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HISTORICAL DOCUMENT REVIEW AND INFORMATION SUMMARY REPORT

Manistique River
Area of Concern
Manistique, Michigan

Task Order No. 0003, WP0, R0/Contract No. EP-S5-06-01

September 2012

PREPARED FOR

EPA
United States
Environmental Protection
Agency

PREPARED BY

CH2MHILL®

Historical Document Review and Information Summary Report

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Acronyms and Abbreviations

AOC	Area of Concern
BBL	Blasland, Bouck, & Lee
BSAF	biota sediment accumulation factor
CSO	combined sewer outfall
CSM	conceptual site model
DAD	diver-assisted dredging
ESEC	Edison Sault Electric Company
FNG	FutureNet Group
MDEQ	Michigan Department of Environmental Quality
MDNR	Michigan Department of Natural Resources
mg/kg	milligrams per kilogram
MPI	Manistique Papers, Inc.
NOAA	National Oceanic and Atmospheric Administration
ppm	parts per million
PCB	polychlorinated biphenyl
SOW	Statement of Work
TEQ	Toxicity Equivalence Quotient
TSCA	Toxic Substance Control Act
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
USEPA	U.S. Environmental Protection Agency
Weston	Weston Solutions, Inc
ww	wet weight
WWTP	wastewater treatment plant

SECTION 1

Introduction

This *Historical Document Review and Information Summary Report* presents the findings of the review of available information for the Manistique River Area of Concern (AOC) in Manistique, Michigan. The report is being submitted pursuant to the U.S. Environmental Protect Agency (USEPA) Statement of Work (SOW) dated February 9, 2012, and the CH2M HILL work plan that was approved by USEPA on March 14, 2012. The work is being conducted in accordance with Task Order No. 0003 under Contract No. EP-R5-11-09.

1.1 Objective

The purpose and goals of this task order are to review available historical reports and data for the Manistique River AOC and to summarize the following: (1) the historical operations and contaminant discharges to the river, (2) the historical sediment, soil, and biological data for the AOC, (3) evaluate the potential for continuing sources of PCBs to the river, and (4) identify potential additional studies and/or data gathering activities that could identify and locate, or rule out, the presence of significant continuing sources of polychlorinated biphenyls (PCBs) if they are apparent. A matrix that catalogs and summarizes the historical reports and data reviewed during preparation of this report is included in Appendix A.

1.2 AOC Description

The Manistique River flows in a southeastern direct through Schoolcraft County in the upper peninsula of Michigan and discharges into Lake Michigan at the City of Manistique (Figure 1). The AOC lies primarily within the city, beginning at the dam and extending through Manistique Harbor to Lake Michigan. The dominant feature and focus of most historical investigations in the AOC is the Manistique Papers, Inc. (MPI) paper manufacturing facility located on the western shore of the river. The facility has been in operation since 1920.

The AOC contains a dam that was built in 1919 to provide water to MPI for hydroelectric power and paper-making processes (Michigan Department of Natural Resource [MDNR] 1987). Water was diverted to the facility through a 3,000-foot-long concrete flume. Downstream of the flume is an area of rapids containing fast water currents. Immediately downstream of the rapids are a series of three channels through which the river flows. Downstream of the channels, the river flows under the US-2 Bridge, through the federal navigation channel and federal harbor and into Lake Michigan.

1.3 Contaminant of Concern

PCBs in sediments have caused Beneficial Use Impairments within the AOC (MDNR 1987). Abundant evidence collected over the past 40 years indicates that the MPI facility is the likely source of PCBs in the AOC. This evaluation focuses on the extent of PCB contamination within the AOC.

SECTION 2

Physical Setting

Section 2 summarizes the physical setting in the Manistique River AOC.

2.1 Topography

The region of Schoolcraft County along the Lake Michigan shoreline and including the AOC is fairly level and characterized by low sandy or gravely ridges alternating with swales and swamps, although the river gradient near the MPI facility is very steep (Foster and Veatch 1939).

2.2 AOC Geology and Sediment Characteristics

The geological conditions in the AOC generally consist of unconsolidated materials ranging 5 to 20 feet thick overlying fractured interbedded limestone/dolomite bedrock (MDNR 1987). The unconsolidated materials vary from anthropogenic fill (for example, paper mill sludges, woody debris, and brick) near the MPI facility to glacial drift composed of medium to coarse sand and gravel.

The Manistique River substrate adjacent to and immediately downstream of the MPI flume is composed primarily of limestone bedrock strewn with large boulders. Substrates within the main channel from the rapids to the U.S. 2 highway bridge are primarily sand, silt, and gravel overlying limestone bedrock. Backwater areas upstream of the U.S. 2 bridge consist mainly of sands intermixed with sawdust and woody debris. Substrate downstream of the U.S. 2 bridge consists of rocks and smaller boulders overlying the limestone bedrock, with sand and sawdust deposition occurring in the areas of slower moving water on each side of the river (MDNR 1987). The deposition zones in the river and harbor continue to accumulate sand and silt, primarily from erosion of bank materials in the upper watershed (MDNR 1996).

Manistique Harbor sediments have been substantially altered due to the accumulation of sawdust and woodchips. The materials originated primarily from lumber-making and paper-making (from wood pulp) activities that historically occurred on the lower Manistique River. With the closing of the sawmills, improved wastewater treatment, and the switch from pulpwood to recycled magazines (materials, including magazines and mixed papers) as raw material at the papermill, the discharge of the woody materials has been eliminated (MDNR 1987).

2.3 Hydrogeology

Bittner (1987) reports soil and groundwater conditions at the Manistique Papers site immediately south of the mill and adjacent to the Manistique River on the west side. Nineteen soil borings were advanced as part of that study. Groundwater monitoring wells were installed at three locations. Groundwater flow was determined to be to the southeast. Bedrock was encountered in eight boring locations at reported elevations ranging from 563 to 570 feet, which approximately correlates to 16 to 23 feet below ground surface at that site.

MDNR (1994) reports the results of a previous hydrogeologic investigation at a site in the City of Manistique on the east side of the Manistique River and south of US-2. The investigation reports that 2 pairs of nested groundwater monitoring wells were installed within 20 to 50 feet of the Manistique River. The shallow well of each pair was screened in unconsolidated materials (glacial drift or fill), and the deep well of each pair was screened in or at the top of the underlying bedrock (dolomite). Water-level measurements from one nested pair (glacial drift/dolomite) indicated a slight downward vertical hydraulic gradient (approximately -0.007). Water-level measurements from the second nested pair (fill/top-of-dolomite) indicated a slight upward vertical hydraulic gradient (approximately 0.005). The first nested pair was located 20 to 50 feet from the shore of the Manistique River, and the second nested pair was located approximately 100 feet from the river. MDNR concluded that there is evidence that groundwater generally flows toward the Manistique River at the site on the east side of the river, and that the shallow wells demonstrate a direction of flow parallel with the river with slight vertical hydraulic gradients consistent with a groundwater discharge zone in hydraulic communication with a surface water body. MDNR attributed the slight difference in vertical hydraulic gradients to the difference between the screened depths of the deep well of each pair (1 at the top of the bedrock, 1 approximately 3.5 feet into the bedrock).

A Great Lakes National Program Office technical memorandum summarized information from the MDNR 1994 (Great Lakes National Program Office undated). It notes that seiches, prevailing southerly winds, and flushing from the papermill may cause non-standard or “reverse” flows, the extent of which was not reported.

2.4 Ecology

Aquatic habitat in the AOC downstream of the dam supports a variety of seasonal sport fish, including northern pike, yellow perch, channel catfish, smallmouth bass, rock bass, walleye, chinook salmon, coho salmon, pink salmon, brown trout, and steelhead (MDNR 1996). Waterfowl and mammals, including muskrat, beaver, and mink also frequent the AOC. The area downstream of the flume where the elevation of the river bed drops approximately 26 feet and flows over shelves of limestone and gravel bars is considered an excellent spawning location for many of the fish species. The remaining length of the river and harbor is basically at the elevation of Lake Michigan and is not considered important for fish spawning. Land habitat in the AOC is primarily sandy beach, low shrubs, and developed sites, which is used by shorebirds and gulls. Bald eagles also forage along the shoreline and waters in the vicinity of the AOC. Waterfowl habitat is available primarily on the eastern shore of the river near U.S. 2, where the dead end channel creates a marsh. Waterfowl have also been observed along the river shoreline and around the islands created by the boat channels. There is little available wildlife habitat elsewhere in the AOC, since the entire AOC lies within the City of Manistique, the shoreline, and nearby areas are relatively developed.

SECTION 3

Historical Operations and Discharges to the River

3.1 MPI Historical Operations and Waste Treatment

The MPI facility has operated since 1920. A chronological summary of facility operations and waste treatment approaches from 1920 through 2011 is provided in the following subsections. Historical aerial photographs of the facility are in Appendix B. The following summarizes facility operations:

- From 1920 through 1959, MPI used ground wood pulp as their stock for producing paper (MDNR 1985).
- After 1959, MPI used ground wood pulp deinking stock made from magazine scraps and recycled paper as their stock for producing paper (MDNR 1985).
- Waste generated from the paper manufacturing process generally consisted of wastewater from the machine room, barking room, and deinking process; fly ash; bottom ash; and other miscellaneous wood and paper waste.
- MPI built two treatment ponds in the early 1960s to dewater wastewater. The ponds discharged partially dewatered wastes to the river (MDNR 1985).
- In 1967, MPI constructed a deinking lagoon to settle the deinking wastewater by blocking off an unused slip along the Manistique River, just south of the papermill (Weston Solutions, Inc. [Weston] 2002). Dikes constructed for the deinking lagoon allowed wastes to seep into the river. The deinking lagoon discharged through Outfall 005_1, which was located at the southern end of the lagoon. Based on review of the 1969 aerial photograph, the former treatment ponds appear to have been filled between construction of the deinking lagoon and 1969.
- In 1969, MPI deepened and restructured the deinking lagoon to meet MDNR requirements for longer retention times (MDNR 1985).
- In the early 1970s, MPI disposed of two drums of Pyranol at an undisclosed location (MDNR 1985).
- In 1973, MPI constructed a primary clarifier, air floatation clarifier unit, and new settling or sludge pond to dewater waste sludge (MDNR 1985). Wastewater from the deinking process was collected and passed through the air flotation clarifier. The system was designed for water from the clarifier to be reused. Water from the bark room and paper machine that was treated in the primary clarifier was discharged from Outfall 005. MPI indicated that the new sludge pond was used for emergency sludge storage. Dewatered wastes from the waste treatment system were placed in a company-owned disposal site located approximately 1.5 miles north of the City of Manistique in the eastern half of the southwest quarter of Section 36, Hiawatha Township, Manistique County (Bittner 1987). The disposal site is located in the Manistique River watershed.
- During 1973 and 1974 inspections, MDNR observed that the air flotation clarifier was not working properly and that untreated deinking wastewater and sludge were being pumped to the settling pond and ultimately being discharged to the Manistique River at Outfall 005 (MDNR 1985).
- In 1973 and 1974, MDNR sampled water from Outfall 005 and did not detect PCBs in any samples (MDNR 1985).
- In 1977, MPI constructed a secondary treatment system (MDNR 1985). Effluent from the primary treatment system flowed to an aeration tank and then into a final clarifier. Effluent from the final clarifier was discharged over a cascade to oxygenate the wastewater prior to discharge into the river through Outfall 006 (Figure 1). Sludge from the clarifiers was pumped to a vacuum-disc filter, and the resulting sludge-filtered cake was disposed of at the company-owned disposal site.
- In 1977, MPI dredged and backfilled the deinking lagoon (MDNR 1985). MPI disposed of the dredged sludge material at the company-owned disposal site.

- In 1985, while inspecting the MPI facility's four electrical transformers, MDNR observed staining on concrete below a leaking transformer in the sludge-loading area. The transformer did not have adequate secondary containment due to a hole in the concrete (MDNR 1985). The transformer contained approximately 425 gallons of Pyranol. According to MPI (1985), the leak occurred multiple times in 1985 but was always smaller than "a dollar bill cut in half," and the hole in the containment concrete was repaired in November 1985. Additional records of continued transformer leaking were not available.
- In 1986, MDNR requested that MPI stabilize the eastern shoreline of the former deinking lagoon because the shoreline was eroding and potentially contaminating the river. MPI stabilized the northeast riverbank of the former deinking lagoon with crushed stone from an area near Outfall 5 to approximately 0.25-mile downstream (MDNR 1987; 1996).

