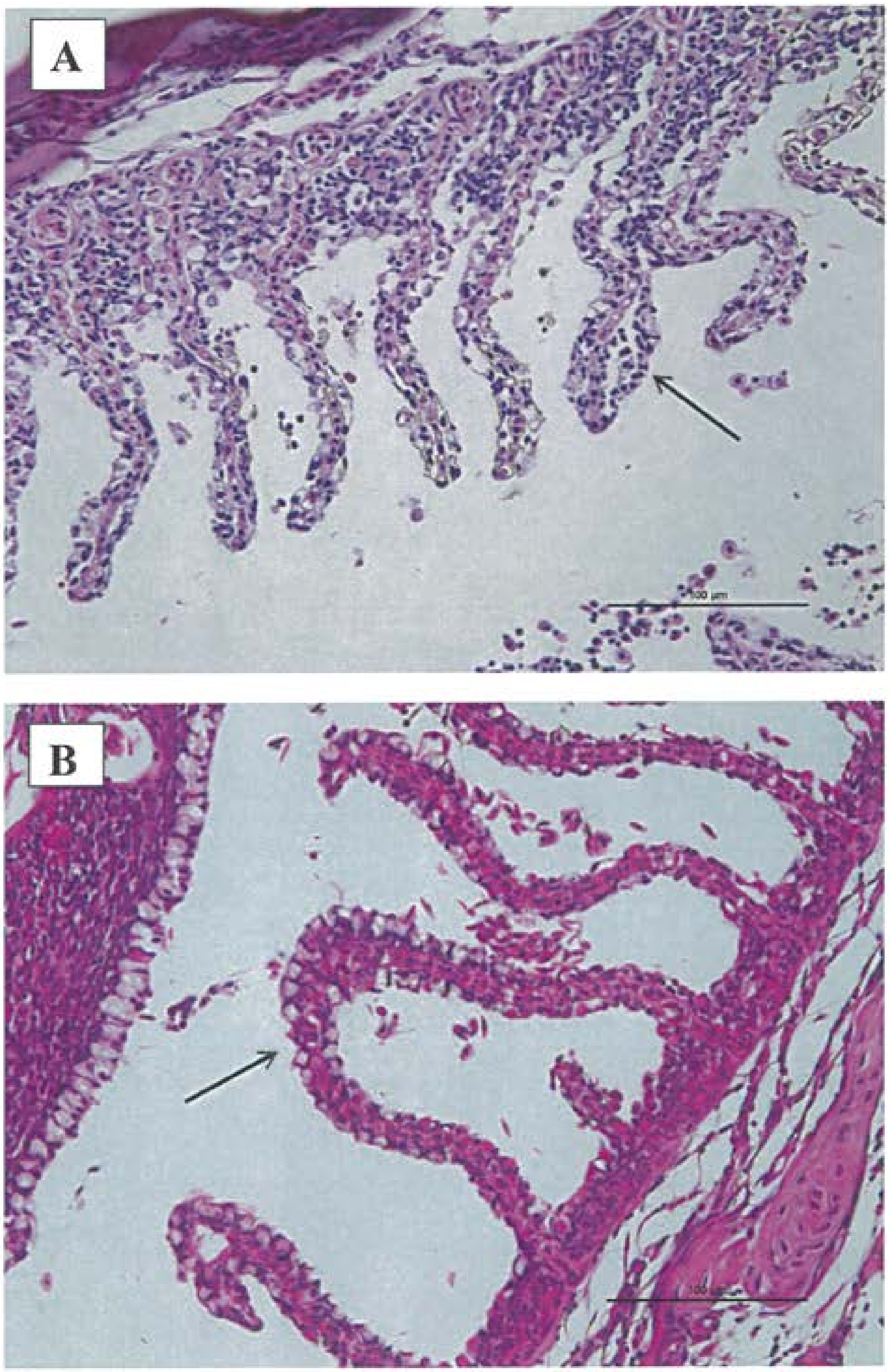

Figure 17. Example of epithelium on *A*, secondary lamellae lifting away from gill (arrow) and *B*, secondary lamellae fusing together (arrow). Scale bar represents 100 microns.

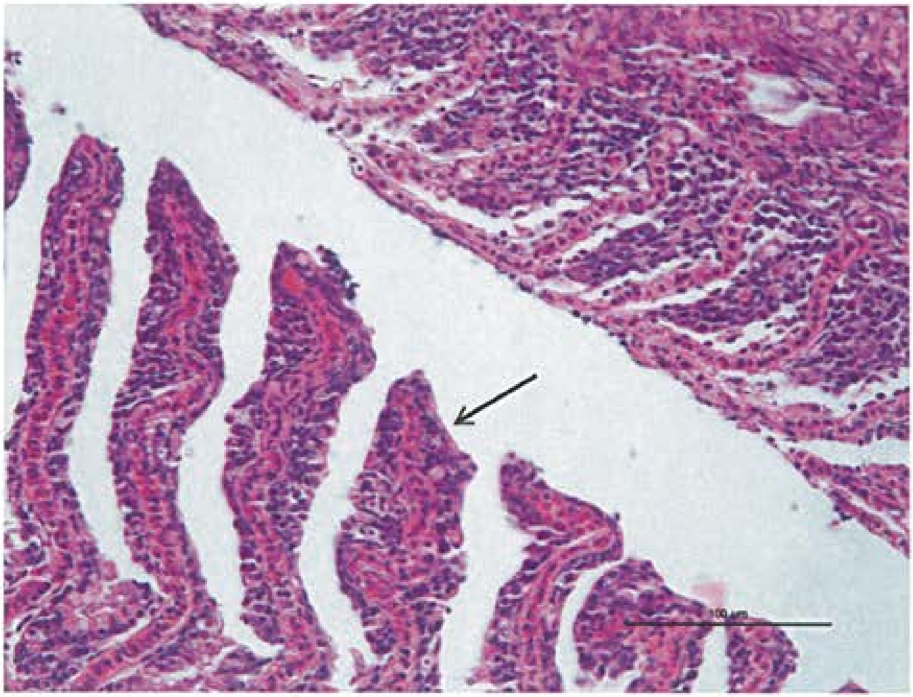

Figure 18. Example of epithelial hyperplasia in secondary lamellae (arrow). Scale bar represents 100 microns.

Table 10. Immunohistochemical staining for CYP1A in gills of smallmouth bass (SMB) and golden redhorse sucker (GRH) from Marshall Impoundment (MI; reference site), Historic Bridge (HB), Legacy Ranch (LR), and Shady Bend (SB). Areas of positive staining were counted on approximately five primary lamellae of five fish[1] for each species and site. Results are reported as mean number of stained areas (Mean), number of fish that did not show any staining (No stain), and the minimum and maximum (Range) of stained cells observed in the sample of fish from a given site.

	Species						
	SMB			GRH			
Site	Mean	No stain	Range	Mean	No stain	Range	Comment
MI	3	1	2–6	2	4	3–6	Stain light
HB	5	0	2–9	5	1	1–23	Large areas stained
LR	5	1	6–8	11	0	2–16	
SB	5	0	2–8	5	0	3–15	

[1]Seven GRH were evaluated for site MI.

Table 11. Estimated age (years) of smallmouth bass from four sites on the Kalamazoo River. (number = N; coefficient of variation = CV).

Site	Sex	N	Mean	Range	CV
Marshall Impoundment	F	10	4	3–7	3
	M	5	5	4–7	4
Historic Bridge	F	7	4	3–7	3
	M	7	6	4–9	3
Legacy Ranch	F	7	3	2–4	6
	M	8	5	3–7	3
Shady Bend	F	5	5	3–10	2
	M	5	6	48	4

Appendix 1. Field datasheets

See attached electronic files or CD

Appendix 2. Chain-of-custody forms

USGS
science for a changing world

U.S.Department of the Interior
U.S.GEOLOGICAL SURVEY
Columbia Environmental Research Center
4200 New Haven Road
Columbia, Missouri 65201

Chain-of-Custody Record **Attachment 1**

Study No	Study Name Enbridge Oil Spill near Marshall, MI Fish Health Assessment	Control No
Samplers (Signature) Diane K. Nicks, John Hess : Employees of MI DNRE		page 1 of 3

Sample Identification	Date	Time	Type *	Remarks and Observations
1-30 tissues	8-19-10		F	Marshall Impoundment Samples, See inventory Attached.
31-60 tissues	8-19-10		F	Historic Bridge Park samples, see inventory Attached.
61-90 tissues	8-19-10 8-20-10		F	Legacy Ranch Samples, see inventory attached.
91-110 tissues	8-20-10		F	Shady Bend Samples, see inventory attached.

Relinquished by (Signature)	Date/Time	Received by (Signature)	Relinquished by (Signature)	Date/Time	Received by (Signature)
Diane K. Nicks	8-20-10 9:30 pm	8-24-10 9:39 AM Diane K. Nicks			
Relinquished by (Signature)	Date/Time	Received by (Signature)	Relinquished by (Signature)	Date/Time	Received by (Signature)
Relinquished by (Signature)	Date/Time	Received for Laboratory by (Signature)	Date/Time	Remarks	

* W=water, S=sediment, P=plant, F=fish, B=benthos, O=other, define in remarks

Appendix 2. (continued)

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Enbridge Oil Spill near Marshall, MI Fish Health Assessment Sample Inventory (x indicates sample present)														
			Histological Samples (10% NBF)			Frozen (-80°C)					blood smear slides			
Site	Fish #	Species	gill (left)	spleen	head kidney	liver A	liver B	bile	plasma A	plasma B	A	B	C	Comments
Marshall Impoundment	1	golden redhorse sucker	x	x	x	x	x	x	x	x	x	x	x	Not noted on data sheet
Marshall Impoundment	2	golden redhorse sucker	x	x	x	x	x	x	x	x	x	x	x	
Marshall Impoundment	3	golden redhorse sucker	x	x	x	x	x	x	x	x	x	x	x	
Marshall Impoundment	4	golden redhorse sucker	x	x	x	x	x	x	x	x	x	x	x	
Marshall Impoundment	5	golden redhorse sucker	x	x	x	x	x	x	x	x	x	x	x	
Marshall Impoundment	6	golden redhorse sucker	x	x	x	x	x	x	x	x	x	x	x	
Marshall Impoundment	7	golden redhorse sucker	x	x	x	x	x	x	x		x	x	x	
Marshall Impoundment	8	golden redhorse sucker	x	x	x	x	x	x	x	x	x	x	x	
Marshall Impoundment	9	golden redhorse sucker	x	x	x	x	x	x	x	x	x	x	x	
Marshall Impoundment	10	golden redhorse sucker	x	x	x	x	x	x	x	x	x	x	x	
Marshall Impoundment	11	golden redhorse sucker	x	x	x	x	x		x	x	x	x	x	
Marshall Impoundment	12	golden redhorse sucker	x	x	x	x	x	x	x	x	x	x	x	
Marshall Impoundment	13	golden redhorse sucker	x	x	x	x	x	x	x	x	x	x	x	Liver A in Bile A vial & Bile in Liver A vial
Marshall Impoundment	14	golden redhorse sucker	x	x	x	x	x	x	x	x	x	x	x	
Marshall Impoundment	15	golden redhorse sucker	x	x	x	x	x	x	x	x	x	x	x	
Marshall Impoundment	16	smallmouth bass	x	x	x	x	x	x	x	x	x	x	x	
Marshall Impoundment	17	smallmouth bass	x	x	x	x	x	x	x		x	x	x	
Marshall Impoundment	18	smallmouth bass	x	x	x	x	x	x	x	x	x	x	x	
Marshall Impoundment	19	smallmouth bass	x	x	x	x	x	x	x		x	x	x	
Marshall Impoundment	20	smallmouth bass	x	x	x	x	x	x	x	x	x	x	x	
Marshall Impoundment	21	smallmouth bass	x	x	x	x	x	x	x	x	x	x	x	
Marshall Impoundment	22	smallmouth bass	x	x	x	x	x	x			x	x	x	sample may be labeled as head kidney
Marshall Impoundment	23	smallmouth bass	x	x	x	x	x	x	x	x	x	x	x	
Marshall Impoundment	24	smallmouth bass	x	x	x	x	x	x	x	x	x	x	x	
Marshall Impoundment	25	smallmouth bass	x	x	x	x	x	x	x	x	x	x	x	
Marshall Impoundment	26	smallmouth bass	x	x	x	x	x	x	x	x	x	x	x	
Marshall Impoundment	27	smallmouth bass	x	x	x	x	x	x	x	x	x	x	x	
Marshall Impoundment	28	smallmouth bass	x	x	x	x	x	x	x	x	x	x	x	
Marshall Impoundment	29	smallmouth bass	x	x	x	x	x	x	x		x	x	x	small sample
Marshall Impoundment	30	smallmouth bass	x	x	x	x	x	x	x	x	x	x	x	
Historic Bridge Park	31	smallmouth bass	x	x	x	x	x	x	x		x	x	x	
Historic Bridge Park	32	smallmouth bass	x	x	x	x	x	x	x		x	x	x	small sample, Liver A in Bile A vial & Bile in Liver A vial
Historic Bridge Park	33	smallmouth bass	x	x	x	x	x	x	x		x	x	x	small sample
Historic Bridge Park	34	smallmouth bass	x	x	x	x	x		x		x	x	x	small sample w/ RBC's ?, Liver A in Bile vial
Historic Bridge Park	35	smallmouth bass	x	x	x	x	x	x	x		x	x	x	small sample w/ RBC's ?
Historic Bridge Park	36	smallmouth bass	x	x	x	x	x				x	x	x	
Historic Bridge Park	37	smallmouth bass	x	x	x	x	x	x	x		x	x	x	
Historic Bridge Park	38	smallmouth bass	x	x	x	x	x	x	x		x	x	x	
Historic Bridge Park	39	smallmouth bass	x	x	x	x	x	x			x	x	x	
Historic Bridge Park	40	smallmouth bass	x	x	x	x	x	x	x		x	x	x	small sample
Historic Bridge Park	41	smallmouth bass	x	x	x	x	x	x	x		x	x	x	small sample w/ RBC's ?
Historic Bridge Park	42	smallmouth bass	x	x	x	x	x	x	x		x	x	x	small sample
Historic Bridge Park	43	smallmouth bass	x	x	x	x	x	x	x		x	x	x	Liver A in Bile A vial & Bile in Liver A vial
Historic Bridge Park	44	smallmouth bass	x	x	x	x	x	x	x	x	x	x	x	
Historic Bridge Park	45	smallmouth bass	x	x	x	x	x	x	x	x	x	x	x	
Historic Bridge Park	46	golden redhorse sucker	x	x	x	x	x	x	x	x	x	x	x	
Historic Bridge Park	47	golden redhorse sucker	x	x	x	x	x	x	x	x	x	x	x	
Historic Bridge Park	48	golden redhorse sucker	x	x	x	x	x		x		x	x	x	
Historic Bridge Park	49	golden redhorse sucker	x	x	x	x	x	x	x		x	x	x	
Historic Bridge Park	50	golden redhorse sucker	x	x	x	x	x	x			x	x	x	Not noted on data sheet
Historic Bridge Park	51	golden redhorse sucker	x	x	x	x	x	x	x		x	x	x	not good sample?
Historic Bridge Park	52	golden redhorse sucker	x	x	x	x	x	x	x		x	x	x	Not noted on data sheet
Historic Bridge Park	53	golden redhorse sucker	x	x	x	x	x		x		x	x	x	
Historic Bridge Park	54	golden redhorse sucker	x	x	x	x	x	x	x	x	x	x	x	
Historic Bridge Park	55	golden redhorse sucker	x	x	x	x	x	x	x	x	x	x	x	Not noted on data sheet
Historic Bridge Park	56	golden redhorse sucker	x	x	x	x	x	x	x	x	x	x	x	
Historic Bridge Park	57	golden redhorse sucker	x	x	x	x	x	x	x	x	x	x	x	
Historic Bridge Park	58	golden redhorse sucker	x	x	x	x	x	x	x	x	x	x	x	
Historic Bridge Park	59	golden redhorse sucker	x	x	x	x	x	x	x	x	x	x	x	
Historic Bridge Park	60	golden redhorse sucker	x	x	x	x	x		x	x	x	x	x	

Appendix 2. (continued)

Page 3 of 3

Enbridge Oil Spill near Marshall, MI Fish Health Assessment Sample Inventory (x indicates sample present)														
			Histological Samples (10% NBF)			Frozen (-80°C)					blood smear slides			
Site	Fish #	Species	gill (left)	spleen	head kidney	liver A	liver B	bile	plasma A	plasma B	A	B	C	Comments
Legacy Ranch	61	smallmouth bass	x	x	x	x	x	x	x		x	x	x	
Legacy Ranch	62	smallmouth bass	x	x	x	x	x	x	x		x	x	x	
Legacy Ranch	63	smallmouth bass	x	x	x	x	x	x	x		x	x	x	small sample
Legacy Ranch	64	smallmouth bass	x	x	x	x	x	x	x		x	x	x	
Legacy Ranch	65	smallmouth bass	x	x	x	x	x	x	x	x	x	x	x	Not noted on data sheet
Legacy Ranch	66	smallmouth bass	x	x	x	x	x	x	x		x	x	x	jelled
Legacy Ranch	67	smallmouth bass	x	x	x	x	x	x	x		x	x	x	sample had very little plasma all RBC's ?
Legacy Ranch	68	smallmouth bass	x	x	x	x	x	x	x		x	x	x	sample had very little plasma all RBC's ?
Legacy Ranch	69	smallmouth bass	x	x	x	x	x	x	x		x	x	x	sample had very little plasma all RBC's ? Bile sample collected from work surface
Legacy Ranch	70	smallmouth bass	x	x	x	x	x	x	x		x	x	x	small sample
Legacy Ranch	71	smallmouth bass	x	x	x	x	x	x	x	x	x	x	x	
Legacy Ranch	72	smallmouth bass	x	x	x	x	x	x	x	x	x	x	x	
Legacy Ranch	73	smallmouth bass	x	x	x	x	x	x	x		x	x	x	
Legacy Ranch	74	smallmouth bass	x	x	x	x	x	x	x	x	x	x	x	
Legacy Ranch	75	smallmouth bass	x	x	x	x	x	x	x		x	x	x	
Legacy Ranch	76	golden redhorse sucker	x	x	x	x	x	x	x		x	x	x	
Legacy Ranch	77	golden redhorse sucker	x	x	x	x	x		x	x	x	x	x	
Legacy Ranch	78	golden redhorse sucker	x	x	x	x	x	x	x	x	x	x	x	
Legacy Ranch	79	golden redhorse sucker	x	x	x	x	x	x	x	x	x	x	x	there is an extra #79 plasma vial??
Legacy Ranch	80	golden redhorse sucker	x	x	x	x	x	x	x	x	x	x	x	
Legacy Ranch	81	golden redhorse sucker	x	x	x	x	x	x	x	x	x	x	x	
Legacy Ranch	82	golden redhorse sucker	x	x	x	x	x	x	x	x	x	x	x	
Legacy Ranch	83	golden redhorse sucker	x	x	x	x	x	x	x	x	x	x	x	
Legacy Ranch	84	golden redhorse sucker	x	x	x	x	x	x	x	x	x	x	x	
Legacy Ranch	85	golden redhorse sucker	x	x	x	x	x	x	x	x	x	x	x	
Legacy Ranch	86	golden redhorse sucker	x	x	x	x	x	x	x	x	x	x	x	
Legacy Ranch	87	golden redhorse sucker	x	x	x	x	x		x	x	x	x	x	
Legacy Ranch	88	golden redhorse sucker	x	x	x	x	x	x	x	x	x	x	x	
Legacy Ranch	89	golden redhorse sucker	x	x	x	x	x	x	x	x	x	x	x	
Legacy Ranch	90	golden redhorse sucker	x	x	x	x	x	x	x	x	x	x	x	
Shaty Bend	91	smallmouth bass	x	x	x	x	x	x	x	x	x	x	x	
Shaty Bend	92	smallmouth bass	x	x	x	x	x	x	x		x	x	x	
Shaty Bend	93	smallmouth bass	x	x	x	x	x	x	x	x	x	x	x	Not noted on data sheet
Shaty Bend	94	smallmouth bass	x	x	x	x	x	x	x	x	x	x	x	Not noted on data sheet
Shaty Bend	95	smallmouth bass	x	x	x	x	x	x	x	x	x	x	x	Not noted on data sheet
Shaty Bend	96	smallmouth bass	x	x	x	x	x	x	x	x	x	x	x	Not noted on data sheet
Shaty Bend	97	smallmouth bass	x	x	x	x	x	x	x		x	x	x	Not noted on data sheet
Shaty Bend	98	smallmouth bass	x	x	x	x	x	x	x	x	x	x	x	Not noted on data sheet
Shaty Bend	99	smallmouth bass	x	x	x	x	x	x	x	x	x	x	x	Not noted on data sheet
Shaty Bend	100	smallmouth bass	x	x	x	x	x	x	x		x	x	x	Not noted on data sheet
Shaty Bend	101	golden redhorse sucker	x	x	x	x	x	x	x	x	x	x	x	Not noted on data sheet
Shaty Bend	102	golden redhorse sucker	x	x	x	x	x	x	x	x	x	x	x	Not noted on data sheet
Shaty Bend	103	golden redhorse sucker	x	x	x	x	x	x	x	x	x	x	x	Not noted on data sheet
Shaty Bend	104	golden redhorse sucker	x	x	x	x	x	x	x	x	x	x	x	Not noted on data sheet
Shaty Bend	105	golden redhorse sucker	x	x	x	x	x	x	x		x	x	x	Not noted on data sheet
Shaty Bend	106	golden redhorse sucker	x	x	x	x	x	x	x	x	x	x	x	Not noted on data sheet
Shaty Bend	107	golden redhorse sucker	x	x	x	x	x	x	x	x	x	x	x	Not noted on data sheet
Shaty Bend	108	golden redhorse sucker	x	x	x	x	x	x	x	x	x	x	x	Not noted on data sheet
Shaty Bend	109	golden redhorse sucker	x	x	x	x	x	x	x	x	x	x	x	Not noted on data sheet
Shaty Bend	110	golden redhorse sucker	x	x	x	x	x	x	x	x	x	x	x	Not noted on data sheet

Appendix G: Fish Status and Trends Report 2010

MICHIGAN DEPARTMENT OF NATURAL RESOURCES
FISHERIES DIVISION
APRIL 2011

SUMMARY REPORT

A FISH SURVEY OF SITES ON THE KALAMAZOO RIVER AND TALMADGE CREEK NEAR THE ENBRIDGE OIL SPILL IN MARSHALL CALHOUN AND KALAMAZOO COUNTIES, MICHIGAN SEPTEMBER 2010

INTRODUCTION

On July 26, 2010, a 30-inch diameter pipeline ruptured discharging heavy crude oil into a wetland and then into Talmadge Creek, a tributary to the Kalamazoo River. The amount of oil discharged is estimated at 819,000 to 1,000,000 gallons. The oil flowed down 2.2 miles of Talmadge Creek, a small coolwater stream, before entering the Kalamazoo River. The oil migrated approximately 35 miles downstream to Morrow Pond. The Kalamazoo River drains approximately 2,020 square miles of southwest Michigan and has a length of 175 miles from it headwaters to Lake Michigan. It is a medium to large sized warmwater river with a sporadically confined channel as it meanders between moraine and man-made features from Marshall to Battle Creek and meanders freely in broad valleys from Battle Creek to Morrow Pond (Wesley 2005).

During September 2010, staff of the Michigan Department of Natural Resources, Fisheries Division with assistance from Entrix, Inc. (a consultant of Enbridge) and Michigan Department of Environmental Quality, Water Resources Division conducted fish community and habitat surveys on the Kalamazoo River and Talmadge Creek. The objective of these surveys was to access the effects of the oil spill and associated cleanup activities on fish communities and habitat. Surface Water Assessment Section, Water Resources Division, Department of Environmental Quality also collected macroinvertebrate and aquatic habitat data using their Procedure 51 protocol (MDEQ 2011). A study plan has been developed and additional surveys will be conducted in the future to monitor the long-term effects of the oil spill and associated cleanup activities on the fish and macroinvertebrate communities and aquatic habitat (Wesley and Walterhouse 2010). Refer to Appendix 1 for more detailed site and catch data.

METHODS

Selected sites (Figure 1) were chosen with emphasis on sites with historic (i.e. baseline) survey data that were collected prior to the oil spill (Wesley and Walterhouse 2010). Fisheries Division has a long-term Status and Trends Site at 11 Mile Road on the Kalamazoo River. Surveys at this site follow standardized sampling procedures that allow for temporal comparisons as well as comparisons to similar streams across the region and state (Wills et al. 2008). This Status and Trends protocol, described in Wills et al. 2008, was used at the other sites for consistency. Wadeable shocking equipment and methods were used on Talmadge Creek at the 17 Mile Road (reference) and 15½ Mile Road sites, and on the Kalamazoo River at the 17 Mile (reference), 15 Mile, and 11 Mile sites. Boomshocking (boat) equipment and methods were used at the Custer Road site on the Kalamazoo River. Historic surveys at these sites used similar shocking equipment except the 15 Mile Road and Custer Road sites were conducted using a fish toxicant known as rotenone (Towns 1984).

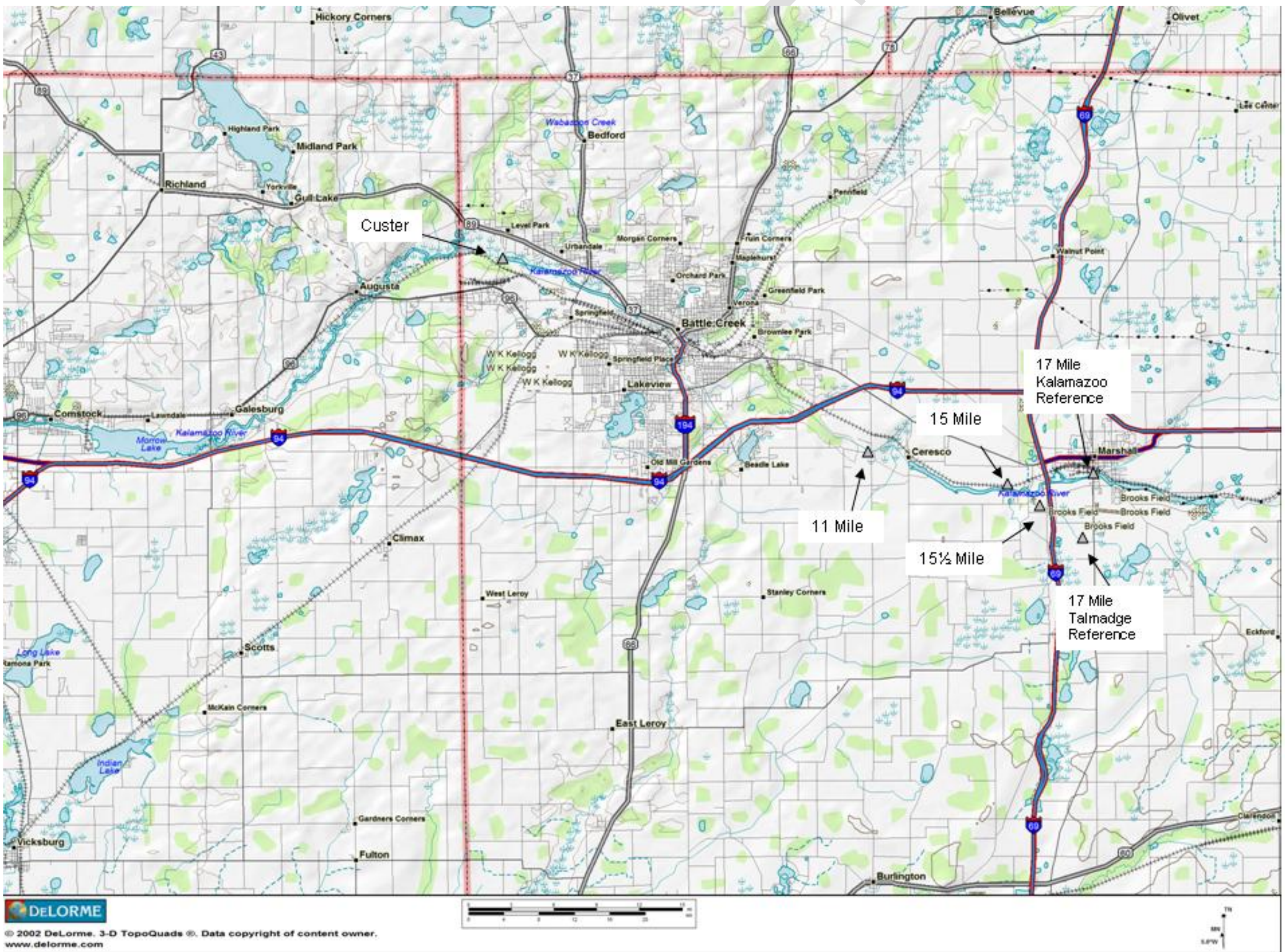

Figure 1. Fish sampling locations on the Kalamazoo River and Talmadge Creek, September 2010.

SUMMARY and OBSERVATIONS

The fish abundance and diversity in Talmadge Creek were significantly lower downstream of the oil spill compared to the reference site and the 2002 survey. Habitat conditions also changed with a wider and shallow stream with low abundance of cover at the downstream location, which was a result of clean up activities.

Fish diversity and catch at the 15 Mile site on the Kalamazoo River was consistent with the reference site at 17 Mile Road. Diversity and catch declined at the 11 Mile Road and Custer Road sites. Smallmouth bass catch was much lower at the 11 Mile Road site compared to 2008 and 2009. There also appeared to be a decline in the number of age 0 smallmouth bass at the 15 and 11 Mile Road sites.

Although the focus of this summary was not on habitat, there was a reduction in woody structure and over-hanging brush at the 15 and 11 Mile Road sites. Bank erosion was observed around the island at 11 Mile Road.

SAMPLING RESULTS

<u>Talmadge Creek</u>

Two surveys were conducted on Talmadge Creek on September 16th, 2010. The reference site was between the spill site and 17 Mile Road. The habitat at 17 Mile Road had more wetland than stream characteristics, so the crew continued downstream until a stream channel was more evident. There was no historic fisheries data for comparison at this reference site. Talmadge Creek was also sampled in the oil impacted reach at 15½ Mile Road (MP 1.25), which was historically surveyed on July 12th, 2000.

<u>Talmadge Creek – 17 Mile Road (Reference)</u>

The 17 Mile Road site had an average stream width of 9.2 ft with an average depth of 4.3 inches. The water clarity was slightly turbid, and it appeared to be at an average flow based on visual observations. The substrate was mostly sand (82%), silt (8%), gravel (5%), large cobble (3%), and small cobble (2%). The stream was characterized as all run habitat. Undercut banks, overhanging vegetation, aquatic vegetation, and woody structure were observed in moderate abundance. The measured stream discharge was 1.04 cfs.

A backpack shocker was used to sample 500 ft of stream. A total of 633 fish were surveyed representing six species. Most of the catch was made up of central mudminnow and mottled sculpin. These species of fish are typically associated with headwater and coolwater streams. For standardization purposes, the catch per effort (number of fish per acre of area surveyed) was calculated to assist with comparison among sites and sample years (Figures 2 and 3).

Talmadge Creek - 15½ Mile Road

The 15½ Mile Road site was located downstream of the road to avoid response activities and for easier access (a wood matt road ran down the floodplain). The stream had an average width of 14.9 ft with an average depth of 3.5 inches. Talmadge Creek gains groundwater between this section and 17 mile Road as the discharge increased to 2.4 cfs. The water clarity was turbid and flowing at an average level based on visual observations. The substrate consisted of gravel (63%), sand (20%), silt (7%), boulders (7%), large cobble (1.5%), and small cobble (1.5%). The stream was characterized as 54% run and 46% riffle habitat. The few boulders and logs were the only cover habitat available. The July 2000 survey was conducted upstream of 15½ Mile Road. This section of stream was narrower (5.5 ft), deeper (1.1 ft), and had more habitat in the form of overhanging brush, wild celery, and watercress. This section was adjacent to a mowed yard.

A backpack shocker was used to sample 500 ft of stream in both the 2000 and 2010 surveys. Only three species of fish were collected in 2010. The central mudminnow was most numerous with 53 fish collected followed by brook stickleback (6) and grass pickerel (1). These species are typically associated with small streams and wetlands. The survey in 2000 collected 11 species of fish with a total of 192 fish collected. The catch per effort was also higher in 2000 compared to 2010 for all species except brook stickleback, which were not observed in 2000 (Figure 3).

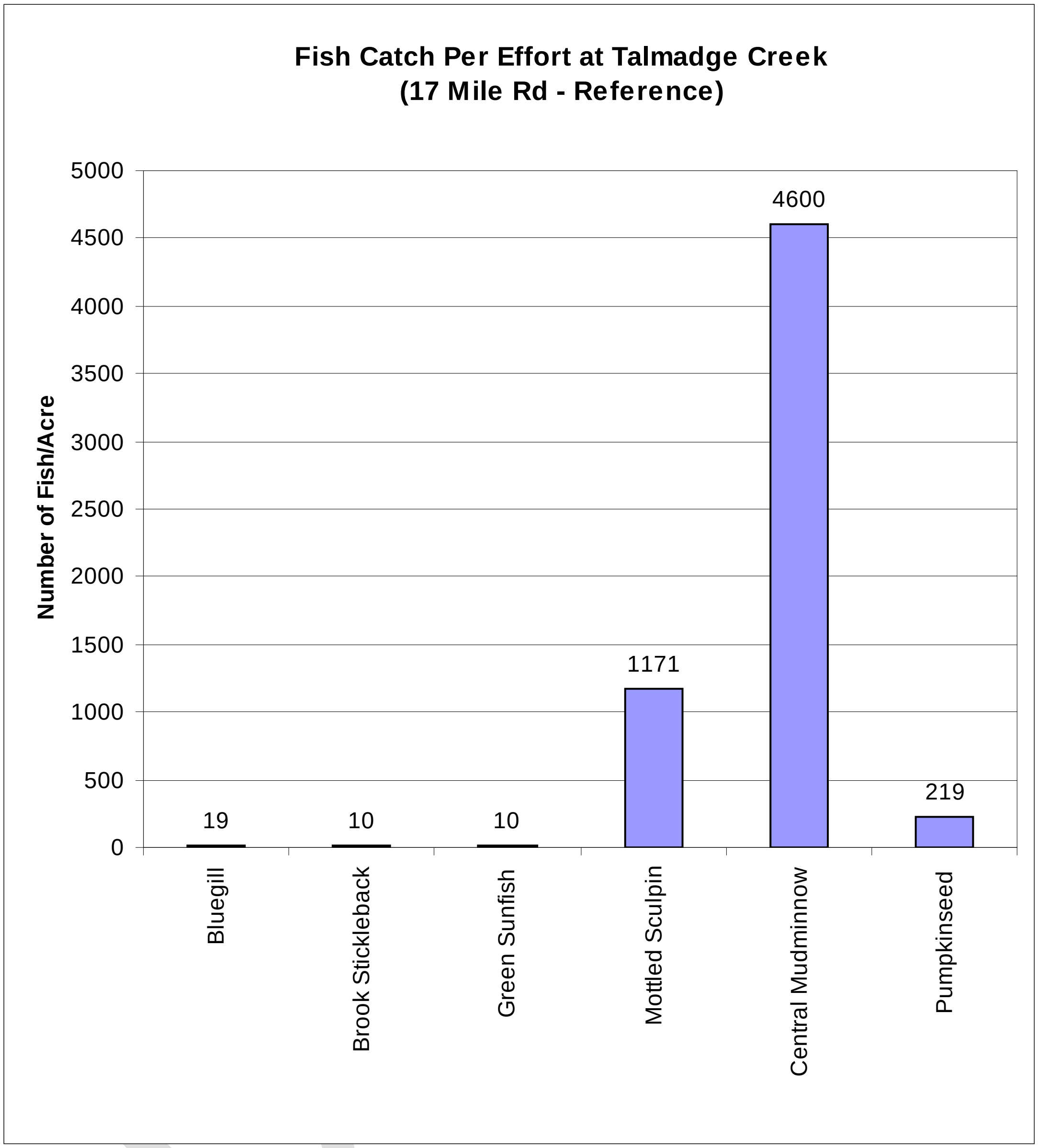

Figure 2. Fish catch per effort (number per Acre) in September 2010 for Talmadge Creek at 17 Mile Road (reference site).

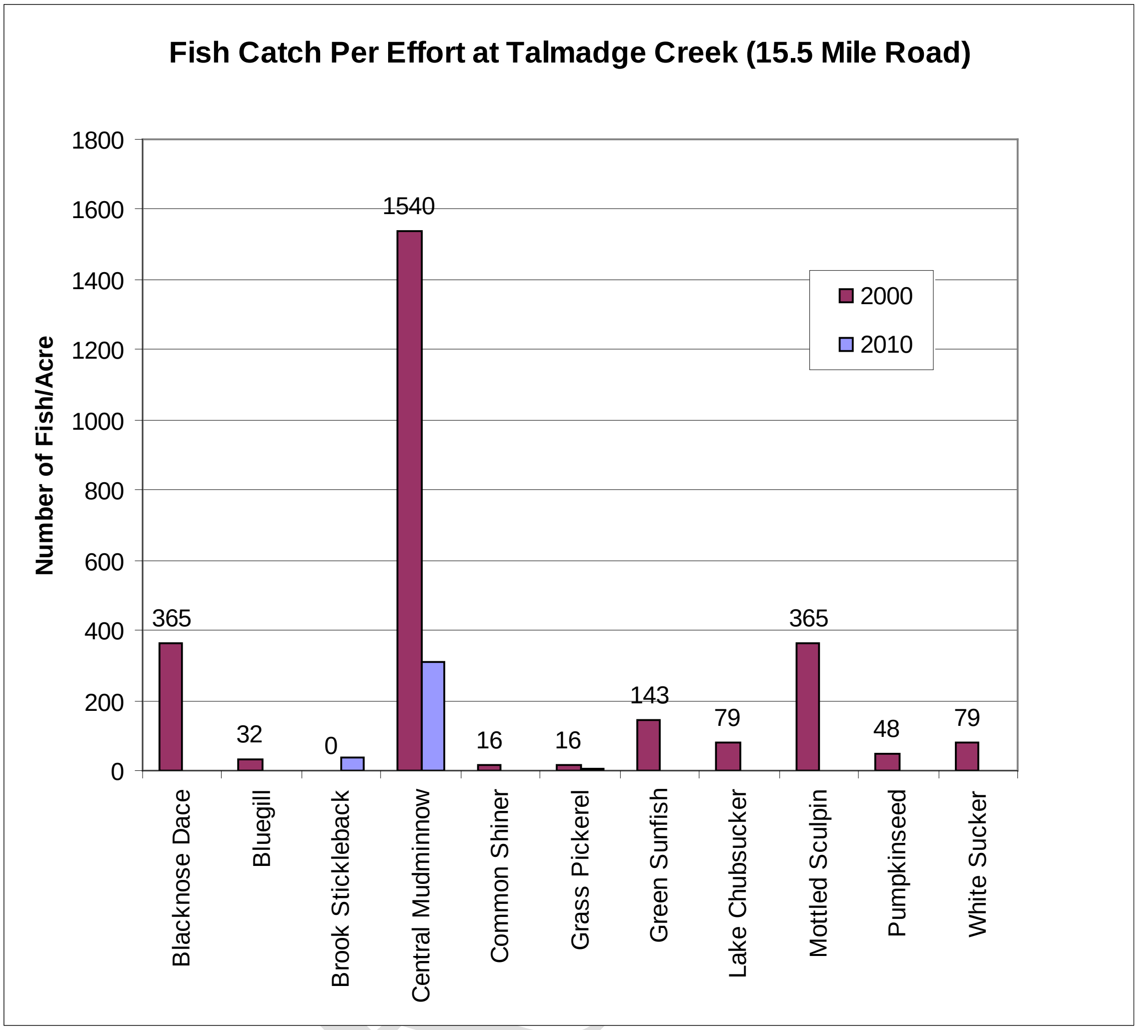

Figure 3. Fish catch per effort (number per Acre) in July 2000 and September 2010 for Talmadge Creek at 15½ Mile Road.

<u>Kalamazoo River – 17 Mile Road (Reference)</u>

The 17 Mile Road location was upstream of the oil spill and had historical fish data from 2002 making it a good reference site for the Kalamazoo River. This site was relatively deep making some areas difficult to wade and shock. As a result, the section length was reduced from 1,000 ft to 800 ft during the survey conducted on September 8, 2010.

The average width was 100 ft with an average depth of 21.6 inches. The water clarity was slightly turbid. Cover consisted of a moderate abundance of undercut banks, aquatic plants, and woody structure with limited deep pools, boulders, and overhanging vegetation. Habitat conditions appeared similar to 2002.

A stream shocker was used to sample the left and right banks. The catch was combined from both banks giving a total catch of 403 fish representing 25 species. Based on catch per effort, northern hog sucker, rock bass, and smallmouth bass were the most abundant species (Figure 4). The catch per effort and species composition were similar between 2010 and 2002 except pumpkinseed sunfish and common white sucker made up more of the catch in 2002. Smallmouth bass from age 0 to age 10 were collected with most (87%) of the catch being age 0. The average length of the smallmouth bass was 4.5 inches.

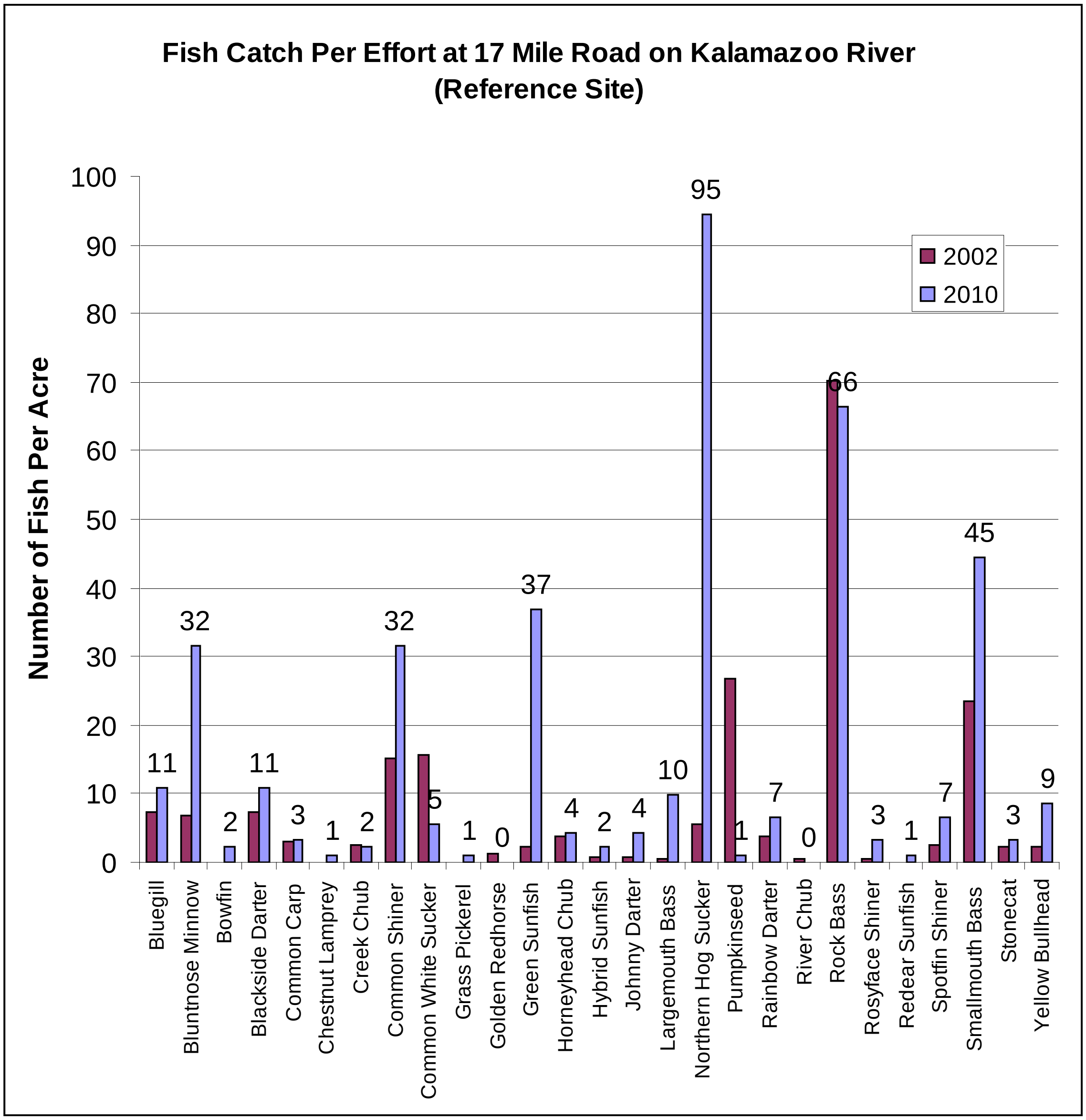

Figure 4. Fish catch per effort (number per Acre) in August 2002 and September 2010 for the Kalamazoo River at 17 Mile Road (reference site).

Kalamazoo River – 15 Mile Road

The 15 Mile Road site started 500 ft below the Squaw Creek mouth and ended 500 ft upstream for a total of 1,000 ft. This section is downstream from the 1982 rotenone survey (Towns 1984), which was conducted right at the 15 Miles Road bridge. The site was moved for a more wadeable section and to move away from a busy response access site.

The average width was 153 ft with an average depth of 18.2 inches. The water clarity was slightly turbid. The channel was characterized as 54% run and 46% riffle habitat. Cover consisted of a moderate abundance of boulders and aquatic plants with limited deep pools, overhanging vegetation, undercut banks, woody structure. The bottom substrate consisted of gravel (45%), small cobble (28%), sand (14%), large cobble (6%), silt (5%), and boulder (2%). Water levels appeared slightly above normal with an estimated discharge of 304 cfs. The section of river surveyed in 1982 was deeper and narrower than this section.

A stream shocker was used to sample the left and right banks. The combined total catch was 871 fish with 27 different species. Rainbow darter, green sunfish, rock bass, and creek chub were the most abundant (Figure 5). The presence and number of darters is a good indication of more riffle habitat compared to the deeper water surveyed upstream in 1982. The relatively high species diversity is an indication of transitional habitat as the Kalamazoo River enters the Ceresco Impoundment. Catch per effort comparisons are shown in Figure 5; however, different methods were used between 1982 (rotenone) and 2010 (stream shocking). Rotenone is a fish toxicant that samples the entire river section; whereas, the stream shocking effort only sampled the left and right banks. Smallmouth bass from age 0 to age 10 were collected with most (63%) of the catch being age 0. The average length of the smallmouth bass was 7.8 inches. The species diversity and catch were similar to the 17 Mile Road reference section, although there appeared to be more and younger smallmouth bass at the reference site compared to this section (based on age data in Appendix 1).

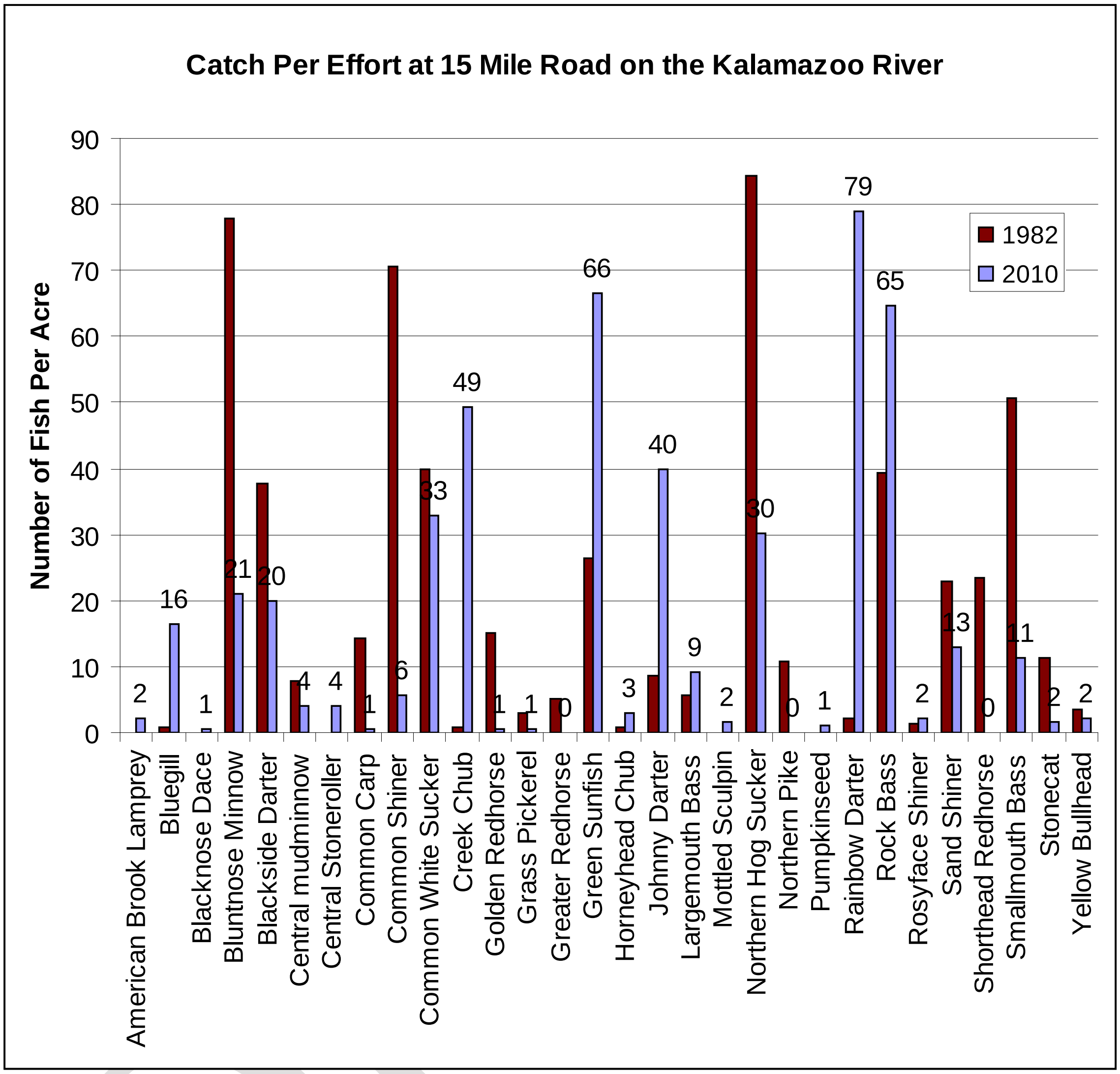

Figure 5. Fish catch per effort (number per Acre) in July 1982 and September 2010 for the Kalamazoo River at 15 Mile Road.

Kalamazoo River – 11 Mile Road

The 11 Mile Road site was a Status and Trends fixed site for smallmouth bass that has been surveyed annually since 2008. Only smallmouth bass were collected in 2008 while all species of fish were collected in 2009 and 2010. The site extends 1,000 ft downstream of 11 Mile Road and is permanently marked to ensure the same effort from year to year. The entire site was wadeable.

The water clarity was slightly turbid. The average width was 142 ft with an average depth of 15.8 inches, which has been consistent for the past three years. The channel habitat was primarily riffle (85%) and run (15%). The bottom type consisted of gravel (33%), small cobble (26%), large cobble (15%), boulder (12%), sand (7%), silt (3%), and island (2%). This is similar to past surveys with a small reduction in the size of the island. The vegetation on the island had been removed, and there was evidence of bank erosion. Cover consisted of a moderate abundance of boulders and aquatic plants with limited deep pools, overhanging vegetation, undercut banks, and woody structure. Water levels appeared above normal with an estimated discharge of 321 cfs.

The combined total catch of the left and right bank streamshocker efforts was 327 fish representing 20 species. These results were lower than the 2009 survey that collected 594 fish representing 24 species. Rock bass dominated the catch (Figure 6). Compared to 2009 the catch of each species was down except for rock bass and green sunfish. The smallmouth bass catch per effort was 56% and 43% lower than 2008 and 2009, respectively. There appeared to be a lack of small sized bass from the 2009 and 2010 year classes. Smallmouth bass ages ranged from 0 to 8 with most (34%) of the catch at age 3. The average length of the smallmouth bass was 10.0 inches.