3.2 Other Potential Sources of PCBs

The AOC contains other potential sources of PCBs including other industrial sites, combined sewer outfalls (CSOs), and the Manistique Wastewater Treatment Plant (WWTP). The following are other potential sources of PCBs in the AOC (Figure 1):

- **Edison Sault Electric Substation.** The substation was built in 1954 and is located just to the south and west of the MPI facility. The substation contained transformers containing PCB oils of unknown composition. The Edison Sault Electric Company (ESEC) substation transformer is a potential source of PCBs to the AOC. PCBs of unknown composition were detected in a storm drain adjacent to the company's substation, fed by an unnamed creek that flows along the south side of the substation property (USEPA 2007). An oil-stained capacitor in the substation yard was also observed during USEPA's investigation. The presence of transformers containing PCBs indicated that the substation could be a source of PCBs to the AOC.
- **MPI Facility.** The MPI facility operated four electric substations each containing varying quantities of Pyranol (MDNR 1985). The third substation located in the sludge-loading area contained a transformer that appeared to have two active leaks during an MDNR investigation. The MDNR observed that the secondary containment under the transformer was deemed inadequate due to a hole in the containment concrete. Due to the presence of a leaking transformer that was confirmed to contain PCBs, the MPI facility is a potential source of PCBs in the AOC.
- **Manistique Wastewater Treatment Plant.** The WWTP is located on the western bank of the river upstream of the harbor (Figure 1). The Manistique WWTP was constructed in 1959 to treat sanitary wastewater generated by the city (MDNR 1987). Prior to construction, stormwater and sanitary waste were directly discharged into the river through combined sewers at CSOs 002 and 003. In 1979, the WWTP was upgraded to secondary treatment. During wet-weather periods when the WTTP capacity is exceeded, untreated stormwater and sanitary wastewater are directly discharged into the river. Due to the unknown nature of the contaminants in the wastewater received by the WTTP, PCBs could have been and could continue to be in the waste stream and discharged into the AOC.
- **CSOs 002 and 003** are possible sources PCB contamination to the Manistique River (MDNR 1987; Figure 1). CSO 002 discharges at the northern end of the slip located west of the former deinking lagoon. CSO 003 discharges on the eastern shore of the Manistique River approximately 700 feet downstream of the Manistique Marina. The 1987 remedial action plan indicated that sampling of the CSO discharges had not occurred. Based on the occurrence of PCBs detected in samples near the outfalls, the outfalls could have been and could continue to be sources of PCBs to the AOC.
- **Warshawsky Property.** The Warshawsky property contains an active metal scrap yard located across the river from the MPI facility on the eastern bank of the Manistique River (Figure 1). In 1992, USEPA inspected the scrap yard and observed a leaking capacitor containing unidentified PCB oils (USEPA 2007). In interviews with USEPA, Sault Edison employees indicated that transformers containing PCB oils were sold as scrap to the Warshawsky

scrap yard during the 1960s and 1970s. The presence of transformers at the property indicates that the Warshawsky property could have been and could continue to be a source of PCBs to the river.

SECTION 4

History of Investigations (1960s to Present)

4.1 Pre-dredging Sediment Investigations

Manistique River and harbor sediment contaminant investigations have been conducted within the AOC since the 1970s. Based on sediment sampling results, sediment dredging actions were implemented from 1995 through 2000 to remove highly contaminated sediments. Figures 3 and 4 present the pre-dredging surficial sediment sampling locations and results. Figures 5 and 6 present the maximum pre-dredging subsurface sampling locations and results. Section 4 provides a summary of the pre-dredging sediment investigations conducted in the AOC. Post-dredging sediment sampling results are provided in Section 6.

4.1.1 1970s

In 1976 and 1978, MDNR conducted sediment sampling in the Manistique River to assess pollutant concentrations, including PCBs (MDNR 1981). Detectable PCB concentrations were observed in all samples except the sample collected from upstream of the dam and the sample collected from the slip west of the former deinking lagoon. The highest PCB concentration of 172 milligrams per kilogram (mg/kg) was found in sediments collected near Outfall 5.

4.1.2 1980s

In 1981, USEPA collected 10 sediment samples through the AOC. All samples contained detectable levels of PCBs, with the highest concentrations being in sediments collected from the harbor (5.71 parts per million [ppm]), the slip west of the former deinking lagoon (4.29 ppm), and downstream of the deinking lagoon (3.75 ppm).

In 1982, the Michigan Department of Transportation collected sediment samples within the embankment area of the proposed U.S. 2 Bridge over the river (MDNR 1985). PCBs were detected in 5 of 30 samples, with the highest concentration (120 ppm) found in the westernmost portion of the channel downstream from the former deinking lagoon.

In 1985, MDNR collected 19 surficial sediment samples from the AOC (MDNR 1987). PCBs were detected in 7 of 19 samples, with the highest concentrations (66 ppm) found in river sediments near Outfall 005 and along the east side of the former deinking lagoon.

In 1988, the U.S. Army Corps of Engineers (USACE) sampled sediment from 12 locations in the river and harbor downstream of the U.S. 2 bridge (Blasland, Bouck, & Lee [BBL] 1994). Surface and subsurface samples were found to have PCB concentrations up to 56 ppm and 660 ppm, respectively. The accuracy of the analytical results was questioned by USACE because the results for some individual samples varied substantially between laboratories that conducted the analyses. Based on the differing results, USACE resampled the area in 1990.

Samples obtained from areas upstream of MPI during pre-dredging sediment investigations in the 1970s and 1980s did not detect PCBs.

4.1.3 1990s

In 1990, USACE sampled sediment from 20 locations in the federal channel and harbor downstream of the U.S. 2 bridge (BBL 1994). Surface and subsurface samples had PCB concentrations up to 92.8 ppm and 338 ppm, respectively.

In 1990, MDNR sampled sediment from 12 locations near the former deinking lagoon and in the federal channel and harbor (MDNR 1993). PCB concentrations up to 100 ppm were found in the harbor sediments; however, relatively low sediment PCB concentrations were found east of the former deinking lagoon.

In 1992, MDNR collected surficial sediment samples from 20 locations within the AOC (BBL 1994). PCBs were not detected from any of the sediment samples collected upstream of the U.S. 2 bridge. Five sediment samples downstream of the bridge contained relatively low PCB concentrations, with the highest concentration of 6.7 ppm found near CSO 003.

In 1992, the University of Minnesota collected and analyzed sediments from within the AOC (BBL 1994). Sediment samples collected from the top 3 to 4 inches of various unidentified locations within the harbor area were composited and analyzed for PCBs and other contaminants. The composite sediment sample was found to have a total PCB concentration of 12.2 ppm. The composite sediment sample was then segregated into five particle-size ranges, and each sample was again analyzed for PCBs. The PCB concentrations in the segregated particle sizes ranged from 5.2 to 97 ppm, with the highest PCB concentration found in the wood chips/sawdust fraction. The university repeated the analysis in 1993. The bulk sediment PCB concentration was 26.7 ppm. The PCB concentrations in the segregated samples were less than 1.4 ppm for all particle sizes less than or equal to 425 microns and 103 ppm for particle sizes greater than 425 microns. The highest PCB concentrations were found in the wood chips/sawdust fraction.

In June and December 1993, BBL collected sediment samples from 87 locations in the AOC (BBL 1994). BBL found elevated PCB concentrations of up to 124 ppm near the CSO 003 and PCBs up to 810 ppm in harbor sediments. Surface sediments had generally lower PCB concentrations than deeper sediments.

4.2 Soil Investigations

In 1985, MDNR collected soil samples from 15 locations along the riverbanks on the perimeter of the former deinking lagoon (MDNR 1987). Soil PCB concentrations up to 400 ppm were found in surface soils collected along the shoreline near the former treatment pond outfall (Outfall 005). MDNR noted that the riverbank near the outfall appeared to contain waste sludge and was eroding into the river.

In 1986, Bittner Engineering collected soil samples from 18 boring locations on the former deinking lagoon (Bittner 1987). Soil PCB concentrations ranged from nondetected to 73 ppm. The highest concentrations were found near the treatment ponds in surficial samples. Soil samples collected from borings taken between the storage sheds within the former deinking lagoon contained detectable PCBs that generally increased in concentration with depth up to 44 ppm between Sheds 2 and 3.

In 1992, MDNR collected surficial soil samples at 11 locations to further assess soil contamination at the former deinking lagoon (MDNR 1992). Soil PCB concentrations were generally less than 10 ppm, with the higher results from samples collected near the treatment ponds.

4.3 Biological Investigations

4.3.1 Fish

In 2008, the Michigan Department of Environmental Quality (MDEQ) conducted a caged fish study to measure the uptake of PCBs into fish from surface water at the AOC (MDEQ 2009). In addition, four species of wild fish were collected from the AOC and from a reference area to determine if fish using the AOC had elevated PCBs relative to reference conditions. The data were also compared to historical data to determine any declines in concentrations over time. The following is a summary of the results of the study:

- Juvenile channel catfish were placed in cages on the river bottom upstream of the dam near the Soo Line Bridge and near the river mouth. The fish were retrieved after 28 days and analyzed for PCB congeners.
- The results of the caged fish study indicate that the Manistique River AOC is not a significant source of water column PCBs.
- Common carp, redhorse sucker, rock bass, and smallmouth bass were collected from the AOC and from Little Bay De Noc and analyzed for PCB congeners.
- Individual fish within a species were similar in size, with the exception of redhorse suckers, which were slightly larger from Little Bay De Noc than from the Manistique River.
- Redhorse sucker, rock bass, and smallmouth bass collected in the Manistique River AOC all had elevated total PCB concentrations relative to the same species collected from Little Bay De Noc. The differences were statistically significant.

- There was no detectable difference in total PCB concentrations in carp collected from the two sampling sites.
- Carp collected in 2008 from the Manistique River AOC had lower total PCB concentrations than those collected in 2004. No detectable differences were observed in the other three species.
- Overall the data show that PCBs remain elevated in certain fish species from the AOC, which could be due to differences in feeding habits of the species leading to greater exposure to and uptake of PCB contamination for certain species.
- Data for the redhorse sucker was available for 2003, 2004, and 2008. Declines in PCB tissue concentrations were observed between 2003 and 2004, but not between 2004 and 2008. The data further suggest that declines in PCBs in fish tissue over time may have stabilized for some species in the AOC.

4.3.2 Tree Swallows

In 2011, the U.S. Geological Survey (USGS) placed tree swallow nests boxes in shoreline areas of the AOC to monitor the flux of PCBs out of sediment and into exposed biota (USGS 2012). The following is a summary of the results:

- A total of five nests were established: three near the deinking lagoon and two near the marina. No nests were established in the outer harbor area.
- Total PCBs measured in tree swallow eggs was low, averaging less than 1 ppm. The measured concentrations were well below the egg concentration known to affect hatching success of approximately 20 ppm.
- Measured PCBs expressed on a dioxin Toxicity Equivalence Quotient (TEQ) basis were low, averaging 118 picograms per gram TEQ wet weight (ww). For reference, this is approximately an order of magnitude below that measured at the Sheboygan River (1,261 picograms per gram TEQ ww) but about an order of magnitude above background (16.3 picograms per gram TEQ ww).
- Overall, the data show that PCBs are fluxing out of the sediment and into the food web. However, the accumulation in tree swallows, a riparian insectivore, is not remarkable relative to other PCB sites actively being monitored.

4.3.3 Spiders

In 2011, the USGS and USEPA conducted an investigation of the flux of PCBs from AOC sediments and accumulation into riparian invertebrate receptors (USEPA 2012). The following section summarizes the study and results:

- Ten sample locations in and near the AOC were established. At each location, four sediment samples were collected along a transect perpendicular to the shoreline. Two species of spiders representing slightly different habitat preferences and feeding habits were collected along the riparian zone adjacent to the sediment transect. The sediment and spiders were analyzed for PCB congeners.
- Sediment and spider total PCB concentrations were higher in the North and West Bay backwaters and the harbor sites than sample locations in the mainstream of the river, with the backwater sediment concentrations being generally higher than the harbor sites. However, the opposite trend of PCB concentrations was observed in the spider concentration, with the harbor sites being higher than the backwater sites.
- Total PCB concentrations between spider taxa were highly correlated, indicating no habitat-specific accumulation differences.
- Spider and sediment concentrations were related but nonlinear. Above sediment concentrations of approximately 100 parts per billion, spider concentrations varied within one order of magnitude, whereas sediment concentrations varied over three orders of magnitude.
- Results showed a shift in homolog distribution to lower chlorinated congeners in spiders from upstream to downstream. The biggest shift occurred between the above-dam sample and the deinking lagoon area sample.

- Overall, the data show that PCBs are fluxing out of the sediment and into the food web, which is consistent with findings of the USGS tree swallow study. The significance of the shift in homolog distribution in tissue relative to sediment is unknown and may be due to differences in sediment organic carbon content, overall sediment concentrations, differences in local prey, or a combination of those and other factors.

4.3.4 Laboratory Bioaccumulation Studies

In 2011, USEPA conducted a laboratory study to determine whether bioaccumulation of PCBs from AOC sediments was typical of other sites or represented an unusual pattern that might suggest an ongoing source other than the in-place PCB contamination (USEPA 2011). The following is a summary of the study and results:

- Four sediment samples (two from the harbor, one from the marina, and one near the former deinking lagoon) were collected and tested using the 28-day Lumbriculus bioaccumulation test.
- Sediment ranged from 4.2 ppm total PCBs in the sample from near the former deinking lagoon to 0.001 ppm total PCBs in a sample from the harbor.
- Sediment samples from the harbor were different in physical characteristics than those from the backwater areas. The harbor sediment was predominantly sand with average total organic carbon content approximately 0.1 percent. The backwater samples were a typical mix of grain sizes (predominantly fine) and had an average total organic carbon content of approximately 8 percent.
- Lumbriculus tissue PCB concentrations at the end of the 28-day exposure ranged from 111.3 milligrams total PCBs per kilogram lipid for the sample near the former deinking lagoon to 6.2 milligrams total PCBs per kilogram lipid for one of the harbor samples.
- The PCB homolog ratios in sediment were generally consistent between samples as were the ratios accumulated during the bioaccumulation test.
- The measured biota sediment accumulation factors (BSAFs) for homolog groups varied to some degree depending on octonal-water partioning coefficient (Log Kow) of the homolog group. However, BSAFs for total PCBs were consistent between sediment samples.
- Overall, the results of the bioaccumulation testing showed that uptake of PCBs from AOC sediments appears typical and consistent with theoretical predictions. The measured BSAFs tend to be slightly greater than other PCB sites such as the Hudson, Grasse, Fox, and Ashtabula River sites, but not unusual relative to theoretical predictions and the expected variance in natural sediments.