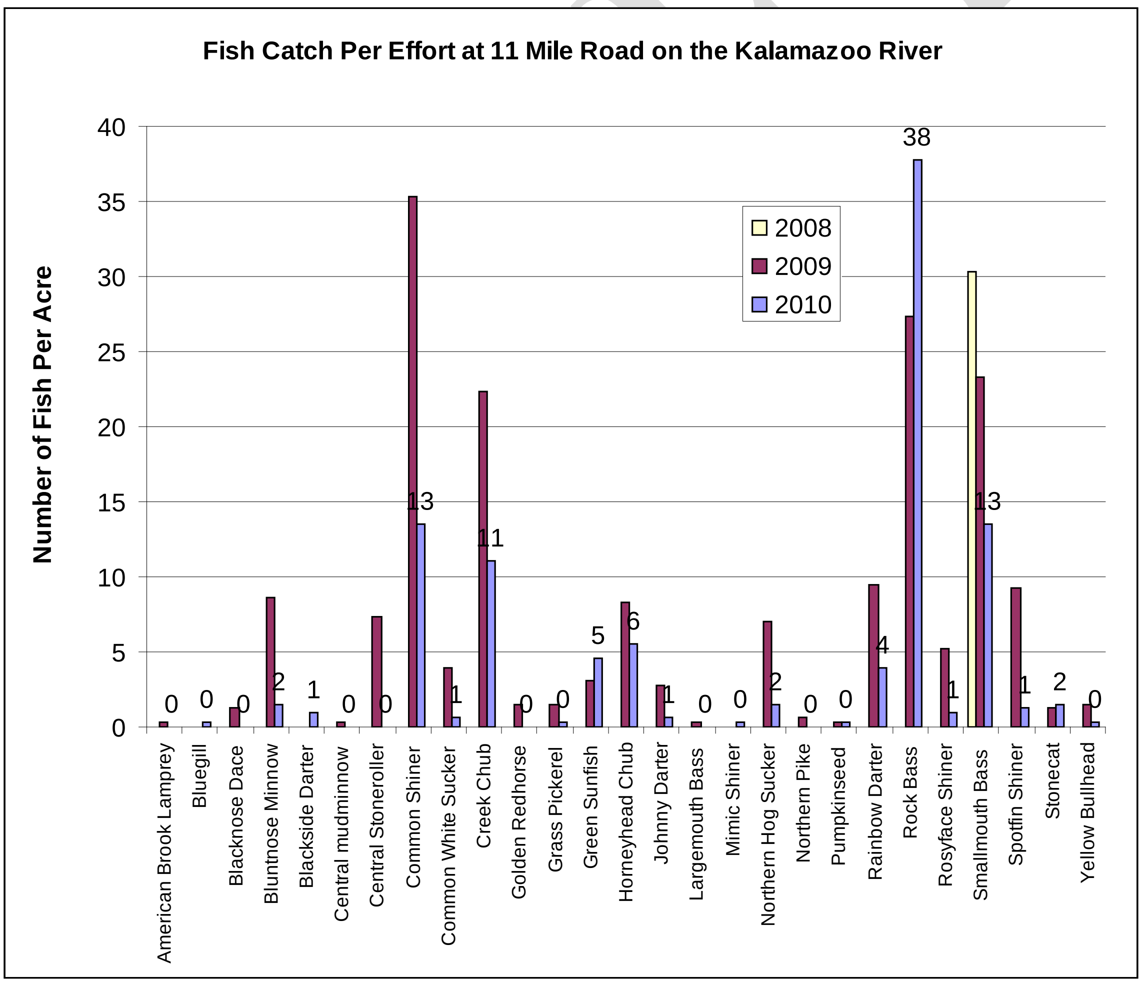

Figure 6. Fish catch per effort (number per Acre) in August 2008, September 2009, and September 2010 for the Kalamazoo River at 11 Mile Road.

Kalamazoo River – Custer Road

This site began approximately 1,320 ft downstream of Custer Road and continued downstream 4,224 ft (approximately MP 21.5 to 22.5). The 1982 rotenone survey sampled 540 ft of stream starting 2,640 ft downstream of Custer Road (Towns 1984). This section of river was not wadeable and required all sampling to be conducted from a boat.

The average width was 71 ft with an average depth of 36 inches. The water clarity was clear. Woody structure and undercut banks were common with limited overhanging vegetation and aquatic vegetation for cover habitat. Due to the depth of the site, other habitat parameters were not measured. Refer to MDEQ (2011) for more habitat details.

A boomshocker (boat) was used to sample the left descending bank in a downstream direction as part of a non-wadeable protocol (Wills et al. 2008). The total catch was 223 fish with 17 different species represented. Golden redhorse, northern hog sucker, rock bass, and smallmouth bass were most abundant (Figure 7). The presence of golden redhorse, walleye, and channel catfish indicate deeper river habitat characteristics. The 1982 survey collected 28 species. The lower species diversity in the 2010 survey was probably due to the difference in sampling procedures. Boomshocking gear sampled the top three to five feet of water, making it difficult to collect smaller species such as darters and minnows that inhabit gravel areas on the bottom of the river. Direct catch per effort comparisons should not be made between 1982 and 2010, since rotenone was used in 1982. Rotenone was much more efficient at sampling all water depths compared to the boomshocking gear. Better comparisons can be made with future boomshocking data at this site. Smallmouth bass from age 1 to age 10 were collected with most (33%) of the catch being age 1. No young of year smallmouth bass were collected. The average length of the smallmouth bass was 11.0 inches.

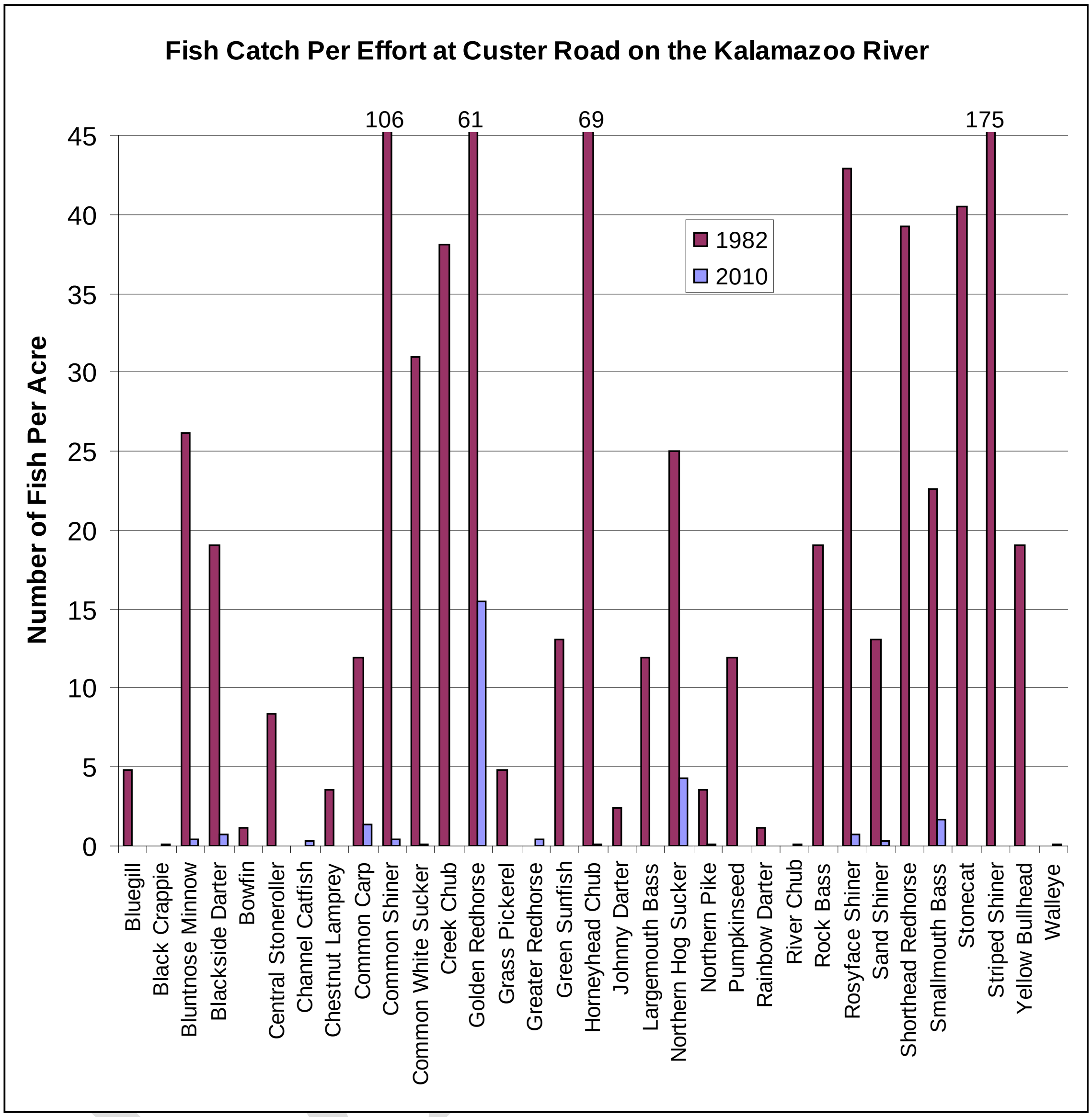

Figure 7. Fish catch per effort (number per Acre) in August 1982 and September 2010 for the Kalamazoo River at downstream of Custer Road.

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Appendix H1: Macroinvertebrate Report 2010

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
WATER RESOURCES DIVISION
FEBRUARY 2011

STAFF REPORT

A BIOLOGICAL SURVEY OF SITES ON THE KALAMAZOO RIVER AND TALMADGE CREEK
NEAR THE ENBRIDGE OIL SPILL IN MARSHALL
CALHOUN COUNTY, MICHIGAN
SEPTEMBER 2010

INTRODUCTION

On July 26, 2010, a 30-inch diameter pipeline ruptured discharging heavy crude oil into a culvert that leads to Talmadge Creek, a tributary to the Kalamazoo River, which drains into Lake Michigan. The amount of oil discharged is estimated at 819,000 to 1,000,000 gallons. The Kalamazoo River is bordered by wetland, forest, residential properties, farmland, and commercial properties for the approximate 35-mile stretch of impacted river in Calhoun County between Marshall and Morrow Lake.

During September 2010, staff of the Surface Water Assessment Section (SWAS), Water Resources Division, conducted qualitative macroinvertebrate community and stream habitat surveys on the Kalamazoo River and Talmadge Creek. The objective of these surveys was to monitor the short-term effects of the oil spill and associated cleanup activities on macroinvertebrate communities and aquatic habitat. SWAS staff also assisted Fisheries Division staff with fish collection efforts and quantitative stream habitat assessments. The Fisheries Division is preparing a separate report, which details the fish and quantitative stream habitat sampling efforts. Additional surveys will be conducted in the future to monitor the short- and long-term effects of the oil spill and associated cleanup activities on the fish and macroinvertebrate communities and aquatic habitat (Wesley and Walterhouse, 2010).

METHODS

Most of the sites that were selected for this survey were specifically chosen because of historic (i.e., baseline) surveys that were conducted prior to the oil spill. An additional site on Talmadge Creek was added just upstream of the oil spill because stream flow at the historic control site further upstream at 17 Mile Road was minimal and the stream habitat had characteristics more typical of a wetland. A survey was also conducted at a site on the Kalamazoo River downstream of Talmadge Creek, where historical survey data was lacking, but the upstream proximity of Talmadge Creek warranted the addition of the site to determine impacts.

The surveys described in this report were conducted according to the guidelines of the SWAS Procedure 51 (MDEQ, 1990). Procedure 51 surveys conducted prior to 2008 and those conducted in 2010 were performed with nearly the same methodology except the macroinvertebrate sample size was increased from 100 to 300 with the 2008 revision to Procedure 51. The macroinvertebrate communities were scored with metrics that rate water bodies from excellent (+5 to +9) to poor (-5 to -9). Macroinvertebrate ratings from +4 to -4 are considered acceptable. Negative ratings that are acceptable are indicative of water bodies that are strongly tending toward poor, while positive ratings that are acceptable indicate slight impairment (Creal et al., 1996). Stream habitat was qualitatively evaluated at each station using a scoring system, which ranged in value from 0 (poor) to 200 (excellent).

Sampling locations are shown in Figure 1.

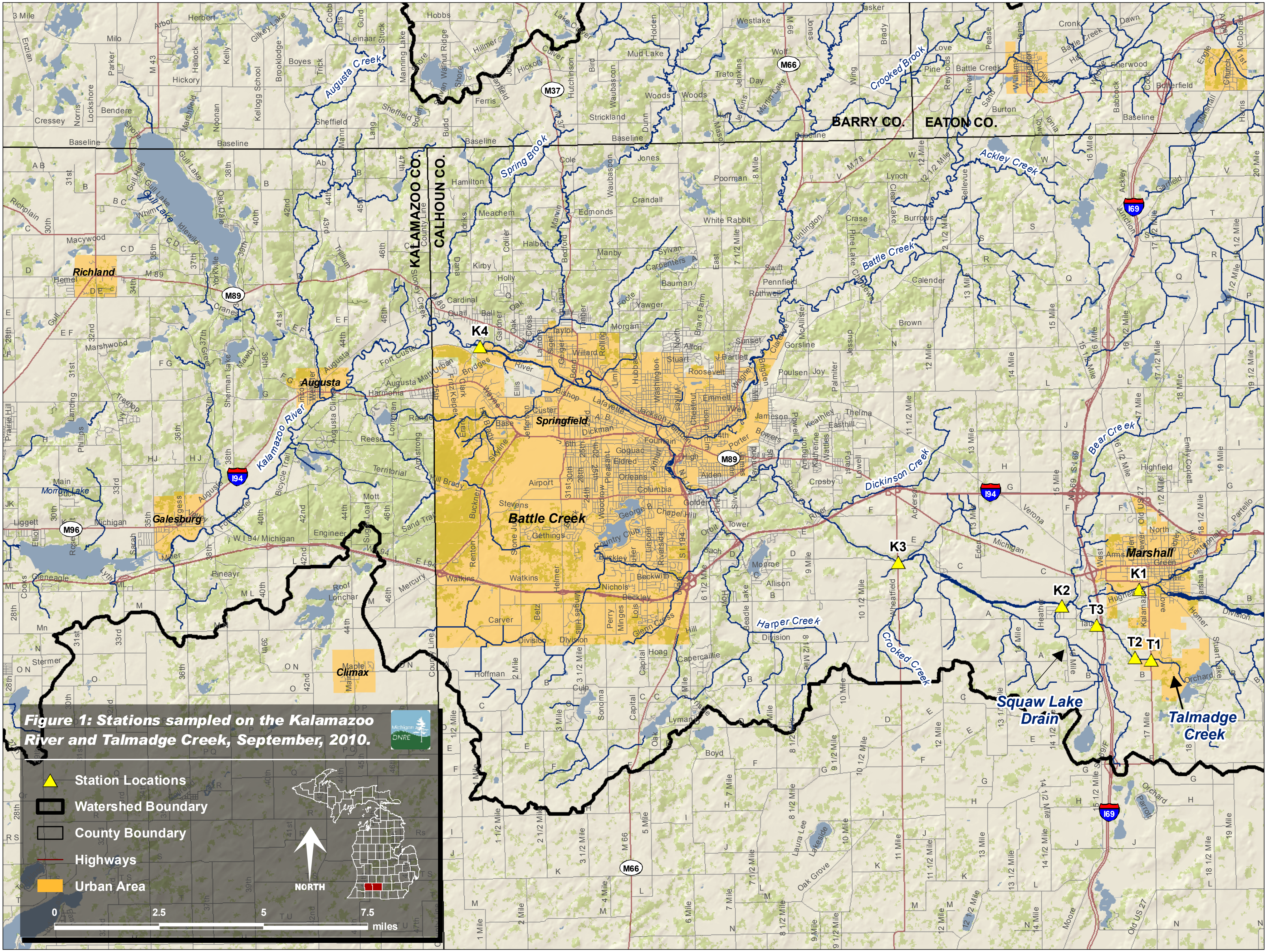

Figure 1: Stations sampled on the Kalamazoo River and Talmadge Creek, September, 2010.

SUMMARY and OBSERVATIONS

Macroinvertebrate abundance and diversity were drastically reduced in Talmadge Creek and the Kalamazoo River downstream of the oil spill. Procedure 51 qualitative macroinvertebrate scores and ratings alone do not adequately measure the impact of the oil spill and associated cleanup activities.

Sampling efforts in depositional zones at all of the impacted sites on Talmadge Creek and the Kalamazoo River caused a disturbance that produced a surface oil sheen. The water and sediment at all of the impacted sites also had a notable petroleum odor.

The shallow riffle habitat at the impacted Kalamazoo River sites (stations K2 and K3) had obviously been heavily disturbed by the boat traffic associated with the cleanup operations. The cobble habitat in the riffles was abnormally clean and free of periphyton, loose (not embedded at all), and many of the boulders and cobbles were marked with material from boat hulls and propellers.

The waves associated with the abnormal boat traffic were creating turbidity and causing bank erosion. The wave action was also likely dislodging macroinvertebrates, especially in shallow habitats.

SAMPLING RESULTS

Talmadge Creek - Macroinvertebrates

The macroinvertebrate community sampling results for stations on Talmadge Creek are presented in Table 1a and the macroinvertebrate community metrics, scores, and ratings are presented in Table 1b. The stations are arranged in an upstream to downstream sequence. Two stations were surveyed as controls upstream of the oil spill. The control station at 17 Mile Road (station T1) was surveyed in 1999 allowing for comparisons with the current survey (Cooper, 2000). The control station downstream of 17 Mile Road (station T2) had never been surveyed but the stream habitat and greater flow volume were more similar to conditions downstream on the oil impacted segment of Talmadge Creek. Talmadge Creek was sampled in the oil impacted reach at 15½ Mile Road (station T3) where a survey was also conducted in 1999 (Cooper, 2000). Station T3 is one mile downstream (Mile Post 1.0) of where oil from the pipeline failure entered Talmadge Creek.

The macroinvertebrate community sampling results documented that of the 3 sites surveyed on Talmadge Creek, station T3 received the lowest score, supported the fewest taxa, and was dominated by Chironomidae (midge) larvae. The upstream site (station T2) that was comparable in terms of stream habitat and flow received an overall score of +1 compared to the score of -4 at station T3. The number of taxa decreased from 27 at station T2 to only 7 at station T3. Specific taxa that were present at both stations T1 and T2 that were absent at station T3 included Hirudinea, Amphipoda, Hydracarina, Caenidae, Limnephilidae, Physidae, Planorbidae, and Sphaeriidae.

The results of the current macroinvertebrate survey are presented along with the historic survey results from 1999 (Cooper, 2000) at stations T1 and T3 in Tables 2a and 2b. The upstream control site at station T1 consisted of taxa predominately associated with wetland habitat during both surveys. Some of the differences in macroinvertebrate community overall scores, number of taxa, and specific community attributes can likely be attributed to seasonal changes in abundance. The 1999 survey was conducted in July while the 2010 survey was conducted in September. At station T3 the overall macroinvertebrate score did not change significantly from 1999 to 2010; however, the overall macroinvertebrate community changed from a rather balanced community where 19 total taxa were identified, to a community dominated by one taxa with only 7 total taxa present.

Kalamazoo River - Macroinvertebrates

The macroinvertebrate community sampling results for stations on the Kalamazoo River are presented in Table 3a and the macroinvertebrate community metrics, scores, and ratings are presented in Table 3b. The stations are arranged in an upstream to downstream sequence. The control station on the Kalamazoo River was upstream of the oil spill in Marshall at Kalamazoo Street (station K1). Three sites on the Kalamazoo River were surveyed in the reach that was impacted by the oil spill and the associated cleanup activities. Station K2 was located on the Kalamazoo River in the vicinity of the Squaw Lake Drain confluence at about Mile Post 2.75. Station K3 was downstream of the Ceresco Dam at 11 Mile Road approximately at Mile Post 7.25. Station K4 on the Kalamazoo River was located downstream of the city of Battle Creek at Custer Drive at about Mile Post 21.25.

The upstream control site on the Kalamazoo River (station K1) had an overall macroinvertebrate community score of +5 and a rating of excellent. The abundance of Simuliidae (black fly) larvae at the site impacted several metrics and lowered the overall score. The macroinvertebrate community at station K2 scored +6 and was rated as excellent. The site still harbored a diversity of taxa, many of which are considered intolerant of pollution. Downstream at station K3, the macroinvertebrate community scored +3 and was rated as acceptable. The site still supported a diversity of taxa, many of which are intolerant of pollution. The macroinvertebrate community further downstream at station K4 scored +2 and was also rated as acceptable. The 20 taxa collected at the site were reduced compared to the upstream sites where greater than 30 taxa were collected. The greater taxa diversity upstream at stations K1, K2, and K3, compared to downstream at station K4, is likely related to the greater diversity of in-stream substrates and cover at the upstream sites.

The results of the 2010 macroinvertebrate survey on the Kalamazoo River at Kalamazoo Street (station K1) are presented along with historic survey results from 1999 (Cooper, 2000) and 2004 (Walterhouse, 2005) in Tables 4a and 4 b. The macroinvertebrate community at K1 scored +4 to +6 during the current and previous sampling events and was rated as acceptable or excellent. The 34 taxa collected in September 2010 compares fairly well with 40 taxa collected in August 2004 and the 20 taxa collected in September 1999.

The results of the macroinvertebrate survey on the Kalamazoo River at 11 Mile Road (station K3) are presented along with historic sampling results from 2004 (Walterhouse, 2005) and 2008 (LeSage, 2009) in Tables 5a and 5b. In August 2004, 44 taxa were collected at the site and the macroinvertebrate community scored +6 and was rated as excellent. In late August 2008, the site was surveyed as part of a quality assurance evaluation of Procedure 51 (method and crew variance) by 2 crews who each sampled the site twice on one day (Lesage, 2009). The number of taxa collected during the four sampling efforts ranged from 44 to 56 and the macroinvertebrate community scores ranged from +2 to +4 with ratings of acceptable. The sampling effort in September 2010 produced only 31 taxa, but still resulted in a macroinvertebrate community score of + 3 and an acceptable rating. Many of the taxa, particularly filter feeding organisms, which were present in 2004 and 2008, were not collected in 2010.

The results of the macroinvertebrate survey on the Kalamazoo River at Custer Drive (station K4) are presented along with historic sampling results from 1994 (Kosek, 1994), 2004 (Walterhouse, 2005) and 2009 (Walterhouse, 2011) in Tables 6a and 6b. Ironically, this site was surveyed on September 15, 2009, and again exactly one year later. In 2009, 33 taxa were collected and the macroinvertebrate community scored +6 and was rated as excellent. In 2010, 20 taxa were collected and the macroinvertebrate community scored +2 and was rated as acceptable. Previous surveys in 1994 and 2004 were conducted in part because of the upstream proximity to the Battle Creek Wastewater Treatment Plant (NPDES #MI0022276) discharge. The previous surveys documented macroinvertebrate scores of +4 and +2 with acceptable ratings in 1994 and 2004, respectively.

Talmadge Creek – Stream Habitat

Qualitative stream habitat assessment results for sites on Talmadge Creek are presented in Table 7. The habitat at station T1 was rated as good primarily because of the wide natural wetland riparian corridor adjacent to the stream channel. The substrate was soft muck and flow was limited creating habitat that would be better classified as wetland habitat. Downstream at station T2 stream habitat was rated as excellent. Flow was slightly greater than at station T1. Riffle habitat was lacking and sand was the predominant substrate but some gravel and cobble were present along with an abundance of in-stream cover. The riparian corridor was a wide undisturbed scrub/shrub wetland.

The in-stream habitat, stream banks, and adjacent riparian corridor at station T3 were highly disturbed due to the cleanup activities and were rated as marginal. Riffle habitat was present but in-stream cover was extremely limited. The substrate was primarily sand with lesser amounts of gravel and limited cobble. A different habitat assessment technique was used in 1999; however, the average stream width was 18 feet this year compared to the width of 6 feet that was documented during the survey in 1999 (Cooper, 2000).

Kalamazoo River – Stream Habitat

The qualitative stream habitat evaluations for sites on the Kalamazoo River are presented in Table 8. Riffle habitat was lacking at the upstream control site (station K1) and glide/pool metrics were used to produce an overall stream habitat rating of good. In-stream habitat was abundant and included moderate amounts of large woody debris, aquatic vegetation, and root wads. The stream substrate was diverse with a nearly equal mixture of cobble, gravel, sand, and silt along with scattered boulders. The only significant detraction from the overall habitat score was the limited width of the riparian zone.

The riffle/run habitat on the Kalamazoo River at station K2 was rated as excellent. The dominant substrate was cobble with lesser amounts of gravel, sand, silt, and boulders. Additional forms of in-stream habitat such as undercut banks, large woody debris, aquatic vegetation, overhanging vegetation, and root wads had been reduced by activities associated with the cleanup activities.

The overall stream habitat at station K3 on the Kalamazoo River was rated as excellent using riffle/run metrics. Cobble and gravel were the dominant substrates along with scattered boulders and lesser amounts of sand and silt along the stream margins. Others forms of in-stream cover that were still moderately abundant included large woody debris, aquatic vegetation, and root wads. Cleanup operations had nearly eliminated all overhanging vegetation.

The Kalamazoo River at station K4 is much larger with an average width estimated at 360 feet and an estimated average depth of 2.5 feet. The overall stream habitat was rated as good using glide/pool metrics. The wide wooded floodplain at this site inflates the overall stream habitat score. In-stream habitat that is suitable for macroinvertebrate colonization was limited. Sand was the predominant form of substrate with scattered patches of gravel and occasional cobbles and boulders. Silt was the second most common form of substrate, but it was primarily limited to the stream margins. Other in-stream cover present in sparse quantities were aquatic vegetation, large woody debris, root wads, and undercut banks.

Macroinvertebrate Abundance

Procedure 51 is a qualitative collection method that involves sampling all available in-stream habitats to produce a composite macroinvertebrate sample that is typically subsampled until 300 organisms have been identified and counted. After 300 organisms have been counted, the remainder of the composite sample is examined for large and/or rare organisms that were not identified in the initial subsamples. These organisms are added as one individual to the total taxa list. Typically, only a small volume of the composite sample is needed to yield the 300 organisms required by Procedure 51. This is especially true in streams such as the Kalamazoo River that have a diversity of in-stream habitat types, especially in riffle habitats that were present at stations K2 and K3. The majority of the sample is typically examined for large and/or rare taxa. Counting the entire composite sample is seldom necessary, except in streams that are either habitat-limited or have serious violations of Michigan's Water Quality Standards. Macroinvertebrate abundance in the composite samples at the upstream control sites on Talmadge Creek (stations T1 and T2) and the Kalamazoo River (station K1) was normal. The abundance of macroinvertebrates in the composite samples collected at all of the impacted sites on Talmadge Creek (station T3) and Kalamazoo River (stations K2, K3, and K4) was so low that the entire composite sample was counted at all of the sites and the goal of enumerating 300 organisms was not achieved at the site on Talmadge Creek and station K4 on the Kalamazoo River.

The sampling effort at the impacted sites on Talmadge Creek and the Kalamazoo River was more intensive than normal. Each macroinvertebrate sample from the different habitat types was inspected before it was added to the composite sample in an effort to identify habitat that was not impacted. It was apparent during the sampling effort that the abundance of macroinvertebrates associated with all of the different habitat types was extremely low and extra effort was expended sampling all forms of habitat at all depths and flow velocities in order to obtain a sample of 300 organisms.

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Table 1A. Qualitative macroinvertebrate sampling results for sites on Talmadge Creek in the vicinity of the Enbridge oil spill, Calhoun County, September, 201(

TAXA	Talmadge Creek 17 Mile Road 9/16/2010 STATION T1	Talmadge Creek downstream 17 Mile Road 9/16/2010 STATION T2	Talmadge Creek 15 1/2 Mile Road 9/16/2010 STATION T3
ANNELIDA (segmented worms)			
Hirudinea (leeches)	31	3	
Oligochaeta (worms)	8		8
ARTHROPODA			
Crustacea			
Amphipoda (scuds)	34	107	
Decapoda (crayfish)		2	
Arachnoidea			
Hydracarina	1	1	
Insecta			
Ephemeroptera (mayflies)			
Baetidae		12	21
Caenidae	37	14	
Odonata			
Anisoptera (dragonflies)			
Libellulidae	7		
Zygoptera (damselflies)			
Calopterygidae	1	27	1
Coenagrionidae		1	
Hemiptera (true bugs)			
Belostomatidae	1	1	1
Corixidae		1	
Gerridae		1	
Notonectidae		1	
Megaloptera			
Sialidae (alder flies)		3	
Trichoptera (caddisflies)			
Hydropsychidae		6	
Leptoceridae		1	
Limnephilidae	1	1	
Uenoidae		1	
Coleoptera (beetles)			
Dytiscidae (total)		1	
Haliplidae (adults)		8	
Hydrophilidae (total)		1	
Diptera (flies)			
Chironomidae	79	38	150
Culicidae		1	
Simuliidae		60	15
MOLLUSCA			
Gastropoda (snails)			
Ancylidae (limpets)	1	28	1
Physidae	4	1	
Planorbidae	5	6	
Pelecypoda (bivalves)			
Sphaeriidae (clams)	81	22	
TOTAL INDIVIDUALS	291	349	197

Table 1B. Macroinvertebrate metric evaluation of sites on Talmadge Creek in the vicinity of the Enbridge oil spill, Calhoun County, September, 2010.

	Talmadge Creek 17 Mile Road 9/16/2010 STATION T1		Talmadge Creek downstream 17 Mile Road 9/16/2010 STATION T2		Talmadge Creek 15 1/2 Mile Road 9/16/2010 STATION T3	
METRIC	Value	Score	Value	Score	Value	Score
TOTAL NUMBER OF TAXA	14	1	27	1	7	-1
NUMBER OF MAYFLY TAXA	1	0	2	1	1	-1
NUMBER OF CADDISFLY TAXA	1	0	4	1	0	-1
NUMBER OF STONEFLY TAXA	0	-1	0	-1	0	-1
PERCENT MAYFLY COMP.	12.71	0	7.45	0	10.66	0
PERCENT CADDISFLY COMP.	0.34	-1	2.58	-1	0.00	-1
PERCENT DOMINANT TAXON	27.84	0	30.66	0	76.14	-1
PERCENT ISOPOD, SNAIL, LEECH	14.09	-1	10.89	-1	0.51	1
PERCENT SURF. AIR BREATHERS	0.34	1	4.30	1	0.51	1
TOTAL SCORE	-1		1		-4	
MACROINV. COMMUNITY RATING	ACCEPT.		ACCEPT.		ACCEPT.	

Table 2a. Qualitative macroinvertebrate sampling results at sites on Talmadge Creek, Calhoun County, 1999 and 2010.

TAXA	Talmadge Creek 17 Mile Road 7/12/1999 STATION T1	Talmadge Creek 17 Mile Road 9/16/2010 STATION T1	Talmadge Creek 15 1/2 Mile Road 7/12/1999 STATION T3	Talmadge Creek 15 1/2 Mile Road 9/16/2010 STATION T3
ANNELIDA (segmented worms)				
Hirudinea (leeches)		31		
Oligochaeta (worms)		8	1	8
ARTHROPODA				
Crustacea				
Amphipoda (scuds)	30	34	10	
Decapoda (crayfish)	2		3	
Arachnoidea				
Hydracarina	3	1	15	
Insecta				
Ephemeroptera (mayflies)				
Baetidae	2		7	21
Caenidae	6	37		
Odonata				
Anisoptera (dragonflies)				
Aeshnidae	4		1	
Gomphidae	1			
Libellulidae		7		
Zygoptera (damselflies)				
Calopterygidae	10	1	3	1
Coenagrionidae	10			
Hemiptera (true bugs)				
Belostomatidae		1		1
Corixidae	1		5	
Gerridae	1		1	
Veliidae			1	
Megaloptera				
Sialidae (alder flies)			1	
Trichoptera (caddisflies)				
Hydropsychidae			1	
Limnephilidae	1	1		
Coleoptera (beetles)				
Elmidae			2	
Diptera (flies)				
Ceratopogonidae	1			
Chironomidae	25	79	30	150
Simuliidae			6	15
Tabanidae			1	
MOLLUSCA				
Gastropoda (snails)				
Ancylidae (limpets)		1	1	1
Physidae	1	4	2	
Planorbidae	3	5	1	
Pelecypoda (bivalves)				
Sphaeriidae (clams)	5	81		
TOTAL INDIVIDUALS	106	291	92	197

Table 2b. Macroinvertebrate metric evaluation at sites on Talmadge Creek, Calhoun County, 1999 and 2010.

	Talmadge Creek 17 Mile Road 7/12/1999 STATION T1		Talmadge Creek 17 Mile Road 9/16/2010 STATION T1		Talmadge Creek 15 1/2 Mile Road 7/12/1999 STATION T3		Talmadge Creek 15 1/2 Mile Road 9/16/2010 STATION T3	
METRIC	Value	Score	Value	Score	Value	Score	Value	Score
TOTAL NUMBER OF TAXA	17	1	14	1	19	0	7	-1
NUMBER OF MAYFLY TAXA	2	1	1	0	1	0	1	-1
NUMBER OF CADDISFLY TAXA	1	0	1	0	1	-1	0	-1
NUMBER OF STONEFLY TAXA	0	-1	0	-1	0	-1	0	-1
PERCENT MAYFLY COMP.	7.55	0	12.71	0	7.61	0	10.66	0
PERCENT CADDISFLY COMP.	0.94	-1	0.34	-1	1.09	-1	0.00	-1
PERCENT DOMINANT TAXON	28.30	0	27.84	0	32.61	0	76.14	-1
PERCENT ISOPOD, SNAIL, LEECH	3.77	1	14.09	-1	4.35	0	0.51	1
PERCENT SURF. AIR BREATHERS	1.89	1	0.34	1	7.61	0	0.51	1
TOTAL SCORE	2		-1		-3		-4	
MACROINV. COMMUNITY RATING	ACCEPT.		ACCEPT.		ACCEPT.		ACCEPT.	

Table 3A. Qualitative macroinvertebrate sampling results for sites on the Kalamazoo River in the vicinity of the Enbridge oil spill, Calhoun County, September 2010.

TAXA	Kalamazoo River Kalamazoo St. 9/9/2010 STATION K1	Kalamazoo River Squaw Lk Drain confluence 9/15/2010 STATION K2	Kalamazoo River 11-Mile Rd 9/9/2010 STATION K3	Kalamazoo River Custer Drive 9/15/2010 STATION K4
PORIFERA (sponges)	1	1		1
ANNELIDA (segmented worms)				
Hirudinea (leeches)	1		3	
Oligochaeta (worms)	1	2	4	1
ARTHROPODA				
Crustacea				
Amphipoda (scuds)	8	43		13
Decapoda (crayfish)	1	2	1	
Isopoda (sowbugs)	1	2		3
Arachnoidea				
Hydracarina	1		2	
Insecta				
Ephemeroptera (mayflies)				
Baetidae	26	67	54	12
Caenidae	1			1
Ephemerellidae		1		
Heptageniidae	22	22	17	4
Isonychiidae	3	11	3	
Tricorythidae	3	10	3	2
Odonata				
Anisoptera (dragonflies)				
Aeshnidae		2	1	1
Gomphidae		1	2	7
Zygoptera (damselflies)				
Calopterygidae	1	13	3	2
Coenagrionidae	1	2	7	34
Plecoptera (stoneflies)				
Perlidae		1		
Pteronarcyidae	2	1	1	
Hemiptera (true bugs)				
Belostomatidae		4		
Corixidae	1	3		
Gerridae	1			1
Nepidae		1		
Pleidae	1			
Megaloptera				
Corydalidae (dobson flies)			2	
Sialidae (alder flies)		2		
Trichoptera (caddisflies)				
Brachycentridae	5			6
Helicopsychidae		5		
Hydropsychidae	18	10		54
Hydroptilidae		1	1	
Leptoceridae	6	1	2	
Limnephilidae		2		
Philopotamidae	2			
Polycentropodidae	1			
Uenoidae		6	3	
Coleoptera (beetles)				
Dytiscidae (total)			1	
Gyrinidae (adults)	1		1	
Haliplidae (adults)			15	
Elmidae	2	5	7	
Psephenidae (larvae)	1		1	
Diptera (flies)				
Ceratopogonidae		1		
Chironomidae	6	20	18	21
Simuliidae	196	27		
Tabanidae	1	1		
Tipulidae		3		
MOLLUSCA				
Gastropoda (snails)				
Ancylidae (limpets)	1	1	1	12
Hydrobiidae		6	3	
Lymnaeidae		17	5	
Physidae	1			2
Planorbidae			1	1
Pleuroceridae	2	1	86	
Pelecypoda (bivalves)				
Corbiculidae	1	9	2	7
Sphaeriidae (clams)	1		49	
Unionidae (mussels)		1	1	
TOTAL INDIVIDUALS	321	308	300	185

Table 3B. Macroinvertebrate metric evaluation of sites on the Kalamazoo River in the vicinity of the Enbridge oil spill, Calhoun County, September 2010.

METRIC	Kalamazoo River Kalamazoo St. 9/9/2010 STATION K1 Value	Score	Kalamazoo River Squaw Lk Drain confluence 9/15/2010 STATION K2 Value	Score	Kalamazoo River 11-Mile Rd 9/9/2010 STATION K3 Value	Score	Kalamazoo River Custer Drive 9/15/2010 STATION K4 Value	Score
TOTAL NUMBER OF TAXA	34	1	38	1	31	1	20	0
NUMBER OF MAYFLY TAXA	5	1	5	1	4	1	4	1
NUMBER OF CADDISFLY TAXA	5	1	6	1	3	0	2	0
NUMBER OF STONEFLY TAXA	1	1	2	1	1	1	0	-1
PERCENT MAYFLY COMP.	17.13	0	36.04	1	25.67	1	10.27	0
PERCENT CADDISFLY COMP.	9.97	0	8.12	0	2.00	-1	32.43	1
PERCENT DOMINANT TAXON	61.06	-1	21.75	0	28.67	0	29.19	0
PERCENT ISOPOD, SNAIL, LEECH	1.87	1	8.77	0	33.00	-1	9.73	0
PERCENT SURF. AIR BREATHERS	1.25	1	2.60	1	5.67	1	0.54	1
TOTAL SCORE	5		6		3		2	
MACROINV. COMMUNITY RATING	EXCELLENT		EXCELLENT		ACCEPT.		ACCEPT.	

Table 4A. Qualitative macroinvertebrate sampling results at Kalamazoo Street (17 Mile Rd), Kalamazoo River, Calhoun County, 1999, 2004 and 2010.

TAXA	Kalamazoo River Kalamazoo St. 9/18/1999 STATION K1	Kalamazoo River Kalamazoo St. 8/16/2004 STATION K1	Kalamazoo River Kalamazoo St. 9/9/2010 STATION K1
PORIFERA (sponges)		1	1
ANNELIDA (segmented worms)			
Hirudinea (leeches)			1
Oligochaeta (worms)		1	1
ARTHROPODA			
Crustacea			
Amphipoda (scuds)	30	5	8
Decapoda (crayfish)		1	1
Isopoda (sowbugs)		2	1
Arachnoidea			
Hydracarina	2	1	1
Insecta			
Ephemeroptera (mayflies)			
Baetidae	15	5	26
Caenidae		2	1
Ephemerellidae		2	
Heptageniidae	4	5	22
Isonychiidae		1	3
Tricorythidae			3
Odonata			
Anisoptera (dragonflies)			
Aeshnidae	2	1	
Gomphidae		1	
Zygoptera (damselflies)			
Calopterygidae		1	1
Coenagrionidae	2	3	1
Plecoptera (stoneflies)			
Perlidae	6		
Pteronarcyidae		1	2
Hemiptera (true bugs)			
Corixidae		5	1
Gerridae	2	1	1
Mesoveliidae		1	
Nepidae		1	
Pleidae			1
Megaloptera			
Sialidae (alder flies)		1	
Trichoptera (caddisflies)			
Brachycentridae	2	5	5
Glossosomatidae	2		
Helicopsychidae	4		
Hydropsychidae	8	15	18
Lepidostomatidae		1	
Leptoceridae		2	6
Limnephilidae	10	3	
Philopotamidae	4	1	2
Phryganeidae		1	
Polycentropodidae		2	1
Uenoidae		1	
Coleoptera (beetles)			
Gyrinidae (adults)		1	1
Elmidae	3	3	2
Gyrinidae (larvae)		1	
Psephenidae (larvae)			1
Diptera (flies)			
Chironomidae	4	15	6
Simuliidae		5	196
Tabanidae		1	1
MOLLUSCA			
Gastropoda (snails)			
Ancylidae (limpets)	1	1	1
Physidae	2		1
Planorbidae		1	
Pleuroceridae			2
Viviparidae		1	
Pelecypoda (bivalves)			
Corbiculidae		1	1
Pisidiidae	2		
Sphaeriidae (clams)	2	1	1
TOTAL INDIVIDUALS	107	104	321

Table 4B. Macroinvertebrate metric evaluation at Kalamazoo Street (17 Mile Rd), Kalamazoo River, Calhoun County, 1999, 2004 and 2010.

	Kalamazoo River Kalamazoo St. 9/18/1999 STATION K1		Kalamazoo River Kalamazoo St. 8/16/2004 STATION K1		Kalamazoo River Kalamazoo St. 9/9/2010 STATION K1	
METRIC	Value	Score	Value	Score	Value	Score
TOTAL NUMBER OF TAXA	20	0	40	1	34	1
NUMBER OF MAYFLY TAXA	2	0	5	1	5	1
NUMBER OF CADDISFLY TAXA	6	1	9	1	5	1
NUMBER OF STONEFLY TAXA	1	1	1	1	1	1
PERCENT MAYFLY COMP.	17.76	0	14.42	0	17.13	0
PERCENT CADDISFLY COMP.	28.04	0	29.81	1	9.97	0
PERCENT DOMINANT TAXON	28.04	0	14.42	1	61.06	-1
PERCENT ISOPOD, SNAIL, LEECH	2.80	1	4.81	0	1.87	1
PERCENT SURF. AIR BREATHERS	1.87	1	8.65	0	1.25	1
TOTAL SCORE	4		6		5	
MACROINV. COMMUNITY RATING	ACCEPT.		EXCELLENT		EXCELLENT	

Table 5a. Qualitative macroinvertebrate sampling results at 11 Mile Road, Calhoun County, 2004, 2008 and 2010.

TAXA	Kalamazoo River 11-Mile Rd 8/16/2004 STATION K3	Kalamazoo River 11-Mile Rd 8/27/2008 STATION K3	Kalamazoo River 11-Mile Rd 8/27/2008 STATION K3	Kalamazoo River 11-Mile Rd 8/27/2008 STATION K3	Kalamazoo River 11-Mile Rd 8/27/2008 STATION K3	Kalamazoo River 11-Mile Rd 9/9/2010 STATION K3
PORIFERA (sponges)	1					
PLATYHELMINTHES (flatworms)						
Turbellaria		4				
BRYOZOA (moss animals)	1					
ANNELIDA (segmented worms)						
Hirudinea (leeches)		1	1	1	3	3
Oligochaeta (worms)	1	13	18	20	19	4
ARTHROPODA						
Crustacea						
Amphipoda (scuds)	5	3	8	54	12	
Decapoda (crayfish)	1	1	1	1	1	1
Isopoda (sowbugs)			2	1	2	
Arachnoidea						
Hydracarina	1	4	2			2
Insecta						
Ephemeroptera (mayflies)						
Baetidae	5	42	46	26	48	54
Caenidae	2	2	1	2	5	
Ephemerellidae		1	1			
Ephemeridae				1		
Heptageniidae	5	6	4	3	2	17
Isonychiidae	3	1	1	4	1	3
Tricorythidae	2	8	8	5	4	3
Odonata						
Anisoptera (dragonflies)						
Aeshnidae	1	1	1	1		1
Gomphidae	1	1	1	1	1	2
Libellulidae	1		1			
Macromiidae			1			
Zygoptera (damselflies)						
Calopterygidae	2	2	13	1	11	3
Coenagrionidae	2	4	3	16	2	7
Plecoptera (stoneflies)						
Perlidae	2					
Pteronarcyidae			1			1
Hemiptera (true bugs)						
Belostomatidae		1		1		
Corixidae	5	3	15	8	7	
Gerridae	1	1	1	2	2	
Mesoveliidae	1	1	2	5	1	
Naucoridae				1		
Notonectidae			1			
Pleidae	1		1	2	1	
Megaloptera						
Corydalidae (dobson flies)	1		1		1	2
Sialidae (alder flies)	1	1	1	3		
Neuroptera (spongilla flies)						
Sisyridae	1					
Trichoptera (caddisflies)						
Brachycentridae		2	3	10	1	
Glossosomatidae			1			
Helicopsychidae	1	8	9	8	4	
Hydropsychidae	12	45	48	19	29	
Hydroptilidae		4	17	6	8	1
Lepidostomatidae			1			
Leptoceridae	1	1	3	1	1	2
Limnephilidae	3	1	1			
Philopotamidae	1	1				
Phryganeidae	1					
Polycentropodidae	2	2	1	1	1	
Uenoidae	2	2	1	1	1	3
Lepidoptera (moths)						
Pyralidae			1	1	1	
Coleoptera (beetles)						
Gyrinidae (adults)	1	1	1			1
Haliplidae (adults)		1	1	4	1	15
Hydrophilidae (total)	1	1	1			
Elmidae	2	9	6	6	5	7
Gyrinidae (larvae)				1	1	
Psephenidae (larvae)			1	1		1
Scirtidae (larvae)		1				
Diptera (flies)						
Ceratopogonidae	1			2	1	
Chironomidae	12	21	20	51	23	18
Culicidae				4		
Ptychopteridae			1			
Simuliidae	5	22	21	2	9	
Tabanidae		3	1	1	2	
Tipulidae		1	1	1		
MOLLUSCA						
Gastropoda (snails)						
Ancylidae (limpets)	1	1	1		2	1
Hydrobiidae		29	10	73	87	3
Physidae		3	1	4	3	
Planorbidae	1	4	6	7	11	1
Pleuroceridae		100	90	21	17	86
Valvatidae	1					
Viviparidae		1	2	1	2	
Pelecypoda (bivalves)						
Corbiculidae	1	1	1	1	1	2
Sphaeriidae (clams)	1	22	10	20	9	49
Unionidae (mussels)	1	1	1	1	1	1
TOTAL INDIVIDUALS	98	389	398	407	346	300

Table 5b. Macroinvertebrate metric evaluation at 11 Mile Road, Calhoun County, 2004, 2008 and 2010.

	Kalamazoo River 11-Mile Rd 8/16/2004 STATION K3		Kalamazoo River 11-Mile Rd 8/27/2008 STATION K3		Kalamazoo River 11-Mile Rd 8/27/2008 STATION K3		Kalamazoo River 11-Mile Rd 8/27/2008 STATION K3		Kalamazoo River 11-Mile Rd 8/27/2008 STATION K3		Kalamazoo River 11-Mile Rd 9/9/2010 STATION K3	
METRIC	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score
TOTAL NUMBER OF TAXA	44	1	48	1	56	1	48	1	43	1	30	1
NUMBER OF MAYFLY TAXA	5	1	6	1	6	1	6	1	5	1	4	1
NUMBER OF CADDISFLY TAXA	8	1	9	1	10	1	7	1	7	1	3	0
NUMBER OF STONEFLY TAXA	1	1	0	-1	1	1	0	-1	0	-1	1	1
PERCENT MAYFLY COMP.	17.35	0	15.42	0	15.33	0	10.07	0	17.34	0	25.67	1
PERCENT CADDISFLY COMP.	23.47	0	16.97	0	21.36	0	11.30	0	13.01	0	2.00	-1
PERCENT DOMINANT TAXON	12.24	1	25.71	0	22.61	0	17.94	1	25.14	0	28.67	0
PERCENT ISOPOD, SNAIL, LEECH	3.06	1	35.73	-1	28.39	-1	26.54	-1	36.71	-1	33.00	-1
PERCENT SURF. AIR BREATHERS	10.20	0	2.31	1	6.03	1	6.63	1	4.05	1	5.67	1
TOTAL SCORE	6		2		4		3		2		3	
MACROINV. COMMUNITY RATING	EXCELLENT		ACCEPT.		ACCEPT.		ACCEPT.		ACCEPT.		ACCEPT.	

Table 6a. Qualitative macroinvertebrate sampling results at Custer Drive, Calhoun County, 1994, 2004, 2009 and 2010.

TAXA	Kalamazoo River Custer Drive 9/9/1994 STATION K4	Kalamazoo River Custer Drive 8/17/2004 STATION K4	Kalamazoo River Custer Drive 9/15/2009 STATION K4	Kalamazoo River Custer Drive 9/15/2010 STATION K4
PORIFERA (sponges)				1
PLATYHELMINTHES (flatworms)				
Turbellaria	2			
BRYOZOA (moss animals)		1		
ANNELIDA (segmented worms)				
Oligochaeta (worms)				1
ARTHROPODA				
Crustacea				
Amphipoda (scuds)	20	20	56	13
Decapoda (crayfish)		1	1	
Isopoda (sowbugs)	1	1	2	3
Insecta				
Ephemeroptera (mayflies)				
Baetiscidae			1	
Baetidae		5	16	12
Caenidae	2			1
Ephemerellidae	25	1		
Heptageniidae	2	5	1	4
Tricorythidae		5	3	2
Odonata				
Anisoptera (dragonflies)				
Aeshnidae	2	1	1	1
Gomphidae			2	7
Libellulidae			3	
Zygoptera (damselflies)				
Calopterygidae	2	2		2
Coenagrionidae	8	1	12	34
Plecoptera (stoneflies)				
Perlidae			1	
Perlodidae	1			
Pteronarcyidae			1	
Hemiptera (true bugs)				
Belostomatidae	2		1	
Corixidae		3		
Gerridae		1	2	1
Mesoveliidae	3	1		
Naucoridae	1			
Pleidae	1	1	1	
Veliidae			2	
Megaloptera				
Corydalidae (dobson flies)			1	
Sialidae (alder flies)	1			
Trichoptera (caddisflies)				
Brachycentridae		5	5	6
Hydropsychidae	4	5	103	54
Leptoceridae			3	
Limnephilidae		2		
Molannidae			2	
Philopotamidae	1		2	
Phryganeidae			1	
Polycentropodidae		1		
Coleoptera (beetles)				
Dytiscidae (total)			1	
Gyrinidae (adults)		1	1	
Elmidae	2	2	16	
Diptera (flies)				
Chironomidae	16	35	54	21
Culicidae		1		
Simuliidae	4	3	2	
MOLLUSCA				
Gastropoda (snails)				
Ancylidae (limpets)	1		6	12
Physidae		1	4	2
Planorbidae				1
Pleuroceridae			1	
Viviparidae		1		
Pelecypoda (bivalves)				
Corbiculidae		1		7
Sphaeriidae (clams)	1	1		
Unionidae (mussels)		1	1	
TOTAL INDIVIDUALS	102	109	309	185

Table 6b. Macroinvertebrate metric evaluation at Custer Drive, Calhoun County, 1994, 2004, 2009 and 2010.

METRIC	Kalamazoo River Custer Drive 9/9/1994 STATION K4 Value	Score	Kalamazoo River Custer Drive 8/17/2004 STATION K4 Value	Score	Kalamazoo River Custer Drive 9/15/2009 STATION K4 Value	Score	Kalamazoo River Custer Drive 9/15/2010 STATION K4 Value	Score
TOTAL NUMBER OF TAXA	22	0	29	1	33	1	20	0
NUMBER OF MAYFLY TAXA	3	0	4	1	4	1	4	1
NUMBER OF CADDISFLY TAXA	2	0	4	0	6	1	2	0
NUMBER OF STONEFLY TAXA	1	1	0	-1	2	1	0	-1
PERCENT MAYFLY COMP.	28.43	1	14.68	0	6.80	0	10.27	0
PERCENT CADDISFLY COMP.	4.90	0	11.93	0	37.54	1	32.43	1
PERCENT DOMINANT TAXON	24.51	0	32.11	0	33.33	0	29.19	0
PERCENT ISOPOD, SNAIL, LEECH	1.96	1	2.75	1	4.21	0	9.73	0
PERCENT SURF. AIR BREATHERS	6.86	1	7.34	0	2.59	1	0.54	1
TOTAL SCORE	4		2		6		2	
MACROINV. COMMUNITY RATING	ACCEPT.		ACCEPT.		EXCELLENT		ACCEPT.	

Table 7. Habitat evaluation for sites on Talmadge Creek in the vicinity of the Enbridge oil spill, Calhoun County, September 2010.