4.3.5 National Oceanic and Atmospheric Administration Mussel Watch

The National Oceanic and Atmospheric Administration (NOAA) monitors sites, including the Manistique River AOC, for a variety of physical, chemical, and biological parameters as part of a comprehensive nationwide program. The parameters include total PCB concentration in both sediment and freshwater mussel tissues. The 2011 monitoring results show that accumulation of total PCBs in mussel tissue at the Manistique River AOC is low relative to other AOCs sampled by NOAA (NOAA 2011). The result is consistent with the other bioaccumulation studies, suggesting that PCB accumulation in the Manistique River AOC is typical of other sites and there is no indication of a unique or unusual bioaccumulation process in the AOC.

SECTION 5

History of Sediment Remediation Activities

Section 5 summarizes the remedial activities conducted in the AOC. Based on investigations conducted in the 1970s, 1980s, and early 1990s, USEPA implemented remediation actions to cover and remove contaminated sediments in the Manistique River and harbor. USEPA conducted an interim action of placing a cover over highly contaminated sediments downstream of the U.S. 2 bridge in 1993. Environmental dredging to remove the contaminated sediments was conducted from 1995 through 2000 (Figure 7). USACE also conducted navigation dredging in the federal channel and harbor in the early 1960s and in 2010.

5.1 USACE Navigational dredging

Since early 1960s, USACE has dredged the Manistique federal channel and harbor for navigational purposes. The following is a summary of USACE dredging and quantities:

- 1963: 12,000 cubic yards
- 1964: 8,050 cubic yards
- 1966: 21,755 cubic yards
- 1967: 10,955 cubic yards
- 2010: 104,237 cubic yards

5.2 Environmental Capping and Dredging

USEPA conducted remediation actions from 1993 through 2000 that included capping and dredging sediment contaminated with PCBs. An estimated total of 10,602 pounds of PCBs was removed from the AOC as a result of dredging, treating, and disposing of approximately 187,500 cubic yards of contaminated sediment (Weston 2002). Figure 7 depicts the dredging and capping locations. The disposal locations for the dredged sediment were not provided. This following summarizes the activities:

- In 1993, USEPA initiated an interim time-critical removal action at a hotspot located in the mainstream area of the river, downstream of U.S. 2, where surface PCB concentrations up to 124 mg/kg were detected (Weston 2002; Triad Engineering 2002). The interim action consisted of placing a 120-foot by 240-foot high-density polyethylene membrane temporary cover over the area.

- In 1995, USEPA dredged approximately 10,000 cubic yards of in situ sediment containing greater than 10 mg/kg from North Bay (Weston 2002). Diver-assisted dredging (DAD) technology was used to remove the contaminated sediments. Dredged sediment was pumped to a water treatment plant where physical separation techniques removed the water from the sediment. The water was pumped to a holding lagoon where it was tested to ensure it met discharge requirements of 0.1 part per billion PCB and then discharged to the river. Dewatered sediment was pumped out through a filter press, which dewatered and solidified the sediment. The procedure was used in subsequent years. Approximately 48 tons of sediments were shipped offsite to a Toxic Substances Control Act (TSCA) landfill, and approximately 1,321 tons of non-TSCA material were shipped offsite for disposal in 1995.

- In 1996, USEPA dredged approximately 15,000 cubic yards of in situ sediment from North Bay in areas where post-dredging sampling identified sediment concentrations exceeding 10 ppm. Upon completion of dredging in North Bay, washed gravel was placed over dredged areas to improve the river bottom for aquatic species and contain contaminated residual sediments (Weston 2002). USEPA also removed the temporary cover placed in 1993 and dredged sediments from the capped area and other locations in the federal channel and harbor. Approximately 558 tons of TSCA sediments and 1,932 tons of non-TSCA sediments were shipped offsite for disposal in 1996.

- In 1997, USEPA continued removing contaminated sediments from the river and harbor (Weston 2002). USEPA focused on removing sediments contaminated with greater than 10 mg/kg PCBs near former CSO 003 and in the harbor. During the 1997 dredge season, approximately 62,000 cubic yards of sediment was dredged, and approximately 3,973 tons of TSCA materials and 8,104 tons of non-TSCA material were disposed of offsite.

- In 1998, USEPA continued to dredge river and harbor sediments that exceeded 10 ppm (Weston 2002). A total of approximately 31,159 cubic yards of sediment was dredged from 22 dredge areas. Approximately 5,668 tons of TSCA and 7,235 tons of non-TSCA sediments were shipped offsite for disposal.
- In 1999, the water levels of Lake Michigan dropped approximately 2 feet from the previous levels observed in 1998 (Weston 2002). USEPA addressed a bedrock obstruction in the river channel by using a hydraulic hammer to break up the obstruction and remove the debris from the river. High amounts of slabwood and branches were observed, and beneath the slabwood, more contaminated sediments were found. An approximately 5-foot layer of grey, fluffy paper pulp and woodchips was found in an area north of the U.S. 2 bridge.
- Touch-up dredging was conducted using DAD technology in some of the areas in the harbor and near the U.S. 2 bridge (Weston 2002). Hydraulic dredging also occurred in the harbor. Approximately, 34,873 cubic yards of sediment was dredged, with 9,470 tons of TSCA sediment and 4,461 tons of non-TSCA sediment disposed of offsite in 1999.
- In 2000, USEPA dredged 12 locations in the river and harbor that contained greater than 10 ppm PCBs following the 1999 dredging (Weston 2002). Approximately 33,130 cubic yards of in situ sediments were dredged, with 10,880 tons of TSCA material and 1,358 tons of non-TSCA material disposed of offsite. This completed the environmental dredging in the AOC.
- Sand was placed over areas were the post-dredge sediment confirmation sampling indicated results in concentrations greater than 10 mg/kg. The first attempt to spread sand resulted in resuspension and turbidity. The remainder of the sand was broadcasted in the river, and the river current naturally distributed 1,400 cubic yards of clean sand to the harbor.
- The environmental dredging ended in 2000. Demobilization was completed in 2001.

5.3 Sediment Contamination—Post-dredging

Sediment investigations conducted in 2001, 2004, 2008, and 2010 continued to identify elevated sediment PCB concentrations following the dredging from 1995 through 2000. Figures 8 through 11 present the results for post-dredging sampling. Total organic carbon concentrations were analyzed during some of the investigations. Although not presented herein, total organic carbon levels can affect PCB distribution and bioaccumulation in the food chain. This subsection summarizes the post-dredging sediment investigations conducted by various agencies since 2001.

5.3.1 2001 Sediment Investigation

On behalf of USEPA, Weston collected sediment samples in May 2001 after dredging activities were completed (Weston 2002). Samples were collected from North Bay, the river channel, and the Manistique Harbor. The overall mean PCB concentration of post-dredged sediments in the AOC was 7 ppm. USEPA FIELDS conducted a data analysis and concluded that the PCB concentration declines with depth in the dredged areas. The average concentration in the top 12 inches was 7.7 ppm, 6.6 ppm for the 24-inch interval, and 3 ppm for the 36-inch interval. The post-dredge sediment samples collected in the North Bay and river channel contained less than 1 ppm of total PCBs. However, some locations in the lower harbor area contained concentrations greater than 100 ppm.

5.3.2 2004 Sediment Investigation

Weston and the USEPA FIELDS team collected surface sediment samples from the AOC in 2004 (Weston 2004). A total of 514 surface samples were collected and analyzed for total PCBs. Out of the 514 samples, only one sample collected from the harbor exceeded a total PCB concentration of 50 ppm. The overall mean sediment PCB concentration in the AOC was 0.76 ppm.

5.3.3 2008 Sediment Investigation

FutureNet Group, Inc. (FNG), under contract with USACE, collected 17 sediment samples from 11 locations, using either a vibracore or ponar sampler, from the river and harbor in 2008 to characterize the sediment and evaluate the proper removal and disposal practices for upcoming navigational dredging (FNG 2008). Three of the 11 locations contained detectable levels of PCBs. Two locations within the marina on the east side of the river were found to contain less that 1 ppm PCBs, and one location just downstream of the marina contained 3.8 ppm PCBs.

5.3.4 2008 Sediment Investigation

Sultrac, under contract with USEPA, collected 533 surficial sediment samples from the river and harbor in 2008 to evaluate changes in total PCB sediment concentrations since the 2004 sampling (Sultrac 2008). Sediment PCB concentrations were detected in approximately 50 percent of the samples collected. Total PCB concentrations ranged from nondetect to 140 ppm, with an overall mean surface sediment concentration of 0.72 ppm. Sultrac performed a comparison of the 2004 results against the 2008 results and concluded the results generally showed a downward trend of sediment PCB concentrations in the harbor over time but no trend for river locations.

5.3.5 2010 Sediment Investigation

Weston, under contract with USEPA, conducted a sediment investigation in the Manistique River AOC in 2010 to further characterize the sediment conditions and the extent of contamination within the AOC (Weston 2011). A total of 181 sediment samples were collected from 86 locations in the AOC. The highest PCB sediment concentration of 490 ppm was identified in a sample collected in North Bay from 12 inches to 38 inches. No other samples contained PCBs with similar PCB concentrations. Analytical results indicated that PCB contamination persists in shallow surface sediment and subsurface sediment at the AOC, and that PCB contaminants that exceed the site-specific action level of 10 mg/kg are generally limited to several pockets in the outer harbor and to the area downstream of the former deinking lagoon.

SECTION 6

Evaluation of Potential PCB Sources

Section 6 discusses potential sources of PCB contamination to sediments in the Manistique River and harbor and evaluates the likelihood they are an ongoing source. The information presented in the previous sections was synthesized into a comprehensive conceptual site model (CSM). A CSM is an important element for evaluating risk, risk reduction approaches, and identifying data gaps and areas of critical uncertainty for additional investigation (USEPA 2005). The CSM was developed using historical information, current site data, and physical site characteristics to develop an understanding of the potential historical source areas, release mechanisms, and transport pathways. The historical information and current conditions are used to identify what are believed to be the primary historical and potential existing sources of the PCB contamination observed in the AOC. A graphical depiction of the CSM is presented in Figures 12 and 13. Potential sources are also depicted in Figures 12 and 13 and are discussed in more detail in the following subsections.

6.1 Potential Source Areas Identified

As depicted in the CSM, and described in previous sections, CH2M HILL has identified the following potential historical and ongoing source areas in the Manistique River AOC:

- Former MPI deinking lagoon
- Former MPI Sludge Waste Settling Pond Area
- MPI Transformers
- Edison Sault Electric Company
- Manistique Combined Sewer Outfalls
- Warshawsky Property
- Manistique WWTP

CH2M HILL has evaluated each of these sources and concluded that the former MPI deinking lagoon and the former MPI sludge waste settling pond area are the potential sources that have the highest likelihood for ongoing contribution of PCBs into the AOC. The data reviewed for this report do not indicate the presence of other potential sources that are likely to be significant contributors of PCBs. The following subsections provide the rationale for these conclusions.

6.1.1 Sources Unlikely to be Significant Ongoing Sources

The following potential sources areas of PCBs were assessed using the information available at this time. The following subsections provide the rationale for why they are not believed to be significant ongoing sources of PCB contamination to the sediments in the Manistique River or harbor.

6.1.1.1 MPI Transformers

In 1985, MDNR conducted a PCB compliance inspection at the MPI facility to document the facility's handling, storage, and disposal practices for PCBs and to determine its compliance with the PCB regulations (MDNR 1985). At the time of inspection, no PCBs were reportedly stored at the facility for disposal. However, it was mentioned that in the early 1970s, the facility disposed of two barrels of Pyranol (commercial brand name for PCB liquids) used for servicing the PCB transformers onsite. No documentation or information on the disposal was provided to MDNR (MDNR 1985). No clear description of the plant's operation in the 1960s and 1970s was available. One sediment sample collected immediately downstream of the MPI facility in 1976 had a PCB concentration of 172 ppm (MDNR 1981), and it is the only known sediment sample upstream of the deinking lagoon that contained PCBs. It is possible that the transformers in the MPI facility or the Pyranol disposal were related to the detected PCBs in that sediment sample and may have contributed to the PCB contamination in the AOC. However, based on the limited available data regarding the status of the PCB-containing transformers at the facility, it is not possible to assess the likelihood that the transformers were, or continue to be, a significant source of PCBs in the AOC, and there is nothing in the available data that directly indicates that these items are significant ongoing sources of PCBs.

6.1.1.2 Edison Sault Electric Company

The ESEC substation transformer containing PCB oils on the western bank of the river is a potential source of PCBs to the AOC based on a single detection of PCBs in a storm drain adjacent to the company's substation fed by an unnamed creek that flows along the south side of the substation property (USEPA 2007). An oil-stained capacitor in the substation yard was also observed during USEPA's investigation. The composition of the PCB oils is unknown. Sampling of the substation in 1987 did not show any detectable levels of PCBs on the property.

The pre-dredge investigations (1970 to 1995) and the post-dredge investigations (2001 to 2010) provide very little evidence relating the PCB contamination in the river with the ESEC facility. While samples collected in the vicinity of the ESEC substation indicate the historical presence of PCBs in the former slip along the west side of the former deinking lagoon, the detections are inconsistent. Based on the lack of PCBs consistently being encountered in the slip sediments, the available information does not suggest that there are ongoing sources of PCB contamination from the ESEC facility.

6.1.1.3 Manistique Combined Sewer Outfalls

Manistique CSO 002 and CS0 003 discharge to the AOC and could contribute PCBs to the AOC. In 1985, MDNR conducted investigations to assess the potential contamination from the CSOs. Sediment and water samples were collected at outfall locations and downstream locations. The sample results showed no elevated levels of PCBs, indicating that the CSOs did not contribute to the PCB contamination in the river and harbor (MDNR 1987). CSO 002 is also associated with the former slip along the west side of the former deinking lagoon. Based on the lack of PCBs consistently being encountered in the slip sediments, the available information does not suggest that there are ongoing sources of PCB contamination from CSO 002.

6.1.1.4 Warshawsky Property

In 1992, the Warshawsky Property was observed to contain leaking capacitors and soils contaminated with PCBs (USEPA 2007). MDNR (1993) and BBL (1994) reported that historical sampling in the east river channel adjacent to the property did not detect elevated concentrations of PCBs. MDNR concluded that it appeared that the PCBs in the river were not being contributed by the property. In addition, a 1995 PCB compliance inspection of the Warshawsky Property did not find detectable PCB concentrations in soils collected near the river (USEPA 2007). Finally, in 1998, USEPA (2007) reported that sampling of the Warshawsky property and the bordering banks of the river showed no elevated levels of PCBs. Based on the lack of elevated PCBs in soils and river sediments near the property boundary, it does not appear that the Warshawsky property is likely a significant source of PCBs to the AOC.

6.1.1.5 Manistique Waste Water Treatment Plant

The Manistique WWTP was investigated as a potential source of PCBs. During 1980 and 1985, MDNR performed compliance inspections and collected samples of the WWTP's effluent and sludge (MDNR 1987). Although a few metals were detected, PCBs were not detected in either the WWTP's effluent or sludge samples (MDNR 1987). Also, sediment samples collected just downstream of the outfalls of the WWTP during sediment investigations in 1985, 2001, 2004, 2008, and 2010 showed no elevated levels of PCBs (Weston 2002, 2004, 2011). Based on the historical sampling results, it does not appear that the WWTP is likely a significant source of PCBs to the AOC.

6.1.2 Potential Significant Ongoing Sources and Transport Pathways

This subsection provides the rationale for concluding that the former MPI deinking lagoon and former MPI sludge waste settling pond area may be possible ongoing sources. The CSM cutaway view (Figure 13) depicts historical and potential existing transport pathways for PCBs to move throughout the AOC. A transport pathway describes the mechanisms whereby site-related constituents, once released, might be transported from a source area to relevant media (soil, sediment, and surface water), where exposures might occur for receptors.

6.1.2.1 Former MPI Deinking Lagoon

PCB-containing wastes were discharged into the former deinking lagoon between 1967 and 1973. Wastes were pumped into the lagoon at its north end and allowed to overflow into the river at its south end. The paper-product waste (woody material) sludges built up over time in the lagoon to depths ranging from up to 20 feet or more (Bittner 1987). While this practice was ongoing, PCBs were entering the environment in the following ways:

(1) discharging directly into the river from Outfall 005_1 at the southern end of the lagoon, (2) infiltrating the banks, and (3) percolating downward through permeable underlying materials like sand and gravel. MPI stopped discharging waste into the deinking lagoon in 1977. The lagoon was partially dredged and backfilled. Soil borings and sampling results from 1987 indicate that substantial amounts of sludge remain at depth, and that PCBs were detected throughout the former lagoon. Appendix C contains a cross section of the former deinking lagoon that depicts soil boring and analytical results.

Transport of PCBs from the former deinking lagoon to the river is a viable transport pathway. The limited water solubility of PCBs makes it unlikely that high concentrations of PCBs are being carried by groundwater to river sediments. The presence of nonaqueous phase liquid (NAPL) would increase the potential transport of PCBs. The available data provide some limited evidence of oily substances in subsurface soil materials. However, samples obtained from the two depth intervals where oily substances were noted on the boring logs (Bittner 1987) correlated with low PCB concentrations (<0.20 mg/kg and 0.27 mg/kg), whereas concentrations of up to 73 mg/kg PCBs were noted from other subsurface depths where oily materials were not denoted on the boring logs from the same study. Although it is believed that the limited water solubility of PCBs would appear to rule out significant aqueous phase transport, further investigation of the former deinking lagoon appear to be required before NAPL transport or enhanced solubility and the status of the former deinking lagoon as a potential ongoing source of PCBs can be fully assessed.

6.1.2.2 Former MPI Sludge Waste Settling Pond Area

The first treatment ponds constructed in the early 1960s were used by MPI to settle solids out of wastewater prior to discharge to the river. Until 1967, when MPI constructed the deinking lagoon, the ponds were the only form of treatment for plant and deinking wastes generated after 1959. It is unclear how the ponds were used, but it is likely that the ponds were ineffective in waste treatment. It appears that the original treatment ponds were filled near the time that the deinking lagoon was constructed. The first reference to a settling pond was made in 1973 (MDNR 1985). MDNR inspections in 1973, 1974, 1977, and 1984 indicated that the primary treatment system installed in 1973 was encountering operation problems, resulting in untreated wastes being pumped through a settling pond and discharging into the river. Sediment and soil sampling results indicate that this area and Outfall 005 were a historical direct source of PCBs to the AOC.

Soil sampling has documented the presence of PCB-contaminated soils in the banks near the former treatment and settling ponds. The PCB contamination in the soils near the former sludge settling pond area may likely be due to infiltration of PCBs into soils underlying the ponds and from overflow into adjacent soils. It is possible that the riverbanks are continuing to act as a source of PCBs to the river sediments through bank sloughing, as happened in the early 1980s. Bank sloughing can occur through natural erosion of exposed soils caused by precipitation, flooding, or wind events or through destabilization of bank soils during dredging or other anthropogenic disturbances.

6.2 Possible Explanations for North Bay Sampling Result

In 2010, Weston sampled AOC sediments to further characterize the sediment conditions and the extent of contamination within the AOC (Weston 2011). One sediment sample collected from the North Bay contained a PCB concentration of 490 ppm. The sediment PCB concentration was more than 10 times higher than the other nearby sediment concentrations, which were generally less than 2 ppm. The result was also unexpected because Weston (2002) reported that sediments with concentrations above 10 ppm were removed and the surficial (0- to 6-inch) average PCB concentration following dredging was 3 ppm in the North Bay area. The following paragraphs provide a possible explanation for the reported elevated PCB sediment concentration.

Sediments from the North Bay were removed using DAD technology in 1995. The process consisted of pumping dredge slurry with a suction hose attached to a barge-mounted pump into a sedimentation basin. In 1996, a floating hydraulic auger dredge was used to dredge the areas of North Bay with sediments greater than 10 ppm following the 1995 dredging. The areas mostly contained wood chips and sawdust contamination. The floating hydraulic auger dredge was installed with a high-torque blade to cut through the wood debris (Weston 2002).

Depth of dredging was not reported. Following dredging in 1996, a layer of washed gravel was placed over the newly dredged surface to improve the habitat of the aquatic species.

The sediment description for the core collected in North Bay that contained 490 ppm PCBs is as follows (Weston 2011):

- 0 to 12 inches: Organic silt
- 12 to 26 inches: Silt and clay with some gravel
- 26 to 28 inches: Sawdust
- 28 to 38 inches: Sand mixed with wood chips

The presence gravel in the 12- to 26-inch layer may indicate the approximate maximum depth of the dredging at that location in North Bay, as gravel was placed in dredge areas after the 1996 dredging. The auger dredge may not have penetrated through the sawdust layer into the sand and wood chips. Given that the 2010 core sample penetrated the sawdust wood layer and extended 10 inches into the sand and wood chip layer, it is possible that the 490-ppm PCB concentration is indicative of PCBs present below the maximum dredge depth. Further, given that the 490-ppm PCB concentration was found in a composite of the 12- to 38-inch core interval, and assuming the 12 to 26-inch interval was similar in concentration to nearby samples that were generally less than 2 ppm, the PCB concentration in the underlying sawdust layer could be higher than the reported 490 ppm. Therefore, given this line of evidence, the 490-ppm result could indicate that material at the sawdust layer was not dredged in 1995 or 1996, and that high levels of PCB contamination may still occur in sediments in North Bay due to "undredged inventory."

Dredging invariably leaves behind residuals, which are contaminated sediments left in or adjacent to the dredging footprint at the completion of a dredging operation. Dredging residuals can be generated by the dredging operation as "fallback," sloughing from the dredge cutface and/or resettlement of contaminated sediments resuspended during dredging. Undisturbed residuals, commonly referred to as "undredged inventory," can also remain following dredging due to incomplete or inadequate pre- and post-dredging sediment characterization, inability of the dredge to access the targeted sediments (for example, an irregular hard bottom, presence of debris, and protection of shoreline structures that inhibits dredging), and other factors. An examination of the existing documentation of dredging activities in the AOC suggests that several of these factors are likely major determinates of the current distribution of PCB-contaminated sediment in the AOC and North Bay. Based on a review of the dredging methods followed in 1995 to 1998, there were likely incidents where the targeted sediment was not completely removed or activities in the dredge units created suspended dredge residuals in the water body, which later resettled.

The limitations on dredging methods used in 1995 to 1998 included limitations on the reach and ability to extend accurately to the dredge-cut levels, and absence of bathymetry surveys until 1999 to confirm the targeted dredge-cut levels were reached. These limitations raise the question of the effectiveness of the dredge methods to completely remove the targeted sediment deposits, and the possibility of undredged inventory becomes an increasingly likely scenario to explain the 490-ppm PCB result.

Another explanation for the 490-ppm PCB result could be related to the close proximity of the shoreline to the location of the 490-ppm sample. Close proximity may have limited the ability to effectively dredge the area. The hydraulic auger dredge with its high-torque blade may not have been able to get close to the shoreline for fear of causing shoreline failure, collapse, or instability, which may have resulted in leaving small, isolated pockets of undredged and contaminated sediments in place.

6.3 Potential Confounding Factors

Manistique River and Lake Michigan currents, including seiches, are viable mechanisms to resuspend and redistribute contaminated sediments throughout the AOC and need to be considered to explain the current distribution of PCB-contaminated sediments in both the North Bay and Manistique Harbor. Seiches occur when a storm surge or high sustained winds from one direction push the water level up at one end of the lake, causing water levels at the mouth of a river to increase and potentially temporarily moving water upstream. For the currents to move sediments upstream, they would need to be of such force that PCBs in the harbor and lower river would be resuspended and transported into upper reaches of the AOC. Information on the force of Lake Michigan currents and seiches for the Manistique River are unknown. CH2M HILL believes the currents and seiches are likely to have redistributed some sediment within the harbor and possibly immediately upstream of the harbor, but are unlikely to have caused significant upstream transport of contaminated sediments from the harbor.

6.4 Is There a Significant Ongoing Source?

After reviewing the available data for the Manistique River AOC, CH2M HILL believes there is adequate data to support the hypothesis that the former deinking lagoon and waste sludge area may continue to contribute PCBs to the AOC. The magnitude and concentrations of those contributions are difficult to estimate; however, based on sampling conducted since 2000, the releases are not anticipated to be excessive. Although PCBs that historically entered the AOC will persist for years, the sampling results for sediments collected since 2000 indicate that mean PCB concentrations in the sediments near the former deinking lagoon are not increasing and PCB concentrations of harbor sediments show a downward trend. The results indicate that a significant ongoing source, if present, has not yet affected sediment PCB concentrations. Compelling evidence that the 490-ppm PCB sample collected from North Bay is a result from an ongoing source was not found; rather, there is evidence to suggest it could be contaminated sediment that was not dredged in 1995 and 1996 further supporting the conclusion that significant ongoing sources of PCBs are not present in the AOC.

In 1997, USEPA began dredging contaminated sediment from the outer harbor area. Redredging was performed in some harbor areas that were shown through confirmation sampling to have residual sediment concentrations exceeding allowable limits through 2000. According to Weston (2002), the dual-suction dredging and DAD conducted in 1998 were not able to reach the final 6 to 12 inches of sediment, which was typically the most contaminated sediment in the 1998 dredging area. The sole location in the 2010 investigation (MRH-OHL-1E) exceeding the site action level of 10 ppm (35 ppm) in the outer harbor area was an area dredged in 1998, indicating that the elevated concentrations observed in the 2010 investigation are a direct result of leftover sediments due to the limitations of the dredge methods in 1998. The inability of the dredging technologies used in the past could account for the highly contaminated sediments found in the harbor. Therefore, elevated harbor sediment PCB concentrations are not likely indicative of a significant ongoing source of PCBs in the AOC.

6.5 Summary and Recommendations

The examination of the core logs and dredging records available at this time indicate that elevated post-dredge PCB concentrations found at depth in isolated hotspots, both in North Bay and in the harbor, show that in each area, there is evidence to suggest that the target dredge depth (or PCB concentration) was not achieved, and that elevated PCB concentrations detected are the result of undredged inventory. In the North Bay, the dredge head may have hit a hard layer that was mistakenly identified as the end of sediment/woody waste material, or the dredge maintained an offset from the shoreline for shoreline stability reasons. In the harbor, the dredging records indicate the suction dredge was not able to effectively reach the last 6 to 12 inches of contaminated sediment in some places.

Further investigation of the North Bay area, former deinking lagoon and former sludge waste settling pond area, particularly close to the shoreline, would be needed to further evaluate those areas for potential ongoing sources of PCB contamination and to map the extent of remaining undredged inventory in North Bay. CH2M HILL suggests that a sediment coring technique that can penetrate gravel and compacted layers of wood chips be employed.