HABITAT METRIC	Station T1 Talmadge Creek 17 Mile Road GLIDE/POOL	Station T2 Talmadge Creek downstream 17 Mile Road GLIDE/POOL	Station T3 Talmadge Creek 15 1/2 Mile Road RIFFLE/RUN
Substrate and Instream Cover			
Epifaunal Substrate/ Avail Cover (20)	10	13	6
Embeddedness (20)*			13
Velocity/Depth Regime (20)*			8
Pool Substrate Characterization (20)**	11	13	
Pool Variability (20)**	10	10	
Channel Morphology			
Sediment Deposition (20)	8	10	13
Flow Status - Maint. Flow Volume (10)	9	9	3
Flow Status - Flashiness (10)	9	10	0
Channel Alteration (20)	13	16	1
Frequency of Riffles/Bends (20)*			18
Channel Sinuosity (20)**	10	15	
Riparian and Bank Structure			
Bank Stability (L) (10)	9	10	0
Bank Stability (R) (10)	9	10	0
Vegetative Protection (L) (10)	10	10	0
Vegetative Protection (R) (10)	10	10	0
Riparian Veg. Zone Width (L) (10)	10	10	5
Riparian Veg. Zone Width (R) (10)	10	10	1
TOTAL SCORE (200):	138	156	68
HABITAT RATING:	GOOD (SLIGHTLY IMPAIRED)	EXCELLENT (NON-IMPAIRED)	MARGINAL (MODERATELY IMPAIRED)

Note: Individual metrics may better describe conditions directly affecting the biological community while the Habitat Rating describes the general riverine environment at the site(s).

Date:	9/16/2010	9/16/2010	9/16/2010
Weather:	Cloudy	Rainy	Cloudy
Air Temperature:	70 Deg. F.	70 Deg. F.	70 Deg. F.
Water Temperature:	62 Deg. F.	62 Deg. F.	58 Deg. F.
Ave. Stream Width:	4 Feet	5 Feet	18 Feet
Ave. Stream Depth:	0.4 Feet	0.3 Feet	0.3 Feet
Surface Velocity:	0.5 Ft./Sec.	0.75 Ft./Sec.	1 Ft./Sec.
Estimated Flow:	0.8 CFS	1.125 CFS	5.4 CFS
Stream Modifications:	Dredged	None	Dredged
Nuisance Plants (Y/N):	N	N	N
STORET No.:	130336	130405	130335
Stream Name:	Talmadge Creek	Talmadge Creek	Talmadge Creek
Road Crossing/Location:	17 Mile Road	downstream 17 Mile Road	15 1/2 Mile Road
County Code:	13	13	13
TRS:	03S06W01	03S06W02	02S06W34
Latitude (dd):	42.2394598	42.2402	42.251717
Longitude (dd):	-84.9632235	-84.97066	-84.9885712
Ecoregion:	SMNITP	SMNITP	SMNITP
Stream Type:	Warmwater	Warmwater	Warmwater
USGS Basin Code:	4050003	4050003	4050003

* Applies only to Riffle/Run stream Surveys
** Applies only to Glide/Pool stream Surveys

COMMENTS:

Table 8. Habitat evaluation for sites on the Kalamazoo River in the vicinity of the the Enbridge oi spill, Calhoun County, September 2010.

HABITAT METRIC	Station K1 Kalamazoo River Kalamazoo St. GLIDE/POOL	Station K2 Kalamazoo River Squaw Lk Drain confluence RIFFLE/RUN	Station K3 Kalamazoo River 11-Mile Rd RIFFLE/RUN	Station K4 Kalamazoo River Custer Drive GLIDE/POOL
Substrate and Instream Cover				
Epifaunal Substrate/ Avail Cover (20)	18	16	15	10
Embeddedness (20)*		18	18	
Velocity/Depth Regime (20)*		18	15	
Pool Substrate Characterization (20)**	18			11
Pool Variability (20)**	16			8
Channel Morphology				
Sediment Deposition (20)	13	16	15	6
Flow Status - Maint. Flow Volume (10)	9	9	9	9
Flow Status - Flashiness (10)	7	7	8	8
Channel Alteration (20)	18	18	18	16
Frequency of Riffles/Bends (20)*		15	15	
Channel Sinuosity (20)**	15			13
Riparian and Bank Structure				
Bank Stability (L) (10)	9	7	9	8
Bank Stability (R) (10)	9	9	9	8
Vegetative Protection (L) (10)	4	6	8	9
Vegetative Protection (R) (10)	8	9	10	9
Riparian Veg. Zone Width (L) (10)	3	6	7	9
Riparian Veg. Zone Width (R) (10)	4	9	10	9
TOTAL SCORE (200):	151	163	166	133
HABITAT RATING:	GOOD (SLIGHTLY IMPAIRED)	EXCELLENT (NON-IMPAIRED)	EXCELLENT (NON-IMPAIRED)	GOOD (SLIGHTLY IMPAIRED)

Note: Individual metrics may better describe conditions directly affecting the biological community while the Habitat Rating describes the general riverine environment at the site(s).

Date:	9/9/2010	9/15/2010	9/9/2010	9/15/2010
Weather:	Sunny	Sunny	Sunny	Sunny
Air Temperature:	71 Deg. F.	55 Deg. F.	72 Deg. F.	64 Deg. F.
Water Temperature:	70 Deg. F.	64 Deg. F.	58 Deg. F.	65 Deg. F.
Ave. Stream Width:	120 Feet	200 Feet	150 Feet	360 Feet
Ave. Stream Depth:	3 Feet	1.5 Feet	1.5 Feet	2.5 Feet
Surface Velocity:	1 Ft./Sec.	1.25 Ft./Sec.	1.25 Ft./Sec.	0.6 Ft./Sec.
Estimated Flow:	360 CFS	375 CFS	281.25 CFS	540 CFS
Stream Modifications:	None	None	None	None
Nuisance Plants (Y/N):	N	N	N	N
STORET No.:	130211	130406	130048	130052
Stream Name:	Kalamazoo River	Kalamazoo River	Kalamazoo River	Kalamazoo River
Road Crossing/Location:	Kalamazoo St.	Squaw Lake Drain confluence	11-Mile Rd	Custer Drive
County Code:	13	13	13	13
TRS:	02S06W26	02S06W33	02S07W25	01S08W29
Latitude (dd):	42.26391	42.25852	42.27429	42.35074
Longitude (dd):	-84.96836	-85.00469	-85.08097	-85.27561
Ecoregion:	SMNITP	SMNITP	SMNITP	SMNITP
Stream Type:	Warmwater	Warmwater	Warmwater	Warmwater
USGS Basin Code:	4050003	4050003	4050003	4050003

* Applies only to Riffle/Run stream Surveys
** Applies only to Glide/Pool stream Surveys

COMMENTS:

Appendix H2: Macroinvertebrate Report 2011

MI/DEQ/WRD-12/012

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
WATER RESOURCES DIVISION
FEBRUARY 2012

STAFF REPORT

A BIOLOGICAL SURVEY OF SITES ON THE KALAMAZOO RIVER AND TALMADGE CREEK NEAR THE ENBRIDGE OIL SPILL IN MARSHALL CALHOUN COUNTY, MICHIGAN AUGUST 2011

INTRODUCTION

On July 26, 2010, a 30-inch diameter pipeline ruptured and discharged heavy crude oil into Talmadge Creek, a tributary to the Kalamazoo River, which drains into Lake Michigan. The amount of oil discharged is estimated at 819,000 to 1,000,000 gallons. The oil flowed down 2.2 miles of Talmadge Creek, a small designated warmwater stream, before entering the Kalamazoo River downstream of Marshall, Michigan. The Kalamazoo River is also a designated warmwater stream that is bordered by wetland, forest, residential properties, farm land, and commercial properties for the approximate 35-mile stretch of impacted river in Calhoun and Kalamazoo Counties between Marshall and Morrow Lake.

During September 2010, staff of the Surface Water Assessment Section (SWAS), Water Resources Division, Michigan Department of Environmental Quality (MDEQ), with assistance from Entrix, conducted qualitative macroinvertebrate community and stream habitat surveys on the Kalamazoo River and Talmadge Creek. The survey documented that macroinvertebrate abundance and diversity were drastically reduced in both water bodies because of the oil spill and associated cleanup activities (Walterhouse, 2011b). SWAS and Entrix staff also assisted staff of the Michigan Department of Natural Resources (MDNR), Fisheries Division, with fish collection efforts and quantitative stream habitat assessments. The MDNR, Fisheries Division, reported reduced fish abundance and diversity along with impacts to stream habitat in Talmadge Creek (Wesley, 2011 [draft]). Fish community diversity and catch also declined at two of the three sites on the Kalamazoo River, which were impacted by the oil spill and cleanup activities.

During August 2011, SWAS staff reconducted qualitative macroinvertebrate community and stream habitat surveys on the Kalamazoo River and Talmadge Creek. The objective of these surveys was to monitor the short- and long-term effects of the oil spill and associated cleanup activities on macroinvertebrate communities and aquatic habitat. SWAS staff also assisted the MDNR, Fisheries Division, staff with fish collection efforts and quantitative stream habitat assessments. The MDNR, Fisheries Division, is preparing a separate report, which details the fish and quantitative stream habitat sampling efforts. Additional surveys will be conducted in the future to monitor the long-term effects of the oil spill and associated cleanup activities on the fish and macroinvertebrate communities and aquatic habitat (Wesley and Walterhouse, 2010).

METHODS

Most of the sites that were selected for this survey were specifically chosen because of historic (i.e., baseline) surveys that were conducted prior to the oil spill (Wesley and Walterhouse, 2010). An additional site on Talmadge Creek was added just upstream of the oil spill because stream flow at the historic control site further upstream at 17 Mile Road was minimal and the habitat had more wetland than stream characteristics. A survey was also conducted at a site on the Kalamazoo River downstream of Talmadge Creek and 15 Mile Road, where historical survey data were lacking, but the proximity of Talmadge Creek upstream warranted the addition of the site to determine impacts.

The surveys described in this report were conducted according to the SWAS Procedure 51 (MDEQ, 1990). Procedure 51 surveys conducted prior to 2008 and those conducted in 2011 were performed with nearly the same methodology except the macroinvertebrate sample size was increased from 100 to 300 with the 2008 revision to Procedure 51. The macroinvertebrate communities were scored with metrics that rate water bodies from excellent (+5 to +9) to poor (-5 to -9). Macroinvertebrate ratings from +4 to -4 are considered acceptable. Negative ratings that are acceptable are indicative of water bodies that are strongly tending toward poor, while positive ratings that are acceptable indicate slight impairment (Creal et al., 1996). Stream habitat was qualitatively evaluated at each station using a scoring system that ranged in value from 0 (poor) to 200 (excellent).

Sampling locations are shown in Figure 1.

SUMMARY AND OBSERVATIONS

Qualitative macroinvertebrate scores and ratings alone do not adequately measure the impact of the oil spill and associated cleanup activities.

In summary, macroinvertebrate abundance and diversity improved in Talmadge Creek, compared to 2010, downstream of the oil spill where cleanup operations have altered the instream and riparian habitat. The stream channel is now completely exposed to sunlight, which appears to have increased productivity at least in terms of taxa diversity. However, overall macroinvertebrate abundance in Talmadge Creek was still impacted compared to the sites upstream of the oil spill.

The abundance and diversity of macroinvertebrates at sites impacted by the oil spill on the Kalamazoo River were also improved compared to 2010, but abundance was still impacted compared to historic sampling efforts prior to the oil spill.

Oil sheen and odors were not noted on the segment of Talmadge Creek where sampling was conducted.

Sampling efforts in depositional zones at all of the impacted sites on the Kalamazoo River caused a disturbance that produced surface oil sheen. The sediments at the impacted sites on the Kalamazoo River also had a notable petroleum odor. Petroleum odors were detected in the water only at the site downstream of Battle Creek (station K4).

The shallow riffle habitat at the impacted Kalamazoo River sites (stations K2 and K3), which were obviously disturbed in 2010 by the abnormally heavy boat traffic associated with the cleanup operations, appeared to be recovering. The cobble habitat was beginning to be colonized by periphyton and macroinvertebrates in the riffles.

Limited observations of areas of Talmadge Creek and the Kalamazoo River where stream bank erosion problems developed during cleanup operations appeared to be stabilized with various stream bank stabilization techniques.

The amount of sediment in the depositional areas of the Kalamazoo River, particularly downstream of Battle Creek, appears to have increased in terms of both depth and aerial coverage.

SAMPLING RESULTS

Talmadge Creek - Macroinvertebrates

The macroinvertebrate community sampling results for stations on Talmadge Creek are presented in Table 1a and the macroinvertebrate community metrics, scores, and ratings are presented in Table 1b. The stations are arranged in an upstream to downstream sequence. Two stations were surveyed as controls upstream of the oil spill. The control station at 17 Mile Road (station T1) was surveyed in 1999 allowing for comparisons with the 2010 and 2011 surveys (Cooper, 2000). The control station downstream of 17 Mile Road (station T2) had never been surveyed but the stream habitat and greater flow volume were more similar to conditions downstream on the oil impacted segment of Talmadge Creek. Talmadge Creek was sampled in the oil impacted reach at 15 ½ Mile Road (station T3) where a survey was also conducted in 1999 (Cooper, 2000). Station T3 is one mile downstream (Mile Post 1.0) of where oil from the pipeline failure entered Talmadge Creek.

The 2011 macroinvertebrate community sampling results documented that of the three sites surveyed on Talmadge Creek, station T3 received the highest score and supported a similar number taxa as the upstream control site (station T2). The upstream site (station T2) that was comparable in terms of stream flow received an overall score of +1 compared to the score of +4 at station T3. The number of taxa decreased slightly from 26 at station T2 to 24 at station T3. The higher macroinvertebrate community score at station T3 was a product of more mayflies and caddisflies in terms of both taxa and overall relative abundance. Specific taxa that were present at both stations T1 and T2 that were absent at station T3 included Hirudinea, Amphipoda, Caenidae, Coenagrionidae, and Sphaeriidae.

The results of the 2010 and 2011 macroinvertebrate surveys are presented along with the historic survey results from 1999 (Cooper, 2000) at station T1 in Tables 2a and 2b. The upstream control site at station T1 consisted of taxa predominately associated with wetland habitat during all of the surveys. The diversity and composition of taxa along with the overall scores at this wetland site has remained fairly constant.

The macroinvertebrate community sampling results from 2010 and 2011 at station T2 are presented in Tables 3a and 3b. The overall macroinvertebrate community score was +1 both years. The number of taxa identified was similar both years with the only major differences from 2010 to 2011 being a decline in the abundance of Simuliidae and mayflies, and an increase in the abundance of Amphipoda.

The results of the 1999 (Cooper, 2000), 2010, and 2011 macroinvertebrate surveys are presented in Tables 4a and 4b. At station T3 the overall macroinvertebrate score did not change significantly from 1999 (-3) to 2010 (-4); however, the overall macroinvertebrate community changed from a rather balanced community where 19 total taxa were identified, to a community dominated by one taxa with only 7 total taxa present. The sampling in 2011 produced 24 taxa and a macroinvertebrate community score of +4. This is a dramatic change from both the 1999 and 2010 survey results and is likely a recovery phase response to cleanup and restoration efforts on Talmadge Creek. The removal of trees, shrubs, herbaceous plants, and grasses during the response phase of the oil cleanup has allowed more direct sunlight and an associated proliferation of filamentous algal growth on the stream substrate. This station showed large numerical increases in filter feeders (Hydropsychidae and Simulidae), collector gatherers (Baetidae), and filamentous algae piercers (Hydroptilidae). These four families accounted for 80 percent of the total macroinvertebrate assemblage, which is not uncommon in disturbed systems during early succession. Mackay (1992) reports, “In many instances, denuded channel areas are recolonized by successions of different invertebrate assemblages. First to appear are blackflies, chironomids, and baetid mayflies, which often reach high densities early in the recolonization." This appears to be what has occurred at this site. Additional years of assessment will be needed to fully document short- and long-term impacts associated with the oil spill aftermath. Note that the stream banks and substrate of Talmadge Creek were disturbed once again after the 2011 survey by additional cleanup operations, so this recovery may be set back once again.

Kalamazoo River - Macroinvertebrates

The macroinvertebrate community sampling results for stations on the Kalamazoo River are presented in Table 5a and the macroinvertebrate community metrics, scores, and ratings are presented in Table 5b. The stations are arranged in an upstream to downstream sequence. The control station on the Kalamazoo River was upstream of the oil spill in Marshall at Kalamazoo Street (station K1). Three sites on the Kalamazoo River were surveyed in the reach that was impacted by the oil spill and the associated cleanup activities. Station K2 was located on the Kalamazoo River in the vicinity of the Squaw Lake Drain confluence at about Mile Post 2.75. Station K3 was downstream of the Ceresco Dam at 11 Mile Road approximately at Mile Post 7.25. Station K4 on the Kalamazoo River was located downstream of the city of Battle Creek at Custer Drive at about Mile Post 21.25.

The upstream control site on the Kalamazoo River (station K1) had an overall macroinvertebrate community score of +6 and a rating of excellent. The macroinvertebrate community at station K2 scored +6 and was rated as excellent. The site harbored the most taxa of any of the stations surveyed on the Kalamazoo River in 2011. Downstream at station K3, the macroinvertebrate community scored +5 and was rated as excellent. The site supported a diversity of taxa, many of which are considered intolerant of pollution. The macroinvertebrate community further downstream at station K4 scored +1 and was rated as acceptable. The 27 taxa collected at the site were reduced compared to the upstream sites where greater than 35 taxa were collected. The greater taxa diversity upstream at stations K1, K2, and K3, compared to downstream at station K4, is likely related to the greater diversity of in-stream substrates and cover at the upstream sites.

The results of the 2011 macroinvertebrate survey on the Kalamazoo River at Kalamazoo Street (station K1) are presented along with historic survey results from 1999 (Cooper, 2000), 2004 (Walterhouse, 2005), and 2010 (Walterhouse, 2011b) in Tables 6a and 6b. The macroinvertebrate community at K1 has scored +4 to +6 during the current and previous sampling events and has rated acceptable or excellent. The 35 taxa collected in August 2011 compares well with the 34 taxa collected in 2010 and the 40 taxa collected in 2004.

The results of the 2010 (Walterhouse, 2011b) and 2011 macroinvertebrate surveys on the Kalamazoo River downstream of 15 Mile Road at the Squaw Lake Drain confluence (station K2) are presented in Tables 7a and 7b. The macroinvertebrate community scored +6 and was rated as excellent during both investigations. The taxa that were present along with the overall composition of the community were fairly consistent between years.

Macroinvertebrate survey results from 2011 on the Kalamazoo River at 11 Mile Road (station K3) are presented along with historic sampling results from 2004 (Walterhouse, 2005), 2008 (LeSage, 2009), and 2010 (Walterhouse, 2011b) in Tables 8a and 8b. In August 2004, 44 taxa were collected at the site and the macroinvertebrate community scored +6 and was rated as excellent. In late August 2008, the site was surveyed as part of a quality assurance evaluation of Procedure 51 (method and crew variance) by two crews who each sampled the site twice on one day (Lesage, 2009). The number of taxa collected during the four sampling efforts ranged from 44 to 56 and the macroinvertebrate community scores ranged from +2 to +4 with ratings of acceptable. The sampling effort in September 2010 produced only 31 taxa, but still resulted in a macroinvertebrate community score of +3 and an acceptable rating. In 2011, the number of macroinvertebrate taxa collected increased to 36 and the community scored +5 and was rated excellent. Several taxa of filter feeding macroinvertebrates that were absent in 2010 were collected once again in 2011.

The results of the macroinvertebrate survey in 2011 on the Kalamazoo River at Custer Drive (station K4) are presented along with historic sampling results from 1994 (Kosek, 1994), 2004 (Walterhouse, 2005), 2009 (Walterhouse, 2011a) and 2010 (Walterhouse, 2011b) in Tables 9a and 9b. Previous surveys in 1994 and 2004 were conducted in part because of the upstream proximity to the Battle Creek Wastewater Treatment Plant (National Pollutant Discharge Elimination System Permit #MI0022276) discharge. The previous surveys documented macroinvertebrate scores of +4 and +2 with acceptable ratings in 1994 and 2004, respectively. In 2009, 33 taxa were collected and the macroinvertebrate community scored +6 and was rated as excellent. In 2010, 20 taxa were collected and the macroinvertebrate community scored +2 and was rated as acceptable. The sampling effort in 2011 produced 27 taxa that resulted in a score of +1 and an acceptable rating. The percentage of surface air breathers relative to the overall macroinvertebrate community in 2011 was abnormally high.

<u>Talmadge Creek – Stream Habitat</u>

Qualitative stream habitat assessment results for sites on Talmadge Creek are presented in Table 10. The habitat at station T1 was rated as good primarily because of the wide, natural wetland riparian corridor adjacent to stream channel. The substrate was soft muck and flow was limited creating habitat that would be better classified as wetland habitat. Downstream at station T2 stream habitat was rated as good. Flow was slightly greater than at station T1. Riffle habitat was lacking and sand was the predominant substrate but some gravel and cobble were present along with an abundance of in-stream cover. The riparian corridor was a wide, undisturbed scrub/shrub wetland.

In 2010, the in-stream habitat, stream banks, and adjacent riparian corridor at station T3 were highly disturbed due to the cleanup activities and were rated as marginal. In 2011, the overall stream habitat was rated at the lower range of good. The stream banks and riparian zone were stabilized with vegetative cover and various structures. The stream channel was narrower than in 2010 and riffle habitat was present, but in-stream cover was still extremely limited. The substrate was primarily sand and gravel with a limited amount of cobble still present. The disturbance from cleanup activities has effectively created a clean channel that is silt free.

It is important to note that after the August 2011 survey, additional cleanup operations were conducted on Talmadge Creek that involved dredging the stream banks and channel. Restoration activities are expected to be completed prior to sampling again in 2012.

<u>Kalamazoo River – Stream Habitat</u>

The qualitative stream habitat evaluations for sites on the Kalamazoo River are presented in Table 11. Riffle habitat was lacking at the upstream control site (station K1) and glide/pool metrics were used to produce an overall stream habitat rating of good. In-stream habitat was abundant and included moderate amounts of large woody debris, aquatic vegetation, and root wads. The stream substrate was diverse with a nearly equal mixture of cobble, gravel, sand, and silt along with scattered boulders. The only significant detraction from the overall habitat score was the limited width of the riparian zone.

The riffle/run habitat on the Kalamazoo River at station K2 was rated at the upper end of good. The dominant substrates were cobble and gravel with lesser amounts of sand, silt, and boulders. Additional forms of in-stream habitat such as undercut banks, large woody debris, aquatic vegetation, overhanging vegetation, and root wads had been reduced by activities associated with the cleanup operations. Submergent aquatic vegetation is beginning to become established once again and was present in about 15 percent of the reach.

The overall stream habitat at station K3 on the Kalamazoo River was rated as good using riffle/run metrics. Cobble and gravel were the dominant substrates along with scattered boulders and lesser amounts of sand and silt along the stream margins. Others forms of in-stream cover that were still moderately abundant included large woody debris, aquatic vegetation, and root wads. Cleanup operations have nearly eliminated all overhanging vegetation. It was observed that the size of the depositional areas had increased, compared to 2010, and the depth of the soft sediments in these areas was also much greater.

The Kalamazoo River at station K4 is much larger with an average width estimated at 360 feet and an estimated average depth of 2.9 feet. The overall stream habitat was rated as good using glide/pool metrics. The wide, wooded floodplain at this site inflates the overall stream habitat score. In-stream habitat that is suitable for macroinvertebrate colonization was limited. Sand was the predominant form of substrate at this site in 2010. Sampling in 2011 found that the predominant form of substrate in this wide, deep segment of the Kalamazoo River is now silt with sand being the second most common form of substrate. Only scattered patches of gravel are present and cobbles and boulders are rare. The amount of large woody debris along the margins of the stream channel has increased due to the severe wind storms, which impacted the Battle Creek area in the spring of 2011. Other in-stream cover present in sparse quantities were aquatic vegetation, root wads, and undercut banks.

Macroinvertebrate Abundance

Procedure 51 is a qualitative collection method that involves sampling all available in-stream habitats to produce a composite macroinvertebrate sample that is typically sub-sampled until 300 organisms have been identified and counted. After 300 organisms have been counted, the remainder of the composite sample is examined for large and/or rare organisms that were not identified in the initial sub-samples. These organisms are added as one individual to the total taxa list. Typically, only a small volume of the composite sample is needed to yield the 300 organisms required by Procedure 51. This is especially true in streams such as the Kalamazoo River that have a diversity of in-stream habitat types, especially in riffle habitats like those present at stations K2 and K3. The majority of the sample is typically examined for large and/or rare taxa. Counting the entire composite sample is seldom necessary, except in streams that are either habitat-limited or have serious violations of Michigan’s Water Quality Standards.

Macroinvertebrate abundance in the composite samples at the upstream control sites on Talmadge Creek (stations T1 and T2) and the Kalamazoo River (station K1) was normal in 2010 and 2011. The abundance of macroinvertebrates in the composite samples collected at all of the impacted sites on Talmadge Creek (station T3) and Kalamazoo River (stations K2, K3, and K4) in 2010 was so low that the entire composite sample was counted at all of the sites and the goal of enumerating 300 organisms was not achieved at the site on Talmadge Creek and station K4 on the Kalamazoo River. In 2011, the abundance of macroinvertebrates was greater than in 2010 at all of the impacted sites on Talmadge Creek and the Kalamazoo River. It was still necessary to count the entire macroinvertebrate composite sample at the impacted site (station T3) on Talmadge Creek and two (stations K2 and K4) of the three impacted sites on the Kalamazoo River. The abundance of macroinvertebrates at station K4 is still extremely limited.

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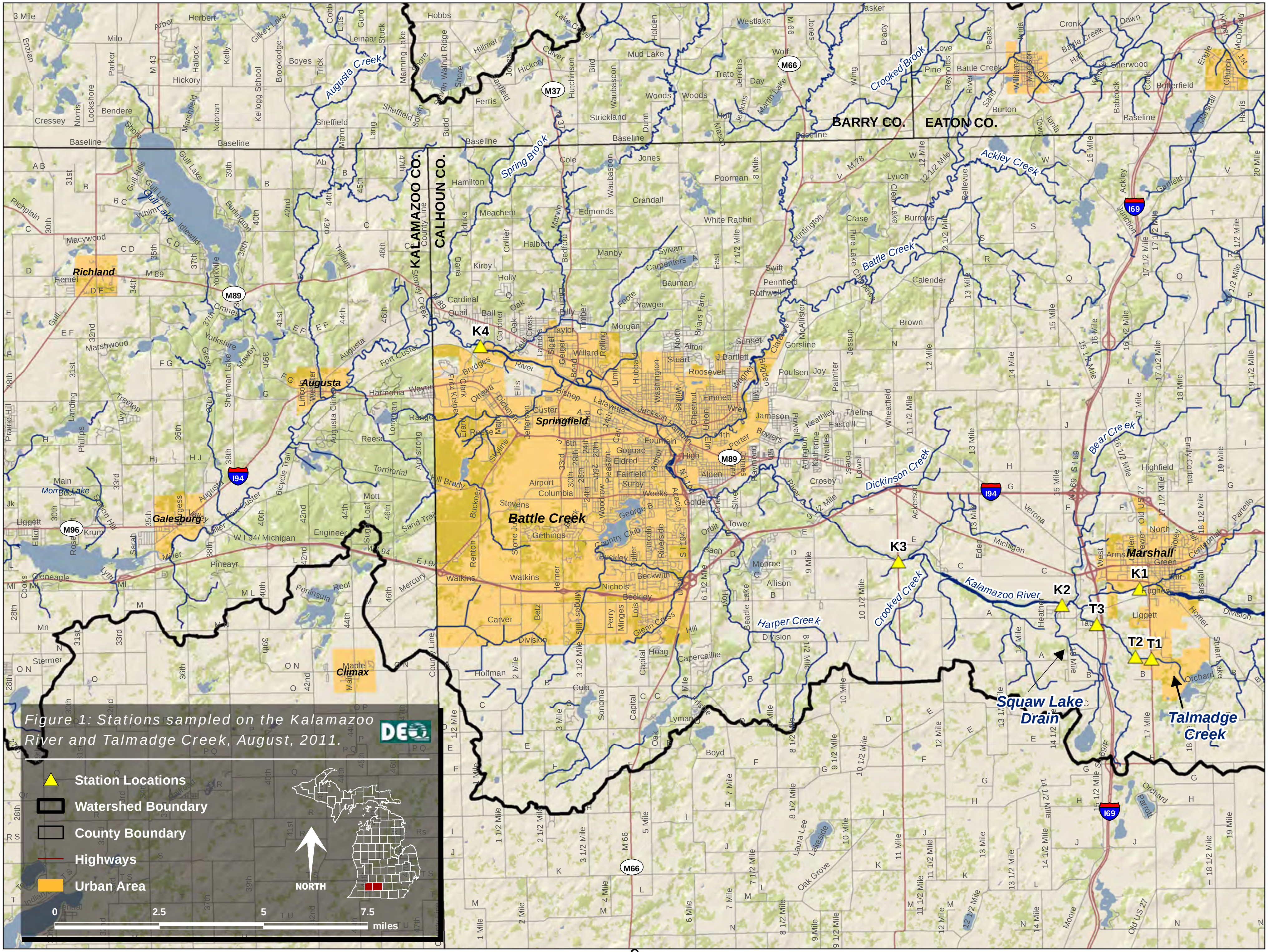

Figure 1: Stations sampled on the Kalamazoo River and Talmadge Creek, August, 2011.

Table 1A. Qualitative macroinvertebrate sampling results for sites on Talmadge Creek in the vicinity of the Enbridge oil spill, Calhoun County, August 2011.

TAXA	Talmadge Creek 17 Mile Road 8/29/2011 STATION T1	Talmadge Creek downstream 17 Mile Road 8/29/2011 STATION T2	Talmadge Creek 15 1/2 Mile Road 8/29/2011 STATION T3
ANNELIDA (segmented worms)			
Hirudinea (leeches)	18	5	
Oligochaeta (worms)	11	1	1
ARTHROPODA			
Crustacea			
Amphipoda (scuds)	3	184	1
Decapoda (crayfish)		2	
Isopoda (sowbugs)	5		
Arachnoidea			
Hydracarina			5
Insecta			
Ephemeroptera (mayflies)			
Baetidae		1	105
Caenidae	65	2	
Heptageniidae			1
Isonychiidae			2
Tricorythidae			8
Odonata			
Anisoptera (dragonflies)			
Aeshnidae		3	1
Libellulidae	2		
Zygoptera (damselflies)			
Calopterygidae		37	15
Coenagrionidae	2	2	
Hemiptera (true bugs)			
Belostomatidae		1	
Gerridae	1	1	1
Notonectidae		5	
Pleidae			1
Veliidae		1	
Megaloptera			
Sialidae (alder flies)		5	
Trichoptera (caddisflies)			
Hydropsychidae		14	48
Hydroptilidae		8	55
Leptoceridae		3	1
Uenoidae			1
Coleoptera (beetles)			
Dytiscidae (total)		1	1
Haliplidae (adults)		2	
Hydrophilidae (total)	1		1
Elmidae		3	
Diptera (flies)			
Chironomidae	7	14	21
Ephydridae			1
Ptychopteridae	1		
Simuliidae		2	57
Tabanidae			1
Tipulidae			1
MOLLUSCA			
Gastropoda (snails)			
Ancylidae (limpets)		1	
Physidae	2	2	1
Planorbidae	1	1	1
Pelecypoda (bivalves)			
Sphaeriidae (clams)	171	4	
TOTAL INDIVIDUALS	290	305	331

Table 1B. Macroinvertebrate metric evaluation of sites on Talmadge Creek in the vicinity of the Enbridge oil spill, Calhoun County, August, 2011.

METRIC	Talmadge Creek 17 Mile Road 8/29/2011 STATION T1 Value	Score	Talmadge Creek downstream 17 Mile Road 8/29/2011 STATION T2 Value	Score	Talmadge Creek 15 1/2 Mile Road 8/29/2011 STATION T3 Value	Score
TOTAL NUMBER OF TAXA	14	1	26	1	24	0
NUMBER OF MAYFLY TAXA	1	1	2	1	4	1
NUMBER OF CADDISFLY TAXA	0	-1	3	0	4	0
NUMBER OF STONEFLY TAXA	0	-1	0	-1	0	-1
PERCENT MAYFLY COMP.	22.41	1	0.98	-1	35.05	1
PERCENT CADDISFLY COMP.	0.00	-1	8.20	0	31.72	1
PERCENT DOMINANT TAXON	58.97	-1	60.33	-1	31.72	0
PERCENT ISOPOD, SNAIL, LEECH	8.97	0	2.95	1	0.60	1
PERCENT SURF. AIR BREATHERS	1.03	1	3.61	1	1.21	1
TOTAL SCORE	0		1		4	
MACROINV. COMMUNITY RATING	ACCEPT.		ACCEPT.		ACCEPT.	

Table 2A. Qualitative macroinvertebrate sampling results at 17 Mile Road, Talmadge Creek, Calhoun County.

TAXA	Talmadge Creek 17 Mile Road 7/12/1999 STATION T1	Talmadge Creek 17 Mile Road 9/16/2010 STATION T1	Talmadge Creek 17 Mile Road 8/29/2011 STATION T1
ANNELIDA (segmented worms)			
Hirudinea (leeches)		31	18
Oligochaeta (worms)		8	11
ARTHROPODA			
Crustacea			
Amphipoda (scuds)	30	34	3
Decapoda (crayfish)	2		
Isopoda (sowbugs)			5
Arachnoidea			
Hydracarina	3	1	
Insecta			
Ephemeroptera (mayflies)			
Baetidae	2		
Caenidae	6	37	65
Odonata			
Anisoptera (dragonflies)			
Aeshnidae	4		
Gomphidae	1		
Libellulidae		7	2
Zygoptera (damselflies)			
Calopterygidae	10	1	
Coenagrionidae	10		2
Hemiptera (true bugs)			
Belostomatidae		1	
Corixidae	1		
Gerridae	1		1
Trichoptera (caddisflies)			
Limnephilidae	1	1	
Coleoptera (beetles)			
Hydrophilidae (total)			1
Diptera (flies)			
Ceratopogonidae	1		
Chironomidae	25	79	7
Ptychopteridae			1
MOLLUSCA			
Gastropoda (snails)			
Ancylidae (limpets)		1	
Physidae	1	4	2
Planorbidae	3	5	1
Pelecypoda (bivalves)			
Sphaeriidae (clams)	5	81	171
TOTAL INDIVIDUALS	106	291	290

Table 2B. Macroinvertebrate metric evaluation at 17 Mile Road, Talmadge Creek, Calhoun County

METRIC	Talmadge Creek 17 Mile Road 7/12/1999 STATION T1 Value	Score	Talmadge Creek 17 Mile Road 9/16/2010 STATION T1 Value	Score	Talmadge Creek 17 Mile Road 8/29/2011 STATION T1 Value	Score
TOTAL NUMBER OF TAXA	17	1	14	1	14	1
NUMBER OF MAYFLY TAXA	2	1	1	0	1	1
NUMBER OF CADDISFLY TAXA	1	0	1	0	0	-1
NUMBER OF STONEFLY TAXA	0	-1	0	-1	0	-1
PERCENT MAYFLY COMP.	7.55	0	12.71	0	22.41	1
PERCENT CADDISFLY COMP.	0.94	-1	0.34	-1	0.00	-1
PERCENT DOMINANT TAXON	28.30	0	27.84	0	58.97	-1
PERCENT ISOPOD, SNAIL, LEECH	3.77	1	14.09	-1	8.97	0
PERCENT SURF. AIR BREATHERS	1.89	1	0.34	1	1.03	1
TOTAL SCORE	2		-1		0	
MACROINV. COMMUNITY RATING	ACCEPT.		ACCEPT.		ACCEPT.	

Table 3A. Qualitative macroinvertebrate sampling results downstream of 17 Mile Road, Talmadge Creek, Calhoun County.

TAXA	Talmadge Creek downstream 17 Mile Road 9/16/2010 STATION T2	Talmadge Creek downstream 17 Mile Road 8/29/2011 STATION T2
ANNELIDA (segmented worms)		
Hirudinea (leeches)	3	5
Oligochaeta (worms)		1
ARTHROPODA		
Crustacea		
Amphipoda (scuds)	107	184
Decapoda (crayfish)	2	2
Arachnoidea		
Hydracarina	1	
Insecta		
Ephemeroptera (mayflies)		
Baetidae	12	1
Caenidae	14	2
Odonata		
Anisoptera (dragonflies)		
Aeshnidae		3
Zygoptera (damselflies)		
Calopterygidae	27	37
Coenagrionidae	1	2
Hemiptera (true bugs)		
Belostomatidae	1	1
Corixidae	1	
Gerridae	1	1
Notonectidae	1	5
Veliidae		1
Megaloptera		
Sialidae (alder flies)	3	5
Trichoptera (caddisflies)		
Hydropsychidae	6	14
Hydroptilidae		8
Leptoceridae	1	3
Limnephilidae	1	
Uenoidae	1	
Coleoptera (beetles)		
Dytiscidae (total)	1	1
Haliplidae (adults)	8	2
Hydrophilidae (total)	1	
Elmidae		3
Diptera (flies)		
Chironomidae	38	14
Culicidae	1	
Simuliidae	60	2
MOLLUSCA		
Gastropoda (snails)		
Ancylidae (limpets)	28	1
Physidae	1	2
Planorbidae	6	1
Pelecypoda (bivalves)		
Sphaeriidae (clams)	22	4
TOTAL INDIVIDUALS	349	305

Table 3B. Macroinvertebrate metric evaluation downstream of 17 Mile Road, Talmadge Creek, Calhoun County.

METRIC	Talmadge Creek downstream 17 Mile Road 9/16/2010 STATION T2 Value	Score	Talmadge Creek downstream 17 Mile Road 8/29/2011 STATION T2 Value	Score
TOTAL NUMBER OF TAXA	27	1	26	1
NUMBER OF MAYFLY TAXA	2	1	2	1
NUMBER OF CADDISFLY TAXA	4	1	3	0
NUMBER OF STONEFLY TAXA	0	-1	0	-1
PERCENT MAYFLY COMP.	7.45	0	0.98	-1
PERCENT CADDISFLY COMP.	2.58	-1	8.20	0
PERCENT DOMINANT TAXON	30.66	0	60.33	-1
PERCENT ISOPOD, SNAIL, LEECH	10.89	-1	2.95	1
PERCENT SURF. AIR BREATHERS	4.30	1	3.61	1
TOTAL SCORE	1		1	
MACROINV. COMMUNITY RATING	ACCEPT.		ACCEPT.	

Table 4A. Qualitative macroinvertebrate sampling results at 15 1/2 Mile Road, Talmadge Creek, Calhoun County.

TAXA	Talmadge Creek 15 1/2 Mile Road 7/12/1999 STATION T3	Talmadge Creek 15 1/2 Mile Road 9/16/2010 STATION T3	Talmadge Creek 15 1/2 Mile Road 8/29/2011 STATION T3
ANNELIDA (segmented worms)			
Oligochaeta (worms)	1	8	1
ARTHROPODA			
Crustacea			
Amphipoda (scuds)	10		1
Decapoda (crayfish)	3		
Arachnoidea			
Hydracarina	15		5
Insecta			
Ephemeroptera (mayflies)			
Baetidae	7	21	105
Heptageniidae			1
Isonychiidae			2
Tricorythidae			8
Odonata			
Anisoptera (dragonflies)			
Aeshnidae	1		1
Zygoptera (damselflies)			
Calopterygidae	3	1	15
Hemiptera (true bugs)			
Belostomatidae		1	
Corixidae	5		
Gerridae	1		1
Pleidae			1
Veliidae	1		
Megaloptera			
Sialidae (alder flies)	1		
Trichoptera (caddisflies)			
Hydropsychidae	1		48
Hydroptilidae			55
Leptoceridae			1
Uenoidae			1
Coleoptera (beetles)			
Dytiscidae (total)			1
Hydrophilidae (total)			1
Elmidae	2		
Diptera (flies)			
Chironomidae	30	150	21
Ephydridae			1
Simuliidae	6	15	57
Tabanidae	1		1
Tipulidae			1
MOLLUSCA			
Gastropoda (snails)			
Ancylidae (limpets)	1	1	
Physidae	2		1
Planorbidae	1		1
TOTAL INDIVIDUALS	92	197	331

Table 4B. Macroinvertebrate metric evaluation at 15 1/2 Mile Road, Talmadge Creek, Calhoun County.

	Talmadge Creek 15 1/2 Mile Road 7/12/1999 STATION T3		Talmadge Creek 15 1/2 Mile Road 9/16/2010 STATION T3		Talmadge Creek 15 1/2 Mile Road 8/29/2011 STATION T3	
METRIC	Value	Score	Value	Score	Value	Score
TOTAL NUMBER OF TAXA	19	0	7	-1	24	0
NUMBER OF MAYFLY TAXA	1	0	1	-1	4	1
NUMBER OF CADDISFLY TAXA	1	-1	0	-1	4	0
NUMBER OF STONEFLY TAXA	0	-1	0	-1	0	-1
PERCENT MAYFLY COMP.	7.61	0	10.66	0	35.05	1
PERCENT CADDISFLY COMP.	1.09	-1	0.00	-1	31.72	1
PERCENT DOMINANT TAXON	32.61	0	76.14	-1	31.72	0
PERCENT ISOPOD, SNAIL, LEECH	4.35	0	0.51	1	0.60	1
PERCENT SURF. AIR BREATHERS	7.61	0	0.51	1	1.21	1
TOTAL SCORE	-3		-4		4	
MACROINV. COMMUNITY RATING	ACCEPT.		ACCEPT.		ACCEPT.	

Table 5A. Qualitative macroinvertebrate sampling results for sites on the Kalamazoo River in the vicinity of the Enbridge oil spill, Calhoun County, August 2011.

TAXA	Kalamazoo River Kalamazoo St. 8/31/2011 STATION K1	Kalamazoo River Squaw Lake Drain confluence 8/31/2011 STATION K2	Kalamazoo River 11-Mile Road 8/31/2011 STATION K3	Kalamazoo River Custer Drive 8/29/2011 STATION K4
PLATYHELMINTHES (flatworms)				
Turbellaria			2	
ANNELIDA (segmented worms)				
Hirudinea (leeches)			1	
Oligochaeta (worms)	1	1	19	2
ARTHROPODA				
Crustacea				
Amphipoda (scuds)	27	11	15	29
Decapoda (crayfish)		1	1	
Isopoda (sowbugs)	3	1		1
Arachnoidea				
Hydracarina	1	5		1
Insecta				
Ephemeroptera (mayflies)				
Baetidae	35	69	71	13
Caenidae		2		1
Ephemerellidae		3	1	
Heptageniidae	21	23	7	5
Isonychiidae	10	21	1	
Potamanthidae				2
Tricorythidae	10	18	9	8
Odonata				
Anisoptera (dragonflies)				
Aeshnidae	1		1	
Gomphidae	3		2	3
Zygoptera (damselflies)				
Calopterygidae	2	5	1	
Coenagrionidae	24	1	11	24
Plecoptera (stoneflies)				
Perlidae	1	2	1	
Pteronarcyidae	1		1	
Hemiptera (true bugs)				
Corixidae	2			
Gerridae	7	8	1	14
Pleidae	1	2		1
Veliidae		1		
Megaloptera				
Corydalidae (dobson flies)			1	
Trichoptera (caddisflies)				
Brachycentridae	20	5	2	1
Helicopsychidae	1	5		
Hydropsychidae	56	22	35	11
Hydroptilidae	1	3	1	5
Leptoceridae	5	9	5	1
Limnephilidae			1	
Philopotamidae	5	5		
Polycentropodidae	1	1	1	
Uenoidae		2	4	
Coleoptera (beetles)				
Dytiscidae (total)		1		
Gyrinidae (adults)	38			63
Haliplidae (adults)		1		
Hydrophilidae (total)		1		1
Elmidae	8	11	32	72
Psephenidae (larvae)		2		
Diptera (flies)				
Athericidae		1		
Chironomidae	9	19	9	4
Culicidae		1		
Simuliidae	30	30	3	1
Tabanidae	2	1	1	
Tipulidae		1		1
MOLLUSCA				
Gastropoda (snails)				
Ancylidae (limpets)	1			1
Hydrobiidae			6	
Physidae	1	4	4	1
Planorbidae	2	2	5	
Pleuroceridae	7	9	27	
Pelecypoda (bivalves)				
Corbiculidae	1	2	1	
Pisidiidae				1
Sphaeriidae (clams)	4	1	54	1
Unionidae (mussels)		1	1	
TOTAL INDIVIDUALS	342	314	338	268

Table 5B. Macroinvertebrate metric evaluation of sites on the Kalamazoo River in the vicinity of the Enbridge oil spill, Calhoun County, August, 2011.

	Kalamazoo River Kalamazoo St. 8/31/2011 STATION K1		Kalamazoo River Squaw Lake Drain confluence 8/31/2011 STATION K2		Kalamazoo River 11-Mile Road 8/31/2011 STATION K3		Kalamazoo River Custer Drive 8/29/2011 STATION K4	
METRIC	Value	Score	Value	Score	Value	Score	Value	Score
TOTAL NUMBER OF TAXA	35	1	42	1	36	1	27	1
NUMBER OF MAYFLY TAXA	4	1	6	1	5	1	5	1
NUMBER OF CADDISFLY TAXA	7	1	8	1	7	1	4	0
NUMBER OF STONEFLY TAXA	2	1	1	1	2	1	0	-1
PERCENT MAYFLY COMP.	22.22	1	43.31	1	26.33	1	10.82	0
PERCENT CADDISFLY COMP.	26.02	0	16.56	0	14.50	0	6.72	0
PERCENT DOMINANT TAXON	16.37	1	21.97	0	21.01	0	26.87	0
PERCENT ISOPOD, SNAIL, LEECH	4.09	0	5.10	0	12.72	-1	1.12	1
PERCENT SURF. AIR BREATHERS	14.04	0	4.78	1	0.30	1	29.48	-1
TOTAL SCORE	6		6		5		1	
MACROINV. COMMUNITY RATING	EXCELLENT		EXCELLENT		EXCELLENT		ACCEPT.	

Table 6A. Qualitative macroinvertebrate sampling results at Kalamazoo Street, Kalamazoo River, Calhoun County.

TAXA	Kalamazoo River Kalamazoo St. 9/18/1999 STATION K1	Kalamazoo River Kalamazoo St. 8/16/2004 STATION K1	Kalamazoo River Kalamazoo St. 9/9/2010 STATION K1	Kalamazoo River Kalamazoo St. 8/31/2011 STATION K1
PORIFERA (sponges)		1	1	
ANNELIDA (segmented worms)				
Hirudinea (leeches)			1	
Oligochaeta (worms)		1	1	1
ARTHROPODA				
Crustacea				
Amphipoda (scuds)	30	5	8	27
Decapoda (crayfish)		1	1	
Isopoda (sowbugs)		2	1	3
Arachnoidea				
Hydracarina	2	1	1	1
Insecta				
Ephemeroptera (mayflies)				
Baetidae	15	5	26	35
Caenidae		2	1	
Ephemerellidae		2		
Heptageniidae	4	5	22	21
Isonychiidae		1	3	10
Tricorythidae			3	10
Odonata				
Anisoptera (dragonflies)				
Aeshnidae	2	1		1
Gomphidae		1		3
Zygoptera (damselflies)				
Calopterygidae		1	1	2
Coenagrionidae	2	3	1	24
Plecoptera (stoneflies)				
Perlidae	6			1
Pteronarcyidae		1	2	1
Hemiptera (true bugs)				
Corixidae		5	1	2
Gerridae	2	1	1	7
Mesoveliidae		1		
Nepidae		1		
Pleidae			1	1
Megaloptera				
Sialidae (alder flies)		1		
Trichoptera (caddisflies)				
Brachycentridae	2	5	5	20
Glossosomatidae	2			
Helicopsychidae	4			1
Hydropsychidae	8	15	18	56
Hydroptilidae				1
Lepidostomatidae		1		
Leptoceridae		2	6	5
Limnephilidae	10	3		
Philopotamidae	4	1	2	5
Phryganeidae		1		
Polycentropodidae		2	1	1
Uenoidae		1		
Coleoptera (beetles)				
Gyrinidae (adults)		1	1	38
Elmidae	3	3	2	8
Gyrinidae (larvae)		1		
Psephenidae (larvae)			1	
Diptera (flies)				
Chironomidae	4	15	6	9
Simuliidae		5	196	30
Tabanidae		1	1	2
MOLLUSCA				
Gastropoda (snails)				
Ancylidae (limpets)	1	1	1	1
Physidae	2		1	1
Planorbidae		1		2
Pleuroceridae			2	7
Viviparidae		1		
Pelecypoda (bivalves)				
Corbiculidae		1	1	1
Pisidiidae	2			
Sphaeriidae (clams)	2	1	1	4
TOTAL INDIVIDUALS	107	104	321	342

Table 6B. Macroinvertebrate metric evaluation at Kalamazoo Street, Kalamazoo River, Calhoun County.

METRIC	Kalamazoo River Kalamazoo St. 9/18/1999 STATION K1 Value	Score	Kalamazoo River Kalamazoo St. 8/16/2004 STATION K1 Value	Score	Kalamazoo River Kalamazoo St. 9/9/2010 STATION K1 Value	Score	Kalamazoo River Kalamazoo St. 8/31/2011 STATION K1 Value	Score
TOTAL NUMBER OF TAXA	20	0	40	1	34	1	35	1
NUMBER OF MAYFLY TAXA	2	0	5	1	5	1	4	1
NUMBER OF CADDISFLY TAXA	6	1	9	1	5	1	7	1
NUMBER OF STONEFLY TAXA	1	1	1	1	1	1	2	1
PERCENT MAYFLY COMP.	17.76	0	14.42	0	17.13	0	22.22	1
PERCENT CADDISFLY COMP.	28.04	0	29.81	1	9.97	0	26.02	0
PERCENT DOMINANT TAXON	28.04	0	14.42	1	61.06	-1	16.37	1
PERCENT ISOPOD, SNAIL, LEECH	2.80	1	4.81	0	1.87	1	4.09	0
PERCENT SURF. AIR BREATHERS	1.87	1	8.65	0	1.25	1	14.04	0
TOTAL SCORE	4		6		5		6	
MACROINV. COMMUNITY RATING	ACCEPT.		EXCELLENT		EXCELLENT		EXCELLENT	

Table 7A. Qualitative macroinvertebrate sampling results downstream of 15 Mile Raod, Kalamazoo River, Calhoun County.

TAXA	Kalamazoo River Squaw Lake Drain confluence 9/15/2010 STATION K2	Kalamazoo River Squaw Lake Drain confluence 8/31/2011 STATION K2
PORIFERA (sponges)	1	
ANNELIDA (segmented worms)		
Oligochaeta (worms)	2	1
ARTHROPODA		
Crustacea		
Amphipoda (scuds)	43	11
Decapoda (crayfish)	2	1
Isopoda (sowbugs)	2	1
Arachnoidea		
Hydracarina		5
Insecta		
Ephemeroptera (mayflies)		
Baetidae	67	69
Caenidae		2
Ephemerellidae	1	3
Heptageniidae	22	23
Isonychiidae	11	21
Tricorythidae	10	18
Odonata		
Anisoptera (dragonflies)		
Aeshnidae	2	
Gomphidae	1	
Zygoptera (damselflies)		
Calopterygidae	13	5
Coenagrionidae	2	1
Plecoptera (stoneflies)		
Perlidae	1	2
Pteronarcyidae	1	
Hemiptera (true bugs)		
Belostomatidae	4	
Corixidae	3	
Gerridae		8
Nepidae	1	
Pleidae		2
Veliidae		1
Megaloptera		
Sialidae (alder flies)	2	
Trichoptera (caddisflies)		
Brachycentridae		5
Helicopsychidae	5	5
Hydropsychidae	10	22
Hydroptilidae	1	3
Leptoceridae	1	9
Limnephilidae	2	
Philopotamidae		5
Polycentropodidae		1
Uenoidae	6	2
Coleoptera (beetles)		
Dytiscidae (total)		1
Haliplidae (adults)		1
Hydrophilidae (total)		1
Elmidae	5	11
Psephenidae (larvae)		2
Diptera (flies)		
Athericidae		1
Ceratopogonidae	1	
Chironomidae	20	19
Culicidae		1
Simuliidae	27	30
Tabanidae	1	1
Tipulidae	3	1
MOLLUSCA		
Gastropoda (snails)		
Ancylidae (limpets)	1	
Hydrobiidae	6	
Lymnaeidae	17	
Physidae		4
Planorbidae		2
Pleuroceridae	1	9
Pelecypoda (bivalves)		
Corbiculidae	9	2
Sphaeriidae (clams)		1
Unionidae (mussels)	1	1
TOTAL INDIVIDUALS	308	314

Table 7B. Macroinvertebrate metric evaluation downstream of 15 Mile Road, Kalamazoo River, Calhoun County.

METRIC	Kalamazoo River Squaw Lake Drain confluence 9/15/2010 STATION K2 Value	Score	Kalamazoo River Squaw Lake Drain confluence 8/31/2011 STATION K2 Value	Score
TOTAL NUMBER OF TAXA	38	1	42	1
NUMBER OF MAYFLY TAXA	5	1	6	1
NUMBER OF CADDISFLY TAXA	6	1	8	1
NUMBER OF STONEFLY TAXA	2	1	1	1
PERCENT MAYFLY COMP.	36.04	1	43.31	1
PERCENT CADDISFLY COMP.	8.12	0	16.56	0
PERCENT DOMINANT TAXON	21.75	0	21.97	0
PERCENT ISOPOD, SNAIL, LEECH	8.77	0	5.10	0
PERCENT SURF. AIR BREATHERS	2.60	1	4.78	1
TOTAL SCORE	6		6	
MACROINV. COMMUNITY RATING	EXCELLENT		EXCELLENT	

Table 8a. Qualitative macroinvertebrate sampling results at 11 Mile Road, Kalamazoo River, Calhoun County.

TAXA	Kalamazoo River 11-Mile Rd 8/16/2004 STATION K3	Kalamazoo River 11-Mile Rd 8/27/2008 STATION K3	Kalamazoo River 11-Mile Rd 8/27/2008 STATION K3	Kalamazoo River 11-Mile Rd 8/27/2008 STATION K3	Kalamazoo River 11-Mile Rd 8/27/2008 STATION K3	Kalamazoo River 11-Mile Rd 9/9/2010 STATION K3	Kalamazoo River 11-Mile Road 8/31/2011 STATION K3
PORIFERA (sponges)	1						
PLATYHELMINTHES (flatworms)							
Turbellaria		4					2
BRYOZOA (moss animals)	1						
ANNELIDA (segmented worms)							
Hirudinea (leeches)		1	1	1	3	3	1
Oligochaeta (worms)	1	13	18	20	19	4	19
ARTHROPODA							
Crustacea							
Amphipoda (scuds)	5	3	8	54	12		15
Decapoda (crayfish)	1	1	1	1	1	1	1
Isopoda (sowbugs)			2	1	2		
Arachnoidea							
Hydracarina	1	4	2			2	
Insecta							
Ephemeroptera (mayflies)							
Baetidae	5	42	46	26	48	54	71
Caenidae	2	2	1	2	5		
Ephemerellidae		1	1				1
Ephemeridae				1			
Heptageniidae	5	6	4	3	2	17	7
Isonychiidae	3	1	1	4	1	3	1
Tricorythidae	2	8	8	5	4	3	9
Odonata							
Anisoptera (dragonflies)							
Aeshnidae	1	1	1	1		1	1
Gomphidae	1	1	1	1	1	2	2
Libellulidae	1		1				
Macromiidae			1				
Zygoptera (damselflies)							
Calopterygidae	2	2	13	1	11	3	1
Coenagrionidae	2	4	3	16	2	7	11
Plecoptera (stoneflies)							
Perlidae	2						1
Pteronarcyidae			1			1	1
Hemiptera (true bugs)							
Belostomatidae		1		1			
Corixidae	5	3	15	8	7		
Gerridae	1	1	1	2	2		1
Mesoveliidae	1	1	2	5	1		
Naucoridae				1			
Notonectidae			1				
Pleidae	1		1	2	1		
Saldidae					1		
Veliidae					1		
Megaloptera							
Corydalidae (dobson flies)	1		1		1	2	1
Sialidae (alder flies)	1	1	1	3			
Neuroptera (spongilla flies)							
Sisyridae	1						
Trichoptera (caddisflies)							
Brachycentridae		2	3	10	1		2
Glossosomatidae			1				
Helicopsychidae	1	8	9	8	4		
Hydropsychidae	12	45	48	19	29		35
Hydroptilidae		4	17	6	8	1	1
Lepidostomatidae			1				
Leptoceridae	1	1	3	1	1	2	5
Limnephilidae	3	1	1				1
Philopotamidae	1	1					
Phryganeidae	1						

Table 8a. Qualitative macroinvertebrate sampling results at 11 Mile Road, Kalamazoo River, Calhoun County.

TAXA	Kalamazoo River 11-Mile Rd 8/16/2004 STATION K3	Kalamazoo River 11-Mile Rd 8/27/2008 STATION K3	Kalamazoo River 11-Mile Rd 8/27/2008 STATION K3	Kalamazoo River 11-Mile Rd 8/27/2008 STATION K3	Kalamazoo River 11-Mile Rd 8/27/2008 STATION K3	Kalamazoo River 11-Mile Rd 9/9/2010 STATION K3	Kalamazoo River 11-Mile Road 8/31/2011 STATION K3
Polycentropodidae	2	2	1	1	1		1
Uenoidae	2	2	1	1	1	3	4
Lepidoptera (moths)							
Pyralidae			1	1	1		
Coleoptera (beetles)							
Dytiscidae						1	
Gyrinidae (adults)	1	1	1			1	
Haliplidae (adults)		1	1	4	1	15	
Hydrophilidae (total)	1	1	1				
Elmidae	2	9	6	6	5	7	32
Gyrinidae (larvae)				1	1		
Psephenidae (larvae)			1	1		1	
Scirtidae (larvae)		1					
Diptera (flies)							
Ceratopogonidae	1			2	1		
Chironomidae	12	21	20	51	23	18	9
Culicidae				4			
Ptychopteridae			1				
Simuliidae	5	22	21	2	9		3
Tabanidae		3	1	1	2		1
Tipulidae		1	1	1			
MOLLUSCA							
Gastropoda (snails)							
Ancylidae (limpets)	1	1	1		2	1	
Hydrobiidae		29	10	73	87	3	6
Lymnaeidae						5	
Physidae		3	1	4	3		4
Planorbidae	1	4	6	7	11	1	5
Pleuroceridae		100	90	21	17	86	27
Valvatidae	1						
Viviparidae		1	2	1	2		
Pelecypoda (bivalves)							
Corbiculidae	1	1	1	1	1	2	1
Sphaeriidae (clams)	1	22	10	20	9	49	54
Unionidae (mussels)	1	1	1	1	1	1	1
TOTAL INDIVIDUALS	98	389	398	407	346	300	338

Table 8b. Macroinvertebrate metric evaluation at 11 Mile Road, Kalamazoo River, Calhoun County.

	Kalamazoo River 11-Mile Rd 8/16/2004 STATION K3		Kalamazoo River 11-Mile Rd 8/27/2008 STATION K3		Kalamazoo River 11-Mile Rd 8/27/2008 STATION K3		Kalamazoo River 11-Mile Rd 8/27/2008 STATION K3		Kalamazoo River 11-Mile Rd 8/27/2008 STATION K3		Kalamazoo River 11-Mile Rd 9/9/2010 STATION K3		Kalamazoo River 11-Mile Road 8/31/2011 STATION K3	
METRIC	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score
TOTAL NUMBER OF TAXA	44	1	48	1	56	1	48	1	44	1	31	1	36	1
NUMBER OF MAYFLY TAXA	5	1	6	1	6	1	6	1	5	1	4	1	5	1
NUMBER OF CADDISFLY TAXA	8	1	9	1	10	1	7	1	7	1	3	0	7	1
NUMBER OF STONEFLY TAXA	1	1	0	-1	1	1	0	-1	0	-1	1	1	2	1
PERCENT MAYFLY COMP.	17.35	0	15.42	0	15.33	0	10.07	0	17.34	0	25.67	1	26.33	1
PERCENT CADDISFLY COMP.	23.47	0	16.97	0	21.36	0	11.30	0	13.01	0	2.00	-1	14.50	0
PERCENT DOMINANT TAXON	12.24	1	25.71	0	22.61	0	17.94	1	25.14	0	28.67	0	21.01	0
PERCENT ISOPOD, SNAIL, LEECH	3.06	1	35.73	-1	28.39	-1	26.54	-1	36.71	-1	33.00	-1	12.72	-1
PERCENT SURF. AIR BREATHERS	10.20	0	2.31	1	6.03	1	6.63	1	4.05	1	5.67	1	0.30	1
TOTAL SCORE	6		2		4		3		2		3		5	
MACROINV. COMMUNITY RATING	EXCELLENT		ACCEPT.		ACCEPT.		ACCEPT.		ACCEPT.		ACCEPT.		EXCELLENT	

Table 9a. Qualitative macroinvertebrate sampling results at Custer Drive, Kalamazoo River, Calhoun County.

TAXA	Kalamazoo River Custer Drive 9/9/1994 STATION K4	Kalamazoo River Custer Drive 8/17/2004 STATION K4	Kalamazoo River Custer Drive 9/15/2009 STATION K4	Kalamazoo River Custer Drive 9/15/2010 STATION K4	Kalamazoo River Custer Drive 8/29/2011 STATION K4
PORIFERA (sponges)				1	
PLATYHELMINTHES (flatworms)					
Turbellaria	2				
BRYOZOA (moss animals)		1			
ANNELIDA (segmented worms)					
Oligochaeta (worms)				1	2
ARTHROPODA					
Crustacea					
Amphipoda (scuds)	20	20	56	13	29
Decapoda (crayfish)		1	1		
Isopoda (sowbugs)	1	1	2	3	1
Arachnoidea					
Hydracarina					1
Insecta					
Ephemeroptera (mayflies)					
Baetiscidae			1		
Baetidae		5	16	12	13
Caenidae	2			1	1
Ephemerellidae	25	1			
Heptageniidae	2	5	1	4	5
Potamanthidae					2
Tricorythidae		5	3	2	8
Odonata					
Anisoptera (dragonflies)					
Aeshnidae	2	1	1	1	
Gomphidae			2	7	3
Libellulidae			3		
Zygoptera (damselflies)					
Calopterygidae	2	2		2	
Coenagrionidae	8	1	12	34	24
Plecoptera (stoneflies)					
Perlidae			1		
Perlodidae	1				
Pteronarcyidae			1		
Hemiptera (true bugs)					
Belostomatidae	2		1		
Corixidae		3			
Gerridae		1	2	1	14
Mesoveliidae	3	1			
Naucoridae	1				
Pleidae	1	1	1		1
Veliidae			2		
Megaloptera					
Corydalidae (dobson flies)			1		
Sialidae (alder flies)	1				
Trichoptera (caddisflies)					
Brachycentridae		5	5	6	1
Hydropsychidae	4	5	103	54	11
Hydroptilidae					5
Leptoceridae			3		1
Limnephilidae		2			
Molannidae			2		
Philopotamidae	1		2		
Phryganeidae			1		
Polycentropodidae		1			
Coleoptera (beetles)					
Dytiscidae (total)			1		
Gyrinidae (adults)		1	1		63
Hydrophilidae (total)					1
Elmidae	2	2	16		72
Diptera (flies)					
Chironomidae	16	35	54	21	4
Culicidae		1			
Simuliidae	4	3	2		1
Tipulidae					1
MOLLUSCA					
Gastropoda (snails)					
Ancylidae (limpets)	1		6	12	1
Physidae		1	4	2	1
Planorbidae				1	
Pleuroceridae			1		
Viviparidae		1			
Pelecypoda (bivalves)					
Corbiculidae		1		7	
Pisidiidae					1
Sphaeriidae (clams)	1	1			1
Unionidae (mussels)		1	1		
TOTAL INDIVIDUALS	102	109	309	185	268

Table 9b. Macroinvertebrate metric evaluation at Custer Drive, Kalamazoo River, Calhoun County.

	Kalamazoo River Custer Drive 9/9/1994 STATION K4		Kalamazoo River Custer Drive 8/17/2004 STATION K4		Kalamazoo River Custer Drive 9/15/2009 STATION K4		Kalamazoo River Custer Drive 9/15/2010 STATION K4		Kalamazoo River Custer Drive 8/29/2011 STATION K4	
METRIC	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score
TOTAL NUMBER OF TAXA	22	0	29	1	33	1	20	0	27	1
NUMBER OF MAYFLY TAXA	3	0	4	1	4	1	4	1	5	1
NUMBER OF CADDISFLY TAXA	2	0	4	0	6	1	2	0	4	0
NUMBER OF STONEFLY TAXA	1	1	0	-1	2	1	0	-1	0	-1
PERCENT MAYFLY COMP.	28.43	1	14.68	0	6.80	0	10.27	0	10.82	0
PERCENT CADDISFLY COMP.	4.90	0	11.93	0	37.54	1	32.43	1	6.72	0
PERCENT DOMINANT TAXON	24.51	0	32.11	0	33.33	0	29.19	0	26.87	0
PERCENT ISOPOD, SNAIL, LEECH	1.96	1	2.75	1	4.21	0	9.73	0	1.12	1
PERCENT SURF. AIR BREATHERS	6.86	1	7.34	0	2.59	1	0.54	1	29.48	-1
TOTAL SCORE	4		2		6		2		1	
MACROINV. COMMUNITY RATING	ACCEPT.		ACCEPT.		EXCELLENT		ACCEPT.		ACCEPT.	

Table 10. Habitat evaluation for sites in the vicinity of the Enbridge oil spill, Talmadge Creek, Calhoun County, August 2011.

HABITAT METRIC	Station T1 Talmadge Creek 17 Mile Road GLIDE/POOL	Station T2 Talmadge Creek downstream 17 Mile Road GLIDE/POOL	Station T3 Talmadge Creek 15 1/2 Mile Road RIFFLE/RUN
Substrate and Instream Cover			
Epifaunal Substrate/ Avail Cover (20)	3	11	8
Embeddedness (20)*			8
Velocity/Depth Regime (20)*			10
Pool Substrate Characterization (20)**	6	13	
Pool Variability (20)**	6	8	
Channel Morphology			
Sediment Deposition (20)	6	8	15
Flow Status - Maint. Flow Volume (10)	9	9	9
Flow Status - Flashiness (10)	9	9	8
Channel Alteration (20)	11	15	10
Frequency of Riffles/Bends (20)*			13
Channel Sinuosity (20)**	6	11	
Riparian and Bank Structure			
Bank Stability (L) (10)	9	9	9
Bank Stability (R) (10)	9	9	9
Vegetative Protection (L) (10)	9	10	3
Vegetative Protection (R) (10)	9	10	3
Riparian Veg. Zone Width (L) (10)	9	10	7
Riparian Veg. Zone Width (R) (10)	9	10	7
TOTAL SCORE (200):	110	142	119
HABITAT RATING:	GOOD (SLIGHTLY IMPAIRED)	GOOD (SLIGHTLY IMPAIRED)	GOOD (SLIGHTLY IMPAIRED)

Note: Individual metrics may better describe conditions directly affecting the biological community while the Habitat Ratin
describes the general riverine environment at the site(s).
* Applies only to Riffle/Run stream Surveys
** Applies only to Glide/Pool stream Surveys

Date:	8/29/2011		8/29/2011		8/29/2011	
Weather:	Sunny		Sunny		Partly Cloudy	
Air Temperature:	60	Deg. F.	72	Deg. F.	80	Deg. F.
Water Temperature:	60	Deg. F.	68	Deg. F.	75	Deg. F.
Ave. Stream Width:	3	Feet	6	Feet	12	Feet
Ave. Stream Depth:	0.3	Feet	0.3	Feet	0.2	Feet
Surface Velocity:	0.5	Ft./Sec.	0.5	Ft./Sec.	0.9	Ft./Sec.
Estimated Flow:	0.45	CFS	0.9	CFS	2.16	CFS
Stream Modifications:	Dredged		None		Bank Stabilization	
Nuisance Plants (Y/N):	N		N		N	
STORET No.:	130336		130405		130335	
Stream Name:	Talmadge Creek		Talmadge Creek		Talmadge Creek	
Road Crossing/Location:	17 Mile Road		downstream 17 Mile Road		15 1/2 Mile Road	
County Code:	13		13		13	
TRS:	03S06W01		03S06W02		02S06W34	
Latitude (dd):	42.2394598		42.2402		42.251717	
Longitude (dd):	-84.9632235		-84.97066		-84.9885712	
Ecoregion:	SMNITP		SMNITP		SMNITP	
Stream Type:	Warmwater		Warmwater		Warmwater	
USGS Basin Code:	4050003		4050003		4050003	
COMMENTS:	Wetland habitat				The riparian zone and the stream channel have been subjected to major alterations during clean up operations	

Table 11. Habitat evaluation for sites in the vicinity of the Enbridge oil spill, Kalamazoo River, Calhoun County, August 2011.

HABITAT METRIC	Station K1 Kalamazoo River Kalamazoo St. GLIDE/POOL	Station K2 Kalamazoo River Squaw Lake Drain confluence GLIDE/POOL	Station K3 Kalamazoo River 11-Mile Road RIFFLE/RUN	Station K4 Kalamazoo River Custer Drive GLIDE/POOL
Substrate and Instream Cover				
Epifaunal Substrate/ Avail Cover (20)	16	13	13	6
Embeddedness (20)*			16	
Velocity/Depth Regime (20)*			16	
Pool Substrate Characterization (20)**	16	16		10
Pool Variability (20)**	16	11		8
Channel Morphology				
Sediment Deposition (20)	14	16	10	11
Flow Status - Maint. Flow Volume (10)	9	9	9	8
Flow Status - Flashiness (10)	7	8	6	4
Channel Alteration (20)	16	18	18	13
Frequency of Riffles/Bends (20)*			11	
Channel Sinuosity (20)**	15	11		6
Riparian and Bank Structure				
Bank Stability (L) (10)	8	9	8	7
Bank Stability (R) (10)	8	9	8	7
Vegetative Protection (L) (10)	7	9	5	9
Vegetative Protection (R) (10)	7	6	9	9
Riparian Veg. Zone Width (L) (10)	3	10	5	9
Riparian Veg. Zone Width (R) (10)	4	3	9	9
TOTAL SCORE (200):	146	148	143	116
HABITAT RATING:	GOOD (SLIGHTLY IMPAIRED)	GOOD (SLIGHTLY IMPAIRED)	GOOD (SLIGHTLY IMPAIRED)	GOOD (SLIGHTLY IMPAIRED)

Note: Individual metrics may better describe conditions directly affecting the biological community while the Habitat Rating describes the general riverine environment at the site(s).
* Applies only to Riffle/Run stream Surveys
** Applies only to Glide/Pool stream Surveys

Date:	8/31/2011	8/31/2011	8/31/2011	8/29/2011
Weather:	Cloudy	Partly Cloudy	Partly Cloudy	Sunny
Air Temperature:	72 Deg. F.	76 Deg. F.	83 Deg. F.	82 Deg. F.
Water Temperature:	70 Deg. F.	69 Deg. F.	72 Deg. F.	72 Deg. F.
Ave. Stream Width:	120 Feet	200 Feet	150 Feet	360 Feet
Ave. Stream Depth:	3 Feet	1.5 Feet	1.5 Feet	2.9 Feet
Surface Velocity:	1 Ft./Sec.	1.25 Ft./Sec.	1.25 Ft./Sec.	0.6 Ft./Sec.
Estimated Flow:	360 CFS	375 CFS	281.25 CFS	626.4 CFS
Stream Modifications:	None	None	None	Dredged
Nuisance Plants (Y/N):	N	N	N	N
STORET No.:	130211	130406	130048	130052
Stream Name:	Kalamazoo River	Kalamazoo River	Kalamazoo River	Kalamazoo River
Road Crossing/Location:	Kalamazoo St.	Squaw Lake Drain confluence	11-Mile Road	Custer Drive
County Code:	13	13	13	13
TRS:	02S06W26	02S06W33	02S07W25	01S08W29
Latitude (dd):	42.26391	42.25852	42.27429	42.35074
Longitude (dd):	-84.96836	-85.00469	-85.08097	-85.27561
Ecoregion:	SMNITP	SMNITP	SMNITP	SMNITP
Stream Type:	Warmwater	Warmwater	Warmwater	Warmwater
USGS Basin Code:	4050003	4050003	4050003	4050003
COMMENTS:		Impacted by oil spill clean up operations	Impacted by oil spill clean up operations	Impacted by oil spill clean up operations

Appendix H3: Macroinvertebrate Report 2012

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
WATER RESOURCES DIVISION
APRIL 2013

STAFF REPORT

A BIOLOGICAL SURVEY OF SITES ON THE KALAMAZOO RIVER AND TALMADGE CREEK NEAR THE ENBRIDGE OIL SPILL IN MARSHALL CALHOUN COUNTY, MICHIGAN SEPTEMBER 2012

INTRODUCTION

On July 26, 2010, a 30-inch diameter pipeline ruptured and discharged heavy crude oil into Talmadge Creek, a tributary to the Kalamazoo River, which drains into Lake Michigan. The amount of oil discharged is estimated at 819,000 to 1,000,000 gallons. The oil flowed down 2.2 miles of Talmadge Creek, a small designated warmwater stream, before entering the Kalamazoo River downstream of Marshall, Michigan. The Kalamazoo River is also a designated warmwater stream that is bordered by wetland, forest, residential properties, farm land, and commercial properties for the approximate 35-mile stretch of impacted river in Calhoun and Kalamazoo Counties between Marshall and Morrow Lake.

In September 2010, staff of the Surface Water Assessment Section (SWAS), Water Resources Division (WRD), Michigan Department of Environmental Quality (MDEQ), with assistance from Entrix (currently Cardno ENTRIX), conducted qualitative macroinvertebrate community and stream habitat surveys on the Kalamazoo River and Talmadge Creek. The survey documented that macroinvertebrate abundance and diversity were drastically reduced in both water bodies because of the oil spill and associated cleanup activities (Walterhouse, 2011). SWAS and Entrix staff also assisted staff of the Michigan Department of Natural Resources (MDNR), Fisheries Division, with fish collection efforts and quantitative stream habitat assessments. The MDNR, Fisheries Division, reported reduced fish abundance and diversity along with impacts to stream habitat in Talmadge Creek (Wesley and Walterhouse, 2010a). Fish community diversity and catch also declined at two of the three sites on the Kalamazoo River, which were impacted by the oil spill and cleanup activities.

In August 2011, SWAS staff again conducted qualitative macroinvertebrate community and stream habitat surveys on the Kalamazoo River and Talmadge Creek. The objective of these surveys was to monitor the short- and long-term effects of the oil spill and associated cleanup activities on macroinvertebrate communities and aquatic habitat. Macroinvertebrate abundance and diversity reported in 2011 (Walterhouse, 2012) in Talmadge Creek were found to have improved from results collected in 2010 (Walterhouse, 2011) in the sections of stream where cleanup activities were conducted, but were still found to be impacted when compared to upstream sites. No oil sheen or odor was noted during the 2011 surveys in Talmadge Creek as both odor and sheen had been observed in 2010. Kalamazoo macroinvertebrate abundance and diversity also improved when compared to 2010 data, but abundance was still impacted when compared to historic data. Oil sheen along with petroleum odor was noted at some Kalamazoo River site locations when sampling near depositional areas. Shallow riffle habitat at Stations K2 and K3 (Figure 1), which were described as having been severely disturbed by cleanup activities during the 2010 survey, were noted in 2011 as recovering with noticeable new colonization of periphyton and macroinvertebrates. Sediment deposition, particularly downstream of Battle Creek, was noted as appearing to have increased by both depth and aerial coverage during the 2011 surveys. Complete results are available in the 2011 MDEQ report (Walterhouse, 2011).

In September 2012, SWAS staff conducted additional qualitative macroinvertebrate community and stream habitat surveys on the Kalamazoo River and Talmadge Creek. The objective of these surveys was to continue to monitor the short- and long-term effects of the oil spill and associated cleanup activities on macroinvertebrate communities and aquatic habitat. Future surveys will be conducted to monitor the long-term effects of the oil spill and associated cleanup activities on the fish and macroinvertebrate communities and aquatic habitat (Wesley and Walterhouse, 2010b).

SWAS staff also assisted the MDNR, Fisheries Division, with fish collection and quantitative stream habitat assessments. The MDNR, Fisheries Division, is preparing a separate report which details the fish and quantitative stream habitat sampling efforts.

METHODS

The sites selected for this survey were specifically chosen because of historic (i.e., baseline) surveys that were conducted prior to the oil spill (Wesley and Walterhouse, 2010a) and the fact that they were used in previous years for monitoring the long-term effects of the oil spill and associated cleanup activities. An additional site (Station T2, Figure 1) on Talmadge Creek was added in 2011 just upstream of the oil spill because stream flow at the historic control site further upstream (Station T1, Figure 2) at 17 Mile Road was minimal. Station T1 could not be sampled due to low water in 2012. Station T2 (Figure 4) is similar in width and flow to the impacted reach at Station T3. The surveys described in this report were conducted according to the SWAS Procedure 51 (MDEQ, 1990; Creal et al., 1996). The macroinvertebrate communities were scored with metrics that rate water bodies from excellent (+5 to +9) to poor (-5 to -9). Macroinvertebrate ratings from +4 to -4 are considered acceptable. Negative ratings that are acceptable indicate water bodies that are tending toward poor, while positive ratings that are acceptable indicate slight impairment (Creal et al., 1996). Stream habitat was qualitatively evaluated at each station using a scoring system that ranged from 0 (poor) to 200 (excellent).

Sampling locations are shown in Figure 1.

SUMMARY AND OBSERVATIONS

Qualitative macroinvertebrate scores and ratings alone do not adequately measure the impact of the oil spill and associated cleanup activities.

Cleanup and channel restoration activities in Talmage Creek continued after the August 2011 survey was completed due to discoveries of undetected oil spill deposits, which required removal. Macroinvertebrate abundance and diversity in Talmadge Creek, downstream of the oil spill where cleanup operations have altered the in-stream and riparian habitat (Station T3, Figure **1**), are much improved in 2012 compared to 2010 data and are similar to 2011 data (Table 1 and 2). The stream channel has been nearly entirely exposed to sunlight for the past two years (Figure 4), which appears to have increased productivity at least in terms of taxa diversity (Table 2 and 4). Station T3 appears to still show signs of impact from the oil spill, consistent with 2011 sampling results, in that the macroinvertebrate species composition at Station T3 is much different from Station T2 (upstream of the oil spill and cleanup activities, Figure 4) and is dominated by species known to reach high densities during the early stages of recolonization (Mackay, 1992). The total number of taxa (Table 2) was slightly higher at

Station T3 and the overall macroinvertebrate Procedure 51 scores at Stations T2 and T3 were both in the “acceptable” category (Table 1).

Kalamazoo River sites reported scores similar to 2011 results (Table 1) with Sites K2, K3, and K4 all showing slight increases in overall scores. The score at Site K1 decreased from +6 in 2011 to +3 in 2012. This decrease can mainly be attributed to the fact that no stoneflies were collected in 2012 during the survey.

Oil sheen or odor was not noted during sampling at any of the Talmadge Creek or Kalamazoo River sites in 2012, but a slight oil sheen was noted in the sampling bucket while processing at the most downstream site (K4). Limited observations of areas of Talmadge Creek and the Kalamazoo River where stream bank erosion issues developed during response and cleanup activities appeared to continue to be stabilized with various stream bank stabilization techniques.

Table 1. Qualitative Macroinvertebrate scores from Procedure 51 surveys conducted over multiple years at Kalamazoo River (K) and Talmadge Creek (T) sites (Figure 1).

	Years							
Station	**1994**	**1999**	**2004**	**2008**	**2009**	**2010**	**2011**	**2012**
T1	--	2	--	--	--	-1	0	--[2]
T2	--	--	--	--	--	1	1	0
T3	--	-3	--	--	--	-4	4	3
K1	--	4	6	--	--	5	6	3
K2	--	--	--	--	--	6	6	8
K3	--	--	6	2,4,3,2[1]	--	3	5	6
K4	4	--	2	--	6	2	1	4

(+5 to +9) Excellent (+4 to -4) Acceptable (-5 to -9) Poor
Surveys conducted prior to 2008 used a Procedure 51 protocol, which only required a macroinvertebrate sample size of 100 compared to the requirement of 300 after the revision.
[1] Location was scored multiple times in 2008 as part of a quality assurance/quality control (QA/QC) process.
[2] Location was not sampled due to low water levels.

Table 2. Total number of taxa recorded from Procedure 51 surveys conducted over multiple years at Kalamazoo River and Talmadge Creek sites (Figure 1).

	Years							
Station	**1994**	**1999**	**2004**	**2008**	**2009**	**2010**	**2011**	**2012**
T1	--	17	--	--	--	14	14	--[2]
T2	--	--	--	--	--	27	26	28
T3	--	19	--	--	--	7	24	30
K1	--	20	40	--	--	34	35	40
K2	--	--	--	--	--	38	42	38
K3	--	--	44	48,56,48,44[1]	--	31	36	42
K4	22	--	29	--	33	20	27	28

[1] Location was scored multiple times in 2008 as part of a QA/QC process.
[2] Location was not sampled due to low water levels.
Surveys conducted prior to 2008 used a Procedure 51 protocol, which only required a macroinvertebrate sample size of 100 compared to the requirement of 300 after the revision.

SAMPLING RESULTS

Talmadge Creek - Macroinvertebrates

The 2012 macroinvertebrate community sampling results for stations (T2, T3, Figure 1) on Talmadge Creek are presented in Table 3. Macroinvertebrate metrics, scores, and ratings for these sites are located in Table 4. Station T1, which had been sampled in past years, was not sampled in 2012 due to lack of flow and low water levels (Figure 2). Station T2 (Figure 4) was sampled to serve as a control station for comparison to Station T3, which is in the impacted portion of Talmadge Creek. The results from these two stations in 2012 are very similar to documented results from 2011 (Walterhouse, 2012). Station T3 received a higher score (3) than the control site (0) and had a slightly greater diversity of invertebrates. Station T3 was highly disturbed by cleanup activities since 2010 and is in a continuing state of recovery. The macroinvertebrate community present at Station T3 is different in species composition when compared to the upstream control at Station T2 and is dominated by species commonly associated with areas that have been disturbed and in the early stages of recolonization (Mackay, 1992). The removal of trees, shrubs, herbaceous plants, and grasses during the response activity has allowed for direct sunlight to reach the stream by opening the vegetated canopy (Figure 3). This increase in direct sunlight has allowed for the proliferation of filamentous algal growth on the stream substrate, which is not present in such quantity at the upstream control station (T2). Blackflies (Simulidae), midges (Chironomidae), and mayflies (Baetidae), which are some of the first species to appear in highly disturbed areas (Mackay, 1992), were prevalent at Station T3 while being absent or at much lesser concentrations at Station T2.

The comparable results from 2011 and 2012 are not unexpected as the stream channel was once again disturbed by additional cleanup activities after the 2011 surveys took place, which likely set back recovery. Additional years of assessment will be needed to fully document short- and long-term impacts associated with the oil spill and response activities.

Kalamazoo River - Macroinvertebrates

The 2012 macroinvertebrate results for the Kalamazoo River sites (K1, K2, K3, and K4) are presented in Table 5. Macroinvertebrate metrics, scores, and ratings are presented in Table 6. The stations are situated in an upstream to downstream sequence as depicted in Figure 1. The control station on the Kalamazoo River was upstream of the oil spill in Marshall at Kalamazoo Street (Station K1). Three sites on the Kalamazoo River were surveyed in the reach impacted by the oil spill and the associated cleanup activities. Station K2 was located on the Kalamazoo River in the vicinity of the Squaw Lake Drain confluence at about Mile Post 2.75. Station K3 was downstream of the Ceresco Dam at 11 Mile Road approximately at Mile Post 7.25. Station K4 on the Kalamazoo River was located downstream of the city of Battle Creek at Custer Drive at about Mile Post 21.25.

The upstream control site (K1) had an overall macroinvertebrate score of +3 and rating of acceptable. This score is down from the 2011 survey results of (+6/excellent). The reduction in score between the 2011 and 2012 (Table 1) results is largely attributed to the fact that no stoneflies (Plecoptera) were noted in 2012 at this location where two individuals were recorded in 2011. Besides the absence of stoneflies, the overall species composition at Station K1 in 2012 was very similar to 2011 results, with more taxa actually being recorded in 2012 (Table 2).

Station K2 received a score of +8 and a rating of “excellent,” which is a slight increase from the 2010 and 2011 rating of excellent (+6). Species composition and diversity was similar to 2011 with 42 taxa recorded in 2011 and 38 identified in 2012. The increase in score can be attributed to a slight decrease in percent dominant taxa and slight increase in percent caddisfly composition.

Downstream at Station K3, the score was +6 with a rating of “excellent.” This station harbored the most diversity of the 2012 Kalamazoo River locations with 42 taxa recorded. The score is a slight increase from +5 in 2011 (Table 1).

Station K4, the most downstream location, produced a score of +4 and a rating of acceptable. As it did in 2010 and 2011, this site produced the least diversity with 28 species documented. This reduction in number of taxa can likely be attributed to the lack of diversity of in-stream substrates, which were abundant at upstream locations. This score is an increase from the score of +1 recorded in 2011. The species composition was similar to that recorded in 2011 (Table 1); a slight change in the percentage composition of some species was the cause of this increase in score.

Macroinvertebrate Abundance

Procedure 51 is a qualitative collection method that involves sampling all available in-stream habitats to produce a composite macroinvertebrate sample that is typically sub-sampled until 300 organisms have been identified and counted. After 300 organisms have been counted, the remainder of the composite sample is examined for large and/or rare organisms that were not identified in the initial sub-samples. These organisms are added as one individual to the total taxa list. Typically, only a small volume of the composite sample is needed to yield the 300 organisms required by Procedure 51. This is especially true in streams such as the Kalamazoo River that have a diversity of in-stream habitat types, especially in riffle habitats like those present at Stations K2 and K3. The majority of the sample is typically examined for large and/or rare taxa. Counting the entire composite sample is seldom necessary, except in streams that are either habitat-limited or have serious violations of Michigan’s Water Quality Standards. Macroinvertebrate abundance in the composite samples at the upstream control sites on Talmadge Creek (Stations T1 and T2) and the Kalamazoo River (Station K1) was normal in 2010 and 2011. The abundance of macroinvertebrates in the composite samples collected at all of the impacted sites on Talmadge Creek (Station T3) and Kalamazoo River (Stations K2, K3, and K4) in 2010 was so low that the entire composite sample was counted at all of the sites and the goal of enumerating 300 organisms was not achieved at Station T3 on Talmadge Creek and Station K4 on the Kalamazoo River.

In 2011, the abundance of macroinvertebrates was greater than in 2010 at all of the impacted sites on Talmadge Creek and the Kalamazoo River. It was still necessary to count the entire macroinvertebrate composite sample at the impacted site (Station T3) on Talmadge Creek and two stations (K2 and K4) of the three impacted sites on the Kalamazoo River. The abundance of macroinvertebrates at Station K4 was extremely limited.

In 2012, the abundance of macroinvertebrates was improved relative to results found in 2011 at the impacted sites on Talmadge Creek and the Kalamazoo River in that none of the sites required the complete enumeration of the entire contents of the composite sample. Abundance at Station K4 was still limited in comparison to the upstream sites.

Talmage Creek - Stream Habitat

Qualitative stream habitat assessment results for 2012 in Talmadge Creek are presented in

Table 7. Stations T2 and T3 both were rated “good,” with Station T2 scoring 138 and Station T3 scoring 125 out of a possible 200. These scores are nearly identical to 2010 results, as little has changed. Again, because of lack of flow and minimal water, Station T1 was not evaluated as it had been in past years.

Riffle habitat at Station T2 was lacking and sand was the predominant substrate, but some gravel and cobble were present along with an abundance of in-stream cover. The riparian corridor was a wide, undisturbed scrub/shrub wetland.

In 2010, the in-stream habitat, stream banks, and adjacent riparian corridor at Station T3 were highly disturbed due to the cleanup activities and were rated as marginal. In 2011, after the August 2011 survey, additional cleanup operations were conducted on Talmadge Creek that involved dredging the stream banks and channel. The overall 2012 habitat score was slightly higher than in 2011, but still on the lower end of “good.” The stream banks and riparian zone were stabilized with vegetative cover and various structures. The stream channel remains narrower than in 2010. Riffle habitat was present, but in-stream cover was still extremely limited. The substrate was primarily sand and small gravel with a limited amount of cobble still present. The disturbance from cleanup activities has effectively created a clean channel that is silt free.

<u>Kalamazoo River - Stream Habitat</u>

The qualitative stream habitat scores for 2012 are presented in Table 8. Results are very similar to the 2011 evaluation. All sites were scored as glide/pool habitat except for Station K3, which had significant riffle/run habitat and was scored as such.

At the upstream control site, Station K1 (17 Mile Road) in-stream habitat was abundant and included moderate amounts of large woody debris, aquatic vegetation, and root wads. The stream substrate was diverse with a nearly equal mixture of cobble, gravel, sand, and silt along with scattered boulders. The only significant detraction from the overall habitat score was the limited width of the riparian zone. This site scored “good” as it did in 2011.

Station K2 (Squaw Lake Drain Confluence) scored on the lower end of “excellent” in comparison to its upper end of “good” rating in 2011. The total score at Station K2 only differed by 7 points with the site receiving 148 in 2011, and 155 in 2012, out of a total of 200 points. In-stream cover was slightly higher and sediment deposition was rated as slightly lower in 2012. The dominant substrates were cobble and gravel with lesser amounts of sand, silt, and boulders. Submergent aquatic vegetation is still only beginning to become established and was present in about 15 percent of the reach.

Station K3 (11 Mile Road) received the exact same score as in 2011, and was rated on the upper end of “good.” Cobble and gravel were the dominant substrates along with scattered boulders and lesser amounts of sand and silt along the stream margins. Others forms of in-stream cover that were still moderately abundant included large woody debris, aquatic vegetation, and root wads. Cleanup operations had nearly eliminated all overhanging vegetation, but regrowth along the river edge is evident. Substantial depositional areas are still observed at this site.

Station K4 (Upstream of Custer Road), is substantially larger in average width and depth than the other sites surveyed (Figure 5). This station was rated “good;” the same as in 2011. The in-stream habitat suitable for colonization is limited at this site, but the wide, forested floodplain helps to increase its habitat score. Sand and silt make up approximately 85 percent of the substrate at this site, with only small, scattered patches of gravel present. Large woody debris resulting from dead trees and wind storms make up the majority of in-stream habitat. Aquatic vegetation, overhanging vegetation, and undercut banks are also present in limited quantities at this location.

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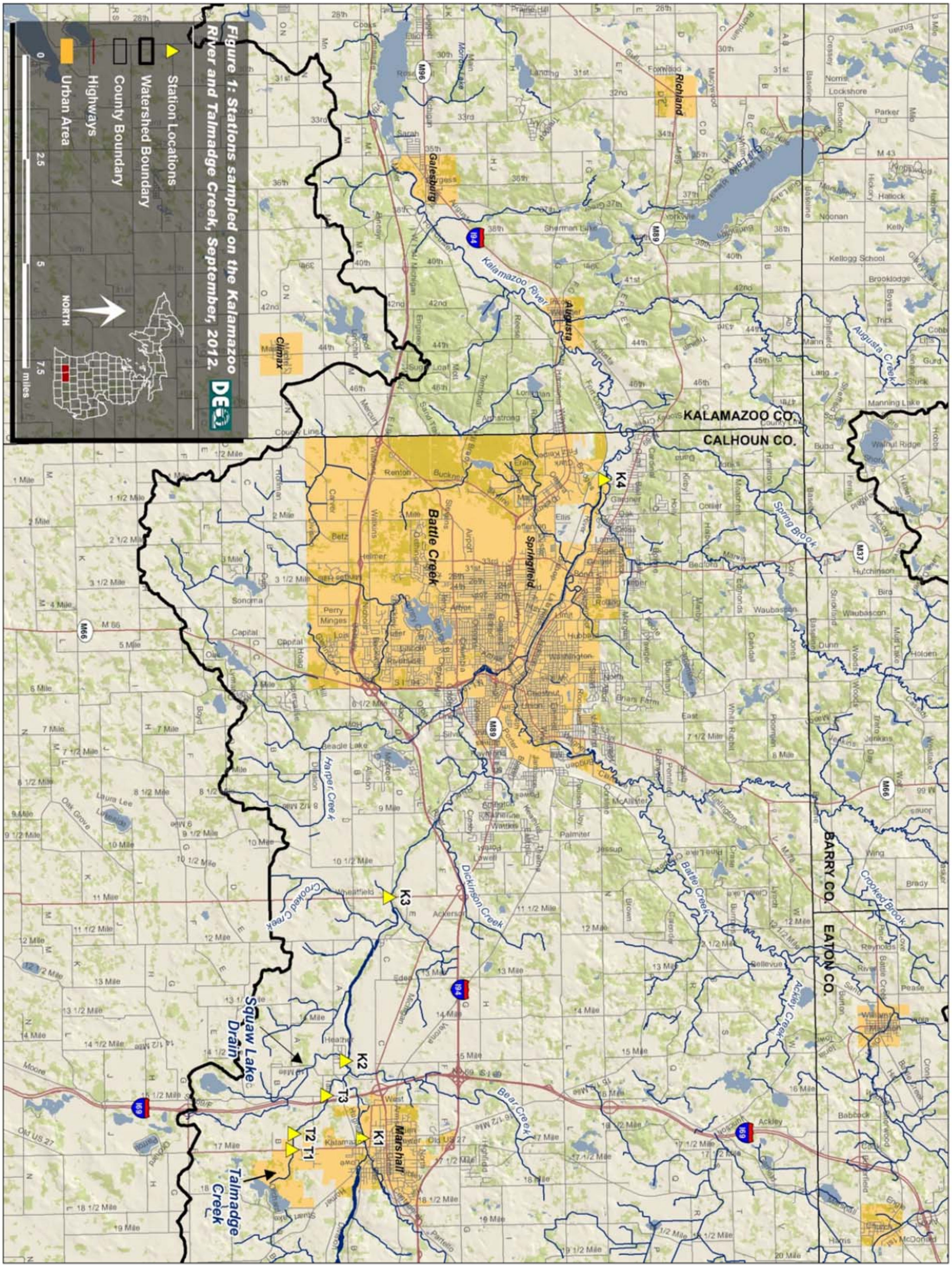

Figure 1. Stations sampled on the Kalamazoo River and Talmadge Creek, September 2012.

Table 3. Qualitative macroinvertebrate sampling results for Talmadge Creek sites, September 2012.

	Talmadge Creek Downstream of 17 Mile Rd. Station T2 9/11/2012	**Talmadge Creek 15 ½ Mile Rd. Station T3** 9/11/2012
TAXA		
ANNELIDA (segmented worms)		
Hirudinea (leeches)	1	
Oligochaeta (worms)	1	4
ARTHROPODA		
Crustacea		
Amphipoda (scuds)	203	18
Arachnoidea		
Hydracarina	5	2
Insecta		
Ephemeroptera (mayflies)		
Baetidae	1	13
Caenidae		3
Ephemerellidae		2
Heptageniidae		15
Isonychiidae		20
Odonata		
Anisoptera (dragonflies)		
Aeshnidae	1	
Gomphidae	1	1
Libellulidae	1	
Zygoptera (damselflies)		
Calopterygidae	17	1
Coenagrionidae	1	1
Hemiptera (true bugs)		
Belostomatidae		1
Corixidae	3	3
Gerridae	1	
Mesoveliidae		1
Nepidae		1
Saldidae	5	
Trichoptera (caddisflies)		
Hydropsychidae	2	76
Hydroptilidae		1
Leptoceridae	1	10
Limnephilidae	1	2
Molannidae	1	1
Coleoptera (beetles)		
Dytiscidae (total)	1	
Haliplidae (adults)	1	1
Elmidae	1	
Gyrinidae (larvae)		1
Haliplidae (larvae)		1
Diptera (flies)		
Ceratopogonidae	1	1
Chironomidae	42	149
Culicidae		2

Table 3. Qualitative macroinvertebrate sampling results for Talmadge Creek sites, September 2012.

	Talmadge Creek Downstream of 17 Mile Rd. Station T2 9/11/2012	**Talmadge Creek 15 ½ Mile Rd. Station T3** 9/11/2012
Simuliidae		13
Tabanidae	1	
Tipulidae	3	
MOLLUSCA		
Gastropoda (snails)		
Ancylidae (limpets)	2	1
Hydrobiidae		1
Physidae	1	6
Planorbidae	4	2
Pelecypoda (bivalves)		
Sphaeriidae (clams)	18	
TOTAL INDIVIDUALS	321	354

Table 4. Macroinvertebrate metric evaluation at Talmadge Creek sites, September 2012.

	Talmadge Creek Downstream of 17 Mile Rd. Station T2 9/11/2012		**Talmadge Creek 15 ½ Mile Rd. Station T3** 9/11/2012	
METRIC	Value	Score	Value	Score
TOTAL NUMBER OF TAXA	28	1	30	1
NUMBER OF MAYFLY TAXA	1	0	5	1
NUMBER OF CADDISFLY TAXA	4	1	5	1
NUMBER OF STONEFLY TAXA	0	-1	0	-1
% MAYFLY COMP.	0.31	-1	14.97	0
% CADDISFLY COMP.	1.56	-1	25.42	0
% DOMINANT TAXON	63.24	-1	42.09	-1
% ISOPOD, SNAIL, LEECH	2.49	1	2.82	1
% SURFACE AIR BREATHERS	3.43	1	2.54	1
TOTAL SCORE	**0**		**3**	
Community Rating	Acceptable		Acceptable	

Table 5. Qualitative macroinvertebrate sampling results for Kalamazoo River sites, September 2012.

TAXA	**Kalamazoo River at Kalamazoo St. (17 Mile Rd.) Station K1** 9/11/2012	**Kalamazoo River Squaw Lake Drain Confluence Station K2** 9/12/2012	**Kalamazoo River 11-Mile Rd. Station K3** 9/12/2012	**Kalamazoo River Custer Drive Station K4** 9/12/2012
PLATYHELMINTHES (flatworms)				
Turbellaria	2		1	
ANNELIDA (segmented worms)				
Hirudinea (leeches)	1		1	
Oligochaeta (worms)	1	9	5	
ARTHROPODA				
Crustacea				
Amphipoda (scuds)	109	22	6	5
Decapoda (crayfish)	1	1	1	1
Isopoda (sowbugs)	5		1	3
Arachnoidea				
Hydracarina		1		2
Insecta				
Ephemeroptera (mayflies)				
Baetidae	24	23	63	37
Caenidae	1	4		4
Ephemerellidae	13	5	11	
Heptageniidae	11	8	3	2
Isonychiidae		3	7	
Leptophlebiidae				1
Tricorythidae	3	19	3	8
Odonata				
Anisoptera (dragonflies)				
Aeshnidae		1	1	1
Gomphidae	1			1
Zygoptera (damselflies)				
Calopterygidae	6	3	3	
Coenagrionidae	18	3	1	32
Plecoptera (stoneflies)				
Pteronarcyidae		2	1	
Hemiptera (true bugs)				
Corixidae	4			1
Gerridae	1		1	6
Mesoveliidae		1		1
Nepidae	1			
Pleidae	1			7
Megaloptera				
Corydalidae (dobson flies)		1		
Sialidae (alder flies)	1		1	
Trichoptera (caddisflies)				
Brachycentridae	40	3	1	1
Glossosomatidae			1	
Helicopsychidae	3	26	2	
Hydropsychidae	34	54	80	85
Hydroptilidae	3	1	2	6

Table 5. Qualitative macroinvertebrate sampling results for Kalamazoo River sites, September 2012.

	Kalamazoo River at Kalamazoo St. (17 Mile Rd.) Station K1 9/11/2012	**Kalamazoo River Squaw Lake Drain Confluence Station K2** 9/12/2012	**Kalamazoo River 11-Mile Rd. Station K3** 9/12/2012	**Kalamazoo River Custer Drive Station K4** 9/12/2012
Leptoceridae	7	8	1	1
Limnephilidae	4		1	
Philopotamidae	3	1		
Polycentropodidae	1			2
Uenoidae		2	27	2
Lepidoptera (moths)				
Pyralidae		1	1	1
Coleoptera (beetles)				
Gyrinidae (adults)	1			
Elmidae	8	3	6	19
Haliplidae (larvae)	1			
Psephenidae (larvae)		3		
Diptera (flies)				
Ceratopogonidae			1	
Chironomidae	15	44	34	77
Culicidae		1	2	
Simuliidae	16	12	19	4
Tabanidae	1		1	
Tipulidae		1		
MOLLUSCA				
Gastropoda (snails)				
Ancylidae (limpets)	8	1	1	8
Hydrobiidae		4	4	
Lymnaeidae	3	10	36	
Physidae	4	2	5	
Planorbidae	1	1	3	4
Pleuroceridae	1	7	13	
Viviparidae			1	
Pelecypoda (bivalves)				
Corbiculidae	1	13	3	
Sphaeriidae (clams)	6	8	8	
Unionidae (mussels)			1	
TOTAL INDIVIDUALS	365	312	364	322

Table 6. Macroinvertebrate metric evaluation at Kalamazoo River sites, September 2012.

	Kalamazoo River at Kalamazoo St. (17 Mile Rd.) Station K1 9/11/2012		**Kalamazoo River Squaw Lake Drain Confluence Station K2** 9/12/2012		**Kalamazoo River 11-Mile Rd. Station K3** 9/12/2012		**Kalamazoo River Custer Drive Station K4** 9/12/2012	
METRIC	Value	Score	Value	Score	Value	Score	Value	Score
TOTAL NUMBER OF TAXA	40	1	38	1	42	1	28	1
NUMBER OF MAYFLY TAXA	5	1	6	1	5	1	5	1
NUMBER OF CADDISFLY TAXA	8	1	7	1	8	1	6	1
NUMBER OF STONEFLY TAXA	0	-1	1	1	1	1	0	-1
% MAYFLY COMP.	14.25	0	19.87	1	23.90	1	16.15	0
% CADDISFLY COMP.	26.03	0	30.45	1	31.59	1	30.12	1
% DOMINANT TAXON	29.86	0	17.31	1	21.98	0	26.40	0
% ISOPOD, SNAIL, LEECH	6.30	0	8.01	0	17.86	-1	4.66	0
% SURFACE AIR BREATHERS	2.19	1	0.64	1	0.82	1	4.66	1
TOTAL SCORE	**3**		**8**		**6**		**4**	
Community Rating	Acceptable		Excellent		Excellent		Acceptable	

Table 7. Habitat evaluation for Talmadge Creek sites, September 2012.

HABITAT METRIC	**Talmadge Creek Downstream of 17 Mile Rd. Station T2** 9/11/2012 RIFFLE/RUN	**Talmadge Creek 15 ½ Mile Rd. Station T3** 9/11/2012 RIFFLE/RUN
Substrate and Instream Cover		
Epifaunal Substrate/ Available Cover (20)	11	8
Embeddedness (20)*	11	14
Velocity/Depth Regime (20)*	11	11
Pool Substrate Characterization (20)**		
Pool Variability (20)**		
Channel Morphology		
Sediment Deposition (20)	11	13
Flow Status - Maintained Flow Volume (10)	8	8
Flow Status - Flashiness (10)	9	8
Channel Alteration (20)	13	5
Frequency of Riffles/Bends (20)*	8	16
Channel Sinuosity (20)**		
Riparian and Bank Structure		
Bank Stability (L) (10)	9	8
Bank Stability (R) (10)	9	8
Vegetative Protection (L) (10)	9	6
Vegetative Protection (R) (10)	9	6
Riparian Veg. Zone Width (L) (10)	10	7
Riparian Veg. Zone Width (R) (10)	10	7
TOTAL SCORE (200):	138	125
HABITAT RATING:	GOOD	GOOD
	(SLIGHTLY IMPAIRED)	(SLIGHTLY IMPAIRED)
Date:	9/11/2012	9/11/2012
Weather:	Sunny	Sunny
Air Temperature:	65 °F	70 °F
Water Temperature:	58°F	65°F

Table 7. Habitat evaluation for Talmadge Creek sites, September 2012.

	Talmadge Creek Downstream of 17 Mile Rd. Station T2 9/11/2012	**Talmadge Creek 15 ½ Mile Rd. Station T3** 9/11/2012
Average Stream Width:	5 ft.	8 ft.
Average Stream Depth:	0.2 ft.	0.25 ft.
Surface Velocity:	0.2 ft./sec	0.5 ft./sec
Estimated Flow:	0.2 cfs	1 cfs
Stream Modifications:	None	Dredged
Nuisance Plants (Y/N):	N	N
Report Number:	MI/DEQ/WRD-13/011	MI/DEQ/WRD-13/011
STORET No.:	130405	130335
Stream Name:	Talmadge Creek	Talmadge Creek
Road Crossing/Location:	D/S of 17 Mile Road	15 1/2 Mile Road
County Code:	13	13
TRS:	03S06W02	02S06W34
Latitude (dd):	42.2402	42.251717
Longitude (dd):	-84.97066	-84.9885712
Ecoregion:	SMNITP	SMNITP
Stream Type:	Warmwater	Warmwater
USGS Basin Code:	4050003	4050003

* Applies only to Riffle/Run stream Surveys

** Applies only to Glide/Pool stream Surveys

Note: Individual metrics may better describe conditions directly affecting the biological community while the Habitat Rating describes the general riverine environment at the site(s).