SECTION 7
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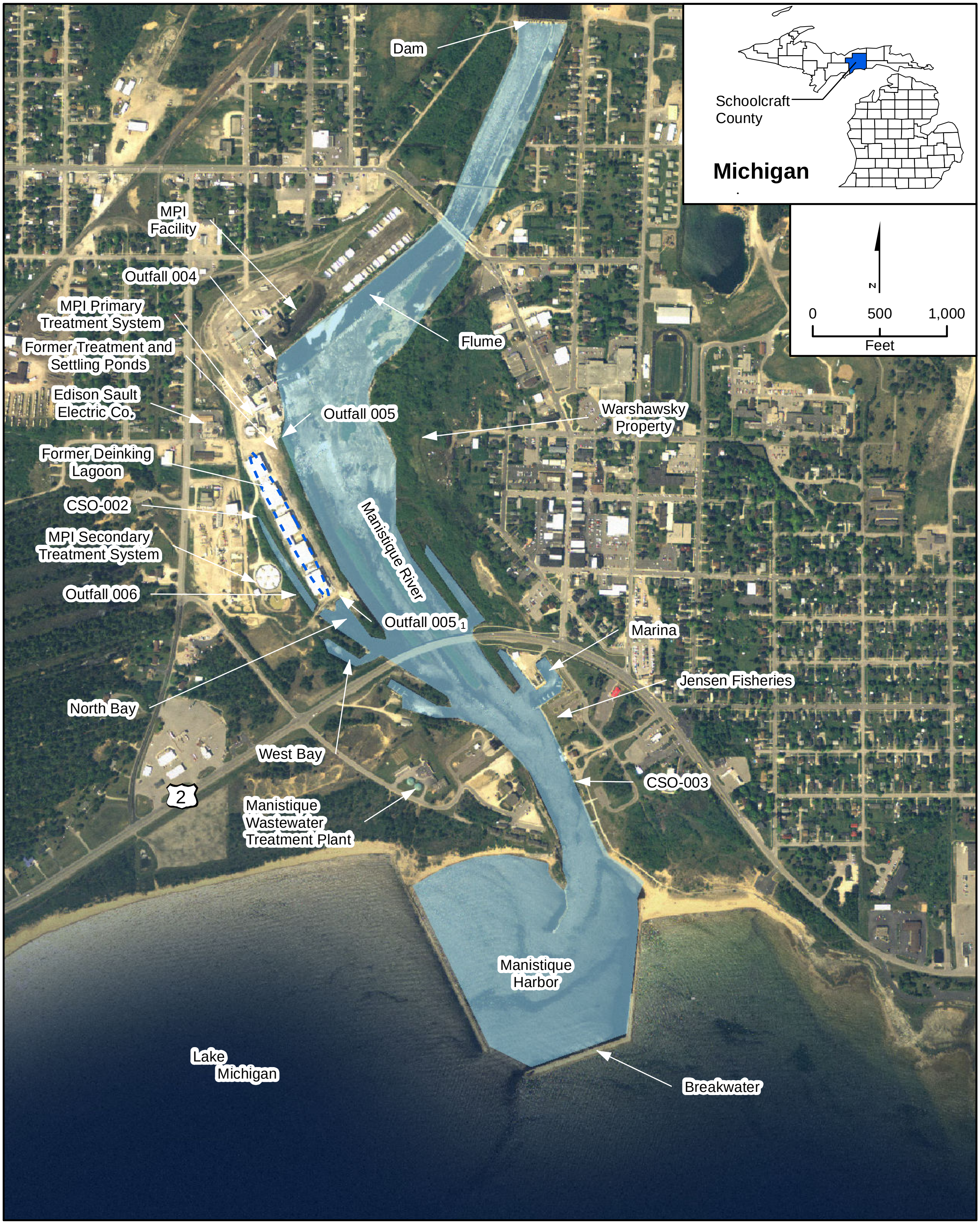
Figures



Legend

Area of Concern

Approximate Boundary of Former De-inking Lagoon

CSO Combined Sewer Outfalls

FIGURE 1
Site Location Map
Historical Document Review and Information Summary Report
Manistique River AOC
Manistique, Michigan

CH2MHILL

I:\USENVIRONMENTALPROTE\434422_MANISTIQUE_RIVER_HARBOR\MANISTIQUE RIVER GIS\MAPFILES\071612\FIGURE 01.MXD JHANSEN1 9/19/2012 3:28:51 PM

2011
- MPI suspends operations. Files for bankruptcy.
- USEPA studied PCB concentrations in spiders found in the River and Harbor.
- USGS studied PCB concentrations in tree swallow eggs collected from nests near the River and Harbor.
- NOAA Mussel Watch Program studied PCB concentrations in mussels and sediments collected from the Harbor.
- USACE found sediment contamination exceeding 50 ppm in navigation channel.
- USEPA studied PCB bioaccumulation in Lumbriculus.

2010
- USACE dredged 104,237 cubic yards in Federal Harbor.
- USEPA found elevated PCB concentrations in North Bay (up to 490 ppm), West Bay (up to 48 ppm), Harbor (up to 35ppm), and beach (up to 6.3 ppm).

2010

2008
- USEPA found elevated PCB concentration in the Harbor (up to 140 ppm). The mean surface sediment PCB concentration was 0.72 ppm.
- MDEQ studied PCB bioaccumulation in fish from Manistique Harbor and Little Bay De Noc.
- USACE found detectable PCB sediment concentrations in the marina (up to 3.8 ppm).

2004
- USEPA found elevated PCB concentration in the Harbor (up to 54 ppm). The mean surface sediment PCB concentration was 0.78 ppm.
- USEPA studied PCB concentrations in surface water, fish, sediments, and SPMDs.

2001
- USEPA conducted a post-final dredge sampling event. Elevated PCB concentrations (up to 543 ppm) were found in the surface sediment of Harbor.

2000

2000
1999
- USEPA conducted "Touch-up" dredging performed based on confirmation sampling of the dredged areas.

1998
1997
- USEPA conducted Time Critical Removal Action No. 3 - Dredge Areas C (near CSO) & D (Harbor) with Pre-dredge PCBs >10 ppm.

1996
1995
- USEPA conducted Time Critical Removal Action No. 2 - Dredging of Area B (North Bay - Pre-dredge PCBs up to 2,510 ppm).

1994
- MPI (BBL) prepared Engineering Evaluation/Cost Analysis.

1993
- MPI (BBL) found elevated PCBs sediment concentrations near the city's CSO (up to 124 ppm) and in the Harbor (up to 810 ppm).
- USEPA conducted Time Critical Removal Action No. 1 - Temporary 110' X 240' cover over Area C (PCBs up to 124 ppm).

1990

1986
- MPI stabilized east bank of old de-inking lagoon to reduce erosion.
- MPI (Bittner Engineering) found soil PCB concentrations up to 73 ppm near the old de-inking lagoon.

1985
- MDPH issued fish consumption advisory for carp.
- MDNR found soil PCB concentrations up to 1800 ppm near the old de-inking lagoon.

1982
- MDOT found elevated PCB concentration up to 120 ppm in sediment under US-2 Bridge.

1981
- Macalady estimated disposal of 5 tons of sawdust into the river and Lake Michigan by lumber mills prior to 1912 and 47,000 tons of sawdust and wood waste into Lake Michigan by MPI from 1941 to 1967.

1980

1977
- Secondary wastewater treatment system constructed.
- De-inking lagoon dredged and filled.

1976
- Sediments near outfalls 4 and 5 were found to contain up to 172 ppm PCBs and fish tissue contained detectable PCBs.

1973
- Primary wastewater treatment system constructed.

1970
- MPI disposed of two barrels of Pyranol (PCB-containing liquid). Disposal location is unknown.

1970

1967
- USACE dredged 10,955 cubic yards in the Manistique Harbor.
- De-inking lagoon constructed. "Leaky" stop logs at each end.

1966
- USACE dredged 21,755 cubic yards in the Manistique Harbor.

1964
- USACE dredged 8,050 cubic yards in the Manistique Harbor.

1963
- USACE dredged 12,000 cubic yards in the Manistique Harbor.

1961
1960
- Two "treatment ponds" built.

1960

1959
- City of Manistique wastewater treatment plant built.
- Paper mill began taking de-inking waste paper.

1920
- Paper mill began operation.

FIGURE 2
Timeline of Investigations and Dredging Activities
Historical Document Review and Information Summary Report
Manistique River AOC
Manistique, Michigan

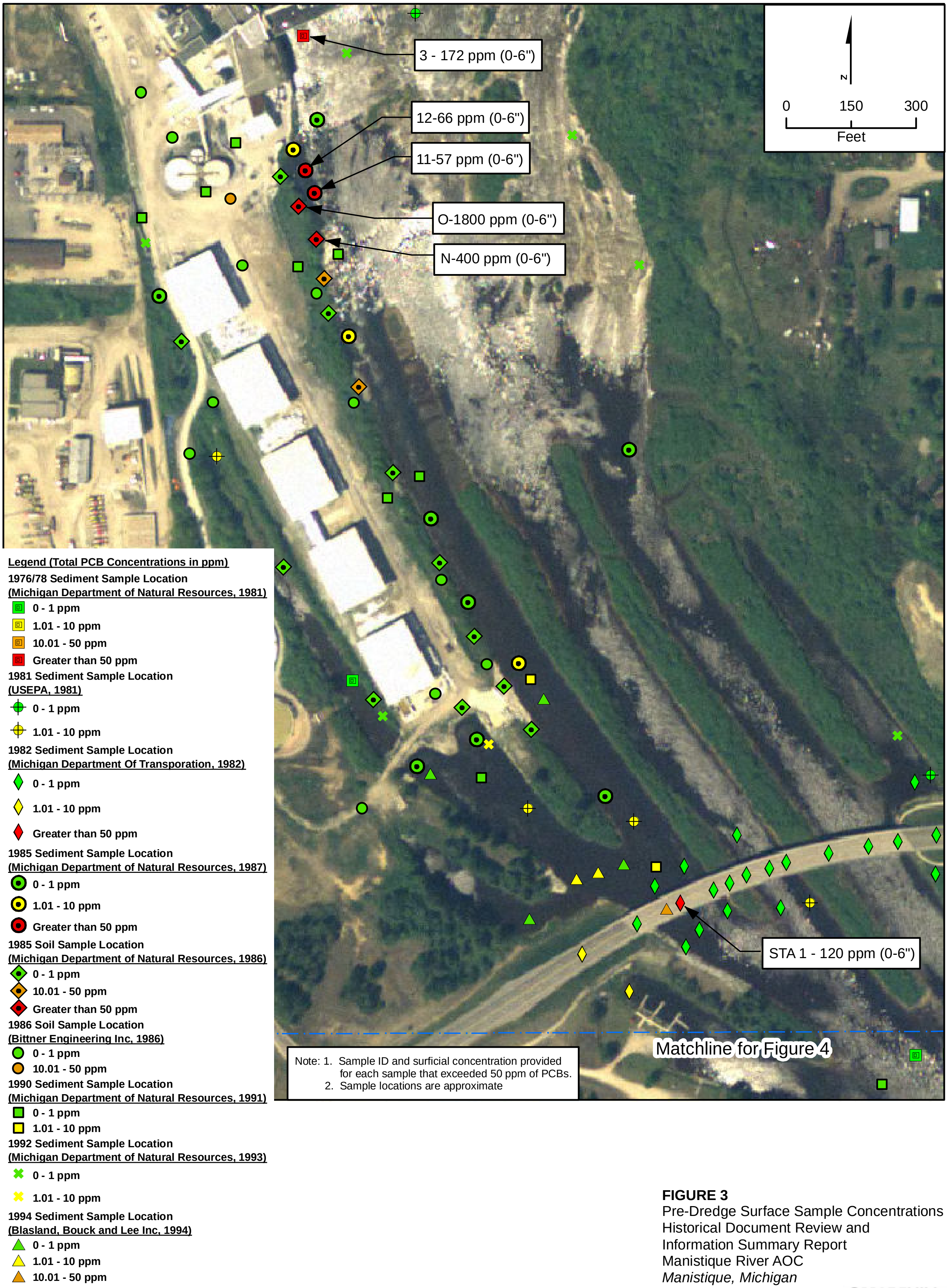


FIGURE 3
Pre-Dredge Surface Sample Concentrations
Historical Document Review and
Information Summary Report
Manistique River AOC
Manistique, Michigan

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\\hercules\proj\UsEnvironmentalProte\434422_Manistique_River_Harbor\Manistique River GIS\mapfiles\071612\Figure 3.mxd