Table 8. Habitat evaluation for Kalamazoo River sites, September 2012.

HABITAT METRIC	**Kalamazoo River at Kalamazoo St. (17 Mile Rd.) Station K1** GLIDE/POOL	**Kalamazoo River Squaw Lake Drain Confluence Station K2** GLIDE/POOL	**Kalamazoo River 11-Mile Rd. Station K3** RIFFLE/RUN	**Kalamazoo River Custer Drive Station K4** GLIDE/POOL
Substrate and Instream Cover				
Epifaunal Substrate/ Available Cover (20)	18	15	15	10
Embeddedness (20)*			16	
Velocity/Depth Regime (20)*			13	
Pool Substrate Characterization (20)**	18	16		13
Pool Variability (20)**	16	15		8
Channel Morphology				
Sediment Deposition (20)	16	18	13	11
Flow Status - Maintained Flow Volume (10)	9	8	8	7
Flow Status - Flashiness (10)	7	7	8	4
Channel Alteration (20)	18	18	16	15
Frequency of Riffles/Bends (20)*			11	
Channel Sinuosity (20)**	13	13		8
Riparian and Bank Structure				
Bank Stability (L) (10)	9	8	8	9
Bank Stability (R) (10)	9	8	8	9
Vegetative Protection (L) (10)	1	9	4	9
Vegetative Protection (R) (10)	8	6	9	9
Riparian Veg. Zone Width (L) (10)	1	10	4	10
Riparian Veg. Zone Width (R) (10)	5	4	10	10

Table 8. Habitat evaluation for Kalamazoo River sites, September 2012.

	Kalamazoo River at Kalamazoo St. (17 Mile Rd.) Station K1	**Kalamazoo River Squaw Lake Drain Confluence Station K2**	**Kalamazoo River 11-Mile Rd. Station K3**	**Kalamazoo River Custer Drive Station K4**
TOTAL SCORE (200):	148	155	143	132
HABITAT RATING:	GOOD	EXCELLENT	GOOD	GOOD
	(SLIGHTLY IMPAIRED)	(NON-IMPAIRED)	(SLIGHTLY IMPAIRED)	(SLIGHTLY IMPAIRED)
Date:	9/11/2012	9/12/2012	9/12/2012	9/12/2012
Weather:	Sunny	Sunny	Sunny	Sunny
Air Temperature:	75°F	70°F	75°F	79°F
Water Temperature:	68°F	65°F	68°F	74°F
Average Stream Width:	120 ft.	210 ft.	160 ft.	360 ft.
Average Stream Depth:	2.5 ft.	1.3 ft.	1.2 ft.	1.5 ft.
Surface Velocity:	0.6 ft./sec	1 ft./sec	1.1 ft./sec	0.7 ft./sec
Estimated Flow:	180 cfs	273 cfs	211.2 cfs	378 cfs
Stream Modifications:	None	None	None	None
Nuisance Plants (Y/N):	N	N	N	N
Report Number:	MI/DEQ/WRD-13/011	MI/DEQ/WRD-13/011	MI/DEQ/WRD-13/011	MI/DEQ/WRD-13/011
STORET No.:	130211	130406	130048	130052
Stream Name:	Kalamazoo River	Kalamazoo River	Kalamazoo River	Kalamazoo River
Road Crossing/Location:	u/s Marshall WWTP - d/s Kalamazoo St.	Squaw Lake Drain confluence	11-Mile Road	Custer Drive
County Code:	13	13	13	13
TRS:	02S06W26	02S06W33	02S07W25	01S08W29
Latitude (dd):	42.26391	42.25852	42.27429	42.35074
Longitude (dd):	-84.96836	-85.00469	-85.08097	-85.27561
Ecoregion:	SMNITP	SMNITP	SMNITP	SMNITP
Stream Type:	Warmwater	Warmwater	Warmwater	Warmwater
USGS Basin Code:	4050003	4050003	4050003	4050003

* Applies only to Riffle/Run stream Surveys

** Applies only to Glide/Pool stream Surveys

Note: Individual metrics may better describe conditions directly affecting the biological community while the Habitat Rating describes the general riverine environment at the site(s).

Figure 2. Site T1 upstream reference site. This site is more of a wetland site than the more downstream locations (T2 and T3). T1 was unable to be sampled in 2012 due to low water levels. Photo taken by William Taft, 2011.

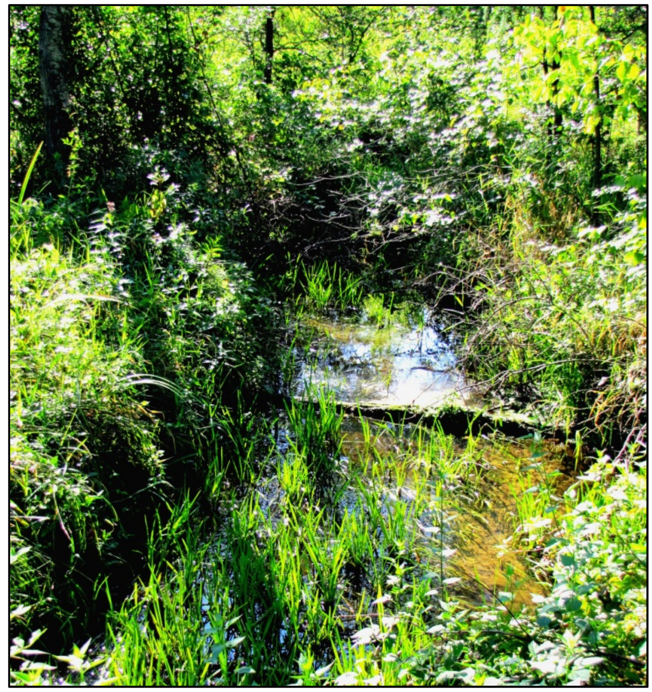

Figure 4. Site T2 upstream reference location. This site was sampled as a reference location in 2010, 2011, and 2012. T2 is heavily vegetated and comparable in flow to T3 (impacted site). Photo by William Taft, 2011.

Figure 3. Site T3 on Talmadge Creek. Image shows open canopy and artificial structure along stream bank. Photo by William Taft, 2011.

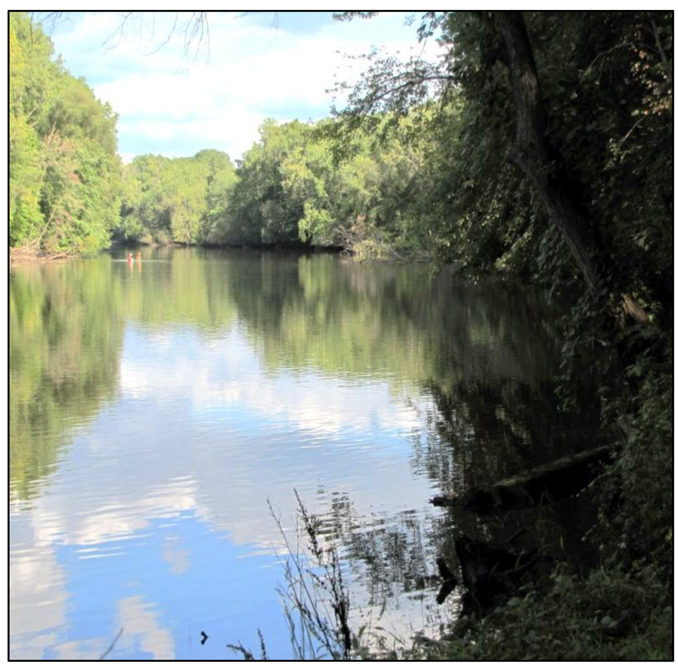

Figure 5. Site K4, Upstream of Custer Drive on the Kalamazoo River. This site is much wider and slower than any of the upstream Kalamazoo River or Talmadge Creek Sites. Photo by William Taft, 2011.

Appendix I: Mussel Shell Survey Report

Mussel Shell Survey Report: Kalamazoo River Unionid Mussel Shell Survey in the Marshall and Battle Creek Area October 2010

Prepared for:

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July 20, 2011

1. Introduction

On July 26, 2010, an oil release from Enbridge Energy Partners, L.P. (Enbridge) line 6B was discovered. The line, located in Marshall, Calhoun County, Michigan, is a 30-inch, 283,000-barrels per day line that transports light synthetics and heavy and medium crude oil. The release occurred in an undeveloped area on the outskirts of town with coordinates of approximately North ½ Section 2, T3S, R6W, Latitude: 42.2395273, Longitude: -84.9662018. Upon discovery of the release, the pipeline was shut down and isolation valves closed, stopping the flow of the oil. The exact amount of oil released prior to the shutdown is unknown. However, it is estimated that at least 1 million gallons of crude oil was released to nearby Talmadge Creek and to the Kalamazoo River (U.S. EPA, 2010; Enbridge Energy, 2011).

Soon after the spill, the Trustees for the Natural Resource Damage Assessment (NRDA), in coordination with Enbridge, began to collect ephemeral data on potentially injured natural resources in Talmadge Creek and the Kalamazoo River and their watersheds. The Trustees include the U.S. Department of the Interior, represented by the U.S. Fish and Wildlife Service and the Bureau of Indian Affairs; the State of Michigan, represented by the Michigan Department of Natural Resources (MDNR), the Michigan Department of Environmental Quality (MDEQ), and the Michigan Attorney General; the U.S. Department of Commerce, represented by the National Oceanic and Atmospheric Administration; the Nottawaseppi Huron Band of the Potawatomi; and the Match-E-Be-Nash-She-Wish Band of Potawatomi. As a part of the ephemeral data collection, a mussel shell survey was conducted in October 2010. The survey was conducted to document post-mortem mussel shells that, depending on their relative condition, may be indicative of injury to mussels as a result of exposure to contaminants released during the spill; physical injuries to mussels as a result of response activities, such as crushing by boat traffic, habitat alterations, and sedimentation; or factors unrelated to the incident.

This report describes the mussel shell survey, which was conducted in October 2010 on the Kalamazoo River from the Marshall Impoundment to the Town of Battle Creek, Michigan, and summarizes the survey findings. The Trustees and Enbridge collaboratively developed the study work plan and conducted the survey field work.

Survey results may be used in combination with other information to help identify and characterize potential injuries to mussel communities resulting from potential exposure to oil or from physical injury (i.e., damaged or crushed shells) caused by oil spill response activities, as well as to distinguish spill-related effects from mortality likely to be unrelated to this incident. Results may also be used to evaluate the need for additional studies to quantify impacts to mussels as a result of the spill and to aid in the development of such studies.

1.1 Background on Unionid Mussels

Freshwater unionid mussels belong to one of four bivalve families that live along the bottoms of creeks, rivers, and lakes in Michigan. Nationwide, unionid mussels are among the most endangered groups of animals. A 1993 review of the status of unionid species by the American Fisheries Society found that 97 of 292 species that occur in the United States are considered endangered (Williams et al., 1993). Mussel population declines have been attributed to habitat degradation from pollution, physical alterations such as dams, and pressure from exotic species [e.g., zebra mussels (*Dreissena polymporpha)*].

Michigan's rivers and streams support significant populations of mussels, including federal- and state-listed endangered species. There are 46 unionid mussel species that occur in Michigan, 19 of which are state-listed as threatened or endangered. A total of 28 unionid mussel species have been observed in the Kalamazoo River Watershed. These include three state endangered species, three state threatened species, and six species of special concern[1] (Badra, 2010). There are no known federally listed mussel species present in the watershed. Between Marshall and Battle Creek, the stretch of the river where this study took place, 13 unionid mussel species have been observed since 1929 (Table 1).

Unionid mussels are an important component of Michigan's natural history and play important ecological roles in stream ecosystems. Unionids can be important to stream foodwebs, often comprising the highest percentage of biomass relative to other benthic stream organisms (Strayer et al., 1994). They are a key component in the food chain, linking aquatic microorganisms to muskrats, crayfish, birds, and other predators. Unionids are also intricately linked to fish communities because they depend on fish to act as hosts in the completion of their life cycle and provide a mechanism for dispersal and gene flow (Kat, 1984; Watters, 1992, 1995). They can also play a role in water quality, as the action of their filter feeding can change the particulate content of river water (Pusch et al., 2001).

Mussels are also important because they can act as ecosystem and water quality indicators. Many unionid mussel species are long-lived, some with life spans of 50 years or more. Mature mussels are generally sessile, spending most of their lives within a particular location in a stream. Furthermore, unionids are sensitive to many contaminants and, because they are filter feeders, can bioaccumulate contaminants. Given these characteristics, mussels can provide long-term information about ecosystem health and can be valuable indicators of water quality and biological integrity (Strayer, 1999; Grabarkiewicz and Davis, 2008).

1. Unlike state-listed threatened or endangered mussel species, species of special concern are not protected by Part 365 of PA 451, 1994 Michigan Natural Resources and Environmental Protection Act, but have been identified by the state to be of concern because of declining populations (MNFI, 2010).

Table 1. Unionid mussel species observed in past surveys of the Kalamazoo River between Marshall, Michigan, and Battle Creek, Michigan. These data may include both shells and live individuals. Historical records were obtained from five separate locations surveyed in 1929 and 1934. In 2000, one location in Wattles Park, Emmett Township, Michigan, near Historic Bridge Park was surveyed.

Common name	Species	State status	Historical records (1929; 1934)	Wattle's Park area (2000)
Mucket	*Actinonaias ligamentina*			X
Elktoe	*Alasmidonta marginata*	Special concern	X	X
Spike	*Elliptio dilatata*		X	
Wabash pigtoe	*Fusconaia flava*		X	X
Plain pocketbook	*Lampsilis cardium*		X	
Fatmucket	*Lampsilis siliquoidea*		X	
White heelsplitter	*Lasmigona complanata*			X
Creek heelsplitter	*Lasmigona compressa*		X	X
Fluted-shell	*Lasmigona costata*		X	X
Round pigtoe	*Pleurobema sintoxia*	Special concern	X	
Strange floater	*Strophitus undulates*		X	X
Ellipse	*Venustaconcha ellipsiformis*	Special concern	X	
Rainbow	*Villosa iris*	Special concern	X	

Sources: University of Michigan Museum of Zoology's Mollusk Collection records; Mulcrone and Mehne (2001).

1.2 Characterization of Mussel Shells Post-Mortem

The degree of mussel shell weathering, location of shells within a river system, and physical condition of shells can provide qualitative estimates of when, where, and how mussel death may have occurred. Rough estimates of time post-mortem can be made by evaluating and scoring the physical weathering of shells. Table 2 describes post-mortem shell age categories and their associated physical characteristics; this scale was developed by the Michigan Natural Features Inventory (MNFI) and adapted for use in this study. This terminology is commonly used to describe the condition of shells (see e.g., Badra 2009, Myers-Kinzie et al 2001, and Hoke 2005), but the physical definitions and estimates of time post-mortem provided in Table 2 were developed specifically for this study based on professional judgment. Shell decay rates are governed by streamflow rates and water chemistry, as described in Strayer and Malcom 2007.

Table 2. Mussel shell weathering scale developed by MNFI

Scale	Category	Physical shell characteristics	Approximate time post-mortem
1	Fresh dead	Soft tissue intact	Less than several days
2	Recent dead	No soft tissue, aside from hinge ligament	Several days to a few (2–3) weeks
3	Moderately worn 1	Hinge intact, marl not covering lower portion, light algae on inside of shell	A few (2–3) weeks to a few (2–3) months
4	Moderately worn 2	Hinge intact or not intact, marl can be covering entire shell, heavy algae and/or marl on inside of shell, most of periostracum intact, shell has most of its original strength	Greater than 2–3 months
5	Heavily worn	Periostracum worn and peeling, shell at least somewhat chalky and fragile	Greater than 3 months

The presence of intact soft tissue and hinge ligament allows for a relatively narrow post-mortem dating of a shell, since tissue and ligament degrade relatively quickly post-mortem. However, beyond this point, it is only possible to match shell wear categories to relatively broad timescales. With increased time post-mortem, microhabitat factors play a larger role in determining the amount of shell wear. For example, a shell that is buried in soft sediments will wear more slowly than a shell that is exposed to stream current on the surface of a rocky substrate. The difference in shell wear between the two would be relatively small over a shorter time period (e.g., one month post-mortem) and relatively large over a longer time period (e.g., five months post-mortem). The approximate time post-mortem given in Table 2 reflects this increased variation in the rate of shell wear as time post-mortem increases.

In addition to the degree of weathering, observations of physical damage to shells (e.g., broken, chipped, or crushed shells) can provide information on impacts to mussels. Shells can be damaged as a result of numerous processes in a river system. The three most relevant processes to this study include physical wearing and breaking of shells as a result of normal (non-spill related) in-stream processes, chipping as a result of animal predation, and crushing as a result of anthropogenic activities. The nature of the damage to the shells resulting from these three processes is quite distinct, and it is often possible to ascertain how shells were damaged by examining the characteristics of the damage.

Shells that have been worn over a relatively long period of time through normal in-stream processes become fragile and are often found with pieces broken off. These shells can be distinguished by the general wearing characteristics and nature of the breakage. For example, these shells typically fall into the “heavily worn” category described in Table 2, as shells having worn and peeling periostraca that are chalky and fragile. Breakage typically initiates around the edges where the shell is thinnest. For the purposes of this study, these shells are referred to as being "broken."

Shells that have been damaged as a result of foraging by aquatic mammals also have many distinguishing features. Piles of foraged mussel shells, or middens, are often found along the banks of rivers that support freshwater mussels and mammals, such as the Kalamazoo River. Middens are easily identified in the field due to the large number of single shells in one area and unique markings on the shells. The shells are typically chipped along the thin edges (where the predator has worked to open the shell) and often have scratches or bite marks. Middens are also identifiable by their physical location. For example, they are typically found in areas with abundant cover and easy access to shallow water, such as logjams.

Shells may also be damaged as a result of being physically crushed when a mussel is still alive or still has most of its original strength (i.e., up to two to three months post-mortem). This type of damage is distinct in that the shells are split with a clean, sharp edge, often through the thickest part of the shell. The crushing of mussel shells requires a relatively heavy impact or force that is not reflective of normal in-stream weathering processes or predation. Following the oil spill prior to this study, anecdotal observations in the Kalamazoo River suggested that mussels were crushed during response activities, including by boats passing over shallow sections of the river where mussels were exposed and by response crews wading in the river and stepping on mussels. Based on previous experience conducting mussel surveys across the state, observations of crushed mussel shells are very unusual. For the purpose of this report, shells exhibiting the characteristics of physical crushing described above are referred to as being "crushed."

This study classified damaged shells into the three categories described above: broken, chipped, or crushed, in order to characterize the type of damage occurring at sampling locations. Table 3 summarizes the definitions of these three categories.

Table 3. Mussel shell damage categories identified for this study by MNFI

Category	Physical characteristics of shell
Broken	Shell is worn and thin, with breakage due to natural river processes in thinnest parts of the shell
Chipped	Shell has scratches and bite marks near the thin edges caused by predation
Crushed	Shell still has most of its original strength, with a sharp-edged break through the thick part of the shell due to non-natural heavy impact

Figures 1 and 2 illustrate the difference between the two types of damage most relevant to this study: broken shells and crushed shells.

Figure 1. Photographs of shells that have been gradually worn to a fragile state over time to a point where they are easily broken, where broken is defined as damage caused by normal in-stream processes. Top: moderately worn 2 strange floater; bottom: heavily worn elktoe.

Photograph taken by J. Matousek on October 18, 2010, in segment MS-1.

Figure 2. Photographs of crushed shells, where crushed is defined as damage caused by a heavy impact. Top: recent spike; bottom: moderately worn 1 pocketbook.

Photograph taken by J. Matousek on October 19, 2010, in segment MS-2.

1.3 Objectives and Scope

Given the ecological importance of mussels and field observations of crushed mussel shells in the Kalamazoo River, the Trustees, in cooperation with Enbridge, designed and initiated this mussel shell survey to document the extent of recent dead mussels at the site that may be attributed to the oil spill and subsequent response actions.

Specifically, the objectives of this study were to:

- Within survey sites, document the proportion of mussel shells observed at each stage of weathering and by species
- Survey selected segments of the Kalamazoo River from the Marshall Impoundment to the Town of Battle Creek for mussel shells that were less than approximately three months post-mortem (i.e., the post-mortem age that could reflect mussel death associated with the spill; the survey was conducted in late October 2010, and the spill occurred three months earlier in late July 2010)
- Document species occurrences in sampling segments using observations of both live mussels and mussel shells
- Delineate the spatial extent of mussel shells that were less than approximately three months post-mortem within the selected river segments.

Information on the degree of weathering of mussel shells and the location of dead mussels is ephemeral and will largely be lost over time as shells deteriorate and are displaced. Thus, this survey was conducted in October 2010 to capture ephemeral, time-sensitive data on the occurrence and location of post-mortem mussel shells. Though the purpose of the study was to survey post-mortem mussel shells, observations of live mussels were also recorded when encountered in the field. In the fall, live mussels begin to burrow deeper into the sediment, where they spend winter months. Thus, observations of live mussels recorded during this survey are likely not representative of live mussel abundance and should not be interpreted as a live mussel population survey. However, information from the mussel shell survey may be used to design a more intensive and quantitative mussel community survey (i.e., a live mussel survey), if deemed necessary, for the late spring or summer.

2. Methods

The mussel shell survey was performed on October 18–21 and October 25, 2010, pursuant to the field work plan (Appendix A). The study was performed by MNFI, with assistance from Stratus

Consulting on behalf of the Trustees, in cooperation with Enbridge and their contractor (Cardno ENTRIX). Survey field work was completed on a daily basis by either six or seven staff (depending upon individual availability), representing MDEQ, MDNR, Stratus Consulting, Cardno ENTRIX, and MNFI. Staff included Pete Badra (MNFI), Michael Carney (Stratus Consulting), Ryan Grafton (Cardno ENTRIX), John Matousek (Cardno ENTRIX), Mike Wilson (MDNR), Matt Wesener (MDEQ), Bill Taft (MDEQ), and Mike Walterhouse (MDEQ). All decisions regarding fieldwork were made by consensus of the field team.

This section describes locations and survey field methods. Modifications from the field work plan, made based on conditions encountered in the field, are also described.

2.1 Segment Locations

Five sampling segments were identified on the Kalamazoo River between the Marshall Impoundment and the Mill Pond in the Town of Battle Creek [Mile Post (MP) 15.5] in the mussel shell survey work plan (see Appendix A). Note that river miles are reported in MPs, the reference system established by Enbridge. The MPs begin at the spill site on Talmadge Creek (MP 0.0), the confluence of Talmadge Creek with the Kalamazoo River is marked as MP 2.2, and MPs extend downriver on the Kalamazoo River to Morrow Lake (MP 37.75).

Prior to sampling each segment, segment start locations were finalized in the field, based on the location of access points and the conditions encountered in the river. As indicated in the work plan, shell surveys were conducted in an upriver direction from the segment start location to the end of the proposed segment or as far upriver as could be covered in a single field day. Table 4 describes each sampling segment. A map of segment locations is provided in Figure 3.

Most sampling segments were accessed on foot. A boat was used at segment MS-5 to transport the survey crew over stretches of habitat that were too deep to wade.

Sampling segment locations were selected according to proximity to the spill site, areas of known response activities, locations of boat launches (and hence elevated boat activity), un-impacted areas upstream of the spill site (e.g., reference locations), and based on locations where mussel shells had been observed during prior NRDA fieldwork.

The following sections of the report describe the methods that were used when conducting the mussel shell survey, specifically, how survey sites within a sampling segment were delineated (Section 2.2) and characterized (Section 2.3). Additional collected information is described in Section 2.4, and documentation procedures are described in Section 2.5. Finally, modifications to the original work plan (Appendix A) that were made during the survey as a result of conditions met in the field are provided (Section 2.6).

Table 4. Summary of segment locations and date sampled. River miles are in MPs downriver from the pipeline release, as reported by Enbridge (with the confluence of Talmadge Creek and the Kalamazoo River at MP 2.2). Segment start and end coordinates were taken at the middle of the down- and upriver extremities, respectively, of each sampling segment.

Segment ID	Segment description and access notes	Nearest MP		Latitude	Longitude	Survey date
MS-1	Reference area downriver of the Marshall Impoundment along River Walk Park to 17 Mile Road Bridge. Segment was accessed from the boardwalk that runs along the north bank of the river.	Start:	[a]	42.26480	-84.96385	10/18/2010
		End:	[a]	42.26211	-84.95550	
MS-2	Talmadge Creek confluence area; segment located just downriver from 15 Mile Road Bridge, boat ramp C0.1. Segment was accessed from community park off of Squaw Creek Road.	Start:	3.0	42.25925	-85.01009	10/19/2010
		End:	2.25	42.25864	-84.99898	
MS-3	11 Mile Road Bridge/C1.5 boat ramp area. Segment was accessed from 11 Mile Road Bridge by walking downriver from the bridge along a trail on left bank to start location.	Start:	7.75	42.27732	-85.09117	10/20/2010
		End:	7.25	42.27443	-85.08154	
MS-4	C3.2 boat ramp area near Historic Bridge Park. Segment was accessed from boat ramp parking lot by walking downriver from the parking lot along a trail on right bank to start location.	Start:	10.25	42.29591	-85.12777	10/21/2010
		End:	9.25	42.29373	-85.12421	
MS-5	C5 boat ramp area near Rivers Edge Landscaping and Mill Pond. Segment was accessed from C5 boat ramp by traveling downriver by boat to start location.	Start:	15.5	42.30768	-85.18924	10/25/2010
		End:	14.5	42.30119	-85.18023	

a. River mile MP not available because sampling segment is upriver of the pipeline release. MS-1 was located approximately 2.5 miles upriver from the spill site.

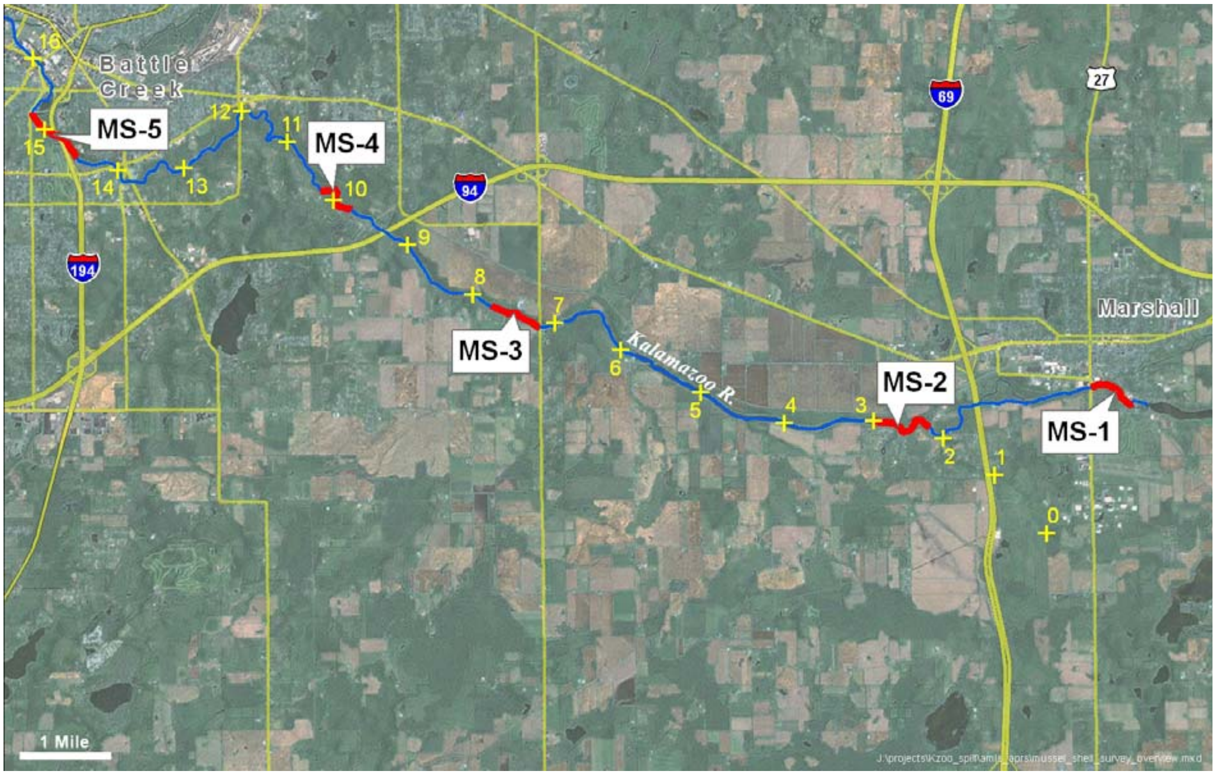

Figure 3. Overview of fall 2010 sampling locations on the Kalamazoo River between Marshall Impoundment and Battle Creek, Michigan.

2.2 Delineation of Survey Sites

Once the sampling segment start location was identified and coordinates recorded, surveyors slowly waded in an upriver direction and inspected the substrate for mussel shells. The field crew used glass-bottom buckets and/or polarized eyeglasses to view the river bottom. Observations of live mussels and mussel shells were recorded in field notebooks. The physical condition of mussel shells was screened according to the shell weathering scale described in Table 2. When a fresh dead or recent dead shell was found (see Table 2), surveyors thoroughly inspected the immediate area for additional fresh dead or recent dead shells. If no additional shells were observed in close proximity [~3 meters (m)], the species, weathering category, and location were recorded in field notebooks, and the survey crew continued upriver in the segment. If more than one fresh dead or recent dead shell was observed, the approximate area in which the fresh dead or recent dead shells were observed was delineated into a survey site. The boundaries of the delineated site encompassed the area in which fresh dead or recent dead shells were found and extended upriver and extended across the river width until shells were no longer observed, with one exception. Survey site 2010.10.21-4-2 was located within a very large area of crushed shells that was too large to fully characterize in one day. Thus, at this site, the crew delineated a smaller area within the large area of crushed shells. Survey site boundary designation rationale for each survey site is provided in the results section (Section 3). The dimensions, river orientation, and boundary coordinates of the survey site were recorded on dedicated field datasheets and are also provided in the results section.

2.3 Survey Site Characterization

All shells and live mussels within a delineated survey site were collected in buckets and mesh bags and brought ashore for examination and enumeration. Each live mussel and shell was identified to species, and the physical condition was scored according to the shell weathering scale (Table 2). Single half shells and connected hinged shells were counted as a single observation. After all mussels and shells from a delineated site were enumerated and scored, shells and live mussels were returned to the river. Habitat information, such as substrate classification and water depth, was also recorded for each survey site.

2.4 Additional Collected Information

In addition to the fresh dead and recent dead mussel shell survey methods described above, additional mussel community information was collected for each sampling segment. This included noting presence of live mussels, non-native dreissenid mussels (*Dreissena polymorpha* and *D. bugensis*), and Asian clams (*Corbicula fluminea*) at each site. Sampling segment-specific species lists were made using observations of shells or live mussels.

2.5 Documentation

Survey information was recorded onto dedicated datasheets and in field notebooks (see Appendices B and C, respectively). Additional information such as field personnel, start and stop times, coordinates, and photograph information was recorded on sampling segment datasheets or in field notebooks.

Each day, field datasheets were scanned to an electronic Portable Document Format (PDF) file and saved on a computer hard drive. Original hardcopy datasheets were retained by MNFI. Photographs were taken with a single camera and backed up to a hard drive at the end of each survey day. Geographic positioning system (GPS) waypoints and track log files were also saved to a hard drive.

2.6 Work Plan Modifications

Table 5 summarizes modifications from the survey work plan.

Table 5. Modifications from the survey work plan

Work plan section	Proposed method	Field modifications
Table 1	Mussel shell weathering scale categories included fresh dead, recent dead, moderately worn, and heavily worn	An additional category of shell weathering was created to better capture the wide range of moderately worn shell characteristics encountered in the field. Specifically, moderately worn was split into two categories, and descriptions for each category were developed (see Table 1 in work plan). All segment characterizations incorporated this change, and include "moderately worn 1" and "moderately worn 2" categories, with the exception of MS-2. Field datasheets were changed to include the additional shell weathering category.
Mussel shell survey protocol	The survey site is delineated and surveyed simultaneously in an upriver direction until fresh dead or recent dead shells are no longer encountered, at which point the site boundary is defined	Survey sites were delineated and then surveyed. Note that single fresh dead/recent dead shell observations were still recorded.
Table 1	Reference sampling segment numbered MS-5 and RM not identified	Location selected for reference survey segment and renumbered MS-1.
None	None	The reference segment was walked, but no survey site was initially delineated, because no fresh dead or recent dead shells were encountered (observation of fresh/recent dead is the trigger for delineation of a survey site within a segment). However, the crew decided to return to the reference segment and delineate a survey site so that there would be a survey site within the reference segment for comparative purposes.

3. Results

This section presents mussel shell survey results. Results are presented for the five survey segments, MS-1 through MS-5. General observations are provided for each segment, and data collected at delineated survey sites within segments are also summarized.

Six survey sites within the five segments were delineated during the survey. This included one survey site in the reference sampling segment (MS-1) and one site in segment MS-2. Two survey sites were delineated in segment MS-3, and two were delineated in MS-4. No sites were delineated in segment MS-5. The location of each survey site is given in Table 6. Completed field datasheets and field notebooks are provided in Appendices B and C, respectively. Photographs taken during the survey are available upon request or can be accessed via the ENTRIX hosted File Transfer Protocol (FTP) site.

Table 6. Mussel shell survey sites that were delineated within sampling segments

Survey site		Latitude (N)	Longitude (W)	Survey date	Segment	Survey site surface area (m^2)
2010.10.21-1-1	Start:	42.26305	-84.95710	10/21/2010	MS-1	133
	End:	42.26284	-84.95668			
2010.10.19-2-1	Start:	42.25979	-85.01019	10/19/2010	MS-2	288
	End:	42.25983	-85.00980			
2010.10.20-3-1	Start:	42.27737	-85.09080	10/20/2010	MS-3	113
	End:	42.27736	-85.09071			
2010.10.20-3-2	Start:	42.27657	-85.08723	10/20/2010	MS-3	248
	End:	42.27661	-85.08678			
2010.10.21-4-1	Start:	42.29591	-85.12740	10/21/2010	MS-4	190
	End:	42.29600	-85.12704			
2010.10.21-4-2	Start:	42.29390	-85.12488	10/21/2010	MS-4	216
	End:	42.29370	-85.12486			

3.1 Segment MS-1

Segment MS-1, a reference area upstream of the pipeline release, was located on the Kalamazoo River 2.5 miles upriver from the Talmadge Creek confluence. Approximately 0.6 miles of the 1-mile segment was surveyed, from the Kalamazoo Avenue Bridge to just downriver of the Marshall Impoundment (Figure 4). Rice Creek enters the Kalamazoo River at the approximate midpoint of this sampling segment. The August 2010 mussel tissue and sediment sampling site (SE-2) was also located in this segment. One survey site was delineated in this segment.

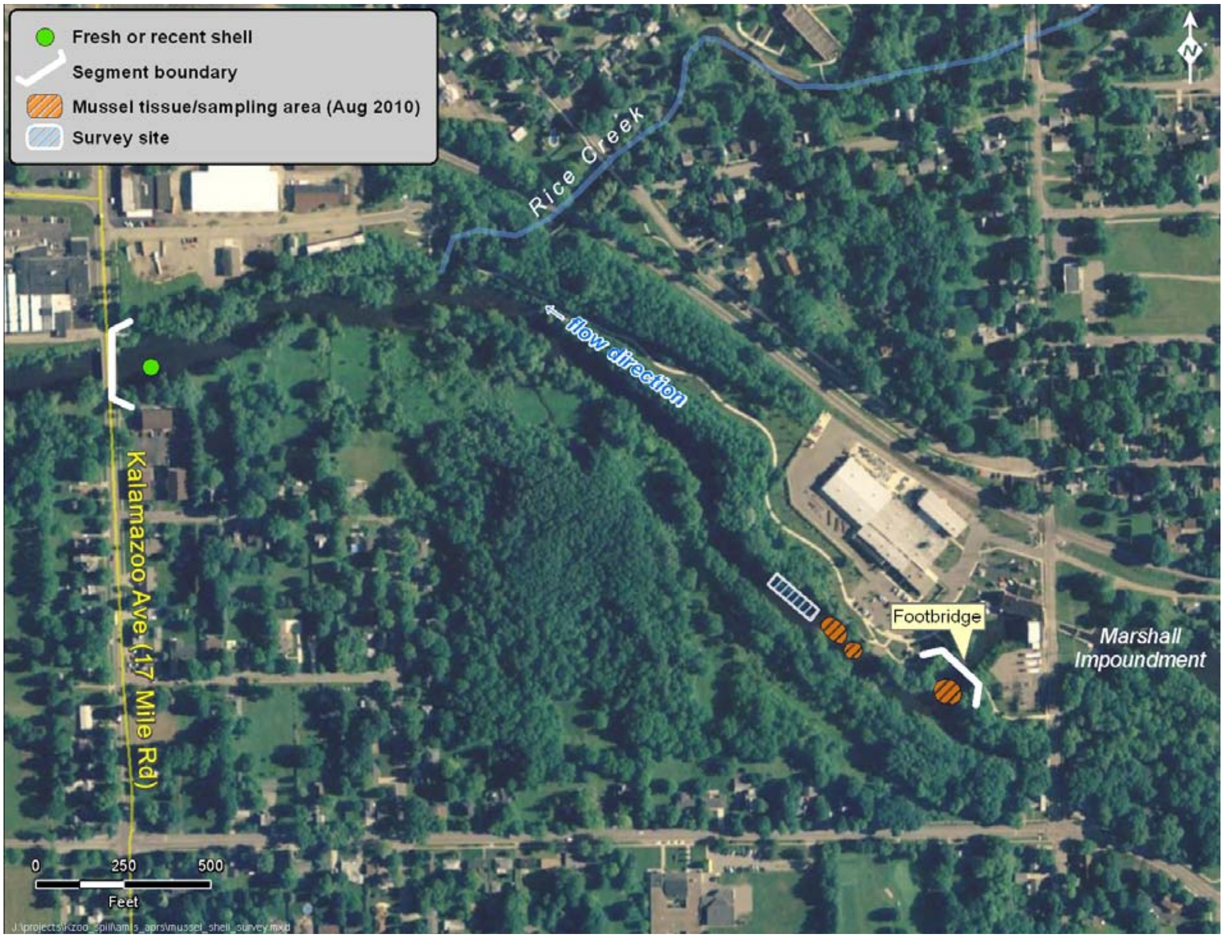

Figure 4. Sampling segment MS-1.

3.1.1 General conditions

During the survey, the weather was seasonably warm (~ 55°F) and cloudy. Turbidity was very low, and the river bottom was visible in all wadeable areas. Approximately 80% of this sampling segment was shallow enough to wade. Most of the area directly downriver of the Rice Creek confluence was too deep to wade. In the area downriver of the Rice Creek confluence, only the substrate in shallower water along the shoreline was surveyed.

The substrate was variable and ranged from sand in depositional areas to coarse gravel and cobble in swift-flowing areas. Encrusting and filamentous algae covered gravel and cobbles. No visible submerged oil or oil sheening was observed during the survey. Glass bottles, pieces of metal, and general refuse were observed throughout the site.

3.1.2 Segment MS-1 shell observations

Shells of 16 unionid mussel species were observed in segment MS-1 (Table 7). This included the state threatened slippershell (*Alasmidonta viridis*) and state endangered eastern pondmussel (*Ligumia nasuta*), which was represented by a single shell observation. As noted in Table 7, four species of special concern were also found in this sampling segment. In addition to finding shells, five species of live mussels were also observed. These included spike, pocketbook, creek heelsplitter, fluted-shell, and ellipse (a species of special concern). Non-native Asian clam shells and live individuals were also observed in this segment.

Table 7. Unionid mussel species[a] observed in sampling segment MS-1. Includes both living and shell observations made throughout the waded 0.6 miles of the segment, including observations in the survey site (2010.10.21-1-1).

			Species observed	
Common name	**Species**	**State status**	**Shell**	**Live**
Mucket	*Actinonaias ligamentina*		X	
Elktoe	*Alasmidonta marginata*	Special concern	X	
Slippershell	*Alasmidonta viridis*	Threatened	X	
Cylindrical papershell	*Anodontoides ferussacianus*		X	
Spike	*Elliptio dilatata*		X	X
Wabash pigtoe	*Fusconaia flava*		X	
Fatmucket	*Lampsilis siliquoidea*		X	
Pocketbook	*Lampsilis cardium*		X	X
White heelsplitter	*Lasmigona complanata*			
Creek heelsplitter	*Lasmigona compressa*		X	X
Fluted-shell	*Lasmigona costata*		X	X
Eastern pondmussel	*Ligumia nasuta*	Endangered	X	
Round pigtoe	*Pleurobema sintoxia*	Special concern	X	
Giant floater	*Pyganodon grandis*		X	
Strange floater	*Strophitus undulates*		X	
Paper pondshell	*Utterbackia imbecillis*	Special concern		
Ellipse	*Venustaconcha ellipsiformis*	Special concern	X	X
Rainbow	*Villosa iris*	Special concern	X	
Total number of unionid species			16	5

a. In addition to unionid mussels, live non-native Asian clam and shells were observed in the segment.

State status sources: MDNRE, 2010; MNFI, 2010.

Observed shells in segment MS-1 were mostly moderately to heavily worn shells. These shells were coated with a layer of encrusting marl and algae to an extent that they often had to be cleaned off with a knife to identify. One recent dead pocketbook mussel shell was observed in the 0.6-mile survey segment (Figure 4). This observation was made near the downriver boundary of the segment. A survey site was not delineated at the location of this shell, because only a single recent dead shell was found.

Damaged shells that were worn and broken were observed in MS-1. These shells all had heavily advanced weathering (i.e., fell within moderately worn 2 and heavily worn categories) indicating the breakage likely occurred as a result of natural in-stream weathering processes. No crushed shells were observed, nor were any middens or chipped shells.

3.1.3 MS-1 survey site 2010.10.21-1-1

One survey site was delineated in segment MS-1 (survey site 2010.10.21-1-1). Only one recent dead shell was observed within segment MS-1, and no fresh dead shells were found. Therefore, a survey site was not delineated during the initial visit to the segment on October 18, 2010. On October 21, 2010, the survey crew decided to return to segment MS-1 and delineate a reference survey site to enable comparison of a reference with downstream survey sites. The survey crew agreed upon an area with a relatively high number of shells at the head of a shallow riffle within the sampling segment to designate as a survey site. This location was chosen because it had a high number of shells and was representative of the general habitat within the segment.

The survey site consisted of a shallow, 0.3- to 0.7-m-deep area that was 19-m-long and 7-m-wide, with a total surface area of 133 square meters (m^2). The survey site boundary delineation was not based on occurrence of fresh dead or recent dead shells. The boundaries were arbitrarily delineated to generate a survey site surface area similar to previously delineated survey sites in other sampling segments. The substrate within the site was a mix of pebble [64–16 millimeters (mm) diameter], gravel (16–2 mm), and sand (2–0.0625 mm).

Table 8 summarizes the mussel species observations and shell weathering characterization results for the MS-1 survey site. Shells from nine species were observed in the survey site. Pocketbook shells were most dominant, comprising 27% of all shells found, followed by fluted-shell (23%). Fatmucket and rainbow shells were least common, contributing less than 1% of the total number of shells observed. One live pocketbook mussel was observed in the survey site.

A total of 213 shells were found in the survey site, representing a density of 1.6 shells/m^2. No fresh dead, recent dead, or moderately worn 1 shells were observed in survey site 2010.10.21-1-1 (Table 8). All of the shells in this site were covered with heavy marl and encrusting algae (Figure 5).

Table 8. Segment MS-1 survey site 2010.10.21-1-1 shell weathering characterization results

Species	Fresh dead	Recent dead	Moderately worn 1	Moderately worn 2	Heavily worn
Mucket	–	–	–	–	–
Elktoe	–	–	–	5	2
Slippershell	–	–	–	–	–
Cylindrical papershell	–	–	–	–	–
Spike	–	–	–	28	8
Wabash pigtoe	–	–	–	25	16
Fatmucket	–	–	–	3	–
Pocketbook	–	–	–	46	11
White heelsplitter	–	–	–	–	–
Creek heelsplitter	–	–	–	–	–
Fluted-shell	–	–	–	30	19
Eastern pondmussel	–	–	–	–	–
Round pigtoe	–	–	–	–	–
Giant floater	–	–	–	–	–
Strange floater	–	–	–	7	4
Paper pondshell	–	–	–	–	–
Ellipse	–	–	–	6	–
Rainbow	–	–	–	2	1
Total number of shells	0	0	0	152	61
Percentage	0.0%	0.0%	0.0%	71%	29%

A total of 14 broken shells were observed within the survey site, mostly Wabash pigtoe. These shells were observed to be broken, rather than crushed.

3.2 Segment MS-2

Sampling segment MS-2 was located on the Kalamazoo River just downriver from the Talmadge Creek confluence. Approximately 0.8 miles of the 1-mile segment was surveyed, from MP 3.0 to 15 Mile Road Bridge (Figure 6). Squaw Creek enters the Kalamazoo River at the approximate midpoint of this sampling segment, and Bear Creek enters the river near the upriver boundary. Boat ramp C0.1 was located in this segment, which was closed at the time of the survey. One survey site was delineated in this segment.

(a)

(b)

Figure 5. Photographs of (a) an MS-1 shell with heavy marl and encrusting algae and (b) shells collected from survey site 2010.10.21-1-1.

Photograph taken by J. Matousek on (a) October 18, 2010, and (b) October 21, 2010.

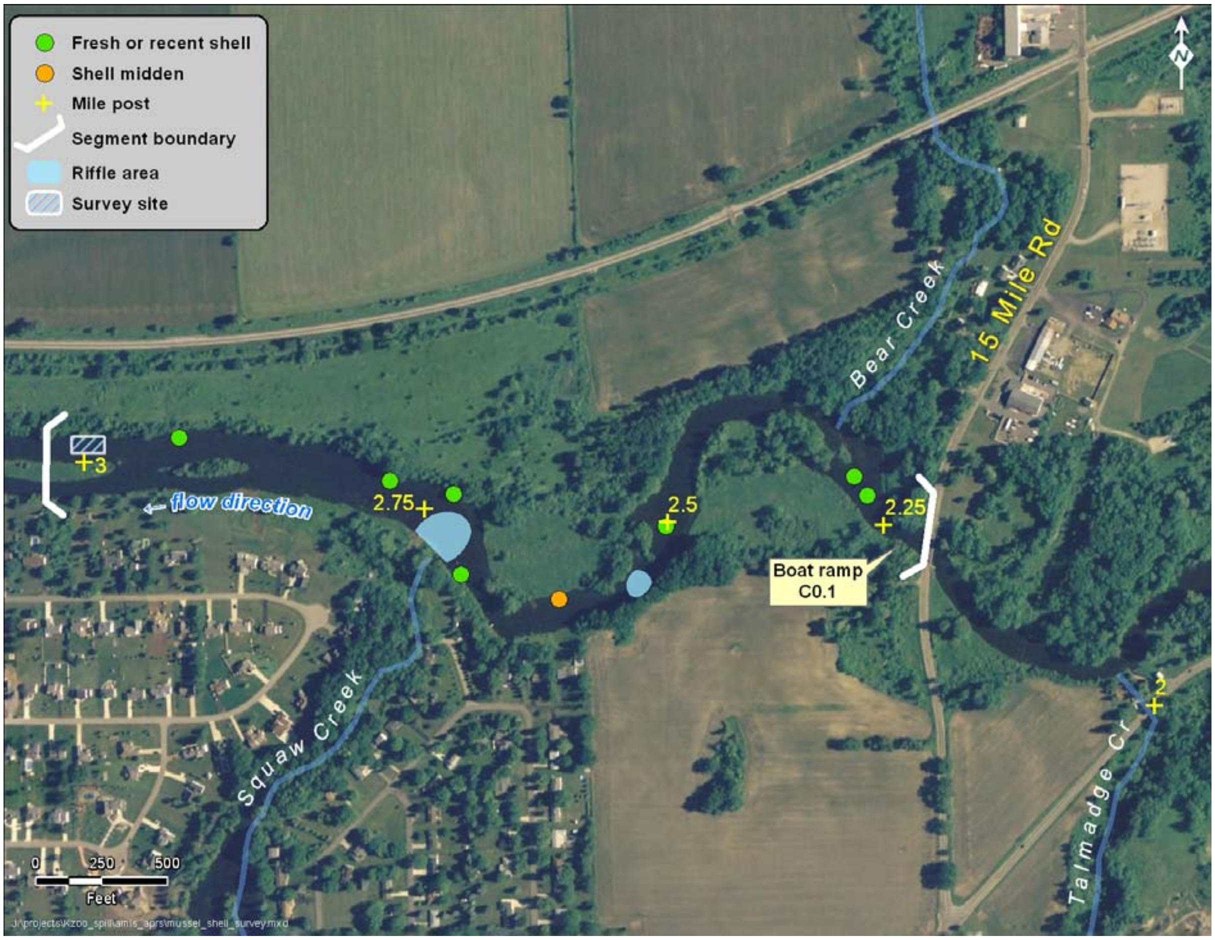

Figure 6. Sampling segment MS-2.

3.2.1 General conditions

During the survey, the weather was seasonably warm (~ 50°F) and cloudy. Turbidity was low, and the river bottom substrate was visible in all wadeable areas. The entire sampling segment was shallow enough to wade. Response/cleanup activities were occurring within this segment at the time of the survey. These activities were centered around islands where cleanup crews were replacing absorbent oil booms. A few air- and propeller-driven boats were also observed throughout the segment, but they did not noticeably affect turbidity.

Most of the river bottom within the segment consisted of shallow runs and riffles with relatively swift water. Coarse gravel and cobble were the dominant substrate types for most of the segment. Fine silty sediment was common in depositional areas, especially around the islands between booms and the shore. A large silt deposit was observed downriver of boat ramp C0.1, located on the right river bank, near 15 Mile Road Bridge (Figure 6). Oil sheens were observed on the water surface after wading through this silt deposit.

3.2.2 Segment MS-2 shell observations

Shells of 15 unionid mussel species were observed in segment MS-2 (Table 9). One state threatened species (slippershell) and four species of special concern were observed. Most live mussels were observed in a deep run just upriver of the Squaw Creek confluence and included spike, Wabash pigtoe, fatmucket, pocketbook, white heelsplitter, and creek heelsplitter species. Non-native Asian clams were also found in this segment.

In addition to the delineated site described below in Section 3.2.3, there were eight observations of fresh dead and recent dead shells made in this segment in areas that were not delineated (Table 10). These shells were recorded, but the observations did not initiate delineation of survey sites, as they were isolated shell occurrences. A single fresh dead pocketbook was found near the Squaw Creek confluence with soft tissue still intact (Figure 7).

Damaged shells were observed throughout this segment and included shells thought to be broken by natural in-stream weathering processes and predator activity and shells thought to be crushed as a result of anthropogenic activity. Heavily weathered and broken shells were observed in the segment. These shells were similar to broken shells observed in the MS-1 reference segment. A shell midden was observed near a shallow riffle, immediately upriver of the Squaw Creek confluence. A resident adjacent to this midden spoke to the survey crew and indicated that they had recently seen a mink near the shell deposit. Crushed shells were also observed, especially in a large shallow riffle just downriver of the Squaw Creek confluence. This riffle seemed to be an area that naturally accumulates mussel shells; most of these shells appeared to be mostly moderately to heavily weathered. Many of the accumulated shells were observed to have been crushed. Since shells were thought to be damaged post-mortem, a survey site was not delineated. This decision was supported by the fact that the same riffle was surveyed for live mussels during the August 2010 mussel tissue and sediment sampling event, at which time no live mussels were observed.

Table 9. Unionid mussel species[a] observed in sampling segment MS-2. Includes both living and shell observations made throughout the waded 0.8 miles of the segment, including observations in the survey site (2010.10.19-2-1).

			Species observed	
Common name	**Species**	**State status**	**Shells**	**Live**
Mucket	*Actinonaias ligamentina*		X	
Elktoe	*Alasmidonta marginata*	Special concern	X	
Slippershell	*Alasmidonta viridis*	Threatened	X	
Cylindrical papershell	*Anodontoides ferussacianus*		X	
Spike	*Elliptio dilatata*		X	X
Wabash pigtoe	*Fusconaia flava*		X	X
Fatmucket	*Lampsilis siliquoidea*		X	X
Pocketbook	*Lampsilis cardium*		X	X
White heelsplitter	*Lasmigona complanata*		X	X
Creek heelsplitter	*Lasmigona compressa*		X	X
Fluted-shell	*Lasmigona costata*		X	
Eastern pondmussel	*Ligumia nasuta*	Endangered		
Round pigtoe	*Pleurobema sintoxia*	Special concern	X	
Giant floater	*Pyganodon grandis*			
Strange floater	*Strophitus undulates*		X	
Paper pondshell	*Utterbackia imbecillis*	Special concern		
Ellipse	*Venustaconcha ellipsiformis*	Special concern	X	
Rainbow	*Villosa iris*	Special concern	X	
Total number of unionid species			15	6

a. In addition to unionid mussels, live non-native Asian clam and shells were observed in the segment.

State status sources: MDNRE, 2010; MNFI, 2010.

Table 10. Isolated observations of fresh dead, recent dead, and crushed shells made within sampling segment MS-2

Observation	Latitude	Longitude	Comments/details
Single recent dead rainbow shell	42.25968	-85.00858	Single shell occurrence
Single recent dead pocketbook shell	42.25954	-85.00601	Single shell occurrence
Two recent dead spike shells found together and two crushed pocketbook shells found	42.25940	-85.00508	Two shells observed in the same location were treated as a single shell occurrence
Single recent dead pocketbook shell	42.25848	-85.00513	Single shell occurrence
Single fresh dead pocketbook shell	42.25790	-85.00304	Single shell occurrence, with soft tissue intact
Single recent dead spike shell	42.25895	-84.99899	Single shell occurrence
Single recent dead pocketbook shell	42.25866	-84.99890	Single shell occurrence
Location of a few recent dead shells	42.25867	-85.00183	Site not delineated due to only finding a few shells, species not identified
Shell midden	42.25800	-85.00352	Pile of chipped shells
Area of crushed shells	42.25889	-85.00510	Mussels were likely not killed by being crushed, but shells crushed post-mortem
Area of crushed shells	42.25820	-85.00215	Mussels were likely not killed by being crushed, but shells crushed post-mortem
Crushed fluted shell, spike, and rainbow found; several live pocketbooks found	42.25825	-85.00249	Crushed shells occurred in shallow riffle areas
A few recent dead and crushed shells found	42.22579	-85.00167	

Figure 7. Photographs of a fresh dead pocketbook with soft tissue intact found in segment MS-2 just upriver from Squaw Creek confluence.

Photograph taken by J. Matousek on October 19, 2010.

3.2.3 MS-2 survey site 2010.10.19-2-1

The survey site delineated in segment MS-2, survey site 2010.10.19-2-1, was located near MP 3.0 at the downriver boundary of the sampling segment. The survey site consisted of a shallow, 0.4-m-deep area that was 32-m-long and 9-m-wide, with a total surface area of 288 m^2. The survey site was delineated after finding a scattered deposit of recent dead shells. The site upriver and river-width boundaries were extended until no further recent shell observations were made. Substrate within the site was a mix of pebble (64–16 mm diameter), gravel (16–2 mm), and sand (2–0.0625 mm).

The observed shells within the site represented 11 species (Table 11). Spike shells were most dominant, comprising 31% of all shells found. Wabash pigtoe shells were also common (19%). Shells of mucket and the threatened slippershell were least common, contributing to less than 1% of the total number of shells observed. Four species of special concern, elktoe, round pigtoe, ellipse, and rainbow, were relatively common in the survey site. No live mussels were observed within the survey site.

Table 11 summarizes the mussel species observed and shell weathering characterization results for the MS-2 survey site. A total of 264 shells were collected (0.9 shells/m^2), which included 6 recent dead shells. Damaged shells were observed within the survey site. These shells appeared to be older shells in which mortality would have occurred prior to the spill. No middens or recent dead/fresh dead crushed shells were observed in this sampling site.

3.3 Segment MS-3

Sampling segment MS-3 was located on the Kalamazoo River between Ceresco and Historic Bridge Park, just downriver from 11 Mile Road Bridge. Approximately 0.6 miles of the 1-mile segment was surveyed, from MP 7.75 to immediately downriver of the 11 Mile Road Bridge (Figure 8). Boat ramp C1.5 was located in this segment, which was closed at the time of the survey. A mussel tissue sample collection site from the mussel tissue and sediment sampling field work that was completed in late August 2010 was also located in this segment. Two survey sites were delineated in this segment.

3.3.1 General conditions

During the survey, the weather was sunny and windy, with an air temperature of ~ 50°F. Turbidity was moderate and gradually increased throughout the day. This limited the crew’s ability to survey the full 1-mile segment. High turbidity may have been associated with dredging in the Ceresco Impoundment, which was occurring upgradient at the same time that this segment was being surveyed.

Table 11. Segment MS-2 survey site 2010.10.19-2-1 shell weathering characterization results

Species	Fresh dead	Recent dead	Moderately worn 1 and 2[a]	Heavily worn
Mucket	–	–	1	–
Elktoe	–	–	4	7
Slippershell	–	–	2	1
Cylindrical papershell	–	–	–	–
Spike	–	2	63	17
Wabash pigtoe	–	1	44	6
Fatmucket	–	–	–	–
Pocketbook	–	1	25	10
White heelsplitter	–	–	–	–
Creek heelsplitter	–	–	–	–
Fluted-shell	–	1	6	5
Eastern pondmussel	–	–	–	–
Round pigtoe	–	–	7	2
Giant floater	–	–	–	–
Strange floater	–	1	18	13
Paper pondshell	–	–	–	–
Ellipse	–	–	14	1
Rainbow	–	–	10	2
Total number of shells	0	6	194	64
Percentage	0.0%	2.3%	74%	24%

a. MS-2 was surveyed prior to the development of “moderately worn 1” and “moderately worn 2” weathering categories. These two subcategories are included in all other segments.

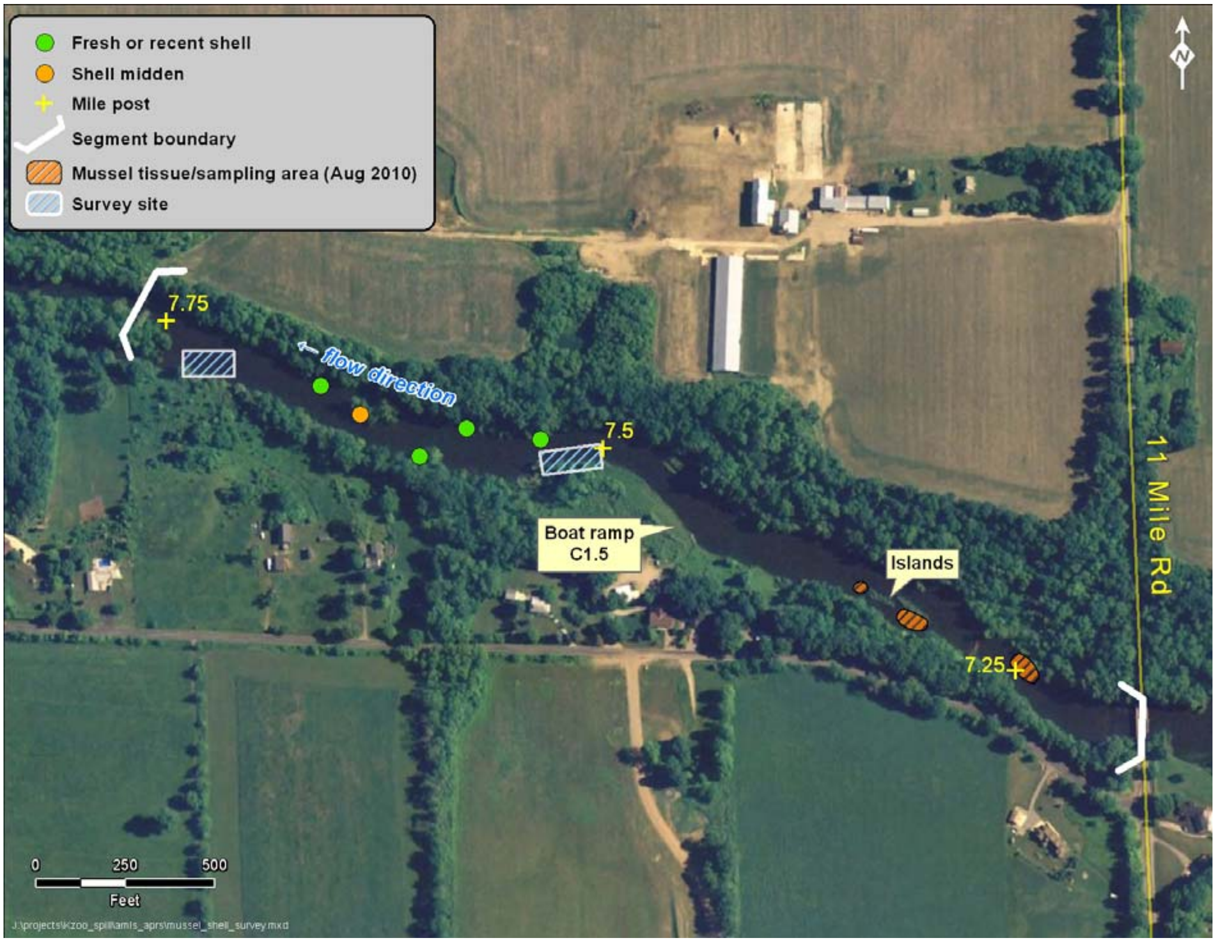

Figure 8. Sampling segment MS-3.

The substrate in segment MS-3 was highly variable. Shallow areas such as riffles with moderate flow were dominated by coarse sand and gravel. Substrates in slower, slightly deeper water and shallow areas near the river bank were covered with a surficial layer of fine silt. In these areas, mussel shells were blanketed with silt. Shell inspections often required picking these shells from the river bottom and washing off accumulated silt. Siltation was notably heavy at the downriver boundary of the segment, near boat ramp C1.5, and around two islands located approximately 0.1 mile downriver from 11 Mile Road Bridge. Larger cobble and bedrock were common between these two islands and 11 Mile Road Bridge. Oil sheening was observed near the two islands and near the boat ramp after wading through the soft, silty sediments. One dead frog was observed, and some oil was noted on the vegetation of one of the islands.

3.3.2 Segment MS-3 shell observations

Shells of 12 unionid mussel species were observed in segment MS-3 (Table 12). This included the state threatened slippershell and two species of special concern. Live mucket were common near the downriver segment boundary and in sediments between bedrock outcrops at the upriver segment boundary. Live spike, Wabash pigtoe, pocketbook, and white heelsplitter species were also observed. Non-native Asian clams were also found in this segment.

Table 12. Unionid mussel species[a] observed in sampling segment MS-3. Includes both living and shell observations made throughout the waded 0.6 miles of the segment, including observations in the survey sites (2010.10.20-3-1; 2010.10.20-3-2).

			Species observed	
Common name	**Species**	**State status**	**Shell**	**Live**
Mucket	*Actinonaias ligamentina*		X	X
Elktoe	*Alasmidonta marginata*	Special concern	X	
Slippershell	*Alasmidonta viridis*	Threatened	X	
Cylindrical papershell	*Anodontoides ferussacianus*		X	
Spike	*Elliptio dilatata*		X	X
Wabash pigtoe	*Fusconaia flava*		X	X
Fatmucket	*Lampsilis siliquoidea*			
Pocketbook	*Lampsilis cardium*		X	X
White heelsplitter	*Lasmigona complanata*		X	X
Creek heelsplitter	*Lasmigona compressa*		X	
Fluted-shell	*Lasmigona costata*		X	
Eastern pondmussel	*Ligumia nasuta*	Endangered		
Round pigtoe	*Pleurobema sintoxia*	Special concern		
Giant floater	*Pyganodon grandis*			
Strange floater	*Strophitus undulates*		X	
Paper pondshell	*Utterbackia imbecillis*	Special concern		
Ellipse	*Venustaconcha ellipsiformis*	Special concern		
Rainbow	*Villosa iris*	Special concern	X	
Total number of unionid species			12	5

a. In addition to unionid mussels, live non-native Asian clam and shells were observed in the segment.

State status sources: MDNRE, 2010; MNFI, 2010.

This was the first segment in which shells were categorized into moderately worn 1 and 2 categories (see Section 2.6). Many moderately worn 1 shells were observed in this segment. Most of these shells were covered by a layer of silt that made classifying between recent and moderately worn 1 weathering categories difficult. For example, silt staining on the inside of a recent shell may have caused it to appear moderately worn. Conversely, silt may have covered a moderately worn 1 shell so that algae did not grow inside of the shell, creating an appearance more consistent with a recent dead shell.

There were multiple isolated observations of recent shells in this segment that were recorded but did not warrant survey site delineation. These observations occurred within four general areas located in the downriver portion of the segment, ending immediately downriver of boat ramp C1.5 (Table 13; Figure 8). The number of shells or species in these four areas was not recorded due to time constraints. However, a survey site was delineated at the upriver end of this area, where moderately worn 1 shell observations became more concentrated (site 2010.10.20-3-2; see Section 3.3.4).

Table 13. Isolated observations of recent dead and crushed shells made within sampling segment MS-3

Observation	Latitude	Longitude	Comments/details
A relatively large concentration of live mussels found along with crushed shells and a few recent dead shells.	42.27723	-85.08967	Species not identified; shells likely crushed post-mortem
A few recent dead shells found with crushed shells	42.27673	-85.08885	Species not identified; shells likely crushed by boats in this shallow area
A few recent dead shells found	42.27683	-85.08839	Species not identified
A few recent dead shells found with crushed shells	42.27670	-85.08770	Species not identified; shells likely crushed by boats in this shallow area
Large deposit of moderately weathered shells	42.27545	-85.08370	Found around the islands near upriver segment boundary; mostly moderately worn 2 but included some moderately worn 1 shells with ligaments attached
Shell midden	42.27710	-85.08945	Pile of chipped shells
Pile of recent dead shells, possible shell midden	42.27599	-85.08549	Uncertain if deposit was a midden or a pile made by someone gathering shells
A concentration of live muckets found	42.27443	-85.08154	

A large deposit of moderately worn shells was observed around the islands immediately downriver of 11 Mile Road Bridge (Table 13; Figure 8). This area was not delineated into a survey site because most of the shells were moderately worn 2. In addition, it was nearing the end of the day and turbidity was increasing, which interfered with the crew's ability to scan the river bottom for shells. Another deposit of recent shells was discovered just upriver and next to boat ramp C1.5. These shells, which were buried in soft silt along the river bank, might have been associated with a midden that was covered with silt but did not show signs of chipping or scratch marks consistent with mussel predation damage. These shells could have been disposed of by someone gathering shells in the area. Although the origin of this shell deposit was not confirmed, it was concluded in the field that it was likely not associated with oil or response activities, thus a survey site was not delineated at this location.

Damaged shells were observed throughout this segment. Similar to segments MS-1 and MS-2, broken, fragile, and worn shells were observed. Chipped shells were also found. These observations were associated with a shell midden. Additionally, a large pile of chipped shells was observed at the tail end of an island downriver from boat ramp C1.5. Observations of crushed shells that were recent dead and moderately worn were made downriver of the boat ramp in shallow riffle areas (Table 13; Figures 8 and 9). Survey site 2010.10.20-3-2 was delineated at the upriver end of this area (see Section 3.3.4).

3.3.3 MS-3 survey site 2010.10.20-3-1

Survey site 2010.10.20-3-1 was located near MP 7.75 at the downriver boundary of the sampling segment. The survey site consisted of a shallow, 0.4-m-deep area that was 15-m-long and 7.5-m-wide, with a total surface area of 113 m^2. The survey site boundary delineation was based on finding a scattered deposit of shells that were characterized as recent/moderately worn 1. Boundaries were extended to the point at which recent dead shells were no longer observed. The substrate within this site was a mix of pebble (64–16 mm diameter), gravel (16–2 mm), and sand (2–0.0625 mm).

Shells from eight species of mussels were found in the delineated site (Table 14), approximately 60% of which were mucket. Wabash pigtoe were also common, comprising 16% of the total number of shells. Elktoe (a species of special concern) and spike shells were least common. No state threatened or endangered species were observed in this site. A total of 14 live mussels were also observed, most of which were mucket.

Figure 9. Photographs of crushed shells found downriver of boat ramp C1.5.

Photograph taken by J. Matousek on October 20, 2010.

Table 14. Segment MS-3 survey site 2010.10.20-3-1 shell weathering characterization results

Species	Fresh dead	Recent dead	Moderately worn 1	Moderately worn 2	Heavily worn
Mucket	–	–	3	88	1
Elktoe	–	–	–	1	–
Slippershell	–	–	–	–	–
Cylindrical papershell	–	–	–	–	–
Spike	–	–	–	1	–
Wabash pigtoe	–	–	–	24	1
Fatmucket	–	–	–	–	–
Pocketbook	–	–	–	7	2
White heelsplitter	–	–	–	2	–
Creek heelsplitter	–	–	–	–	–
Fluted-shell	–	–	3	16	1
Eastern pondmussel	–	–	–	–	–
Round pigtoe	–	–	–	–	–
Giant floater	–	–	–	–	–
Strange floater	–	–	–	3	2
Paper pondshell	–	–	–	–	–
Ellipse	–	–	–	–	–
Rainbow	–	–	–	–	–
Total number of shells	0	0	6	142	7
Percentage	0.0%	0.0%	3.9%	92%	4.5%

A total of 155 shells were collected from survey site 2010.10.20-3-1, which equates to 1.4 shells/m^2. Although no fresh dead or recent dead shells were found, six moderately worn 1 shells (3.9% of all shells collected) were observed. As mentioned above, distinguishing between recent and moderately worn 1 weathering of shells was difficult due to heavy siltation in this segment and survey site. Only one damaged shell, a mucket, was identified in this survey site. The low occurrence of damaged shells at this site might be associated with its location in the river. This site was located in slow-moving water near the right river bank (Figure 8) in an area that may not have been impacted by boat or foot traffic.

3.3.4 MS-3 survey site 2010.10.20-3-2

Survey site 2010.10.20-3-2 was a river bar located near MP 7.5, downriver of boat ramp C1.5. The depth of this site was variable (0.3–0.7 m). Site dimensions were 31-m-long and 8-m-wide, with a total surface area of 248 m^2. The survey site boundary delineation was based on finding a scattered deposit of recent dead shells; boundaries were extended to the point at which recent shells were no longer found. The substrate was a mix of pebble (64–16 mm diameter), gravel (16–2 mm), and sand (2–0.0625 mm).

Shells from 10 species were observed in this survey site (Table 15). Strange floater shells were most common (26% of all shells) followed by spike, elktoe, and mucket; all shells were found in similar proportions. Cylindrical papershell and creek heelsplitter shells were least common, represented by only one shell observation each. Five slippershell shells (state threatened) also were observed. Eight live mucket were found in this site.

Table 15. Segment MS-3 survey site 2010.10.20-3-2 shell weathering characterization results

Species	Fresh dead	Recent dead	Moderately worn 1	Moderately worn 2	Heavily worn
Mucket	–	–	2	17	1
Elktoe	–	–	–	11	10
Slippershell	–	–	–	–	5
Cylindrical papershell	–	–	–	1	–
Spike	–	4	4	12	2
Wabash pigtoe	–	–	2	7	1
Fatmucket	–	–	–	–	–
Pocketbook	–	–	–	–	–
White heelsplitter	–	–	–	–	–
Creek heelsplitter	–	–	–	1	–
Fluted-shell	–	–	–	5	2
Eastern pondmussel	–	–	–	–	–
Round pigtoe	–	–	–	–	–
Giant floater	–	–	–	–	–
Strange floater	–	2	1	23	8
Paper pondshell	–	–	–	–	–
Ellipse	–	–	–	–	–
Rainbow	–	–	–	3	5
Total number of shells	0	6	9	80	34
Percentage	0.0%	4.7%	7.0%	62%	26%

A total of 129 shells were collected from this survey site (0.5 shells/m^2). Approximately 12% of the shells collected at this site were either recent dead (4.7%) or moderately worn 1 (7.0%), indicative of being less than three months post-mortem. Crushed elktoe, strange floater, and spike were also observed within this survey site. The total number of crushed shells was not recorded.

3.4 Segment MS-4

Sampling segment MS-4 was located on the Kalamazoo River just downriver from Historic Bridge Park. Approximately 0.5 miles of the 1-mile segment was surveyed, from MP 10.25 to MP 9.25 (Figure 10). Boat ramp C3.2 was located in this segment, which was in use at the time of the survey. The upriver boundary of the segment was approximately 1/5 of a mile downriver of where the August 2010 mussel tissue and sediment sampling occurred near boat ramp C3.2 at Historic Bridge Park. Two survey sites were delineated in this segment.

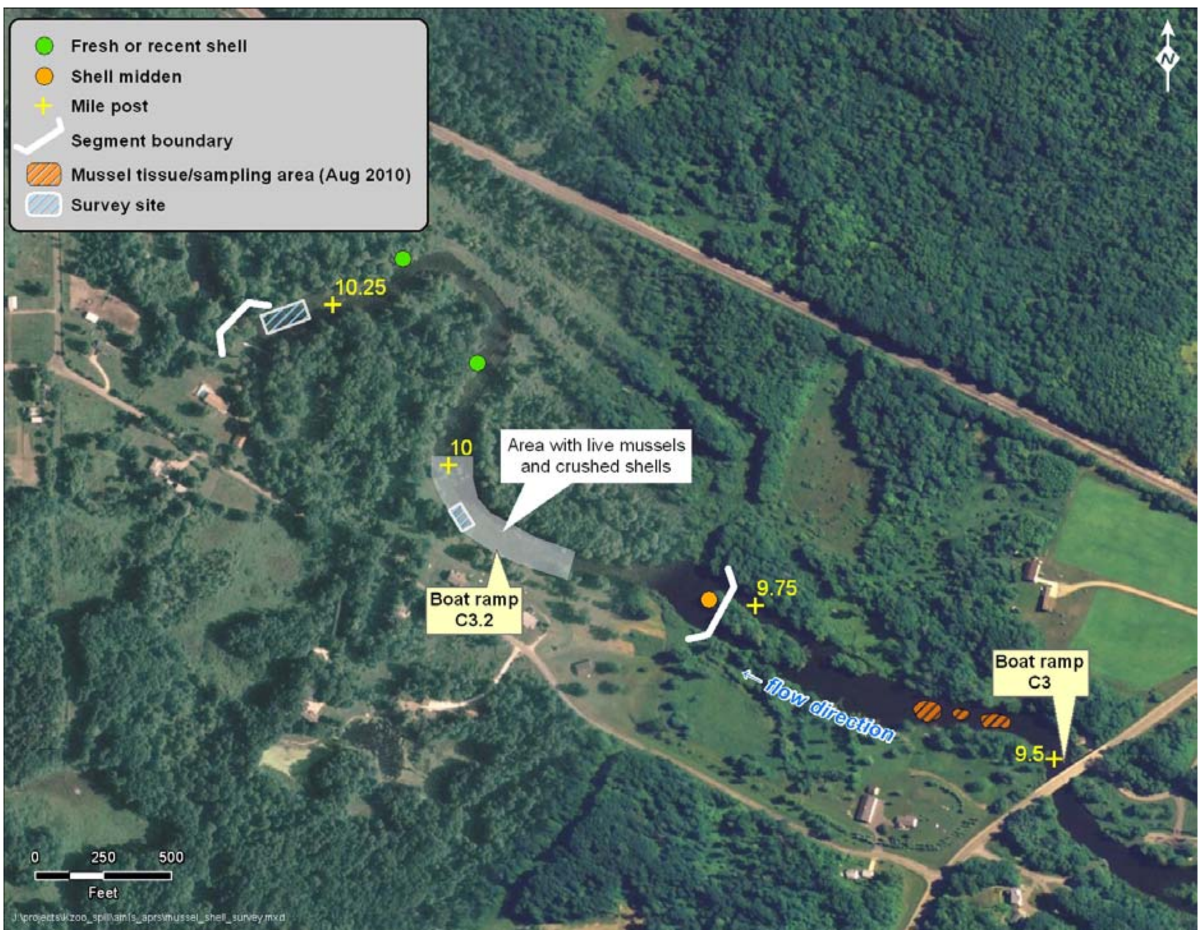

Figure 10. Sampling segment MS-4.

3.4.1 General conditions

At the start of the survey, the weather was sunny and cool (~ 45°F) but deteriorated to windy and cold with rain soon thereafter. Moderate turbidity was noted throughout the survey area, with periods of high turbidity when airboats ran through the segment. The survey was interrupted a number of times due to airboat passage. Interruptions generally lasted a few minutes in order to allow water to clear and enable viewing of the substrate. At times airboat traffic was so heavy that the survey crew exited the river due to safety concerns. Airboats were also observed hitting the bottom of the river when they powered up to get over shallow riffle areas.

Substrate was dominated by gravel and cobble, with areas of coarse sand and silt. Silt was common near boat ramp C3.2 and along the river banks. Most of the segment consisted of runs and riffles with shallow swift-flowing water. Shallow areas showed signs of being scoured by airboats and included lighter-colored sediments where the river bottom was disturbed. Oil sheening was observed near the toe of an island at the upriver boundary of this segment.

3.4.2 Segment MS-4 shell observations

Shells of 12 unionid mussel species were observed in segment MS-4 (Table 16). This included the state threatened slippershell and two species of special concern. Live mucket were common and live spike and Wabash pigtoe were also observed. A notable number of live mucket were observed downriver and in deeper water in undisturbed sediments directly across from boat ramp C3.2. Non-native Asian clams were found in this segment.

Shells representative of all weathering states were observed in segment MS-4. Two accumulations of recent shells were observed in the segment that were not delineated as survey sites in order to allow more time to survey the rest of the segment (Table 17). These accumulations included three recent mucket and two recent Wabash pigtoe mussel shells.

Damaged shells were observed throughout this segment. Similar to all other segments, fragile and worn shells were observed. Chipped shells were also found. These observations were associated with a shell midden observed at the tail end of an island located at the upriver segment boundary (Table 17). Crushed shells were observed in three shallow areas within this segment. The first was a shallow riffle at the downriver segment boundary. This area was delineated into survey site 2010.10.21-4-1. A second smaller area of crushed shells was noted just upriver from this site (Table 17). This second area was not delineated as a survey site because it was smaller and time did not allow further sampling. The third area of crushed mussels was located downriver of boat ramp C3.2. A survey site was delineated in this area (site 2010.10.21-4-2). However, due to the large extent of crushed mussels in this area and time constraints, the survey site represented only a small proportion of the total area of crushed shells. The approximate boundaries of this large area of crushed shells and survey site 2010.10.21-4-2 are shown in Figure 10.

Table 16. Total unionid mussel species[a] observed in sampling segment MS-4. Includes shell observations made throughout the waded 0.5 miles of the segment, including observations in the survey sites (2010.10.21-4-1; 2010.10.21-4-2).

			Species observed	
Common name	**Species**	**State status**	**Shell**	**Live**
Mucket	*Actinonaias ligamentina*		X	X
Elktoe	*Alasmidonta marginata*	Special concern	X	
Slippershell	*Alasmidonta viridis*	Threatened	X	
Cylindrical papershell	*Anodontoides ferussacianus*		X	
Spike	*Elliptio dilatata*		X	X
Wabash pigtoe	*Fusconaia flava*		X	X
Fatmucket	*Lampsilis siliquoidea*			
Pocketbook	*Lampsilis cardium*		X	
White heelsplitter	*Lasmigona complanata*		X	
Creek heelsplitter	*Lasmigona compressa*		X	
Fluted-shell	*Lasmigona costata*		X	
Eastern pondmussel	*Ligumia nasuta*	Endangered		
Round pigtoe	*Pleurobema sintoxia*	Special concern		
Giant floater	*Pyganodon grandis*			
Strange floater	*Strophitus undulates*		X	
Paper pondshell	*Utterbackia imbecillis*	Special concern		
Ellipse	*Venustaconcha ellipsiformis*	Special concern		
Rainbow	*Villosa iris*	Special concern	X	
Total number of unionid species			12	3

a. In addition to unionid mussels, live non-native Asian clam and shells were observed in the segment.

State status sources: MDNRE, 2010; MNFI, 2010.

Table 17. Isolated observations of recent dead and crushed shells made within sampling segment MS-4

Observation	Latitude	Longitude	Comments/details
A few crushed recent dead shells found	42.29617	-85.12585	Shells found in a 2–3 m^2 area; included mucket and Wabash pigtoe shells
A few crushed moderately worn 1 and recent dead shells found	42.29573	-85.12447	Observed species included mucket and Wabash pigtoe
Notable number of live mussels, recent dead shells, and crushed shells observed	42.29464	-85.12506	Coordinates indicate the start point of observations; Figure 10 shows the full extent of the area A survey site was delineated within this area
Area with crushed shells	42.29608	-85.12664	Species not identified; shells likely crushed by boats in this shallow area
Midden	42.29300	-85.12127	Pile of chipped shells located at upriver segment boundary
A few crushed recent dead shells found in riffle	42.29581	-85.12732	
One heavily worn slippershell found	42.29624	-85.12480	Shell was encased in marl

Live mussels in this segment and in survey sites were observed lying on their sides in shallow water. This was not observed in any other segments and could have been caused by boats scraping along the river bottom. Some of these displaced mussels had deep scratches on their shells but were not cracked. Observations of crushed shells were also made in this area (Figure 11). This was particularly evident in the area where survey site 2010.10.21-4-2 was delineated.

3.4.3 MS-4 survey site 2010.10.21-4-1

Sampling site 2010.10.21-4-1 was located near MP 10.25 at the downriver boundary of the sampling segment. The survey site consisted of a shallow riffle, 0.4-m-deep area that was 19-m-long and 10-m-wide, with a total surface area of 190 m^2. This survey site boundary delineation was based on finding a deposit of recent shells; boundaries were extended to the extent of recent shell observations. The substrate was a mix of pebble (64–16 mm diameter), gravel (16–2 mm), and sand (2–0.0625 mm).

Figure 11. Photograph of a crushed live mucket. This mussel was found approximately 10 m downriver from boat ramp C3.2.

Photograph taken by J. Matousek on October 21, 2010.

Shells from eight mussel species were found in this survey site (Table 18). Mucket shells were dominant, representing 72% of all shells that were found. Wabash pigtoe, the second most common species, only represented 11% of all shells. Slippershell (state threatened), creek heelsplitter, and strange floater shells were least common, with only a single shell found for each species. Shells from one species of special concern, elktoe, were also observed in low numbers. Three live mucket were also observed in this site.

A total of 74 shells were collected from this survey site (0.4 shells/m^2). Nine recent dead shells (12% of all shells collected) and eight moderately worn 1 shells (11%) were also observed. Some of these recent dead shells were categorized as crushed. The survey crew observed an airboat scraping against the river bottom while surveys were underway in the delineated site. The crew walked over the riffle where the airboat had passed and observed crushed recent dead shells in this area.

Table 18. Segment MS-4 survey site 2010.10.21-4-1 shell weathering characterization results

Species	Fresh dead	Recent dead	Moderately worn 1	Moderately worn 2	Heavily worn
Mucket	–	7	4	41	1
Elktoe	–	–	–	1	1
Slippershell	–	–	–	1	–
Cylindrical papershell	–	–	–	–	–
Spike	–	–	–	3	1
Wabash pigtoe	–	1	3	4	–
Fatmucket	–	–	–	–	–
Pocketbook	–	–	–	–	–
White heelsplitter	–	–	–	–	–
Creek heelsplitter	–	–	1	–	–
Fluted-shell	–	–	–	4	–
Eastern pondmussel	–	–	–	–	–
Round pigtoe	–	–	–	–	–
Giant floater	–	–	–	–	–
Strange floater	–	1	–	–	–
Paper pondshell	–	–	–	–	–
Ellipse	–	–	–	–	–
Rainbow	–	–	–	–	–
Total number of shells	0	9	8	54	3
Percentage	0.0%	12%	11%	73%	4.1%

3.4.4 MS-4 survey site 2010.10.21-4-2

Site 2010.10.21-4-2 was located just downriver of boat ramp C3.2. Depth was 0.4 m and the dimensions were 18-m-long and 12-m-wide, with a surface area of 216 m^2. This survey site boundary delineation was based on finding a scattered deposit of recent dead shells, many of which were crushed. The extent of the recent dead shells was larger than the site boundaries (Figure 10), but the entire area was not included due to time constraints. Therefore, this survey site is only a subsample of the total area of recent dead and crushed shells. The substrate was a mix of pebble (64–16 mm diameter), gravel (16–2 mm), and sand (2–0.0625 mm).

Shells from eight species were observed in this site. Similar to the other MS-4 survey site (2010.10.21-4-1), mucket were the dominant species observed, comprising 85% of all shells. Elktoe (species of special concern) and Wabash pigtoe shells were also common (both 5% of the total shells). Cylindrical papershell, pocketbook, and rainbow (a species of special concern) shells were least common, comprising less than 1% of all shells observed at the site. No state threatened or endangered species shells were observed in this site. A total of 12 live mucket and two Wabash pigtoe shells were also observed in this site.

A total of 155 shells were collected from the survey site (0.7 shells/m^2). Approximately 7% of the shells collected at this site were either recent dead (3.9%) or moderately worn 1 (3.2%). Twenty-one damaged shells were observed in this site. Nineteen of these shells were considered to be crushed (all mucket). One crushed live mucket and one Wabash pigtoe shell were also observed (Table 19).

Table 19. Segment MS-4 survey site 2010.10.21-4-2 shell weathering characterization results

Species	Fresh dead	Recent dead	Moderately worn 1	Moderately worn 2	Heavily worn
Mucket	–	3	4	124	–
Elktoe	–	–	1	4	3
Slippershell	–	–	–	–	–
Cylindrical papershell	–	–	–	1	–
Spike	–	–	–	1	2
Wabash pigtoe	–	3	–	5	
Fatmucket	–	–	–	–	–
Pocketbook	–	–	–	1	–
White heelsplitter	–	–	–	–	–
Creek heelsplitter	–	–	–	–	–
Fluted-shell	–	–	–	2	–
Eastern pondmussel	–	–	–	–	–
Round pigtoe	–	–	–	–	–
Giant floater	–	–	–	–	–
Strange floater	–	–	–	–	–
Paper pondshell	–	–	–	–	–
Ellipse	–	–	–	–	–
Rainbow	–	–	–	–	1
Total number of shells	0	6	5	138	6
Percentage	0.0%	3.9%	3.2%	89%	3.9%

3.5 Segment MS-5

Sampling segment MS-5 was located just upriver from the Mill Pond in Battle Creek. This was the most downriver segment that was surveyed. Approximately 0.7 miles of the 1-mile segment was surveyed, from MP 15.25 to MP 14.5 (Figure 12). Boat ramp C5 was located in this segment, which was in use at the time of the survey. No survey sites were delineated in this segment.

Figure 12. Sampling segment MS-5.

3.5.1 General conditions

During the survey, the weather was partly cloudy and seasonably warm (~ 60°F). A boat was used to access this segment because the water was too deep to safely wade through. Approximately one-third of MS-5 was too deep to survey (> 1 m). In addition, this segment was partially impounded by the Mill Pond Dam, and slow current speed caused fine particles to settle out of the water column and cover the bottom. This heavy sedimentation also limited the amount of habitat that could be thoroughly surveyed and made inspecting the river bottom in some areas difficult. A sudden and noticeable increase in turbidity occurred just as the surveyors reached the upstream end of the sampling segment, which effectively ended survey activities.

3.5.2 Segment MS-5 shell observations

Despite high turbidity and sedimentation, 12 mussel species were observed in this segment (Table 20). This was the only segment that did not contain cylindrical papershell and creek heelsplitter and the only site in which paper pondshell, a species of special concern, was observed (Figure 13). Only two species, spike and Wabash pigtoe, were observed live. Asian clams were also observed in this segment.

Shells in this segment were mostly moderately worn 2. No fresh dead or recent dead shells were observed. Moderately worn 1 shells were observed, but a survey site was not delineated because these shells were associated with a shell midden. Two crushed mucket shells were observed, one near boat ramp C5 and one near MP 14.75 in shallow water. Heavy sedimentation of fine particles and turbidity obscured the view of shells on the bottom and may have reduced the surveyors' ability to find fresh dead or recent dead shells within this segment.

4. Summary

4.1 Species Observed

Shells from 18 unionid species were observed in the Kalamazoo River during this survey. This included one state endangered species, one state threatened species, and five species of special concern (Table 21). When compared to University of Michigan Museum of Zoology's Mollusk Collection records and Wattles Park (Historic Bridge Park) survey results reported by Mulcrone and Mehne (2001), five new mussel species were observed during this survey, including the state endangered eastern pondmussel and threatened slippershell. In addition, non-native Asian clam (*Corbicula fluminea*) were found in all of the sampling segments.

Table 20. Total unionid mussel species[a] observed in sampling segment MS-5

Common name	Species	State status	Species observed
Mucket	*Actinonaias ligamentina*		X
Elktoe	*Alasmidonta marginata*	Special concern	X
Slippershell	*Alasmidonta viridis*	Threatened	X
Cylindrical papershell	*Anodontoides ferussacianus*		
Spike	*Elliptio dilatata*		X[b]
Wabash pigtoe	*Fusconaia flava*		X[b]
Fatmucket	*Lampsilis siliquoidea*		
Pocketbook	*Lampsilis cardium*		X
White heelsplitter	*Lasmigona complanata*		X
Creek heelsplitter	*Lasmigona compressa*		
Fluted-shell	*Lasmigona costata*		X
Eastern pondmussel	*Ligumia nasuta*	Endangered	
Round pigtoe	*Pleurobema sintoxia*	Special concern	X
Giant floater	*Pyganodon grandis*		
Strange floater	*Strophitus undulates*		X
Paper pondshell	*Utterbackia imbecillis*	Special concern	X
Ellipse	*Venustaconcha ellipsiformis*	Special concern	
Rainbow	*Villosa iris*	Special concern	X
Total number of unionid species			12

a. In addition to unionid mussels, live non-native Asian clam and shells were observed in the segment.
b. In addition to observing shells of this species, live individuals were also observed in the segment.

State status sources: MDNRE, 2010; MNFI, 2010.

The number of species and dominant species observed varied across segments (Table 22). The reference segment (MS-1) had the highest number of mussel species (16). Pocketbook shells were dominant in this segment, and shells of other species such as fluted-shell were also common. At MS-2, shells of 15 mussel species were observed. Spike shells were dominant in the MS-2 survey site, followed by Wabash pigtoe. In both the MS-3 and MS-4 segments, shells representative of 12 mussel species were identified, and mucket shells were dominant at all surveyed sites in these two segments. At MS-5, 12 species were observed. MS-5 was the only segment in which paper pondshell shells (species of special concern) were observed and cylindrical papershell and creek heelsplitter shells were not observed.

Figure 13. Photograph of a moderately worn 2 paper pondshell observed in segment MS-5.

Photograph taken by J. Matousek on October 25, 2010.

Table 21. Occurrences of state listed and special concern mussel species for each sampling segment

Species	State status	MS-1	MS-2	MS-3	MS-4	MS-5
Elktoe	Species of special concern	X	X	X	X	X
Slippershell	Threatened species	X	X	X	X	X
Eastern pondmussel	Endangered species	X				
Round pigtoe	Species of special concern	X	X			X
Paper pondshell	Species of special concern					X
Ellipse	Species of special concern	X	X			
Rainbow	Species of special concern	X	X	X	X	X

Sources: MDNRE, 2010; MNFI, 2010.

Table 22. Mussel shell species observed in each sampling segment

Species	MS-1	MS-2	MS-3	MS-4	MS-5
Mucket	X	X	X	X	X
Elktoe	X	X	X	X	X
Slippershell	X	X	X	X	X
Cylindrical papershell	X	X	X	X	
Spike	X	X	X	X	X
Wabash pigtoe	X	X	X	X	X
Fatmucket	X	X			
Pocketbook	X	X	X	X	X
White heelsplitter		X	X	X	X
Creek heelsplitter	X	X	X	X	
Fluted-shell	X	X	X	X	X
Eastern pondmussel	X				
Round pigtoe	X	X			X
Giant floater	X				
Strange floater	X	X	X	X	X
Paper pondshell					X
Ellipse	X	X			
Rainbow	X	X	X	X	X
Total number of unionid species	16	15	12	12	12

4.2 Shell Weathering

Table 23 provides shell weathering characterization results for the six survey sites. Fresh dead, recent dead, and moderately worn 1 shells were estimated to be less than three months post-mortem, as described in the agreed-upon work plan (Attachment A and Table 2 of this document), and these categories were combined in Table 23 for analysis purposes. The proportion of these shells within survey sites increases downriver from the spill, with the greatest percentage observed in segment MS-4 at site 2010.10.21-4-1 (23%). No fresh dead, recent dead, or moderately worn 1 shells were observed in the upstream reference segment, despite having the greatest density of shells. In summary, fresh dead, recent dead, and moderately worn 1 shells were more common in segments and survey sites downriver of the spill site compared to the reference site.

Table 23. Summary of delineated survey site shell weathering results. Percentage of shells < 3 months post-mortem was derived by dividing the total number of fresh dead, recent dead, and moderately worn 1 shells by the total number of shells observed in the site.

Segment/survey site	Shell density (shells/m^2)	Total number of shells	Number of fresh and recent dead shells	Number of moderately worn 1 shells	Shells < 3 months post-mortem (%)
MS-1					
2010.10.21-1-1	1.6	213	0	0	0%
MS-2					
2010.10.19-2-1	0.9	264	6	N/A	2.3%
MS-3					
2010.10.20-3-1	1.4	155	0	6	3.9%
2010.10.20-3-2	0.5	129	6	9	12%
MS-4					
2010.10.21-4-1	0.4	74	9	8	23%
2010.10.21-4-2	0.7	155	6	5	7.1%
MS-5 – no survey sites delineated within this segment					

N/A = MS-2 was surveyed prior to the development of “moderately worn 1” and “moderately worn 2” weathering categories; therefore, the number of moderately worn 1 shells is not available.

4.3 Shell Damage

Damaged shells were observed in all five segments, but crushed shells were only found in the segments downriver of the spill site (Table 24). Broken shells that were in advanced stages of weathering were common in all segments, as would be expected as a result of natural in-stream weathering processes. Piles of chipped mussel shells were also common. These observations were associated with shell middens, which were observed in all but one of the segments. Crushed shells were observed in segments downriver of the spill site. No crushed shells were observed in the reference segment. The crushed shells included recent and moderately worn 1 shells, and crushed live mussels were also observed. Crushed shells were most often found in shallow water habitats downriver from boat ramps and in areas of high boat traffic. The largest area of crushed shells was found just downriver from boat ramp C3.2 in segment MS-4. The substrate in this area was discolored where boats had scraped along the river bottom. This area also contained a notable number of live mussels, some of which were lying exposed on their sides, with scratches on their shells. Others were crushed, including one individual that was still alive.

Table 24. Summary of damaged shells observed in each sampling segment. As categorized by the field team for the purposes of this study, broken shells are considered shells damaged due to advanced weathering, chipped shells are associated with predation, and crushed shells are defined as shells damaged by heavy impact (e.g., boat or foot traffic).

	Broken shells	Chipped shells	Crushed shells
MS-1	X		
MS-2	X	X	X
MS-3	X	X	X
MS-4	X	X	X
MS-5	X	X	X

4.4 Additional Observations

Additional observations of potential oil-spill-related impacts to mussel habitat were noted in sampling segments downriver from the spill site. Observations included oil sheens, elevated turbidity, and sedimentation/siltation:

- In segment MS-2, near boat ramp C1.5, oil sheens were observed in a heavily silted area near the location of two recent dead mussel shells. Moderate to high turbidity and siltation were observed in segments downriver from the spill site.
- Heavy siltation of river substrate and mussel shells were observed in segment MS-3. Fine silt covered the river substrate and mussel shells in areas with slow-moving water, and recent dead shells were often observed in these areas. Siltation may be the result of high turbidity from upriver dredging, eroding banks (observed near boat ramp C1.5), and/or boat traffic.
- Turbidity increased in segment MS-4, especially when boats passed through the survey site.
- Turbidity was greatest at the most downriver segment (MS-5), where it adversely affected the ability to conduct the survey. Despite conducting the survey of segment MS-5 under conditions of high turbidity and heavy sedimentation, crushed mussel shells were observed in this segment. This included two crushed mucket shells, one near boat ramp C5 and one near MP 14.75 in shallow water.
- A relatively large number of young live spike and mucket shells was found at MS-5. Based on a count of visible annular rings, these individuals were as young as three years old. This is notable because unionid mussels this young are not often observed during surveys, indicating that successful reproduction has occurred for these species in the recent past.

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A. Mussel Shell Survey Work Plan

October 16, 2010

Unionid mussel shell survey in the Kalamazoo River watershed, in the Marshall and Battle Creek, MI area

Introduction

On July 26, 2010, Enbridge Energy, Limited Partnership discovered a release of heavy crude oil (Cold Lake Blend) from line 6B just west of milepost 608 in the vicinity of its pump station located in Marshall, Calhoun County, Michigan. Line 6B is a 30-inch, 190,000 barrels per day (bpd) line transporting light synthetics, heavy and medium crude oil from Griffith, IN, to Sarnia, Ontario. The location of the release from Line 6B is located in an undeveloped area in the outskirts of town with coordinates of approximately North ½ Section 2, T3S, R6W, Latitude: 42.2395273 Longitude: -84.9662018. Upon discovery of the release the pipeline was shut down and isolation valves closed, stopping the source of the oil; however, initial estimates are that approximately 1 million gallons of crude oil may have been released to Talmadge Creek (approximately 1.5 miles) and to the Kalamazoo River.

Unionid mussels are an important biological resource in the state of Michigan and component of the state's natural heritage. Of the 46 unionid species that occur in Michigan, 19 are threatened or endangered in the state. One state endangered, three state threatened, and six special concern species have been documented in the Kalamazoo River since 1989 (Peter Badra, MNFI, personal communication, 2010). Anecdotal observations of dead mussels, and "fresh" and recent dead mussel shells (see below for definition of "fresh" and "recent") in areas of response activities in the river are suggestive of mussel injuries, including physical injuries caused by the breaking of shells by boat and other transportation on the river, as well as potentially injuries due to exposure to released contaminants.

Scope

This work plan describes freshwater bivalve (mussel) shell survey activities on the Kalamazoo River from Marshall impoundment to the town of Battle Creek, MI. The proposed survey will be conducted by the Michigan Natural Features Inventory (MNFI) and Stratus Consulting on behalf of the natural resource trustees (Trustees) in cooperation with Enbridge. Results may be used to identify and characterize potential injury to mussel communities resulting from toxicity due to exposure to hazardous substances, and physical injury (e.g., crushed shells) as a result of response activities, associated with the release of oil into Talmadge Creek and Kalamazoo River. Some of these data are ephemeral. Information on the location of dead mussels and the "freshness" of mussel shells will largely be lost over time and during spring high water events, if not observed and recorded this fall. Additionally, survey information can be used to design a more intensive mussel community survey to be conducted next year.

The survey will focus on locating “fresh” or “recent” dead mussel shells. Interpretation of the age of mussel shells post-mortem can be made based on the condition of the shells according to the scale and physical characteristics described in Table 1. Classification of the age of shells post-mortem using this scale is qualitative and somewhat approximate. However, the scale is sufficiently precise for the purposes of this survey, which is to identify shells of dead mussels associated with the spill event and response activities. In other words, shells that fall into the first two categories in Table 1.

Table 1. Mussel shell scale

Scale	Category	Physical characteristics	Approximate post-mortem shell age
1	Fresh dead	Soft tissue intact	Several days
2	Recent dead	No soft tissue, aside from hinge ligament	Couple of weeks up to ~3 months
3	Moderately worn	Most of periostracum intact, shell has most of its original strength	3 months to one year
4	Heavily worn	periostracum worn and peeling, shell at least somewhat chalky and fragile	Greater than one year

Note that this survey is focused on mussel shells, and it is not intended as a mussel population survey. Occurrence and abundance of live mussels will be documented, if they are encountered during the shell survey. However, the survey is being conducted in the fall, the time of year when live mussels burrow into the sediment, where they spend winter months. Therefore, estimates on live mussel abundance made during this survey may not reflect the actual of live mussel abundance at surveyed sites.

The survey will be conducted in October 2010. It is anticipated that the survey will take approximately five days in the field, with five crew members, and may require a boat and supplies, to be arranged by MNFI.

Objectives

The objectives of this study are as follows:

- Survey selected segments of the Kalamazoo River from Marshall impoundment to the town of Battle Creek for fresh and recent dead mussel shells.

- Delineate the spatial extent of fresh and recent dead mussel shells within the selected segments. Delineated spatial areas of fresh and recent dead mussel shells will define survey sites.

- Within survey sites, document mussel shells observed, including species and condition (state of shell weathering; 1 through 4). Observed live mussels will also be recorded.

Preliminary Sampling Locations

Five discrete sampling segments have been identified on the Kalamazoo River between Marshall Impoundment and the Mill Pond at the Town of Battle Creek (approximate river mile 15.5). Sampling segments have been selected according to proximity to the spill site, areas of known response activities, locations of boat launches (and hence elevated boat activity), and prior mussel tissue and sediment sampling locations. The mussel shell survey protocol will be conducted at each of the sampling segment as time permits. Note that the locations may be subject to change, depending upon conditions encountered when in the field. The segments consist of one reference and four locations downstream of the release. An additional reference segment may be added, based on need, as judged by the crew while in the field.

Each sampling segment represents approximately one mile of river. One sampling segment will be sampled each day as described in Table 2. The crew will cover as much of the mile identified at each site as they can in one day, and then progress to the next site the following day. Though the crew may be successful at covering the full mile at each site, this is somewhat uncertain, and will depend upon field conditions encountered. The crews will move to a new segment each day even if the previous segment was not fully surveyed to ensure adequate coverage of the impacted length of the river. The segments will only be surveyed in habitat that is practically accessible. (i.e., not too deep or swift to wade, or contain complex habitat that limits observation of the river bottom).

Table 2. Mussel shell survey sampling segments and schedule. River miles area as reported by Enbridge.

Sampling day	Sampling segment (river miles; RM)	Attributes	Map figure number
1	MS-1: Down river of Marshall Impoundment (RM not available)	Reference area, contains a past survey location	Figure 1
2	MS-2: Talmadge Creek confluence area (RM 2.25 to 3.25)	Exposure area, contains a boat ramp and near a past survey location	Figure 2
3	MS-3: Boat ramp near 11 Mile Road Bridge (RM 7.00 to 8.00)	Exposure area, contains a boat ramp and past survey location	Figure 3
4	MS-4: Boat ramp near Historic Bridge Park (RM 9.25 to 10.25)	Exposure area, contains two boat ramps and past survey location	Figure 4
5	MS-5: Boat ramp at Rivers Edge Landscaping (RM 14.5 to 15.5)	Exposure area, contains a boat ramp and near sediment sparging/removal locations	Figure 5

Figure 1. Sampling segment downriver of Marshall Impoundment (MS-1).

Figure 2. Talmadge Creek confluence area sampling segment (MS-2).