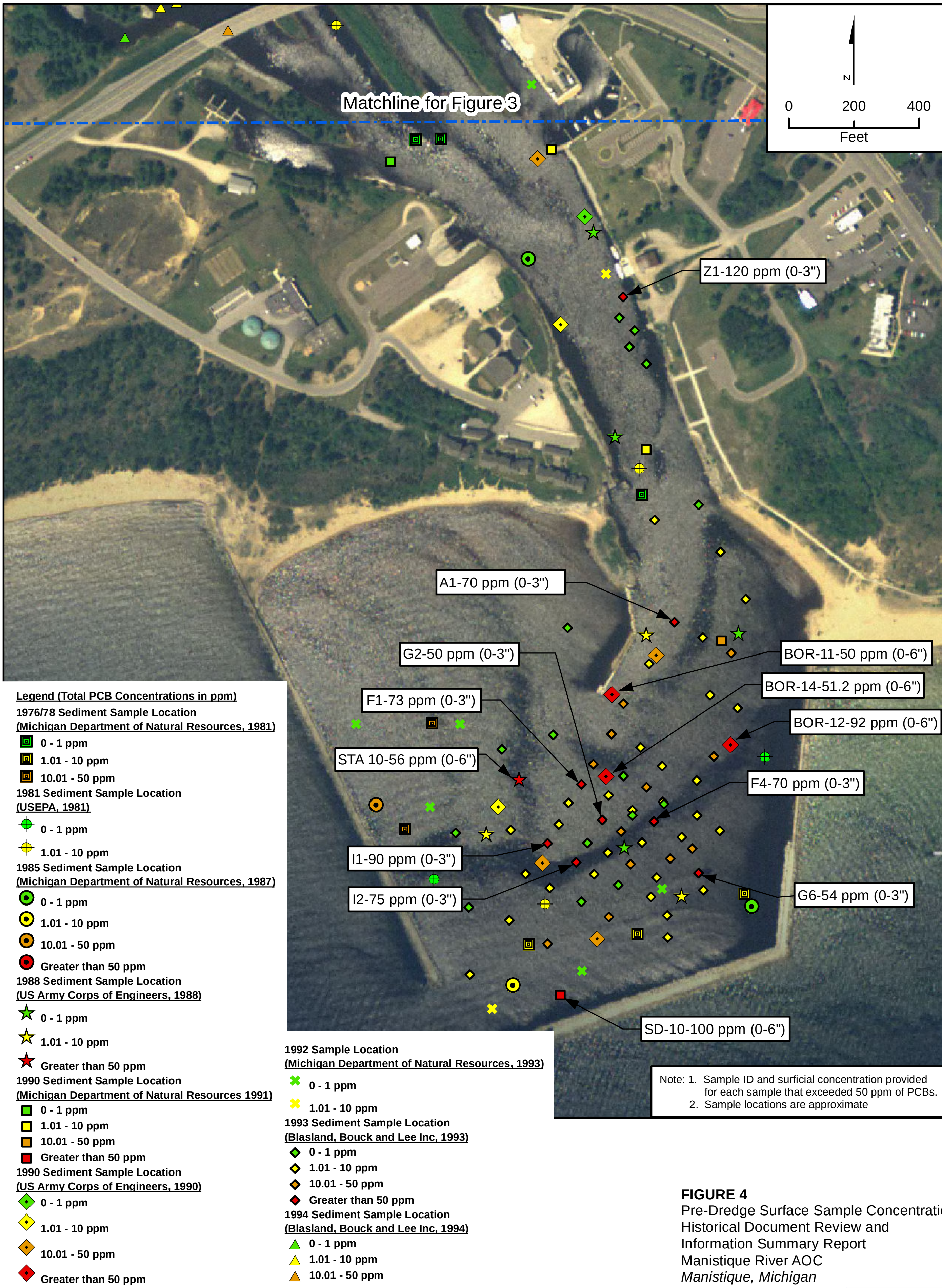

FIGURE 4
Pre-Dredge Surface Sample Concentrations
Historical Document Review and
Information Summary Report
Manistique River AOC
Manistique, Michigan

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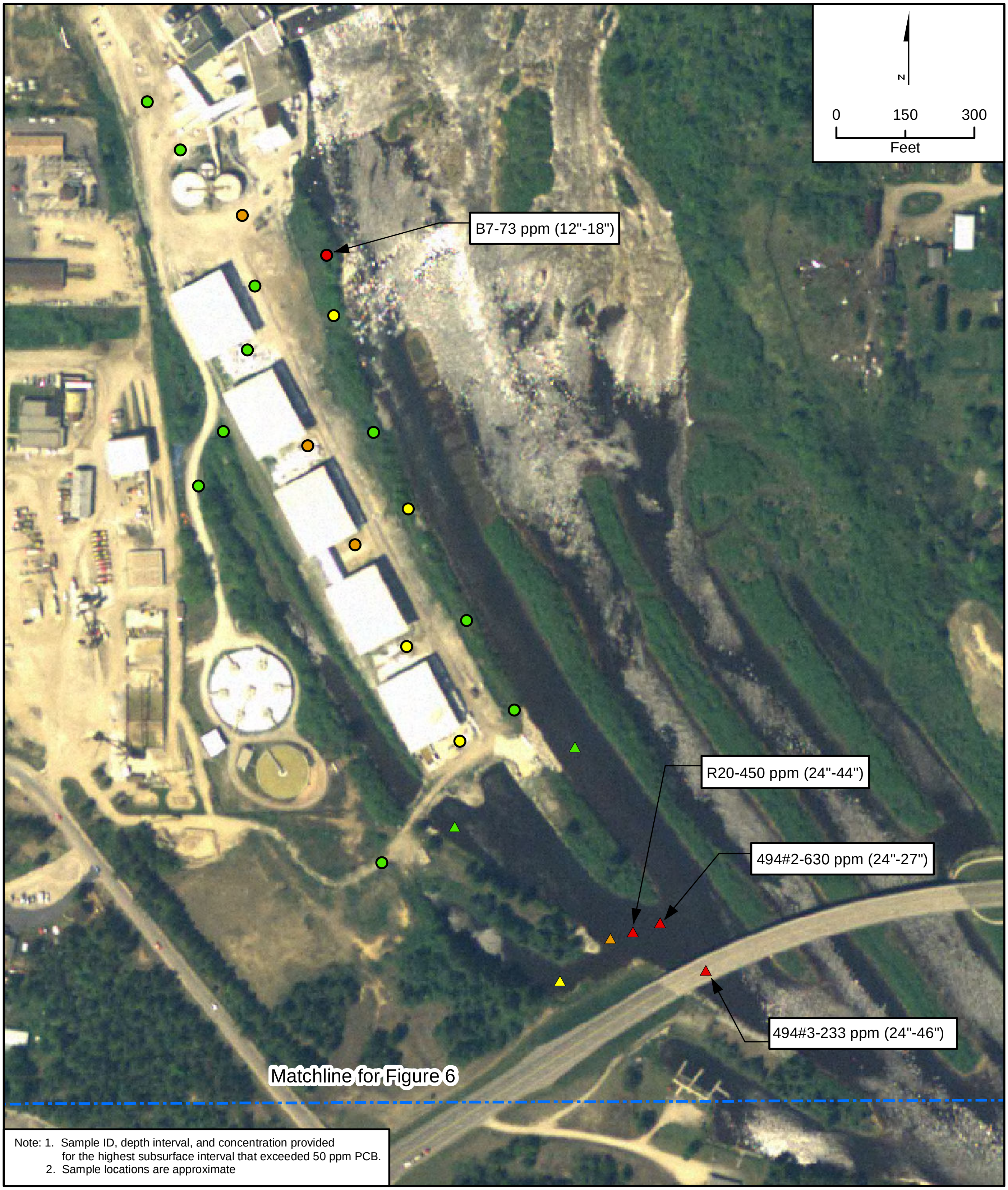
\\hercules\proj\UsEnvironmentalProte\434422_Manistique_River_Harbor\Manistique River GIS\mapfiles\071612\Figure 4.mxd



Legend (Total PCB Concentrations in ppm)

1986 Soil Sample Location
(Bittner Engineering Inc, 1986)
- **0 - 1 ppm**
- **1.01 - 10 ppm**
- **10.01 - 50 ppm**
- **Greater than 50 ppm**

1994 Sediment Sample Location
(Blasland, Bouck and Lee inc, 1994)
- **0 - 1 ppm**
- **1.01 - 10 ppm**
- **10.01 - 50 ppm**
- **Greater than 50 ppm**

FIGURE 5
Pre-Dredge Maximum Subsurface Sample Concentrations
Historical Document Review and Information Summary Report
Manistique River AOC
Manistique, Michigan

\\hercules\Proj\UsEnvironmentalProte\434422_Manistique_River_Harbor\Manistique River GIS\mapfiles\071612\Figure 05.mxd

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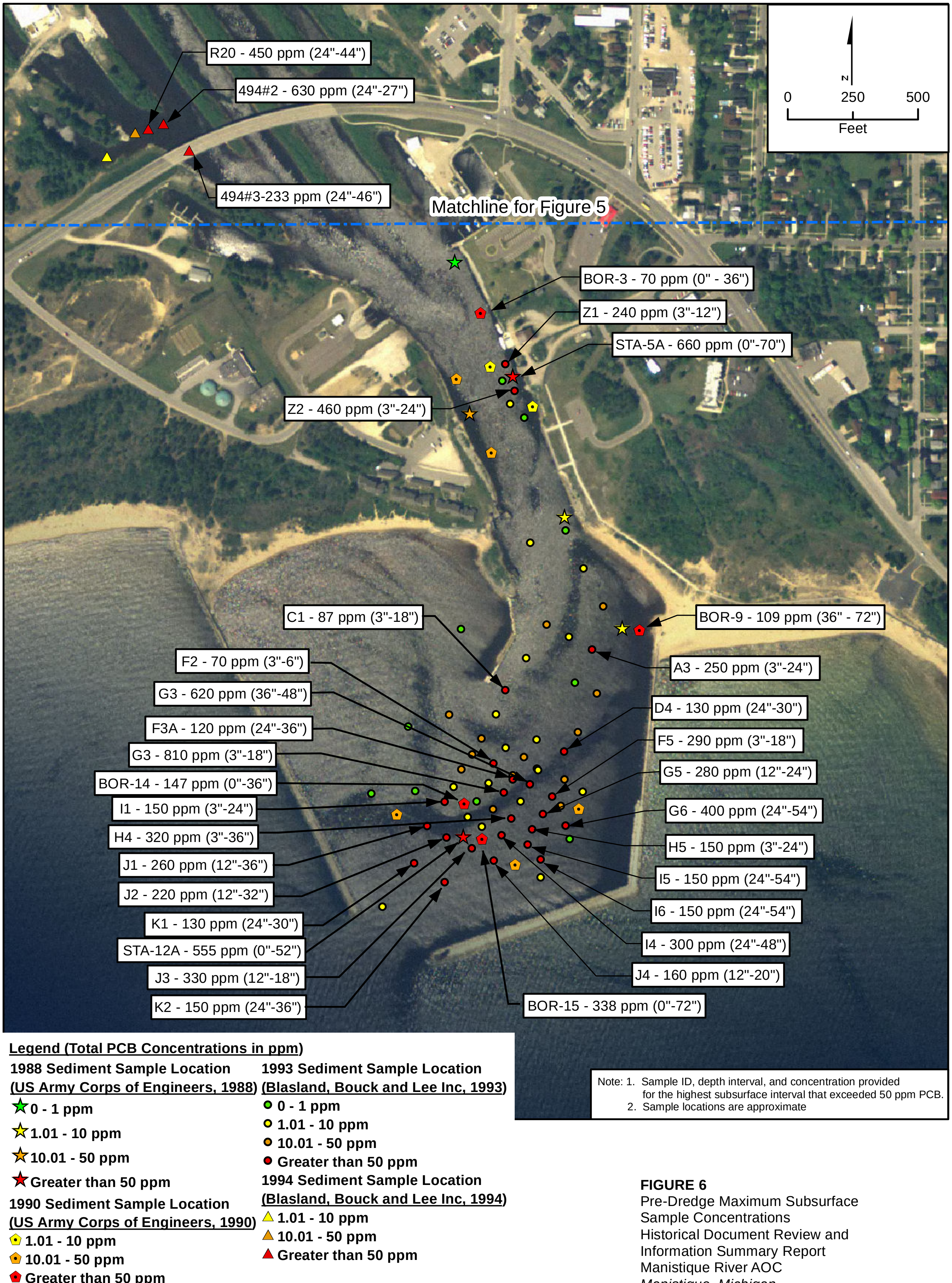

FIGURE 6
Pre-Dredge Maximum Subsurface Sample Concentrations
Historical Document Review and Information Summary Report
Manistique River AOC
Manistique, Michigan

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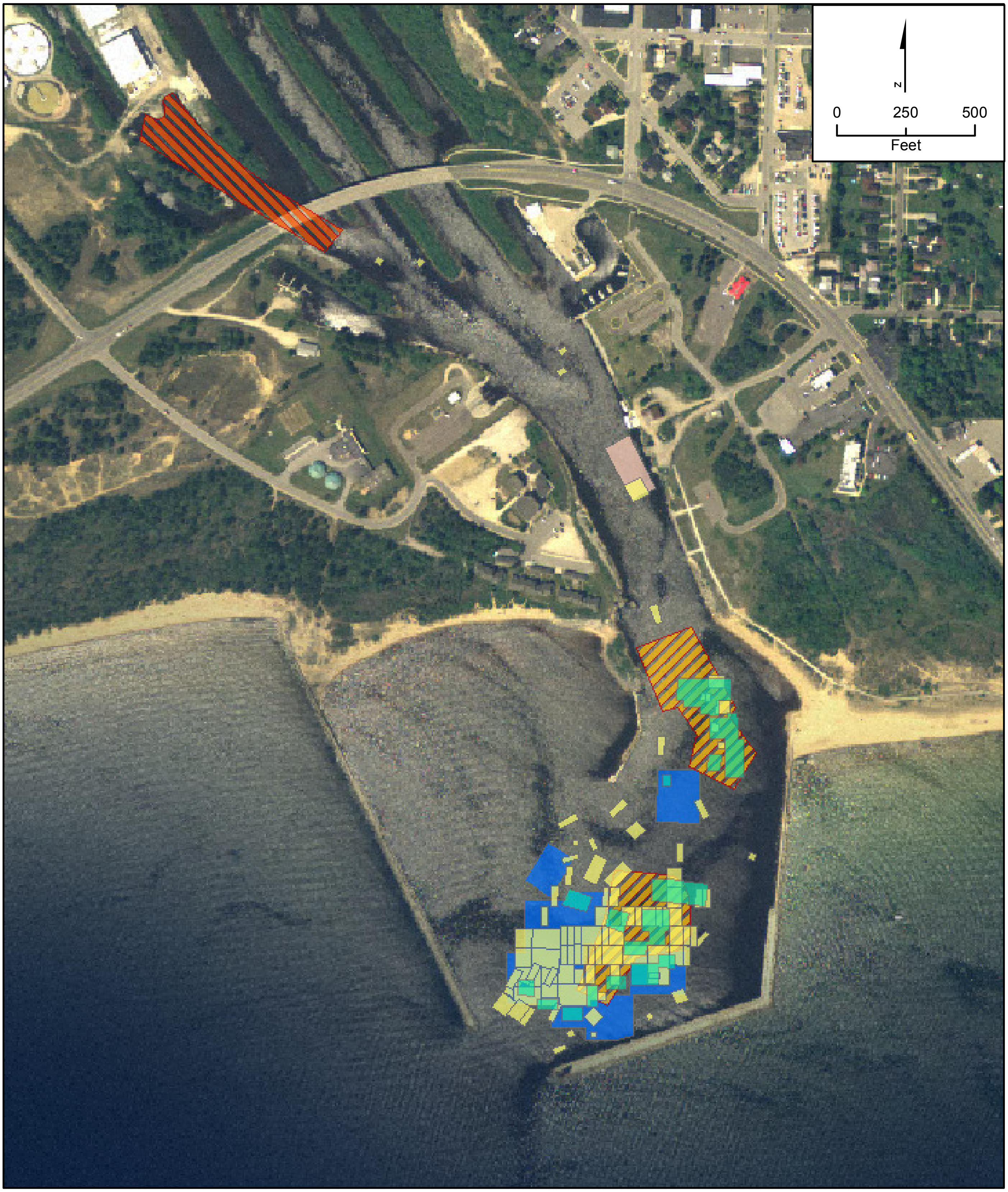
\\hercules\Proj\UsEnvironmentalProte\434422_Manistique_River_Harbor\Manistique River GIS\mapfiles\071612\Figure 06.mxd