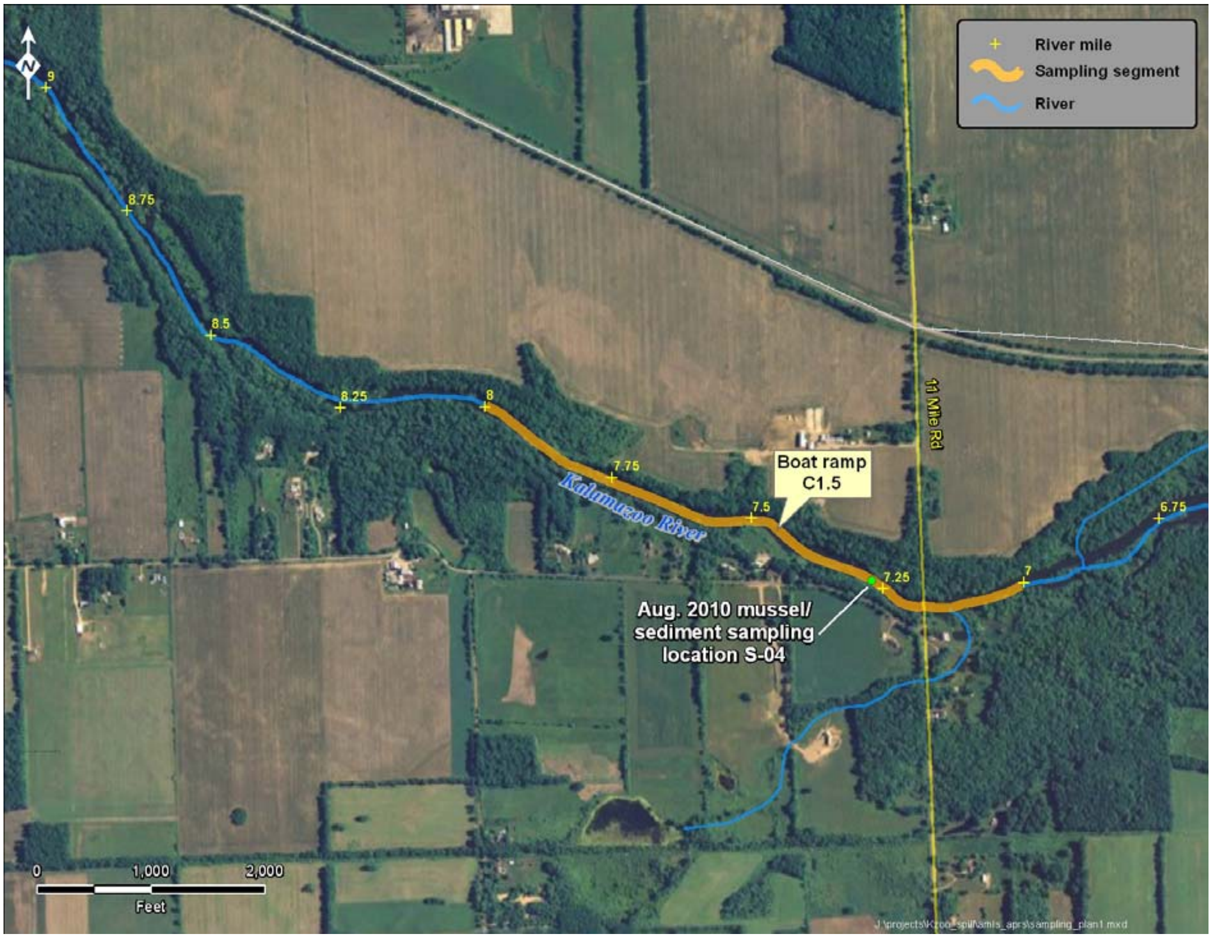


Figure 3. Sampling segment near 11 Mile Road bridge (MS-3).

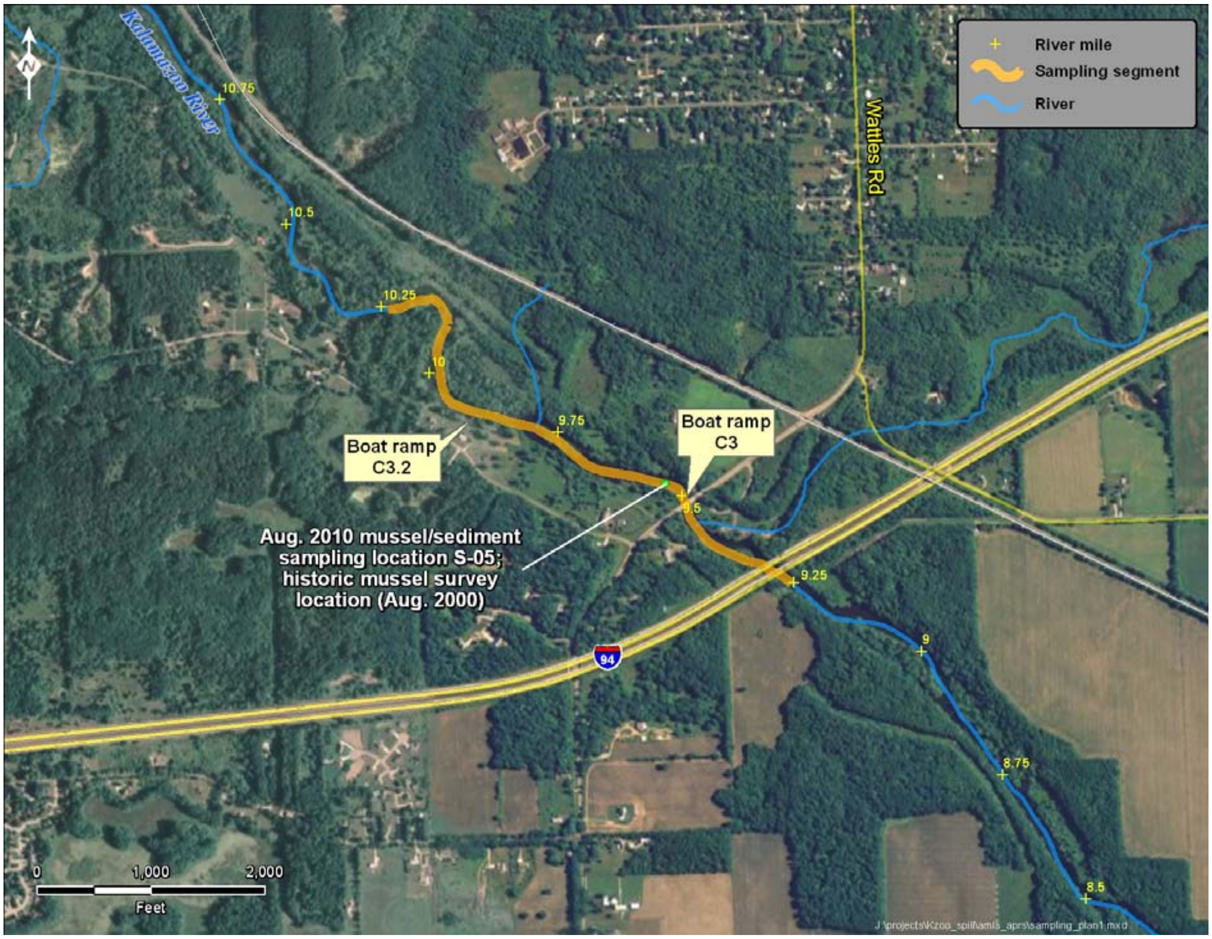


Figure 4. Sampling segment near Historic Bridge Park (MS-4). Historic mussel survey conducted by (Mulcrone and Mehne, 2001) in the summer of 2000.

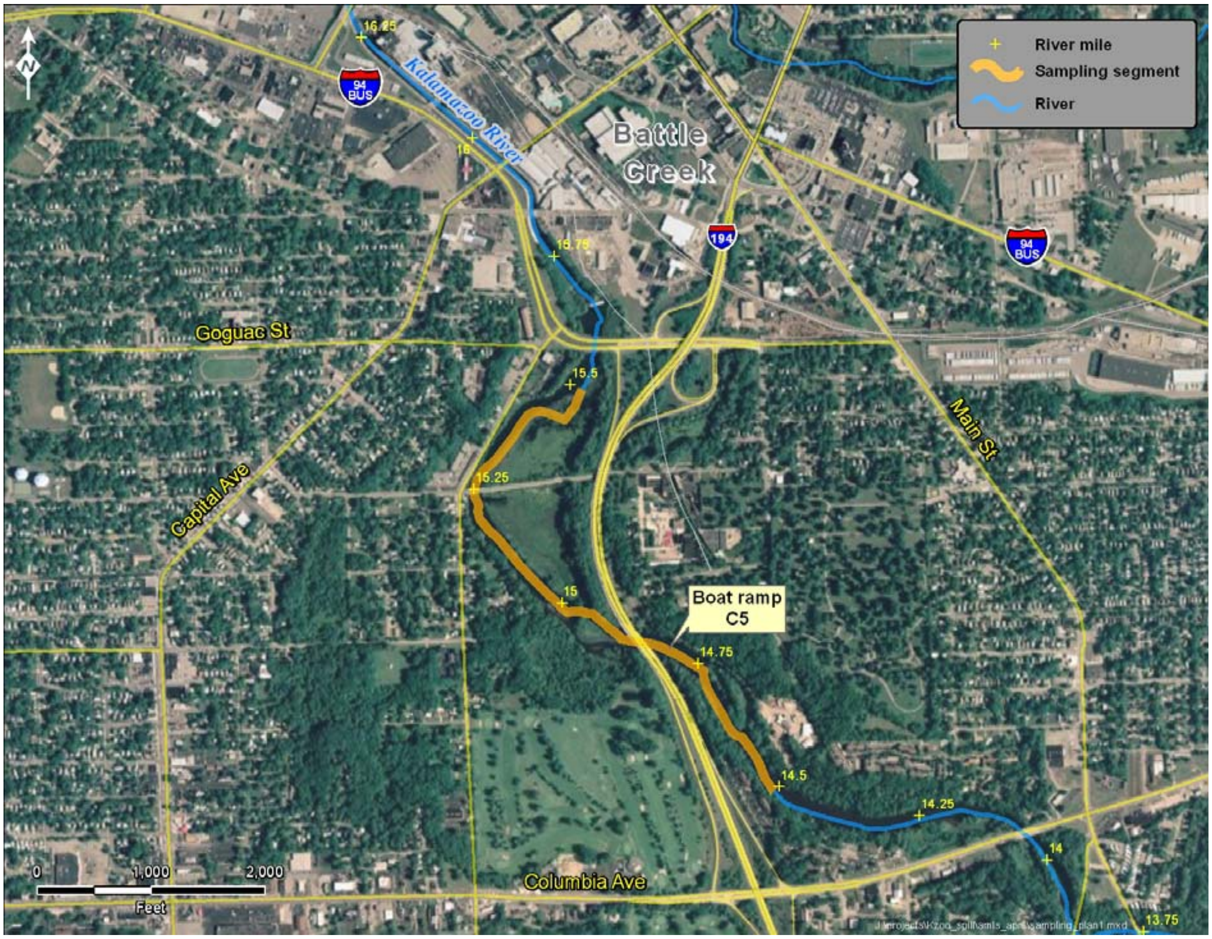


Figure 5. Sampling segment near Rivers Edge Landscaping in Battle Creek, MI (MS-5).

Survey Methods

The mussel shell survey will led by MNFI and Stratus Consulting on behalf of the Trustees, in cooperation with Enbridge representatives. There will be a total of four to five crew members. Surveys will follow the mussel shell survey protocol (provided below). These methods may be modified to suit conditions encountered in the field as necessary. Any changes to the method made in the field will be recorded and shared with all parties involved. This survey will focus on identifying fresh and recent dead native mussel species shells. However, presence of older shells (category 3 and 4), and live mussels and non-native dreissenid mussels (*Dreissena polymorpha* and *Dreissena bugensis*) and Asian clams (*Corbicula fluminea*) will be noted in survey sites.

Survey information will be recorded onto a survey site-dedicated datasheet (Attachment 1). One datasheet will be used for each survey site. Additional information such as field personnel, start and stop times and coordinates, and photograph information will be recoded on a sampling segment datasheet. Only one sampling segment datasheet will be completed each day.

Note, that the survey will not be possible if river conditions, such as high flow and turbidity, limit observation of mussel shells. If it is determined that the substrate and mussel shells observations can not be made in wadable river reaches (depths ~1 meter) the survey will not be conducted until conditions improve.

Mussel Shell Survey Protocol

- Travel upriver through the sampling segment by wading.

- The crew will wade the river in a parallel line, inspecting the substrate with a stream bottom viewer and/or polarized glasses. Encountered objects may need to be picked up to enable identification of shells, and their categorization according to the shell scale (see Table 1).

- When fresh dead or recent dead mussel shells are encountered, this defines the downriver boundary of a survey site:

  - The survey site boundary GPS coordinates are taken and recorded in the datasheet (Attachment 1)
  - Survey sites will be named according to a predetermined naming convention:
    - Survey date (Year.Month.Day) – sampling segment ID – consecutive survey number conducted in the sampling segment
    - Example: 2010.10.26–2–004

- The survey site is delineated and surveyed simultaneously:

  - The crew continues to advance upriver (and across the wadable river-width), and all shells encountered are picked up and examined to identify the species and condition of the shell according to the shell scale (see Table 1 for shell scale).
  - Each observed shell, its species, and condition (1-4) are recorded in the field datasheet (Attachment 1).
  - Each observed live mussel is also identified and recorded in the datasheet.
  - Once crew members reach a point (upriver and across the wadable river width) where fresh/recent dead shells are no longer encountered, this defines a boundary of the survey site. At this boundary, the crew stops recording shell and live mussel observations.
  - Once the boundaries of the survey site have been identified, the dimensions of the survey site are then recorded in the datasheet, including survey site boundary lengths, a sketch of the survey site is drawn, and average water depth is recorded.

- An estimated proportion of substrate surface area covered with fresh/recent dead shells in the entire survey site (see datasheet for percentage categories) is then recorded on the datasheet.

  - Proportion estimates will be performed by at a minimum two crew members (and preferably with all crew members), and the agreed upon values will be recorded on one datasheet

- Notes regarding occurrence of shell piles, or other pertinent survey related information on the field datasheet in the spaces provided.

- Representative shell samples may be collected; samples will be place inside a labeled paper bag; shells will be stored at MNFI.

  - Sample labels will include the following information:
    - Collection date, time, and GPS coordinates (decimal degrees to five decimal places)
    - Name, affiliation, and phone number of collector
    - Species and condition represented by the sampled shell

- Pictures should be taken so that each species and shell condition is documented for the survey site. Pictures should also be taken of any other pertinent subjects while conducting the survey. The crew will work with a GPS unit and keep a tracklog running.

  - A common GPS unit and camera will be used and supplied by Entrix
  - The GPS unit will be reset, once, at the beginning of the survey

  - Once a day, a picture of the GPS screen will be taken (the easiest way is to take it from a distance and do not zoom in) that shows the time on the GPS screen to the nearest second (see Attachment 2 for GPS tracklog and photo management protocol).

- Continue traveling upriver inspecting substrate, until fresh/recent dead shells are observed again. This defines the downriver boundary of the next survey site. Continue defining survey sites, and conducting surveys until the entire sampling segment has been inspected.

  - If the mile long sampling segment cannot be surveyed in the scheduled field day (Table 2), then estimated proportion of the sampling segment that had been sampled will be documented on the field datasheet

- At the end of each day field datasheets will be scanned into a pdf file. Scanned datasheets, pictures, and GPS tracklogs will be saved onto a backup device, such as a USB port or external drive. These data will then be uploaded to the Entrix and trustee's ftp sites. Trustees will retain the original datasheets and will provide copies to Entrix/Enbridge as requested.

  - Pdf datasheets and pictures files will be named according to a predetermined naming convention:
    - YearMonth.Day.Shell.Datasheet.sequential.series (example: 2010.Oct.25.Shell.Datasheet.015)
    - YearMonth.Day.Shell.Tracklog (example: 2010.Oct.25.Shell.Tracklog)
    - YearMonth.Day.Shell.Picture.sequential.series (example: 2010.Oct.25.Shell.Picture.005).

Reporting

The survey will be summarized in report format. The report will include a summary of survey methods and results. The report will include a map showing surveyed locations and brief description of relevant conditions at each location. For each survey site location, the report will include a description of the weathering condition of dead shells in the entire survey location for each native mussel species. Locations of live mussels and occurrence of non-native mussels will also be reported.

Reference

Mulcrone, R.S. and C. Mehne. 2001. Freshwater Mussels of the Kalamazoo River, Michigan, from Battle Creek to Saugatuck. Prepared for Lisa L. Williams U. S. Fish and Wildlife Service. October 1.

Attachment 1. Field Datasheets

Field Recorder:	Page ___/___
Enbridge Oil Spill Mussel Shell Survey Field Datasheet	
Location Information	
Sampling Segment:	
Site Description/Landmarks/Access/Other Notes:	
GPS Coordinates (decimal degrees to 5 decimal places)	
Start location	End location
Latitude:	Latitude:
Longitude:	Longitude:
Start Time:	End Time:
Weather Conditions:	
Air Temperature:	
Personnel Present	
Name - Affiliation	Name - Affiliation

Photograph Documentation

Camera id/owner: GPS unit id/owner:

Photo #	Time	Photographer/Camera	Subject

Survey Site	(in consecutive order)	Page ___/___
Surveyor(s):		Date:

Enbridge Oil Spill Mussel Shell Survey – Mussel Survey Data

Habitat Information

Coordinates at downriver boundary:

Survey Site Area Measurements

Dimensions	Est. length (m)	Draw shape (label sides and flow direction)
Side 1		
Side 2		
Side 3		
Side 4 (opt)		
Depth (1/10 meter)		

Proportion of substrate covered by shells

Coverage (check one)

>1%	1 to 5%	6 to 25%	26 to 50 %	51 – 75%	>75%

Shell piles: y/n

Notes:

Non-native species present (Y/N):

Sampling Segment:							Page ___/___
Field Recorder:							Date:
Shell and Mussel Observations							
		Shell Condition (check one)					
Species (G. species)	Live Mussel (check)	Fresh	Recent dead	Mod. worn	Heavily worn	Crushed shells (Y/N)	Notes/observations

Sampling Segment:							Page ___/___
Field Recorder:							Date:
Shell and Mussel Observations (cont'd)							
		Shell Condition (check one)					
Species (G. species)	Live Mussel (check)	Fresh	Recent dead	Mod. worn	Heavily worn	Crushed shells (Y/N)	Notes/observations

Sampling Segment:			Page ___/___
Field Recorder:			Date:
Photograph Documentation (cont)			
Photo #	Time	Photographer/Camera	Subject

Attachment 2. Entrix Protocol for Using a Digital Camera, GPS, and the Photolink Software

- GPS (these directions typically apply to Garmin handheld units)
  - Set GPS units to decimal degrees
    - Main menu/setup/units/hddd.ddddd
  - Set GPS track mode to on
    - Main Menu/tracks
    - It is best if the track log is cleared before you start
    - Intervals should be adjusted based on mode of transportation (i.e., increase interval if walking, decrease interval if boating)
  - Setup GPS track mode
    - Main menu/tracks/options/setup track log
  - Select local time for time display
    - Main menu/setup/time
  - Check to make sure that the GPS is “ready to navigate” when you are taking pictures
  - To save a waypoint
    - Main menu/mark/ok – saves the waypoint using the number in the flag as the ID number. The number automatically increases with each waypoint you save. You can rename the waypoint by editing the label in the flag.
  - To navigate to a waypoint
    - Main menu/find/waypoints

- Camera
  - Set camera time to GPS date and time to the nearest second.
  - After changing camera batteries, check to make sure time has not reset to some default.
  - Take a picture of the GPS screen (the easiest way is to take it from a distance and do not zoom in) that shows the time on the GPS screen to the nearest second. **This only needs to be done once per day.**

- Photolink
  - You must have the GPS with you and have the track-logs on in order to georeference your pictures.
  - The GPS photolink program automatically downloads your track log when you process your photos. Be aware that you can not use a track log saved on the GPS in photolink.

- You can save track logs to your computer using the Garmin Mapsource software if you do not have the photolink software. This is the only program I’ve found that saves the tracklog in a format that can be used by photolink. It comes with most Garmin map packages and is available as a stand alone program.

B. Field Datasheets

15mile +

Field Recorder: J. Matousek	Date: 10/18/10	Page 1/1

Enbridge Oil Spill Mussel Shell Survey Field Datasheet

Location Information

Sampling Segment: Reference Location

Site Description/Landmarks/Access/Other Notes:

Start @ 17mile Rd Bridge

GPS Coordinates (decimal degrees to 5 decimal places)

Start location 17mile start	17mile end End location
Latitude: N 42.26480	Latitude: N 42.26211
Longitude: W084.96385	Longitude: W084.95550
Start Time: 10:20 am	End Time: 15:33

Weather Conditions: Cloudy, 55°F

Air Temperature: 55°F

Personnel Present

Name - Affiliation	Name - Affiliation
John Matousek / ENTRIX	
Matt Wesener / DNRE	
Bill Taft / DNRE	
Mike Wilson / DNRE	
Pete Badra / MNFI	
Mike Kaminsky / Stratus	

Photograph Documentation

Camera id/owner: GPS unit id/owner:

Photo #	Time	Photographer/Camera	Subject
1			Spike, Recent dead
2			Eastern pond mussel, mod worn
3			Rainbow, mod. worn
4			Spike, Live
5			Pocketbook, Live
6			Pocketbook, mod worn
7			Rainbow, mod worn
8			Elk toe, heavily worn
9			Cylindrical papershell, heavily worn
10			Slipper shell, mod worn
11			Ellipse, Live
12			Giant floater, mod worn
13			Strange floater, mod worn
14			Creek heelsplitter, Heavily worn
15, 16, 17			Crew photo
18, 19			Mucket, Mod. worn
20, 21			Round pigtoe, Mod worn

Field Recorder: J. Matousek	Date: 19 Oct 2010	Page 1/3

Enbridge Oil Spill Mussel Shell Survey Field Datasheet

Location Information ~~MS-2~~ MS-02

Sampling Segment:

Site Description/Landmarks/Access/Other Notes:

Start at River mile 3.0

GPS Coordinates (decimal degrees to 5 decimal places)

MS02 STRT Start location	Boat launch End location MS02END
Latitude: N 42.25925	Latitude: N 42.25864
Longitude: W085.01009	Longitude: W 084.99898
Start Time: 09:30	End Time: 16:44

Weather Conditions: Cloudy

Air Temperature: ~50°F

Personnel Present

Name - Affiliation	Name - Affiliation
John Matousek - ENTRIX	
Mike Wilson - DNRE	
Matt Wesener - DNRE	
Bill Taft - DNRE	
Pete Badra - MNFI	
Mike Cornely - Stratus	

Photograph Documentation

Camera id/owner: GPS unit id/owner:

Photo #	Time	Photographer/Camera	Subject
1,2		GPS time	GPS, time
3,4			Wabash pigtoe - mod worn
5			Strange floater - mod worn
6			Rainbow - mod. worn
7			Asian Clam - mod worn
8			Spike - Recent dead
9			Pocketbook - Live
10			Elktoe - mod. worn
11			Creek heelsplitter, mod worn
12, 13			fluted shell, mod. worn
14			Wabash pigtoe, mod. worn
15			Ellipse, mod worn
16			White heelsplitter, Live
17			Mucket, Mod. shell
18			Fluted shell, stain wide
19			Elk toe, crushed top
20			Slipper shell
21,22,23			Crew photos
24			Pocketbook, cracked, Recent dead

25 - Recent spike

26 - Mod. worn broken shell pocket book

Survey Site	(in consecutive order)	Page 21 ~~4~~
MS-02 Transect 1		

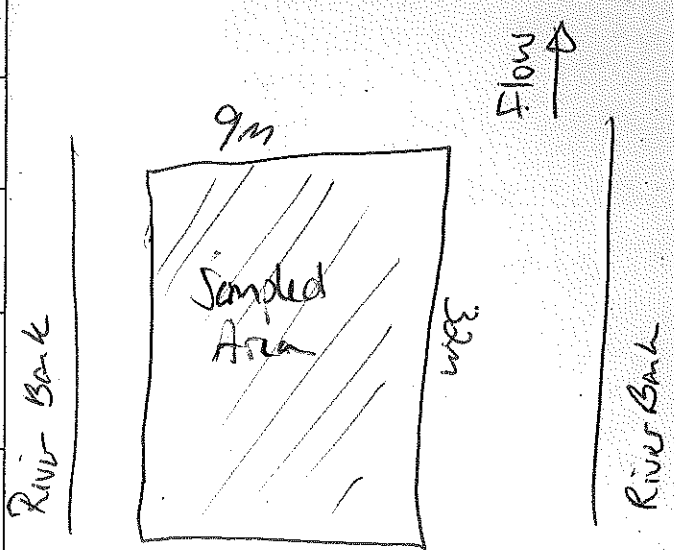
Surveyor(s):	Date:
Matousek, Taft, Badra, Weaver, Carney, Wilson	19 Oct 10

Enbridge Oil Spill Mussel Shell Survey – Mussel Survey Data

Habitat Information

Coordinates at downriver boundary:
N42.25979 W085-01019 to N42.25983 W085-00996

Survey Site Area Measurements

Dimensions	Est. length (m)	Draw shape (label sides and flow direction)
Side 1	9m	
Side 2	32m	
Side 3	9m	
Side 4 (opt)	32m	
Depth (1/10 meter)	4/10 m	

Proportion of substrate covered by shells

Coverage (check one)

< 1%	1 to 5%	6 to 25%	26 to 50 %	51 – 75%	>75%
Less than 1%					

Shell piles: y/n

Notes:
Asian Clams observed

Non-native species present (Y/N):

Start ~5m from (L) bank, cover ~~approx 10m~~ 9m of stream channel wide and 32m long

Sampling Segment: MS-02 transect 1 (at Mile 3.0 sign)							Page 3
Field Recorder: J. Matousek							Date: 19 Oct 10
Shell and Mussel Observations (cont'd) waypt MS02TRANSTRT							
		Shell Condition (check one)				N42.25979 W085.01019	
Species (G. species)	Live Mussel (check)	Fresh	Recent dead	Mod. worn	Heavily worn	Crushed shells (Y/N)	Notes/observations
Wabash pigtoe			|	𝍸𝍸 𝍸𝍸 𝍸𝍸	𝍸|		moderate 𝍸𝍸||||
~~Spike~~							
Spike			||	𝍸𝍸 𝍸𝍸 𝍸𝍸 𝍸𝍸 𝍸𝍸	𝍸𝍸 𝍸||		moderate 𝍸𝍸|||
Pocket book			|	𝍸𝍸 𝍸𝍸 𝍸	𝍸𝍸		
Rainbow				𝍸𝍸	||		
Fluted shell			|	𝍸|	𝍸		
Mucket				|			
Elk toe				||||	𝍸||		
Elipse				𝍸𝍸 ||||	|		
Strange floater			|	𝍸𝍸 𝍸|	𝍸𝍸 |||		
Round pigtoe				𝍸||	||		
Slipper-shell				||	|		

Asian Clams also observed

Endpoint MS02TRANEND (12:15)

N42.25983 W085.00980

Sampling Segment: MS-02 Page 4/4

Field Recorder: Matruch Date: 19 Oct 10

Photograph Documentation (cont)

Photo #	Time	Photographer/Camera	Subject
27			Pocketbook, midwing, broken shell
28			Spike, recent, dead, broken shell
29			Pocketbook, recent, broken shell
30			shell deposit (animal related)
31			Fat mucket, Live
32, 33, 34			fresh dead pocketbook
35			broken shells
36			broken spike shells, + pocketbook
37			Cylindrical papershell

Field Recorder: J. Matousek	Date: 20 oct 2010	Page 1/4

Enbridge Oil Spill Mussel Shell Survey Field Datasheet

Location Information

Sampling Segment: MS-03

Site Description/Landmarks/Access/Other Notes:

Put in at the 11 mile road bridge crossing
Walked down to Mile marker 7.75

GPS Coordinates (decimal degrees to 5 decimal places)

time 10:13 Start location mile marker 7.75	End location
Latitude: N42.27732	Latitude: N42.27443 W085.08154
Longitude: W085.09117	Longitude: W085.08154
Start Time: 10:13	End Time: 16:30

Weather Conditions: Sunny

Air Temperature: ~50°F

Personnel Present

Name - Affiliation	Name - Affiliation
Ryan Grafton Cardno Entrix	
John Matousek Cardno Entrix	
Pete Badra - MNFI	
Matt Wesner - DNRE	
Mike Wilson DNRE	
Mike Carney - Stratus	

Photograph Documentation

Camera id/owner: GPS unit id/owner:

Photo #	Time	Photographer/Camera	Subject
1,2		Matousek / #1	GPS time/date
3			Mucket / moderate 2
4			Elk toe / moderate 2
5			Spike / moderate 1
6			White heelsplitter / Live
7			Black pigtoe / moderate 2
8			fluted shell / moderate 2
9			Strange floater / moderate 2
10			Pocketbook / moderate 2
11,12,13			Comp plates
14,15			Moderate / example Mucket
16			Rainbow Moderate 2
17			Mucket with hole/damage
18			Slipper - heavy worn
19			Cylindrical papershell mod 2
20			Recent looking shells

Survey Site	(in consecutive order)	Page 2/4
MS-3 Transect 1		

Surveyor(s): Matousek, Boden, Carney, Grafton, Wilson, Wesner   Date: 20 oct 2010

Enbridge Oil Spill Mussel Shell Survey – Mussel Survey Data

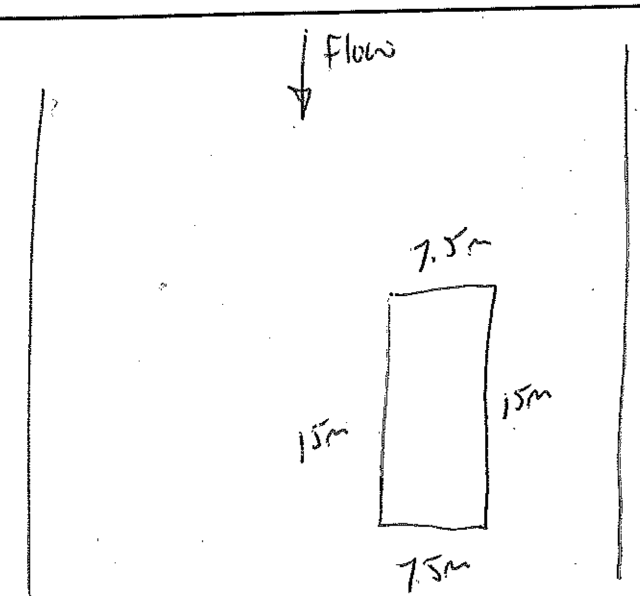
Habitat Information

Coordinates at downriver boundary: N42.27737 W085.09080   Upstream boundary N42.27736 W085.09071

Survey Site Area Measurements

Dimensions	Est. length (m)
Side 1	7.5m
Side 2	15m
Side 3	7.5m
Side 4 (opt)	15m
Depth (1/10 meter)	4/10m

Draw shape (label sides and flow direction)



* mile marker 7.75

Proportion of substrate covered by shells

Coverage (check one)

>1%	1 to 5%	6 to 25%	26 to 50 %	51 – 75%	>75%
	✓				

Shell piles: y/n

Notes: Very encrusted shells. All/most shell with significant marl coating

Non-native species present (Y/N):

Asian Clams

7.5m x 15 m Rectangular Section

Sampling Segment: MS-3 Transect 1							Page 3/4
Field Recorder: J. Matousek							Date: 20 Oct 2010

Shell and Mussel Observations (cont'd)

Species (G. species)	Live Mussel (check)	Shell Condition (check one): Fresh	Recent dead	Mod. worn (1)	~~Heavily worn~~ Mod (2)	~~Crushed shells (Y/N)~~ Heavily worn	Notes/observations
Pocketbook					𝍸 ||	||	
Mucket	𝍸 𝍸			|||	𝍸 𝍸	|	broken shells |
	|				𝍸 𝍸		additional mod(2)
					𝍸 𝍸		𝍸 𝍸 𝍸 𝍸 𝍸
					𝍸 𝍸		|||
					𝍸 𝍸		
					𝍸 𝍸		
Fluted shell				|||	𝍸 𝍸	|	
					𝍸 |		
Wabash pigtoe	||				𝍸 𝍸	|	
					𝍸 𝍸		
					||||		
Elk toe					|		
White heelsplitter					||		
Strange floater					|||	||	
Spike	|				|		

Bar x31m

Sampling Segment: MS-3 Transect 2							Page 4/4
Field Recorder: Matousek							Date: 20 Oct 2010

Shell and Mussel Observations (cont'd)

		Shell Condition (check one)					
Species (G. species)	Live Mussel (check)	Fresh	Recent dead	Mod. worn (1)	~~Heavily worn~~ Mod (2)	~~Crushed shells (Y/N)~~ Heavily worn	Notes/observations
Mucket	~~||||~~ |||			||	~~||||~~ ~~||||~~ ~~||||~~ ||	|	
Slipper shell						~~||||~~	
Elktoe					~~||||~~ ~~||||~~ |	~~||||~~ ~~||||~~	broken shell on some
Strange floater			||	|	~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ || |	~~||||~~ |||	broken shells on some
Spike			||||	||||	~~||||~~ ~~||||~~ ||	||	broken shell on some
Wabash pigtoe				||	~~||||~~ ||	|	
Rainbow					|||	~~||||~~	
Fluted shell					~~||||~~	||	
Cylindrical papershell					|		
Creek heelsplitter					|		

Asian Clam

Survey Site (in consecutive order) Page _1_/__

MS-3 Transect 2

Surveyor(s): Matousek, Bodnar, Werner, Wilson, Corley, Grafton Date: 20 oct 2010

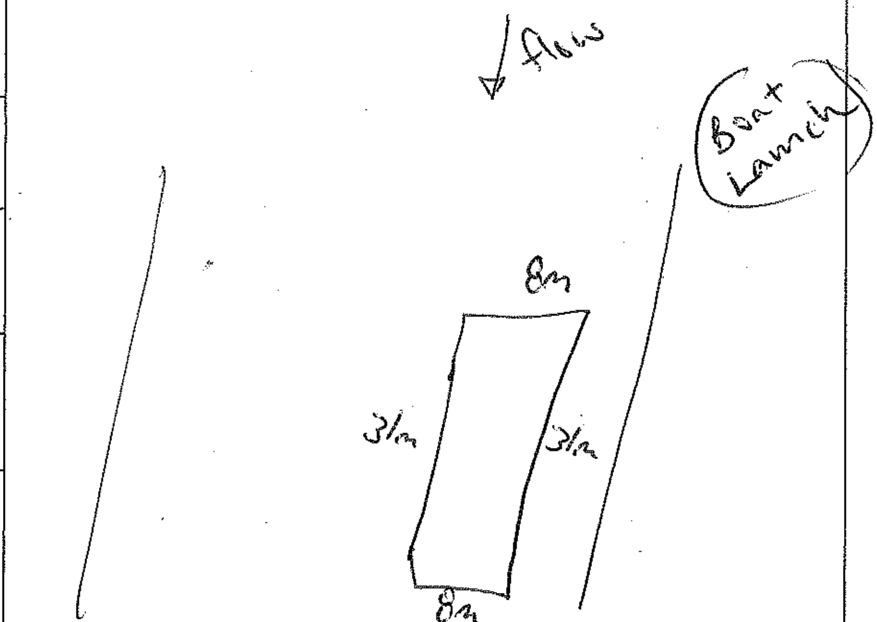
Enbridge Oil Spill Mussel Shell Survey – Mussel Survey Data

Habitat Information

Coordinates at downriver boundary: upriver boundary

Start N42.27657 W085.08723 end N42.27661 W085.08678

Survey Site Area Measurements

Dimensions	Est. length (m)	Draw shape (label sides and flow direction)
Side 1	8m	
Side 2	3/m	
Side 3	8m	
Side 4 (opt)	3/m	
Depth (1/10 meter)		

Proportion of substrate covered by shells

Coverage (check one)

< ~~1~~1%	1 to 5%	6 to 25%	26 to 50 %	51 – 75%	>75%
✓					

Shell piles: y/n

Notes:

Non-native species present (Y/N):

Asian Clams

Field Recorder: J. Matonah	Date: 21 oct 2010	Page 1/8

Enbridge Oil Spill Mussel Shell Survey Field Datasheet

Location Information

Sampling Segment: MS-4

Site Description/Landmarks/Access/Other Notes:

Started below mile marker 10.25 below boat launch @ 3.2

GPS Coordinates (decimal degrees to 5 decimal places)

Start location	End location
Latitude: N42.29591	Latitude: N42 29373
Longitude: W085.12777	Longitude: W 085.12421
Start Time: 09:30	End Time: 13:13

Weather Conditions: Sunny

Air Temperature: ~45 - 55° F

Personnel Present

Name - Affiliation	Name - Affiliation
John Matonah / Cardno Entrix	
Ryan Grafton / Cardno Entrix	
Bill Taft / DNRE	
Matt Wesener / DNRE	
Mike Wilson / DNRE	
Mike Carney / Stantec	

Photograph Documentation

Camera id/owner: GPS unit id/owner:

Photo #	Time	Photographer/Camera	Subject
1,2		Matonah / #1	GPS data/time
3,4			Boat Launch
5			Strange floater, Moderate 2
6			Mucket, Moderate 2
7			Elk toe, Heavy worn
8			Wabash pigtoe, Moderate 2
9			Pocket book, Heavy worn
10			Slippershell, Cracked
11			Spike / moderate 1
12			White heelsplitter, Recent
13			fluted shell / moderate 2
14			Creek heelsplitter / broken
15,16,17			Craw photos
18,19			Rainbow mottled slippershell
20			Cylindrical papershell

21,22 Mucket, cracked shell - Live

wide
19m X 10m

Survey Site	(in consecutive order)	Page 2/8
MS-4	Transect 1	

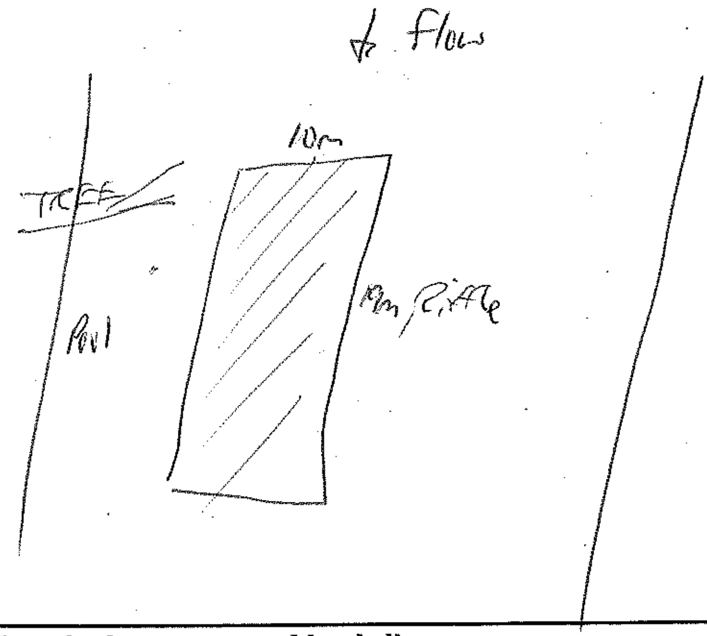
Surveyor(s):	Date:
Matusick, Wiseman, Taft, Carney, Bader, Wilson, Grother	21 oct 2010

Enbridge Oil Spill Mussel Shell Survey – Mussel Survey Data

Habitat Information

Coordinates at downriver boundary: MS4 TRNSTRT upstream boundary
N42.29591 W085.12740 N42.29600 W085.12704

Survey Site Area Measurements

Dimensions	Est. length (m)	Draw shape (label sides and flow direction)
Side 1	10m	
Side 2	19m	
Side 3	10m	
Side 4 (opt)	19m	
Depth (1/10 meter)		

Proportion of substrate covered by shells

Coverage (check one)

< 1%	1 to 5%	6 to 25%	26 to 50 %	51 – 75%	>75%
✓					

Shell piles: y/n

Notes:
Some cracked and Recent dead found in this area

Non-native species present (Y/N):
Asian Clams

Sampling Segment: MS-4 Transect 1							Page 3/8
Field Recorder: Matousek							Date: 21 Oct 2010

Shell and Mussel Observations (cont'd)

Species (G. species)	Live Mussel (check)	Shell Condition (check one) Fresh	Recent dead	Mod. worn (1)	~~Heavily worn~~ Mod (2)	~~Crushed shells (Y/N)~~ Heavy	Notes/observations
Mucket	/		卌 ||	||||	卌 卌	/	some cracked/broken shells
					卌 卌		additional mod (2)
					卌 卌		/
					卌 卌		
Wabash pigtoe	/		/	|||	||||		
Fluted shell					||||		
Elk toe					/	/	
Spike	/				|||	/	
Creek heelsplitter				/			
Slipper shell					/		
Strange floater			/				

Survey Site (in consecutive order) Page 4/8

MS-4 Transect 2

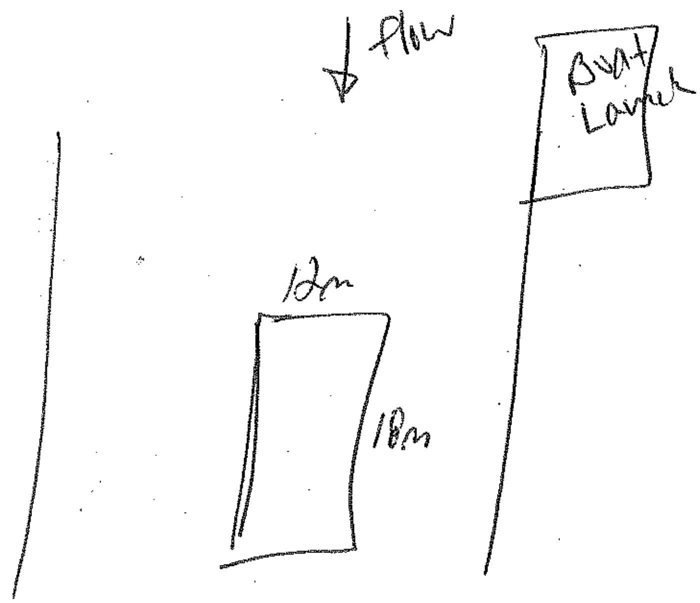
Surveyor(s): Matosik, Weser, Taft, Grafton, Corey, Wilson, Badra Date: 21-Oct-2010

Enbridge Oil Spill Mussel Shell Survey – Mussel Survey Data

Habitat Information

Coordinates at downriver boundary: N42.29390 W085.12488 upstream boundary N42.29370 W085.12486

Survey Site Area Measurements

Dimensions	Est. length (m)	Draw shape (label sides and flow direction)
Side 1	12m	
Side 2	18m	
Side 3	12m	
Side 4 (opt)	18m	
Depth (1/10 meter)		

Proportion of substrate covered by shells

Coverage (check one)

>1%	1 to 5%	6 to 25%	26 to 50 %	51 – 75%	>75%
	<1%				

Shell piles: y/n

Notes:
Many shell pieces, recent dead, and shell fragments - Heavy Boat traffic through this area

Non-native species present (Y/N):
Asian Clams

Sampling Segment: MS-4 Transect 2							Page 57 8
Field Recorder:							Date: 21 oct 2010

Shell and Mussel Observations (cont'd)

Species (G. species)	Live Mussel (check)	Shell Condition (check one): Fresh	Recent dead	Mod. worn (1)	~~Heavily worn~~ Mod (2)	~~Crushed shells (Y/N)~~ Heavy	Notes/observations
Mucket	卌 卌		III	IIII	卌 卌		broken shells/cracked 卌 卌卌 IIII
	II				卌 卌		
					卌 卌		Cracked-Live I (photo taken)
					卌 卌		
					卌 卌		additional mod(2)
					卌 卌		卌 卌 卌 卌 卌 卌 卌 卌 卌 卌
					卌 卌		IIII
fluted					II		
Wabash pigtoe	II		III		卌		broken shells/cracked I
Spike					I	II	
Cylindrical papershell					I		
Pocketbook					I		
Elktoe				I	IIII	III	
Rainbow						I	

Asian Clam

Field Recorder: J. Matousek	Date: 21 oct 2010	Page 6 of 8

Enbridge Oil Spill Mussel Shell Survey Field Datasheet

Location Information

Sampling Segment: MS-1

Site Description/Landmarks/Access/Other Notes:

Reference location just downstream of Marshall impoundment
Set up a transect for reference to spill area transects

MS1 TRN1STRT wypt.

GPS Coordinates (decimal degrees to 5 decimal places)

Start location	End location
Latitude: N42.26305	Latitude: N42.26284
Longitude: W084.95710	Longitude: W084.95668
Start Time: 15:53	End Time: 17:00

Weather Conditions: Partly cloudy

Air Temperature: 50°F

Personnel Present

Name - Affiliation	Name - Affiliation
John Matousek - Cardno Entrix	
Mike Carney - Stratus	
Matt Wesener - DNRE	
Bill Taft - DNRE	
Mike Walker - DNRE	
Pete Badra - MNFI	
Ryan Grafton - Cardno Entrix	

Photograph Documentation

Camera id/owner: GPS unit id/owner:

Photo #	Time	Photographer/Camera	Subject
1			Reference area Transect 1

Survey Site	(in consecutive order)	Page 7/8
MS1 Transect 1		

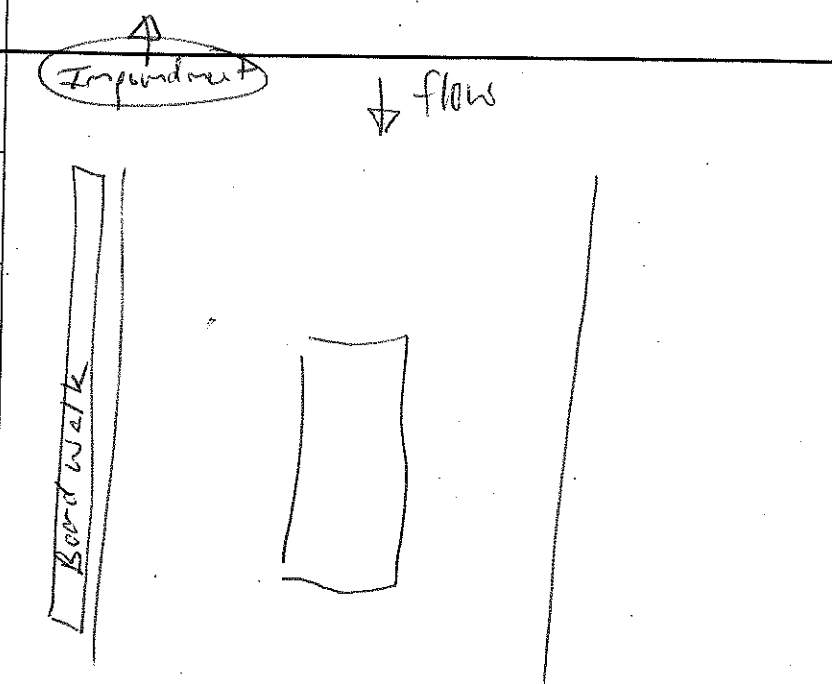
Surveyor(s):	Date:
Toft, Wesener, Matousek, Craney, Graham, Bodm, Wilson	21 Oct 2010

Enbridge Oil Spill Mussel Shell Survey – Mussel Survey Data

Habitat Information

Coordinates at downriver boundary:
N 42 26305 W084.95710 upstream boundary N 42.26284 W084.95668

Survey Site Area Measurements

Dimensions	Est. length (m)	Draw shape (label sides and flow direction)
Side 1	7m	
Side 2	19m	
Side 3	7m	
Side 4 (opt)	19m	
Depth (1/10 meter)		

Proportion of substrate covered by shells

Coverage (check one)

>1%	1 to 5%	6 to 25%	26 to 50 %	51 – 75%	>75%

Shell piles: y/n

Notes:
Reference Area

Non-native species present (Y/N):
Asian Clams

19m x 7m

Sampling Segment: MS-1 Transect 1							Page 8/8
Field Recorder: Matousek							Date: 21Oct2010

Shell and Mussel Observations (cont'd)

		Shell Condition (check one)					
Species (G. species)	Live Mussel (check)	Fresh	Recent dead	Mod. worn (1)	~~Heavily worn~~ Mod(2)	~~Crushed shells (Y/N)~~ Heavy	Notes/observations
fluted shell					卌 卌 卌 卌 卌 卌	卌 卌 卌 ||||	
Pocketbook	|				卌 卌 卌 卌 卌 卌 卌 卌 卌	卌 卌 |	crushed shell ||||
Spike					卌 卌 卌 卌 卌 |||	卌 |||	crushed shell |||
Wabash pigtoe					卌 卌 卌 卌 卌	卌 卌 卌 |	crushed shell 卌 |
Strange floater					卌 ||	||||	
Rainbow					||	|	
Elktoe					卌	||	crushed shell |
fat Mucket					|||		
Ellipse					卌 |		

Heavy Mud and algae on all shells found

10/25/10 JM

Field Recorder: Matousek	Date: ~~10/26/10~~ 10/25/10	Page 1

Enbridge Oil Spill Mussel Shell Survey Field Datasheet

Location Information

Sampling Segment: MJ-5

Site Description/Landmarks/Access/Other Notes:

Kenosha + Forda intersection Boat launch at ~~Riverside~~ Riverside

GPS Coordinates (decimal degrees to 5 decimal places)

Start location	End location
Latitude: N42.30768	Latitude: N42.30119
Longitude: W085.19924	Longitude: W085.18023
Start Time: 10:00	End Time: 12:30

Weather Conditions: ~60° Partly Cloudy

Air Temperature: ~60°

Personnel Present

Name - Affiliation	Name - Affiliation
Matt Wesener DNRE	
Mike Waltehouse DNRE	
Bill Taft DNRE	
Mike Wilson - DNRE	
John Matousek - ENTRIX	
Pete Badra - MNFI	

Photograph Documentation

Camera id/owner: GPS unit id/owner:

Photo #	Time	Photographer/Camera	Subject
1423			GPS time date
4			Paper pondshell mod 2
5			White heelsplitter mod 2
6			Slipper shell mod 2
7			Wabash pigtoe mod 2
8			Muckets - mod 2
9			Fluted shell - mod 2
10			Pocketbook - mod 2
11			Spike - mod 2
12			Elktoe - mod 2
13			Rainbow - mod 2
14			Strange floater - mod 2
15			Round pigtoe

No transect conducted at MJ-5 due to lack of recent Dead shells, High siltation, and Water depth

C. Field Notebooks

 MC | Oct. 18 2010 / Marshall Imp. River Front park

- Arrived @ site around 9:00 am for the group safety meeting and go over the plan

- Started @ bridge approx 1/4 of a mile from the proposed downstream end of the sampling segment (water below bridge was fast and deep) - Also developed potential private property issues if we would have had to portage

- access river from the apartment parking lot and walked upriver

- finished with site around 3:30 @ the park

- saw less live mussels than when conducting the mussel tissue survey

MC | Oct 18 2010 / Marshall, MI

- Site MS-2 Recon

- Boat ramp and decon areas are closed and posted as such

- no way to launch a boat there might be hard to park there as well

- Directions to community park

~~1~~5 mile Rd ~~R~~ R on A Drive North
R on River Park Drive

L on Squaw Creek Rd

immediately R onto gravel Rd.
@ Light / Pwr pole

MC / Oct 19, 2010 / Marshall MI

- mussel survey site MS-02
  Down River of 15 Mile Rd Bridge
- good visibility / low turbidity
- some response / clean up work
  occurring around islands
  replacing absorbent boom
- little ~~boat~~ traffic
- conducted survey for most
  of sampling segment
- ended @ C-1 boat ramp
- seemed like there was a lot of
  siltation around boat ramp
- oil sheen obs. when walking
  through sediments around boat ramp
- live mussels observed in deeper runs
  in middle of sampling segment

MC / Oct 20, 2010 / Marshall MI

- mussel survey site - MS-03
- walked along trail downriver
  to start of sampling segment
- noticed that there where a lot
  of mussel shells in the same
  condition between ~~fresh~~ recent and
  moderate at start of segment
  lots of live mussels also obs.
  at start of survey segment
- turbidity was high throughout
  most of the day but could
  still see the bottom for most
  of the segment.
- obs. shell piles near areas with
  live mussels, obviously from an
  animal, bite marks on edge of shells

MC / Oct 21 2010 / Watkins Park MI

- Boat ramp c3 2, sampling site MS-04
- walked downriver to start of sampling segment and decided to extend site downriver another ~100 meters to include a shallow riffle
- cracked shells obs. in and around shallow riffle in areas w/ lighter substrate, lighter substrate looked like it was an artifact of boats bottoming out, actually saw a boat bottom out and power through the riffle
- live mussels obs. on top of substrate in boat scraped substrate, some live mussels had scratched shells

MC / Oct 21 2010 / Site MS-04

- lots of boat traffic - almost to the point where it was unsafe to be in river, had to move out of the channel when we heard them coming.
- ~~not~~ high turbidity throughout the day especially when the boats would go by
- large shallow area just downriver of boat launch had alot of crushed mussel shells, scratched live mussels and displaced live mussels
- upriver of boat ramp there was lots of silt on substrate, ended survey just upriver of boat ramp

10/18/10

Mussel shell survey @ River front park
MNFI, ENTRIX, stratus, DNRE
participating in survey ~ 9:30 start time
Safety paperwork completed for
ENTRIX and Enbridge
Walked downstream to put in @
17mile bridge to walk upstream
to begin survey.
Asian Clams seen
Little mussel List Between (17mile st-rt)

~~Pocket Book~~		Shell	Live
Pocketbook	~~||||~~	✓	1 ✓
Wabash pig toe	|||	✓	
Eastern pond mussel			✓	
Fluted shell			1 ✓
Spike		✓	✓
Rainbow		✓	
Elktoe		✓	
Cylindrical papershell		✓	
Slipper shell		✓	
Elipse			✓
Giant floater		✓	
Strange floater		✓	
Creek heelsplitter		✓	✓

Stop for lunch 12:40
Return to River @ 13:40 pm
Same crew from morning, Put back into River at same spot as took out. 5 people using viewers or clear bottom buckets. J. Matousek taking notes and photos. A few deeper spots avoided due to depth of water.
No more than 20 m of complete River avoided Left or Right bank necessary to avoid due to water depth throughout entire reach.

	Live	Shell
Mucket		✓
Roundpigtoe		✓

Pocketbook observed displaying lure Gills with larvae.
Crew worked up to small island just downstream of impoundment
End time 15:33

JCB

19 oct 2010

Mussel Shell survey
Location MS2
ENTRIX, DNRE, MNFI, Stratus participating in survey
MS-02 strt
N 42.25925 W 085.01009

Species List

	Live	Shell
Strange floater		✓
Rainbow		✓
Asian Clam		✓
Spike	✓	✓
Pocketbook	✓	✓
Creek heelsplitter	✓	✓
Elktoe		✓
Fluted shell		✓
Wabash pigtoe	✓	✓
Round pigtoe (?)		✓
Ellipse		✓
White heelsplitter	✓	
Mucket		✓
Slipper shell		✓
Fat Mucket	✓	
Cylindrical papershell		✓

"Rite in the Rain"

Some Recent dead found near 3 Mi marker. Some crushed shell as well but difficult to determine how old crushed top shells are. Looks like old shell that maybe got stepped on by cleaning crew - may have broken due to older condition of shell.

A single Recent dead Rainbow found at waypt. Recentrainbow
N 42.25968 W 085.00858

A single recent dead pocketbook found at waypt. Recentpocket
N 42° 25954 W 085.00601
- photo taken

A single spike found at waypt. Recentspike
N 42.25940 W085.00508 (Mile post 2.75)
- photo taken
- at same point, broken shell pocketbook found - photo taken
- another pocketbook w/ broken shell collected here - photo taken
- another recent dead spike here photo taken

A recent dead pocketbook w/ broken shell found at waypt. Recentpocbook
N 42.025848 W 085.00513
- photo taken

Stopped for lunch break @ 13:40
Returned to River @ 14:40
Crew worked upstream from park searching for recent/fresh dead shells upstream travel fairly quick, scanning for shells

Deposit of recent dead shells found Decision made that likely due to animal feeding and deposit of shells photo taken next to log that shells are near. Confirmed sighting of a mink by landowner next to the shell deposit area.

Fresh dead pocketbook found at waypt. FRESHPOCKET
N 42.25790 W 085.00304
no damage evident to shell flesh contained in shell pic taken

"Rite in the Rain"

Some broken shells found at
Broken shells (waypt.)
N 42.25825 W 085.00249
fluted shell, spike, + Rainbow
pic. taken
Several live pocketbooks found
in this area
Scattered broken shells in this
Area likely due to high foot/boat
traffic to this area. Concentrated
to shallow riffle areas
Live muskrat seen near bank
waypt "Brokespikes"
N 42.22579 W 085.00167
pic taken just downstream of
mile marker 2.5
A few recent dead shells and cracked
shells found along side, but agreed
that many fewer than expected
were seen
Stopped survey @ boat launch at
15 mile Road crossing
N 42.25864 W 084.99898
Recent dead pocketbook found at wypt.
"Recentpock" N 42.25866 W 084.99890
Recent dead spike found at wypt "Recspike"
N 42.25895 W 084.99899

20 Oct 2010

MS-3
DNRE, Status, MNFI, ENTRIX on
crew. Parked at 11 mile road bridge
traveled downstream to begin survey
Decided to add category to the
moderately worn designation

moderate 1
- hinge intact
- marl not covering lower portion
- light algae ~~—~~ ~~note~~ on inside of shell

moderate 2
- hinge intact or not intact
- marl can be covering entire shell
- heavy algae or sedimentation on inside

Will be noted during a delineated
section survey and on photos

Species List	Live	Shell
Mucket	✓	✓
Elktoe		✓
Spike		✓
White heelsplitter	✓	✓
Wabash pigtoe	✓	✓
fluted shell		✓
Strange floater		✓

"Rite in the Rain"

Cont. Species List	Live	Shell
Asian Clams		✓
Pocketbook	✓	✓
Rainbow		✓
Creek heelsplitter		✓
Slipper shell		✓
Cylindrical papershell		✓

Large quantity of Mucket shell and fluted shells in this area along with Live muckets.
Site delineated for survey just upstream of mile marker ~~2~~ 7.75
Start point waypt. (MS3 TRAN1STRT)
N 42.27737 W 085.09080
Large Concentration of Live mussels upstream of transect 1 at point
N 42.27723 W085.08967
also shell fragments in area and recent dead
A few recent dead and cracked shells at
N 42.27673 W 085.08885

More recent shells found at
N 42.27.683 W 085.08839
this is the area below the main boat launch at
Reduced number of recent dead and broken shells noted at
N 42.27670 W085.08770
Stopped for lunch @ 12:45
Returned to river at 13:45
Decision made to do another transect just downstream of the boat launch near mile marker 7.5
labeled as MS-3 transect 2
Start (downstream)
N 42.27657 W 085.08723
End (upstream)
N 42.27661 W085.08678
Periodic ~~p~~ turbidity noticed during survey, perhaps due to upstream dredging or boat traffic
Deposit of Recent to Moderate shells found at N42.27599 W 085.08549
probable animal deposit and then covered in sediment. Shells appear to be recent but this likely due to the

sediment they were trapped in. These shells were likely uncovered by boat traffic ad wave action. Photo taken. No damage to shells evident, Look to be in good condition but were contained in sediment. River visibility much less than earlier mainly due to turbidity increase.

Significant amount of Live Muckets noted below bridge @ 11 mile crossing @ N42.27443 W085.08154

Oil sheen noticed when walking through soft sediment. Completed Survey @ 11 mile bride 16:30

ILB

JJH 21Oct2010

09:30 21 oct 2010

Start Point at boat launch at 3-2 @ N42.29296 W085.12425 Walked downstream to area below mile marker 10.25 to riffle observed to have shell available. Start point of survey @ "MS4 STRT" N 42.29591 W 085.12777

Species List	Live	Shell
Mucket	✓	✓
Strange floater		✓
~~Mucket~~ Elktoe		✓
Slipper shell		✓
Asian Clam		✓
Spike	✓	✓
Wabash pigtoe	✓	✓
Pocketbook		✓
White heelsplitter		✓
Fluted shell		✓
Cylindrical papershell		✓

Some Recent and broken shells
in riffle at N42.29581 W08512732
Started trasect 1 @ "MS4TRNSTRT"
N42.29.591 W085.12740 (bottom)
Area chosen due to observation of
recent dead shells and cracked shells at
riffle location.
MS4 TRNEND N42.29600 W085.12704
19m x 10m trasect
Some broken shells @ N42.29608 W085.12664

Recent dead found @ N42.29617 W085.12585
Mucket, wabash pigtoe, found in a
Limited area ~ 2-3m²
Slipper shell heavy worn @
N42.29624 W085.12448
Some Mucket (1) / Recent dead
found at
N42.29573 W085.12447
Mucket (2), wabash pigtoe
Also some broken shell observed
Significant amount of Live shells
at N42.29464 W085.12544
from this pt. to the boat launch
several Recent dead, cracked, broken
shell + pieces observed more than through
the rest of the reach

MS-4 transect 2 started just
downstream of boat launch @ mile
Marker 10.0
Stop for lunch @ 12:50 returned
to River @ 1:50
Completed count of Transect 2
mussels collected.
Good population of Live mussels
observed directly across from boat
launch @ N42.29373 W085.12421
Some animal shell deposits observed
upstream of boat launch
Significant amount of turbidity due to
boat traffic.
Decision made to survey up to mile
marker 9.75 and terminate survey
due to turbidity + reduced visibility
Also high boat traffic a safety concern
Left MS-4 @ 15:15 to travel
to Reference area to complete a
transect there
MS-1 Transect 1 completed @
N42.26385 W084.95710 (start)
N42.26384 W084.95668 (end)
end time ~17:00

"Rite in the Rain"

10/25/10 Site MS-5
intersection of Kenosha + Ford Boat launch at area We will be using the MNFI Boat at this location. ENTRIX, MNFI, DNRE present for this location. Stratus unable to attend.
Launched boat @ 09:30. Traveled downstream to begin survey just downstream of Mile marker 15.25. Water too deep to wade, looked for boat while traveling upstream. Booms blocking downstream travel past mile 15.25
Exited boat @ "MS-5 STRT"
N42.30768 W085.18924
Water temp 56°F

Species	Live	Shell
Paper pondshell		✓
White heelsplitter		✓
Slippershells		✓
Mucket		✓
Spike	✓	✓
Wabash pigtoe	✓	✓
fluted shell		✓
Pocketbook		✓

Heavy fresh siltation. Difficult to see shells, likely buried in slower areas
Animal midden found at
N 42.30683 W 085.18854

Continued

Species	Life	Shell
Elktoe		✓
Rainbow		✓
Strange floater		✓
Asian Clam		✓
Round pigtoe		✓

Traveled by boat and walking through lower ½ of Reach. Several deep areas that had to be avoided due to water depth and Limited visibility. Some air boat traffic causing some turbidity issues
Large Animal deposit found all around area N42.30583 W085.18172
Almost all Muckets with a few Wabash pigtoe and spikes. Most are Moderately worn (2) with an occasional Mod. (1)

Rite in the Rain

End of transect is at mile marker 14.25 @ N42.30119 W085.18023
Water become very turbid at 12:00 visibility very poor.
No Recent dead shells found to trigger conducting a transect. Also deep water and siltation a factor limiting success of a survey.
End time 12:30

"Rite in the Rain"

Appendix J: Summary of Public Comments and Trustee Responses

Appendix J: Summary of Public Comments and Trustee Responses

This appendix summarizes the written and verbal public comments by topic and provides the response of the Trustees to each issue. A copy of the written public comments is provided in Appendix K.

Support for Proposed Projects

One commenter noted that the recommended project ideas are all worthy projects that will ultimately improve the Kalamazoo River and its surrounding communities. None of the commenters expressed any concerns with the proposed preferred projects.

> *Trustee Response:*
> The Trustees appreciate the positive comment and have selected all of the proposed preferred projects that were described in the Draft DARP/EA.

Battle Creek Concrete Channel Restoration

One commenter urged the Trustees to include the removal of the channelized portion of the Kalamazoo River within the City of Battle Creek in this NRDA process as well as for an NRDA that is currently being conducted for the Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site that is downstream of the portion of the Kalamazoo River that was impacted by the discharges of oil from the Enbridge Line 6B. This latter NRDA is referred to as the PCB NRDA in the comment. The commenter suggested that funding from the Enbridge NRDA settlement be used to fund a full hydrology study of the system and that the PCB NRDA could be used toward removal of the concrete channel. This commenter described the project in some detail in an attachment to her comment. An additional 33 commenters expressed support for this comment.

> *Trustee Response:*
> The Trustees have carefully reviewed this proposed project and have expanded their description of this project in the Final DARP/EA (Section 4.9.1). The Trustees agree that this project could provide significant benefits to natural resources in-stream and along a restored riparian corridor, if feasible, and have shared this suggestion and the information provided with the Trustees for the PCB NRDA. Because the Trustees can provide benefits to natural resources to compensate for the losses through the other proposed preferred projects at a lower cost, the Trustees did not select the Battle Creek concrete channel restoration project at this time.

Additional Restoration Suggestions

In addition to supporting the Battle Creek concrete channel restoration, one commenter suggested additional ideas for locations where land could be purchased to expand or create riparian parks and where paddling park features could be added in the Battle Creek area, including removing a low head dam at the Washington Ave Bridge and replacing it with a white water paddling feature.

> *Trustee Response:*

By accepting as restoration the creation and expansion of riparian parks that Enbridge has already completed, the Trustees believe that the public has been fully compensated for interim recreational lost use of natural resources.

Proposed Penalties

One commenter stated that the proposed penalties for Enbridge were “grossly insufficient”.

Trustee Response:

NRDA is a compensatory process, not punitive. Penalties for Enbridge are being addressed under different authorities.

Appendix K: Compilation of Public Comments Received on Draft Damage Assessment and Restoration Plan / Environmental Assessment

Enbridge NRDA: Public Comments on Draft DARP/EA

Compiled by Lisa L. Williams, USFWS
July 28, 2015

Comment #1
From: Daniel Burton <dtburton15@gmail.com>
Date: Wed, Jun 17, 2015 at 8:50 PM
Subject: Enbridge NRDA Comment
To: kzoorivernrda@fws.gov

I would like to provide a few comments with regard to the Enbridge NRDA. I think the list of recommended improvement project ideas are all worthy projects and will ultimately improve the Kalamazoo River and its surrounding communities. I also agree for the most part with the assessment for improvements of the concrete channel in Battle Creek. This nearly mile long channel significantly impacts the rivers aesthetic quality, its recreational value as well as its overall health.Removal is not a likely option due to flooding concerns, yet I would like to suggest a study to route the river to the east side of the city moving the confluence with the Battle Creek River just above the downtown area. The design of the new river should allow for the river to be diverted into the current concrete channel during high flow events to avoid flooding, yet allow the river to flow more naturally during normal flows. The ecological and aesthetic value to the new river flow are obvious, and I believe there would also be economical value by combining the Kalamazoo and Battle Creek Rivers before the downtown area. The combined flows could allow the downtown area of the Battle Creek River to be developed into a paddlers park. I am not proposing a whitewater park, but instead a beginner to intermediate place to learn the basics of paddling in moving water (eddies, ferries, turning, stopping, etc). Where a family could take the kids to develop safe paddling skills before heading off into more remote and unknown rivers where accidents can be more dangerous. A place where paddlers new to the sport or coaches looking for a venue to teach beginners to paddle could go to improve their skills. Downtown Battle Creek could benefit economically from such development.

In addition to that larger idea, I would like to toss out a couple more:
- purchase the forested property next to Paddlers Grove to expand this park while protecting more undeveloped riparian
- purchase the riparian land on the south side of the Battle Creek River between Washington Ave and the Kalamazoo River confluence. Remove the empty buildings and convert into Confluence Park. Remove the current unsafe low head dam at the Washington Ave Bridge and replace with a white water feature with access using the confluence park. In addition, add a few whitewater features on the last 100 feet of the concrete channel on the Kalamazoo River at the confluence to again provide whitewater paddling to the area. These improvements will add economical and recreational value to the river.

Thanks for your efforts to improve the Kalamazoo River and its watershed.

Dan Burton

Comment #2
From: Christine Kosmowski <ckosmowski@calhouncountymi.gov>
Date: Wed, Jul 22, 2015 at 4:50 PM

Subject: Enbridge NRDA Comment
To: "kzoorivernrda@fws.gov" <kzoorivernrda@fws.gov>
Cc: "John Macfarlane (jmacfarlane@mumfordlaw.com)" <jmacfarlane@mumfordlaw.com>

Hello, Lisa:

I am writing to urge the inclusion of the removal of the channelized portion of the Kalamazoo River within the City of Battle Creek for the Enbridge NRDA and the PCB NRDA. I suggest that monies from the Enbridge NRDA be used to fund a full hydrology study of the system and that PCB NRDA monies be applied towards the removal of the concrete. The reasons for the suggestion are outlined in the attached document. In general, however, the removal of the concrete channel will help create better aquatic habitat, improve water quality, and will help reconnect the community to this valuable water resource after having been disconnected from it for over 50 years.

Thank you for your consideration.

Sincerely,
Christine Kosmowski
Water Resources Commissioner
Calhoun County
315 W. Green Street
Marshall, MI 49068
T: 269-781-0790
C: 269-317-4000
E: ckosmowski@calhouncountymi.gov

Attachment – NRDA_Concrete_Channel.pdf

Restoration of the Channelized Portion of the Kalamazoo River in Battle Creek, Michigan

Project Description

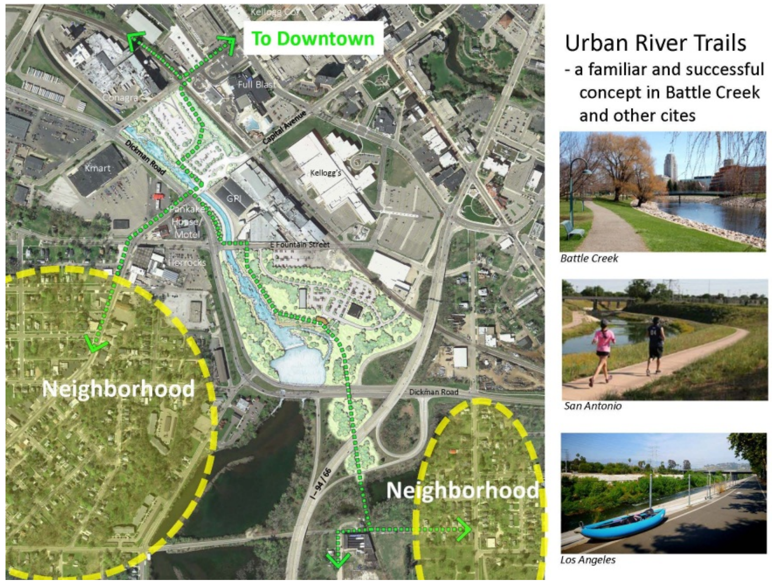
The Kalamazoo River in downtown Battle Creek, Michigan was channelized with concrete by the United States Army Corp of Engineers (USACE) approximately fifty years ago for flood control. The channelization eliminates the potential for spawning, resting and feeding areas for a broad variety of fish, amphibians, plant life and other terrestrial organisms and thus acts as a deterrent to the establishment wildlife. In addition, the riparian buffer has been removed which has caused the water temperature to increase above the tolerance of some fish species. This segment of the Kalamazoo River is also inaccessible to the public for recreational purposes, affords poor water quality and has a very poor aesthetic character.

Restoration Objectives

This project is intended to provide compensatory restoration for the in-stream habitats and aquatic natural resources (like mussels and fish) that were injured as a result of the Enbridge Line 6B oil discharges by increasing the aquatic functions and values directly in the Kalamazoo River.

The proposed project is the modification of approximately 4,000 linear feet of concrete channel and the restoration of the channel to a natural setting by adding pools and riffles, a riparian buffer, and a fish passage at the dam upstream of the channel.

The proposed project includes creation of naturally landscaped park space along the river banks, together with a non-motorized pathway, in order to allow for access to and recreational use of the river.

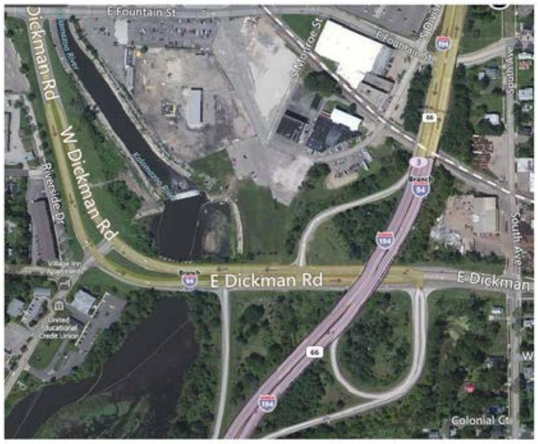


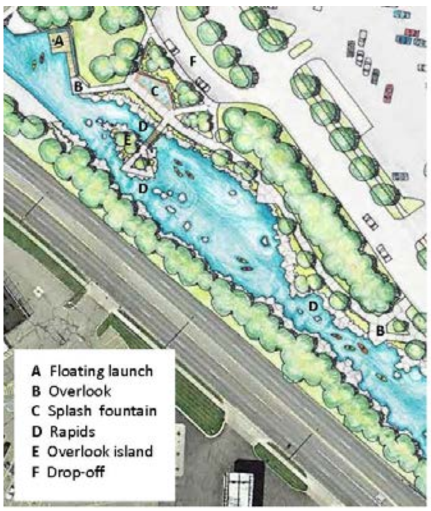
Probability of Success and Monitoring
Removing the concrete armor along the stretch of the Kalamazoo River within the city limits of Battle Creek, Michigan, will be highly successful in restoring aquatic habitat, native riparian plant communities, fish migration and spawning areas. It will also improve water quality. The biggest barriers to the success of the project are the cost to remove the concrete, property acquisition, and the removal of contaminated sediment from a brownfield site adjacent to the river. A full hydrology study is also needed to adequately determine the engineering design.

The United States Army Corps of Engineers (USACE) developed a pre-feasibility model and rejected the removal of the channel. However, the model was based on limited data. Per the USACE report, "the accuracy and precision of the hydraulic model is uncertain and the output is only an approximation at best." Therefore, a complete hydraulic model should be funded to be able to fully determine the feasibility of removing the channel. The Kalamazoo River Watershed Council supports the funding of such a study.

Environmental and Socio-Economic Impacts
No long-term adverse environmental or socio-economic impacts are expected from this project. In fact, positive benefits are expected. The project will have the added bonus of reconnecting the community to this water source that has been inaccessible for the past 50 years. The project ties in nicely with two recent statewide initiatives: *Michigan Blue Economy* and *Sustaining Michigan's Water Heritage* (Water Strategy). Both emphasize the importance of water and Placemaking for communities. The Water Strategy, for example, stresses the importance of protecting and restoring aquatic ecosystems and creating vibrant waterfronts and areas for water-based recreation.

Mill Pond Site






Cherry Creek, Denver


LA River, Los Angeles

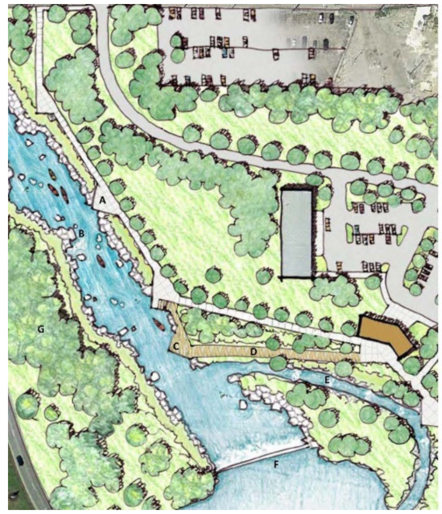
Adaptive Kayak Launch


Newly constructed launch on the Detroit River at Bishop Park in Wyandotte

Floating platform with hinged approach will be required due to fluctuating river elevation.

Platform is equipped with electronic lift powered by solar voltaic cells.

Confluence Park, where Cherry Creek meets the South Platte River, Denver



Natural fish by-pass, Williamston, MI

Rouge River, Detroit

Cost
$30 to $50M for the full restoration. $100K to $300K is anticipated for a full hydrology study of the system. This project is expected to be a partnership among the City of Battle Creek, Battle Creek Whitewater, Inc., the Battle Creek Community Foundation, the Calhoun County Water Resources Commissioner, and other community organizations.

Evaluation
The stretch of the channelized section of the Kalamazoo River was directly impacted by the Enbridge Line 6B Oil Discharges from July 2010. The oil from the discharge flowed completely through this community of 53,000. One of the larger areas of submerged oil that resulted from the event is just upstream of the channel in the area known as the Mill Ponds. Submerged oil remains there and will need to be monitored for many years to come.

This project will have negative short-term impacts to natural resources, but will have overall long-term positive environmental impacts by restoring aquatic habitat, native riparian plant communities, fish migration and spawning areas, and improving water quality

Comment #3
From: John Macfarlane <jmacfarlane@mumfordlaw.com>
Date: Fri, Jul 24, 2015 at 11:59 AM
Subject: Enbridge NRDA comment
To: "kzoorivernrda@fws.gov" <kzoorivernrda@fws.gov>
Cc: "Christine Kosmowski (ckosmowski@calhouncountymi.gov)" <ckosmowski@calhouncountymi.gov>, "Larry Rizor (architects.inc@prodigy.net)" <architects.inc@prodigy.net>

Dear Dr. Williams, I am writing on behalf of Battle Creek Whitewater, Inc. in support of the comments submitted by Christine Kosmowski, Calhoun County Water Resources Commissioner, regarding the removal of the concrete channel within the Kalamazoo River in the City of Battle Creek. Battle Creek Whitewater, Inc. is a nonprofit foundation established for the purpose of promoting the restoration of the Kalamazoo River within the City of Battle Creek to a more natural waterway, as well as to promote the creation and operation of a public park along and within the Kalamazoo River. The portion of the Kalamazoo River that is encased in a concrete channel as it flows through the City of Battle Creek is a blight on the landscape and a deterrent to any type of recreational use of the river. The removal of the concrete channel will help create better aquatic habitat, improve water quality, and will help reconnect the community to this valuable water resource. Please consider funding a hydrology study to evaluate the feasibility of removing of this unsightly concrete channel, or at least a portion of the channel, under the DARP or the NRDA PCB process. Thank you.

John H. Macfarlane
On behalf of Battle Creek Whitewater, Inc.
68 E. Michigan Ave.
Battle Creek, MI 49017
ph. 269-968-6146
fax 269-968-1147
jmacfarlane@mumfordlaw.com
www.westmichiganlawyers.com

Comment #4
From: Conor Macfarlane <csm@3eyetech.com>
Date: Fri, Jul 24, 2015 at 3:48 PM
Subject: Enbridge NRDA Comment
To: "kzoorivernrda@fws.gov" <kzoorivernrda@fws.gov>

Dear Dr. Williams,

I am writing in support of the comments submitted by Christine Kosmowski, Calhoun County Water Resources Commissioner, regarding the removal of the concrete channel within the Kalamazoo River in the City of Battle Creek. The removal of the concrete channel will help create better aquatic habitat, improve water quality, and will help reconnect the community to this valuable water resource.

As a local business owner, I am particularly interested in relocating my growing company headquarters to downtown Battle Creek along a renovated and more aesthetically pleasing river.

Please consider funding the removal of this unsightly concrete channel, or at least a portion of the channel, under the DARP or the NRDA PCB process.

Thank you.

Conor Macfarlane
President & CEO
3Eye Technologies
csm@3eyetech.com
O 269.841.5064
C 773.301.5537

Comment #5
From: Brian Turk <bturk@3eyetech.com>
Date: Fri, Jul 24, 2015 at 4:01 PM
Subject: Enbridge NRDA Comment
To: "kzoorivernrda@fws.gov" <kzoorivernrda@fws.gov>

I am writing in support of the comments submitted by Christine Kosmowski, Calhoun County Water Resources Commissioner, regarding the removal of the concrete channel within the Kalamazoo River in the City of Battle Creek.

The removal of the concrete channel will help create better aquatic habitat, improve water quality, and will help reconnect the community to this valuable water resource.

Please consider funding the removal of this unsightly concrete channel, or at least a portion of the channel, under the DARP or the NRDA PCB process. Thank you.

Comment #6
From: Mandi Weiss <mandi@3eyetech.com>
Date: Fri, Jul 24, 2015 at 4:02 PM
Subject: Enbridge NRDA Comment
To: "kzoorivernrda@fws.gov" <kzoorivernrda@fws.gov>

Dr. Williams-

I am writing in support of the comments submitted by Christine Kosmowski, Calhoun County Water Resources Commissioner, regarding the removal of the concrete channel within the Kalamazoo River in the City of Battle Creek.
The removal of the concrete channel will help create better aquatic habitat, improve water quality, and will help reconnect the community to this valuable water resource.
Please consider funding the removal of this unsightly concrete channel, or at least a portion of the channel, under the DARP or the NRDA PCB process.

Thank you.

Mandi Weiss
3Eye Technologies
Corporate Account Manager
312-241-1482 (office)
269-753-2995 (cell)

Comment #7
From: Patrick McClure <patrick@3eyetech.com>
Date: Fri, Jul 24, 2015 at 4:05 PM
Subject: Enbridge NRDA Comment
To: "kzoorivernrda@fws.gov" <kzoorivernrda@fws.gov>

Dr. Williams,

I am writing in support of the comments submitted by Christine Kosmowski, Calhoun County Water Resources Commissioner, regarding the removal of the concrete channel within the Kalamazoo River in the City of Battle Creek.

The removal of the concrete channel will help create better aquatic habitat, improve water quality, and will help reconnect the community to this valuable water resource.

Please consider funding the removal of this unsightly concrete channel, or at least a portion of the channel, under the DARP or the NRDA PCB process. Thank you.

Thanks,

Patrick McClure
3Eye Technologies
Operations Coordinator
269-841-5298 (office)
269-377-3250 (cell)
patrick@3eyetech.com

Comment #8
From: Dominick Reed <dreed@3eyetech.com>
Date: Fri, Jul 24, 2015 at 4:06 PM
Subject: Enbridge NRDA Comment
To: "kzoorivernrda@fws.gov" <kzoorivernrda@fws.gov>

I am writing in support of the comments submitted by Christine Kosmowski, Calhoun County Water Resources Commissioner, regarding the removal of the concrete channel within the Kalamazoo River in the City of Battle Creek.
The removal of the concrete channel will help create better aquatic habitat, improve water quality, and will help reconnect the community to this valuable water resource.
Please consider funding the removal of this unsightly concrete channel, or at least a portion of the channel, under the DARP or the NRDA PCB process.

Thank you.

Dominick Reed
3Eye Technologies
Marketing Coordinator
312-241-1480 (office)
269-589-9542 (cell)
dreed@3eyetech.com
Connect with 3Eye on LinkedIn

<u>Comment #9</u>
From: TJ Hagist <tjhagist@3eyetech.com>
Date: Fri, Jul 24, 2015 at 4:09 PM
Subject: Enbridge NRDA Comment
To: "kzoorivernrda@fws.gov" <kzoorivernrda@fws.gov>
Hello,

I am writing in support of the comments submitted by Christine Kosmowski, Calhoun County Water Resources Commissioner, regarding the removal of the concrete channel within the Kalamazoo River in the City of Battle Creek.
The removal of the concrete channel will help create better aquatic habitat, improve water quality, and will help reconnect the community to this valuable water resource.
Please consider funding the removal of this unsightly concrete channel, or at least a portion of the channel, under the DARP or the NRDA PCB process. Thank you.

TJ Hagist
3Eye Technologies
Warehouse Manager
tjhagist@3eyetech.com
O: 269-841-5584

<u>Comment #10</u>
From: Nancy Macfarlane <nancy.macfarlane54@gmail.com>
Date: Sat, Jul 25, 2015 at 1:36 PM
Subject: Enbridge NRDA Comment
To: kzoorivernrda@fws.gov

As a former Battle Creek city commissioner and over 30 year resident of Battle Creek, I am in support of the removal of the concrete channel within the Kalamazoo River in Battle Creek.

Restoring the river will enhance economic development, improve water quality, and be much more aesthetically appealing.

The channelled portion of the river is located in one of the main gateways into downtown Battle Creek. Besides the cement, the "river" channel is surrounded on both sides by tall chain link fence, making a visually unappealing entry into the city, and prohibiting community members from using the river. Restoring the river could remedy this situation.

Please remove the channel under the DARP or NRDA PCB process.

Sincerely,

Nancy Macfarlane
104 Lakewood Dr.
Battle Creek, MI 49015

Comment #11

From: Brian Engelhardt <brian.james.engelhardt@gmail.com>
Date: Sat, Jul 25, 2015 at 2:01 PM
Subject: Enbridge NRDA Comment
To: kzoorivernrda@fws.gov

I am writing in support of the comments submitted by Christine Kosmowski, Calhoun County Water Resources Commissioner, regarding the removal of the concrete channel within the Kalamazoo River in the City of Battle Creek.
The removal of the concrete channel will help create better aquatic habitat, improve water quality, and will help reconnect the community to this valuable water resource.
Please consider funding the removal of this unsightly concrete channel, or at least a portion of the channel, under the DARP or the NRDA PCB process. Thank you.

Comment #12
From: <nelsonx5@comcast.net>
Date: Sat, Jul 25, 2015 at 3:05 PM
Subject: Enbridge NRDA Comment
To: kzoorivernrda@fws.gov

I am writing in support of the comments submitted by Christine Kosmowski, Calhoun County Water Resources Commissioner, regarding the removal of the concrete channel within the Kalamazoo River in the City of Battle Creek.

The removal of the concrete channel will help create better aquatic habitat, improve water quality, and will help reconnect the community to this valuable water resource.

Please consider funding the removal of this unsightly concrete channel, or at least a portion of the channel, under the DARP or the NRDA PCB process.

Thank you.

Laura Nelson
Kalamazoo, MI

Comment #13
From: R.Adams <hob641@gmail.com>
Date: Sat, Jul 25, 2015 at 3:55 PM
Subject: Enbridge NRDA Comment
To: kzoorivernrda@fws.gov

I am writing in support of the comments submitted by Christine Kosmowski, Calhoun County Water Resources Commissioner, regarding the removal of the concrete channel within the Kalamazoo River in the City of Battle Creek.

The removal of the concrete channel will help create better aquatic habitat, improve water quality, and will help reconnect the community to this valuable water resource. Please consider funding the removal of this unsightly concrete channel, or at least a portion of the channel, under the DARP or the NRDA PCB process.

Thank you,

Ron Adams
IT Software, Staffing, Consultancy
734-355-6166

Comment #14
From: Karen Parker <kwparker1099@gmail.com>
Date: Sun, Jul 26, 2015 at 7:26 AM
Subject: Enbridge NRDA Comment
To: kzoorivernrda@fws.gov

Dear Dr. Lisa Williams -
I am writing in fervent support of the comments submitted by Christine Kosmowski, Calhoun County Water Resources Commissioner, regarding the removal of the concrete channel within the Kalamazoo River in the City of Battle Creek.

The removal of the concrete channel will help create better aquatic habitat, improve water quality, and will help reconnect the community to this valuable water resource.

Please consider funding the removal of this unsightly concrete channel, or at least a portion of the channel, under the DARP or the NRDA PCB process.

Your thoughtful consideration - and funding approval - is greatly appreciated!

Karen W. Parker
922A Capital Avenue SW
Battle Creek, MI 49015
269-967-5069

Comment #15

From: Jackie DeHaan <jdh49017@gmail.com>
Date: Sun, Jul 26, 2015 at 4:16 PM
Subject: Enbridge NRDA Comment
To: kzoorivernrda@fws.gov

Dr. Williams -
I am writing in support of the comments submitted by Christine Kosmowski, Calhoun County Water Resources Commissioner, regarding the removal of the concrete channel within the Kalamazoo River in the City of Battle Creek.
The removal of the concrete channel will help create better aquatic habitat, improve water quality, and will help reconnect the community to this valuable water resource.
This project is very important to Battle Creek, as well as its neighbors.
Please consider funding the removal of this unsightly concrete channel, or at least a portion of the channel, under the DARP or the NRDA PCB process. Thank you.
Jackie DeHaan

____

Jackie DeHaan
Nonprofit Consultant
jdh49017@gmail.com
269-966-9030
www.jackiedehaan.com

Comment #16

From: <kathleenbess@comcast.net>
Date: Sun, Jul 26, 2015 at 4:55 PM
Subject: Enbridge NRDA Comment
To: kzoorivernrda@fws.gov

I am writing in support of the comments submitted by Christine Kosmowski, Calhoun County Water Resources Commissioner, regarding the removal of the concrete channel within the Kalamazoo River in the City of Battle Creek.
The removal of the concrete channel will help create better aquatic habitat, improve water quality, and will help reconnect the community to this valuable water resource.
Please consider funding the removal of this unsightly concrete channel, or at least a portion of the channel, under the DARP or the NRDA PCB process. Thank you.

Kathleen L. Bess
Battle Creek, Michigan

Comment #17

From: alcoa1961 <alcoa1961@tx.rr.com>
Date: Sun, Jul 26, 2015 at 8:43 PM
Subject: "Enbridge NRDA Comment"
To: EastLansing@fws.gov, kzoorivernrda@fws.gov, Annette_Trowbridge@fws.gov

The proposed penalties for Enbridge after their heinous Kalamazoo pipeline spill in 2010 are grossly insufficient.

Unless you enact much more expensive penalties, Enbridge and other pipeline companies will laugh themselves to death in their private board rooms, while screaming bloody murder in public.

Please increase those penalties by at least a factor of five. Use the extra money to hire more pipeline inspectors so that pipeline companies can't continue to build risky pipelines and operate them unsafely.

Thank you,
[unsigned in original e-mail]

Comment #18
From: Macfarlane, Teresa <Teresa.Macfarlane@kellogg.com>
Date: Mon, Jul 27, 2015 at 8:58 AM
Subject: Enbridge NRDA Comment
To: "kzoorivernrda@fws.gov" <kzoorivernrda@fws.gov>

I am writing in support of the comments submitted by Christine Kosmowski, Calhoun County Water Resources Commissioner, regarding the removal of the concrete channel within the Kalamazoo River in the City of Battle Creek.
The removal of the concrete channel will help create better aquatic habitat, improve water quality, and will help reconnect the community to this valuable water resource.
Please consider funding the removal of this unsightly concrete channel, or at least a portion of the channel, under the DARP or the NRDA PCB process. Thank you.

Teresa Macfarlane
Kellogg Company
Director, Customer Operations
269-961-3796 (office)
773-410-8423 (cell)

Comment #19
From: Adams Hagist, Megan <Megan.Adamshagist@kellogg.com>
Date: Mon, Jul 27, 2015 at 9:04 AM
Subject: Enbridge NRDA Comment
To: "kzoorivernrda@fws.gov" <kzoorivernrda@fws.gov>

Good morning –

I am writing in support of the comments submitted by Christine Kosmowski, Calhoun County Water Resources Commissioner, regarding the removal of the concrete channel within the Kalamazoo River in the City of Battle Creek.

The removal of the concrete channel will help create better aquatic habitat, improve water quality, and will help reconnect the community to this valuable water resource.

Please consider funding the removal of this unsightly concrete channel, or at least a portion of the channel, under the DARP or the NRDA PCB process. Thank you.

Megan Adams Hagist
IT Business Analyst – OCM | Workplace Solutions | Kellogg Company
O: 269-282-7054
megan.adamshagist@kellogg.com

Comment #20
From: Sosville, Wendy <Wendy.Sosville@kellogg.com>
Date: Mon, Jul 27, 2015 at 9:07 AM
Subject: Enbridge NRDA Comment
To: "kzoorivernrda@fws.gov" <kzoorivernrda@fws.gov>

I am writing in support of the comments submitted by Christine Kosmowski, Calhoun County Water Resources Commissioner, regarding the removal of the concrete channel within the Kalamazoo River in the City of Battle Creek.

The removal of the concrete channel will help create better aquatic habitat, improve water quality, and will help reconnect the community to this valuable water resource.

Please consider funding the removal of this unsightly concrete channel, or at least a portion of the channel, under the DARP or the NRDA PCB process. Thank you.

Wendy Sosville
KNA PMO
(O) 269/961-2742
(M) 269/209-8583

Comment #21
From: Cascioli, Debra <Debra.Cascioli@kellogg.com>
Date: Mon, Jul 27, 2015 at 9:08 AM
Subject: Enbridge NRDA Comment
To: "kzoorivernrda@fws.gov" <kzoorivernrda@fws.gov>

I am writing in support of the comments submitted by Christine Kosmowski, Calhoun County Water Resources Commissioner, regarding the removal of the concrete channel within the Kalamazoo River in the City of Battle Creek.
The removal of the concrete channel will help create better aquatic habitat, improve water quality, and will help reconnect the community to this valuable water resource.
Please consider funding the removal of this unsightly concrete channel, or at least a portion of the channel, under the DARP or the NRDA PCB process.

Thank you!

Debra Cascioli
Kellogg Company
Customer Logistics Services
269-961-2643 (office)

Comment #22

From: Nelson Karre <NKarre@vcflaw.com>
Date: Mon, Jul 27, 2015 at 9:16 AM
Subject: Enbridge NRDA Comment
To: "kzoorivernrda@fws.gov" <kzoorivernrda@fws.gov>
Cc: Nelson Karre <NKarre@vcflaw.com>

I am writing in support of the comments submitted by Christine Kosmowski, Calhoun County Water Resources Commissioner, regarding the removal of the concrete channel within the Kalamazoo River in the City of Battle Creek.
I share with Ms. Kosmowski the view that the removal of the concrete channel will help create better aquatic habitat, improve water quality, and will help reconnect the community to this valuable water resource. This will help bring more healthy activity to Battle Creek's downtown.
Please consider funding the removal of this unsightly concrete channel, or at least a portion of the channel, under the DARP or the NRDA PCB process. Thank you.

Nelson Karre
70 West Michigan Ave., Suite 450
Battle Creek, MI 49017
269.965.7000
269.965.0646 facsimile

Comment #23
From: Beuchler, Tyra <Tyra.Beuchler@kellogg.com>
Date: Mon, Jul 27, 2015 at 9:24 AM
Subject: Enbridge NRDA Comments
To: "kzoorivernrda@fws.gov" <kzoorivernrda@fws.gov>

I am writing in support of the comments submitted by Christine Kosmowski, Calhoun County Water Resources Commissioner, regarding the removal of the concrete channel within the Kalamazoo River in the City of Battle Creek.

The removal of the concrete channel will help create better aquatic habitat, improve water quality, and will help reconnect the community to this valuable water resource.

Please consider funding the removal of this unsightly concrete channel, or at least a portion of the channel, under the DARP or the NRDA PCB process. Thank you.

Tyra Beuchler
Global IT Commercial Business Solutions
Process & Engagement Team
Office: 269.961.3877|Mobile: 269.924.6255

Comment #24
From: Mike Segal <segal_mike@hotmail.com>
Date: Mon, Jul 27, 2015 at 10:00 AM
Subject: Enbridge NRDA Comment
To: kzoorivernrda@fws.gov

Dr. Lisa L. Williams,

I am writing in support of Calhoun County Water Resources Commissioner Christine Kosmowski's comments regarding the removal of the concrete channel within the Kalamazoo River in the City of Battle Creek.

I fully support the improved water quality and better habitat that the removal of the concrete channel will help foster.

Please consider funding the removal of this unsightly concrete channel, or at least a portion of the channel, under the DARP or the NRDA PCB process.

Thank you,

Mike Segal

Comment #25
From: Rebecca L. Fleury <RLFleury@battlecreekmi.gov>
Date: Mon, Jul 27, 2015 at 10:35 AM
Subject: Enbridge NRDA Comment
To: "kzoorivernrda@fws.gov" <kzoorivernrda@fws.gov>

To Whom it May Concern:
I am writing in support of the comments submitted by Christine Kosmowski, Calhoun County Water Resources Commissioner, regarding the hydrology study and exploration of removal of the concrete channel within the Kalamazoo River in the City of Battle Creek.
The hydrology study is important to determine whether or not the concreate channel can be removed to help create better aquatic habitat, improve water quality, and will help reconnect the community to this valuable water resource.
Please consider funding the study and exploration of the removal of the concrete channel, or at least a portion of the channel, under the DARP or the NRDA PCB process. Thank you.
Sincerely,
Rebecca L. Fleury
City Manager
City of Battle Creek
10 North Division Street Rm 206
Ph – 269-966-3378
Ex – 1201
rlfleury@battlecreekmi.gov

Mission for Battle Creek City Government
To ensure a safe, prosperous and culturally enriched community.

Vision for Battle Creek City Government
We envision Battle Creek as an extraordinary community where
people choose to live, work and play.

Comment #26
From: Mark Schauer <mark.schauer@comcast.net>
Date: Mon, Jul 27, 2015 at 11:42 AM
Subject: Enbridge NRDA Comment
To: "kzoorivernrda@fws.gov" <kzoorivernrda@fws.gov>

Dear Dr. Williams:

I'm writing in support of the comments submitted by Christine Kosmowski, Calhoun County Water Resources Commissioner, regarding the removal of the concrete channel within the Kalamazoo River in the City of Battle Creek.

The removal of the concrete channel will help create better aquatic habitat, improve water quality, and will help reconnect the community to this valuable water resource.

Please consider funding the removal of this unsightly concrete channel, or at least a portion of the channel, under the DARP or the NRDA PCB process.

Thank you,

Mark Schauer
1795 Hamilton Road
Battle Creek, MI 49017
269.209.3940

<u>Comment #27</u>
From: Kate <katesegal@hotmail.com>
Date: Mon, Jul 27, 2015 at 11:50 AM
Subject: Enbridge NRDA Comment
To: "kzoorivernrda@fws.gov" <kzoorivernrda@fws.gov>

I am writing in strong support of the comments submitted by Christine Kosmowski, Calhoun County Water Resources Commissioner, regarding the removal of the concrete channel within the Kalamazoo River in the City of Battle Creek.

The removal of the concrete channel will help create better aquatic habitat, improve water quality, and will help reconnect the community to this valuable water resource. Currently, the concrete channel prevents the community from taking full advantage of this water resource and creates a blight throughout our downtown.

Please consider funding the removal of this unsightly concrete channel, or at least a portion of the channel, under the DARP or the NRDA PCB process.

Thank you,
Kate Segal
108 Pinehurst Lane
Battle Creek, MI 49015

<u>Comment #28</u>
From: Stuart Family <snmstuart@hotmail.com>
Date: Mon, Jul 27, 2015 at 1:05 PM
Subject:

To: "kzoorivernrda@fws.gov" <kzoorivernrda@fws.gov>

I am writing in support of the comments submitted by Christine Kosmowski, Calhoun County Water Resources Commissioner, regarding the removal of the concrete channel within the Kalamazoo River in the City of Battle Creek.

The removal of the concrete channel will help create better aquatic habitat, improve water quality, and will help reconnect the community to this valuable water resource.

Please consider funding the removal of this unsightly concrete channel, or at least a portion of the channel, under the DARP or the NRDA PCB process. Thank you.

Mark F Stuart 2624 Ramblin Dr. Battle Creek, Mi 49014

<u>Comment #29</u>
From: Andy Helmboldt <helmboldt4bc@gmail.com>
Date: Mon, Jul 27, 2015 at 1:40 PM
Subject: Enbridge NRDA Comment
To: kzoorivernrda@fws.gov

I am writing in support of the comments submitted by Christine Kosmowski, Calhoun County Water Resources Commissioner, regarding the removal of the concrete channel within the Kalamazoo River in the City of Battle Creek.

The removal of the concrete channel will help create better aquatic habitat, improve water quality, and will help reconnect the community to this valuable water resource.

Please consider funding the removal of this unsightly concrete channel, or at least a portion of the channel, under the DARP or the NRDA PCB process. Thank you.

Andy Helmboldt
Battle Creek City Commissioner, At-Large
269-660-9659

<u>Comment #30</u>
From: Turk, Stephanie <Stephanie.Turk@kellogg.com>
Date: Mon, Jul 27, 2015 at 3:15 PM
Subject: Enbridge NRDA Comment
To: "kzoorivernrda@fws.gov" <kzoorivernrda@fws.gov>

I am writing in support of the comments submitted by Christine Kosmowski, Calhoun County Water Resources Commissioner, regarding the removal of the concrete channel within the Kalamazoo River in the City of Battle Creek.
The removal of the concrete channel will help create better aquatic habitat, improve water quality, and will help reconnect the community to this valuable water resource.

Please consider funding the removal of this unsightly concrete channel, or at least a portion of the channel, under the DARP or the NRDA PCB process. Thank you.
Stephanie Turk
Stephanie Turk | Sr.Manager| Kellogg Customer Operations |O: 269-961-3021 C: 269-420-1724

Comment #31
From: Annette Chapman <Annette@bccfoundation.org>
Date: Mon, Jul 27, 2015 at 3:20 PM
Subject: Enbridge NRDA Comment
To: "kzoorivernrda@fws.gov" <kzoorivernrda@fws.gov>
Cc: Brenda Hunt <Brenda@bccfoundation.org>

Dr. Lisa L. Williams, Chair NRDA Trustees:

On behalf of the Battle Creek Community Foundation, it is my pleasure to provide this email of support for funding consideration under the DARP or the NRDA PCB process, specifically for the removal of the concrete channel within the Kalamazoo River in the City of Battle Creek, submitted by Christine Kosmowski, Calhoun County Water Resources Commissioner.

We are supportive of the comments submitted by Christine Kosmowski, Calhoun County Water Resources Commissioner, regarding the removal of the concrete channel within the Kalamazoo River in the City of Battle Creek. The removal of the concrete channel will assist in creating better aquatic habitat, improve water quality, and will help reconnect the community to this valuable water resource.

The mission of the Battle Creek Community Foundation is to assist people and organizations in investing in our community and its residents to make a positive difference, therefore creating a vibrant, healthy and viable community. We feel that supporting the goal of restoring the shores of the Kalamazoo River in its confines of the existing channel or in part, is an important investment to effectively facilitate positive community change.

We have been working with the City of Battle Creek and the Calhoun County Water Resource Commissioner as a partner, in supporting environmental stewardship efforts in our community, as well as other projects that contribute directly to our community's health, welfare and quality of life.

Please consider funding the removal of this unsightly concrete channel, or at least a portion of the channel, under the DARP or the NRDA PCB process. Thank you.

Brenda L. Hunt
President & CEO
Battle Creek Community Foundation
32 West Michigan Avenue
Battle Creek, MI 49017
Phone: (269) 962-2181
Fax: (269) 962-2182
www.bccfoundation.org

Comment #32
From: Hagist, Jack <Jack.Hagist@kellogg.com>
Date: Mon, Jul 27, 2015 at 3:45 PM
Subject: Enbridge NRDA Comment
To: "kzoorivernrda@fws.gov" <kzoorivernrda@fws.gov>

I am writing in support of the comments submitted by Christine Kosmowski, Calhoun County Water Resources Commissioner, regarding
the removal of the concrete channel within the Kalamazoo River in the City of Battle Creek.

The removal of the concrete channel will help create better aquatic habitat, improve water quality, and will help reconnect the community to this valuable water resource. It will also go a
Long way to improve the look and feel of downtown Battle Creek.
Please consider funding the removal of this unsightly concrete channel, or at least a portion of the channel, under the DARP or the NRDA PCB process. Thank you.

Jack Hagist
Office: 269-961-2499
Cell: 269-274-3022
Kellogg's Global Business Services

Comment #33
From: Kathryn Sellers <ksellers131@gmail.com>
Date: Mon, Jul 27, 2015 at 3:59 PM
Subject: "Enbridge NRDA Comment
To: kzoorivernrda@fws.gov

I am writing in support of the comments submitted by Christine Kosmowski, Calhoun County Water Resources Commissioner, regarding the removal of the concrete channel within the Kalamazoo River in the City of Battle Creek.

The removal of the concrete channel will help create better aquatic habitat, improve water quality, and will help reconnect the community to this valuable water resource.

Please consider funding the removal of this unsightly concrete channel, or at least a portion of the channel, under the DARP or the NRDA PCB process. Thank you.

Comment #34
From: Architects Incorporated <architects.inc@prodigy.net>
Date: Mon, Jul 27, 2015 at 5:04 PM
Subject: " Enbridge NRDA Comment"
To: "Dr. Lisa L. Williams" <kzoorivernrda@fws.gov>
Cc: JMacfarlane@mumfordlaw.com

Dr. Williams,
I'm writing in support of the comments made by Christine Kosmowski, Calhoun County Water Resources Commissioner, regarding the removal of the concrete channel within the City of Battle Creek, Michigan.
The removal of the concrete channel will help create better water aquatic habitat,improve water quality, and will help reconnect the community to this valuable resource.
Please consider funding the removal of this unsightly concrete channel, or removal of portions of channel where oppurtunity for river enhancement and development are possible under the DARP or NERDA PCB process.
My company renovated a historic barn at the confluence of the Battle Creek and Kalamazoo rivers and have investigated other historic properties along the concrete channel. At this pivotal time a number of vacant industrial zoned properties exist and are available for acquisition which would allow river widening along the channel between street bridges crossing the channel. Such improvements could provide more and safer access to the river for recreational and development purposes as well as wetland creation and possibly increasing flood capacity.
The flood control project has worked in the past but now is a barrier to community revitalization and treats the river like a waste product. It is time that the channel be removed so the river can again re-energize the community's development as it has done so many times in the past.
Larry Rizor,Historic Barn LLC

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Comment #35
From: Larry Anderson <larryanderson077@gmail.com>
Date: Tue, Jul 28, 2015 at 12:05 AM
Subject: “Enbridge NRDA Comment”
To: kzoorivernrda@fws.gov
Cc: Chris Kosmowski <ckosmowski@calhouncountymi.gov>

We are writing in support of the comments submitted by Christine Kosmowski, Calhoun County Water Resources Commissioner, regarding the removal of the concrete channel within the Kalamazoo River in the City of Battle Creek.

Our Kalamazoo River is not only a beautiful but wonderful resource for Battle Creek and Calhoun County. This river essentially comes to a screeching halt as far as canoers and kayakers are concerned when it reaches downtown Battle Creek due to the concrete channel. There certainly newer concepts for replacing the flood channel that will not only protect property from flood damage, but open this stretch to enhance the west entrances to downtown Battle Creek, provide a continuation of the "navigable" river for canoes and kayaks and perhaps even rafters. Restoring this section will also improve fishing, habitat for water birds, and beneficial aquatic plants.

Under the DARP or the NRDA PCB process, we are hopeful that a project or projects would help restore the concrete channel to a more natural state.

Thanks you for considering our comments.

Sincerely,

Larry and Susan Anderson
12 Lakeside Drive
Battle Creek, MI 49015
269-964-4752