Legend

- 1993 Temporary Cover Location (Area C)
- 1995-1996 Dredge Areas
- 1997 Dredge Areas
- 1998 Dredge Areas
- 1999 Dredge Areas
- 2000 Dredge Areas

FIGURE 7
Environmental Dredged Areas
Historical Document Review and
Information Summary Report
Manistique River AOC
Manistique, Michigan

\\hercules\Proj\UsEnvironmentalProte\434422_Manistique_River_Harbor\Manistique River GIS\mapfiles\071612\Figure 07.mxd

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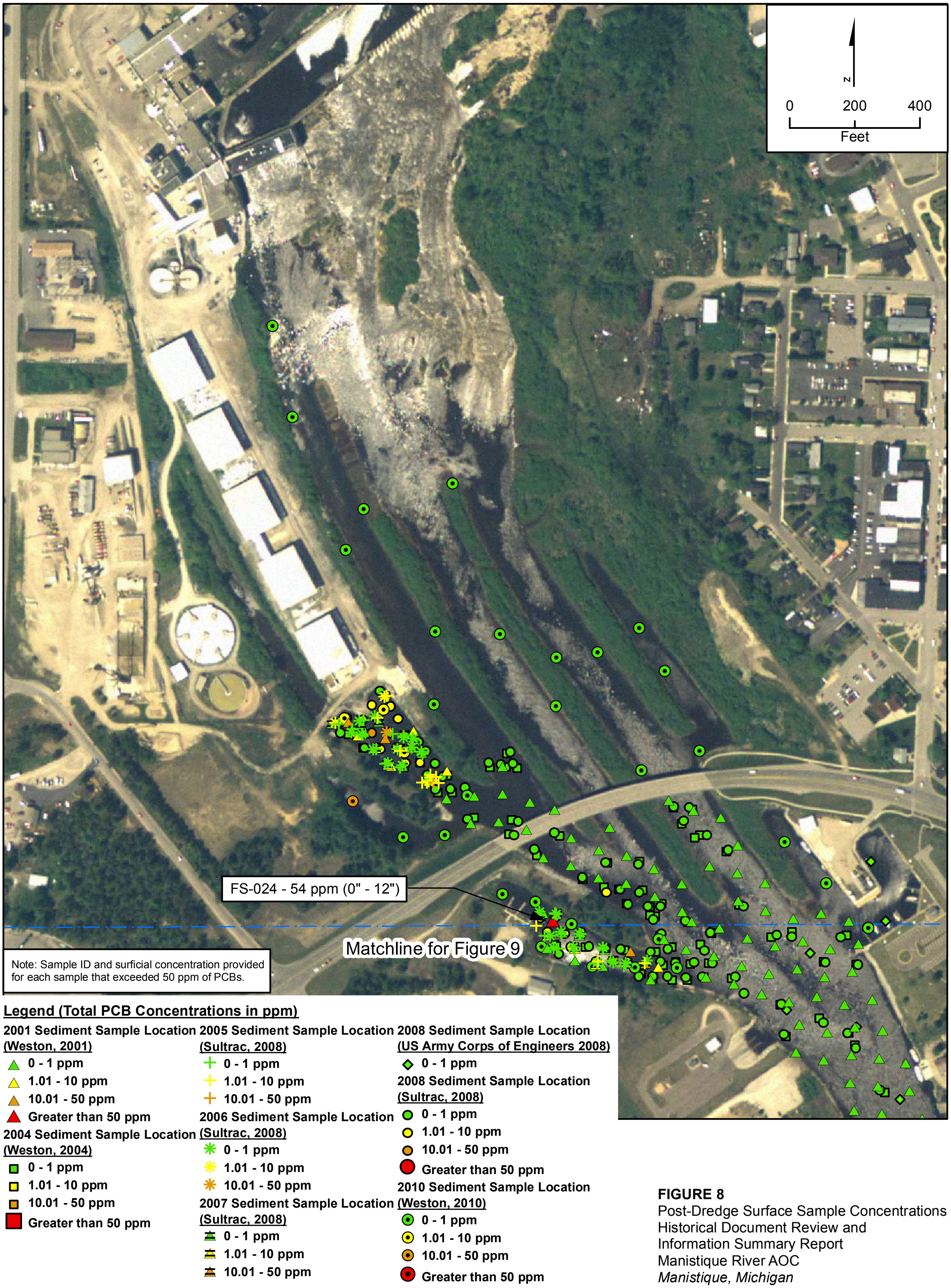

FIGURE 8
Post-Dredge Surface Sample Concentrations
Historical Document Review and Information Summary Report
Manistique River AOC
Manistique, Michigan

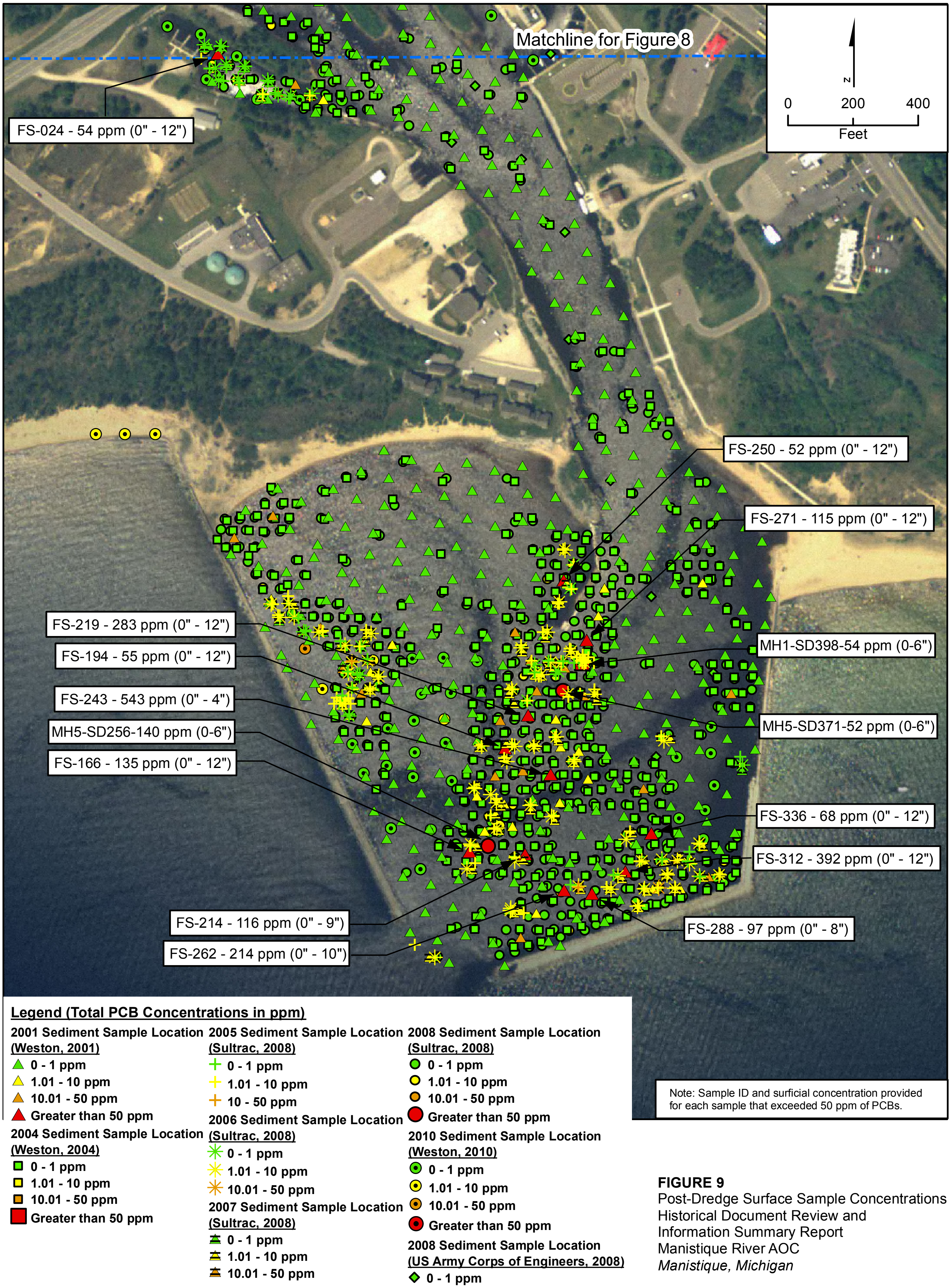

FIGURE 9
Post-Dredge Surface Sample Concentrations
Historical Document Review and Information Summary Report
Manistique River AOC
Manistique, Michigan

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Legend (Total PCB Concentrations in ppm)

2001 Sediment Sample Location (Weston, 2001)	2010 Sediment Sample Location (Weston, 2010)
0 - 1 ppm	0 - 1 ppm
1.01 - 10 ppm	1.01 - 10 ppm
10.01 - 50 ppm	10.01 - 50 ppm
Greater than 50 ppm	Greater than 50 ppm

FIGURE 10
Post-Dredge Maximum Subsurface Sample Concentrations
Historical Document Review and Information Summary Report
Manistique River AOC
Manistique, Michigan

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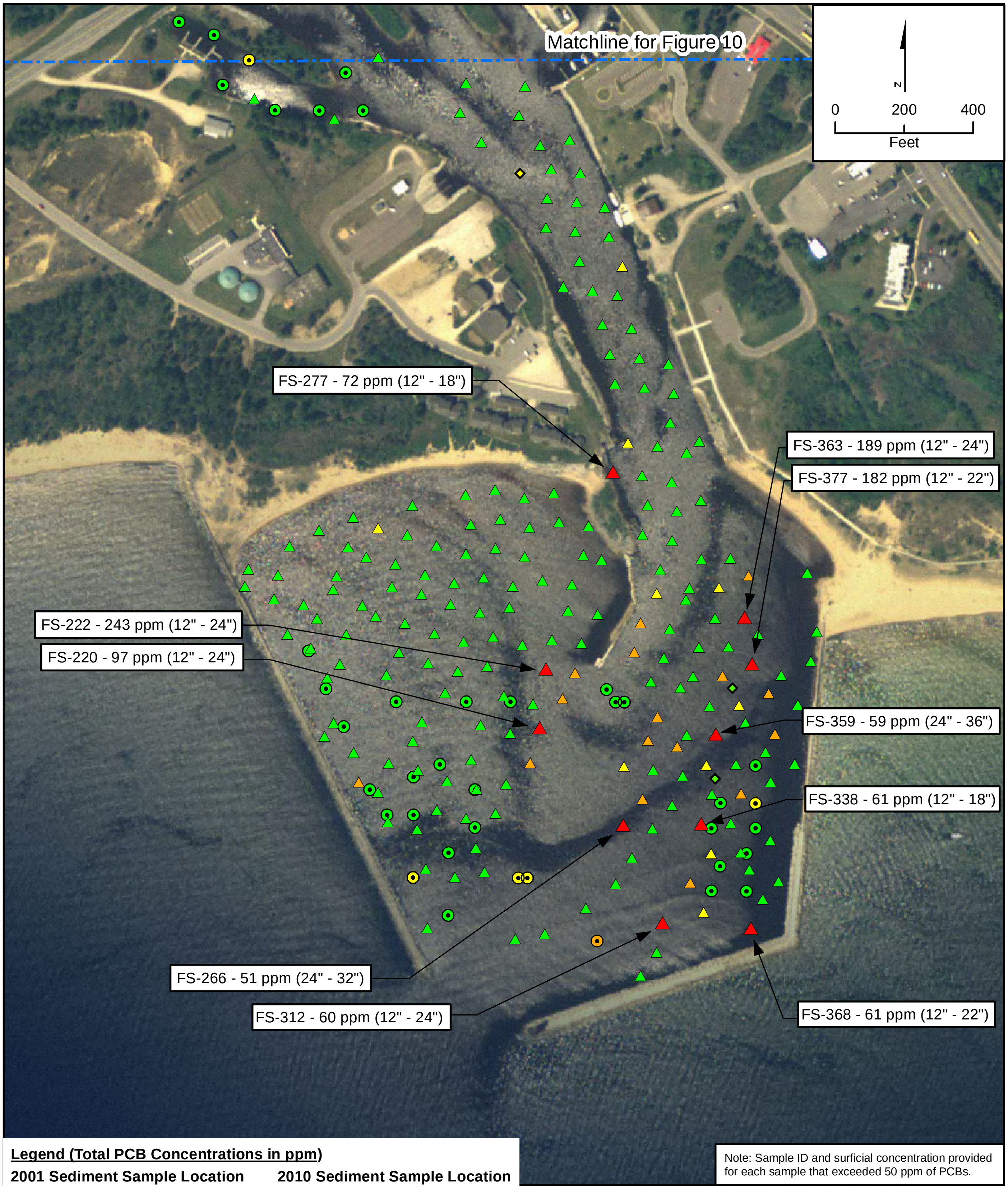
\\hercules\Proj\UsEnvironmentalProte\434422_Manistique_River_Harbor\Manistique River GIS\mapfiles\071612\Figure 10.mxd



Note: Sample ID and surficial concentration provided for each sample that exceeded 50 ppm of PCBs.

Legend (Total PCB Concentrations in ppm)

2001 Sediment Sample Location (Weston, 2001)
- 0 - 1 ppm
- 1.01 - 10 ppm
- 10.01 - 50 ppm
- Greater than 50 ppm

2008 Sediment Sample Location (US Army Corps of Engineers, 2008)
- 0 - 1 ppm
- 1.01 - 10 ppm

2010 Sediment Sample Location (Weston, 2010)
- 0 - 1 ppm
- 1.01 - 10 ppm
- 10.01 - 50 ppm
- Greater than 50 ppm

FIGURE 11
Post-Dredge Maximum Subsurface Sample Concentrations
Historical Document Review and Information Summary Report
Manistique River AOC
Manistique, Michigan

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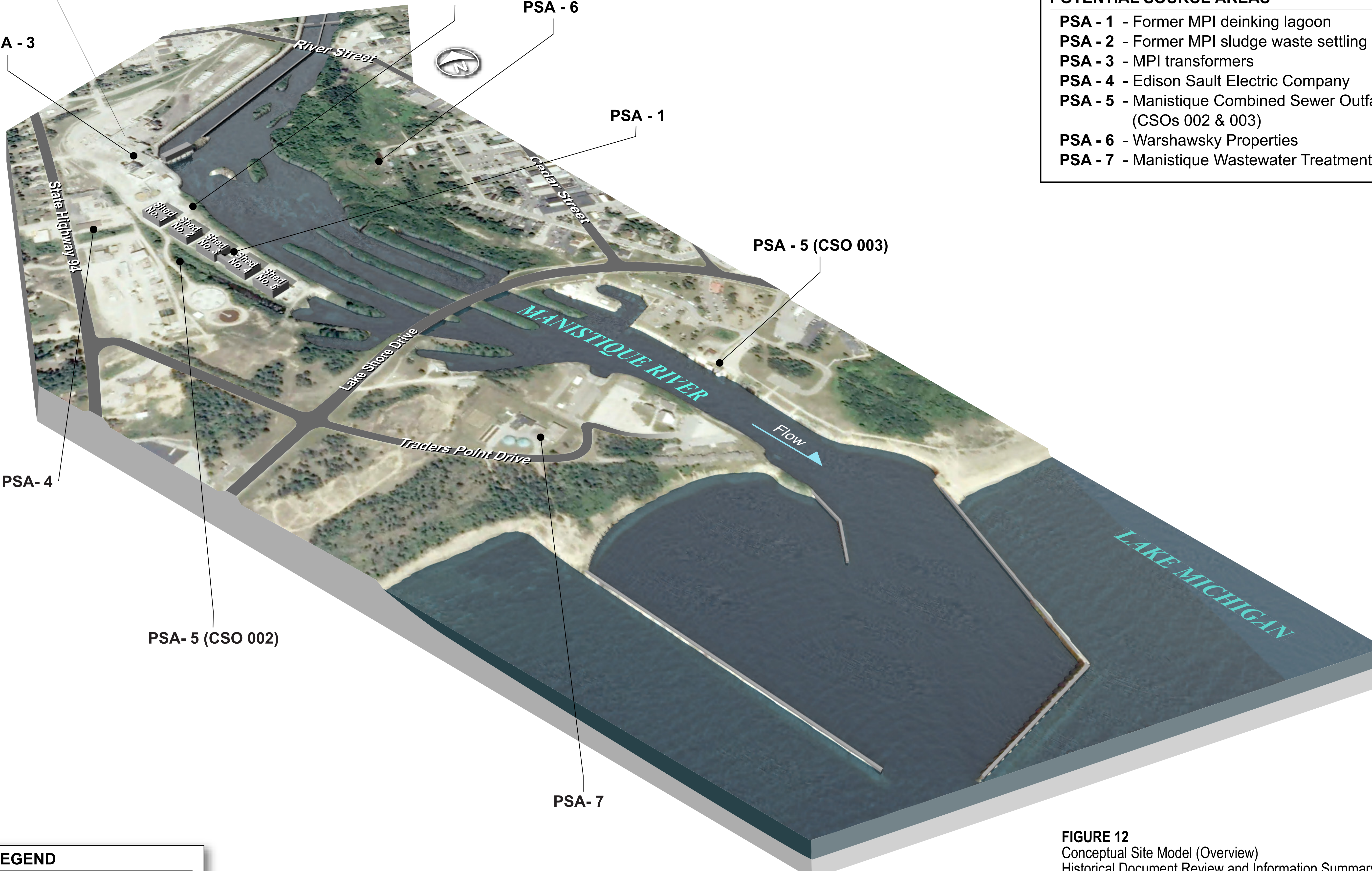
\\hercules\Proj\UsEnvironmentalProte\434422_Manistique_River_Harbor\Manistique River GIS\mapfiles\071612\Figure 11.mxd



POTENTIAL SOURCE AREAS	
PSA - 1	- Former MPI deinking lagoon
PSA - 2	- Former MPI sludge waste settling pond
PSA - 3	- MPI transformers
PSA - 4	- Edison Sault Electric Company
PSA - 5	- Manistique Combined Sewer Outfalls (CSOs 002 & 003)
PSA - 6	- Warshawsky Properties
PSA - 7	- Manistique Wastewater Treatment Plant

LEGEND

PSA Potential Source Areas

Not to scale.

FIGURE 12
Conceptual Site Model (Overview)
Historical Document Review and Information Summary Report,
Manistique River Area of Concern,
Manistique, Michigan

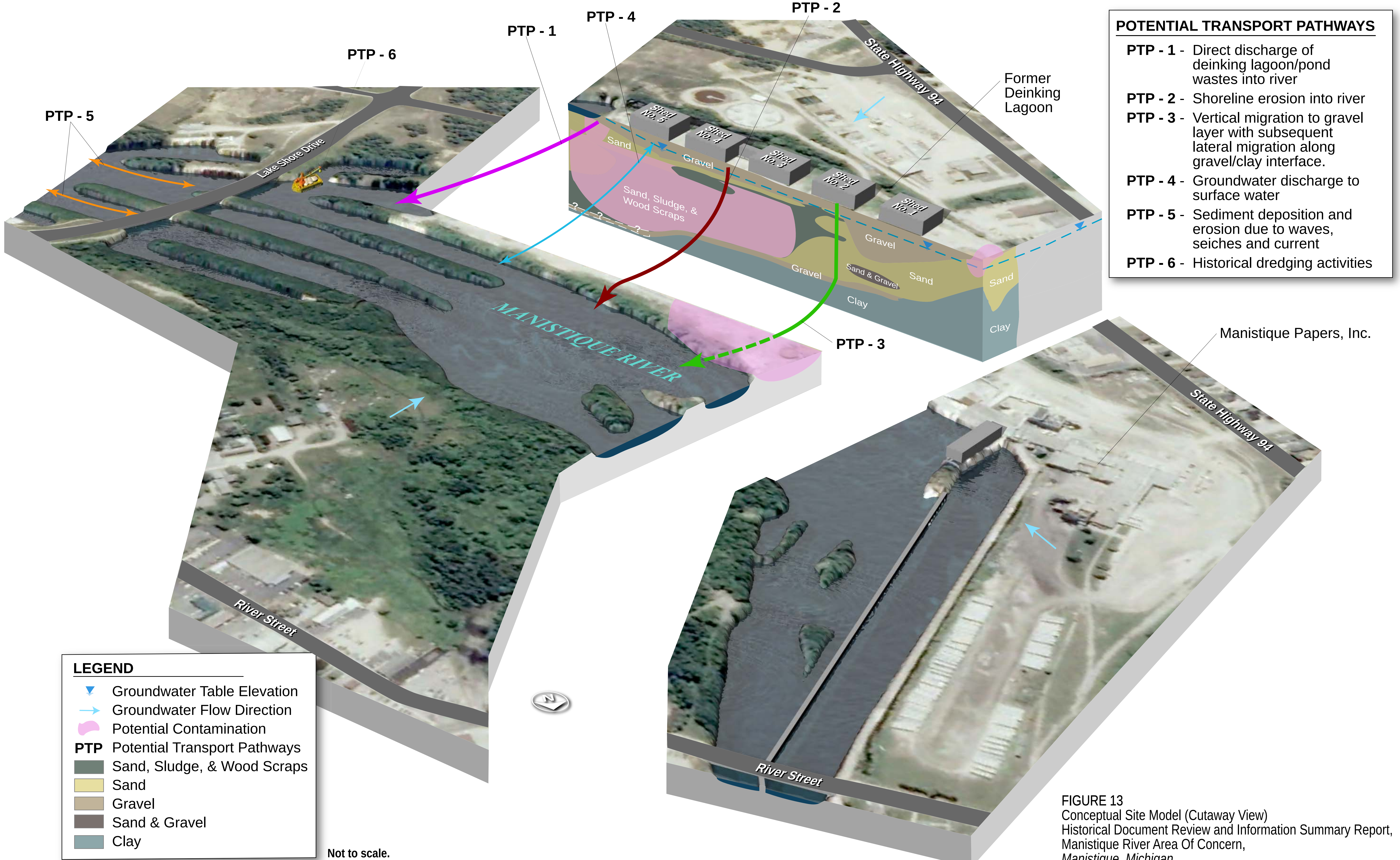


FIGURE 13
Conceptual Site Model (Cutaway View)
Historical Document Review and Information Summary Report,
Manistique River Area Of Concern,
Manistique, Michigan

Appendix A
Summary Matrix and Description of Available Data Sources

Summary Matrix and Description of Available Data Sources
Manistique River Area of Concern
September 2012

S.No	Document Title	File Name	Document Author(s)	Year	Summary of Information
1	*Sawdust and Wood Chip Deposits in Near-shore Lake Michigan Waters Near Manistique, Michigan*	Macalady 1981 Saw Dust and Wood Chip Deposits.pdf	Northern Michigan University	1981	1. Study to investigate the nature and origin of sawdust and other wood waste deposits that occur on beaches near Manistique. 2. Interviews with interested citizens, beach observations, collection of wind data, and a SCUBA diving survey of the lake and river bottom of the study area. 3. The following study objectives were included: (1) Determine the location and extent of sedimented wood waste deposits on the bottom of Lake Michigan near Manistique, (2) Develop a body of information related to prevailing winds and resulting water movements, which would enable prediction of movement of wood waste deposits, and (3) Assemble historical and geographical information about the nature and extent of the beach deposits. 4. Wood wastes appear to be localized in the river and mouth of the river. 5. The thick layers of wood wastes in the Manistique River and Harbor continue to be a major source of wood wastes added to Lake Michigan.
2	*A Biological, Sediment, and Water Survey of the Manistique River near Manistique, Schoolcraft County, Michigan August 1976 and July 1978*	1981 Biological, Sediment, and Water Survey.pdf	Kenaga, David	1981	1. Water, sediment, fish, and macroinvertebrate sampling upstream and downstream of Manistique Papers, Inc. 2. Surface water analytical results similar for upstream and downstream samples. 3. High polychlorinated biphenyl (PCB) concentrations near Outfall 5 (172 parts per million [ppm]), and in the harbor (5 to 17 ppm). 4. Fish above the dam had no detectable PCBs, and fish below the dam had detectable PCB concentrations, some above 5 ppm. 5. Macroinvertebrate community more dense, diverse, and pollution-intolerant upstream of the dam.
3	Figure 4-5, PCB Sampling Locations - Sediment, Manistique River, 1985	Page45_RAP_PCBLocationsMap.pdf	Michigan Department of Natural Resources	1987	1. Figure 4-5 from 1987 Remedial Action Plan (RAP) with PCB sediment sample locations in the Area of Concern (AOC). No other data or information provided.
4	*Chronology of Manistique Papers Transformers*	1985_ManistiquePapersInc_TransformerChronology.pdf	Manistique Papers, Inc.	1985	1. This letter/technical memorandum presents the chronology of leaks/stains that appeared on the Transformer #3 _____ and the action taken to mitigate the leaks/stains. 2. The activities took place between July 28, 1985, and December 6, 1985.
5	*Manistique Papers De-inking Wastes*	MDEQ_DeinkingWastes.pdf	Michigan Department of Environmental Quality	1985	1. This interoffice communication technical memorandum provides a short chronology and description of de-inking waste treatment, disposal, and results of sediment and water sampling from 1950-1979. 2. It provides a figure showing the deinking facility location, area of lagoon overflow, settling area, outfall locations, and treatment plant location. 3. It contains an excerpt of sediment sampling locations and results from sampling conducted in 1976 and 1978 (Kenaga 1981). 4. See Kenaga (1981) for additional complete review of sediment sampling results.

S.No	Document Title	File Name	Document Author(s)	Year	Summary of Information
6	*Report on Inspection to Determine Compliance with 40 CFR Part 261 PCB Regulations*	ManistiquePapersInc_PCBComplianceInspection.pdf	Michigan Department of Natural Resources	1985	1. This document is a report of inspection of Manistique Papers, Inc.'s handling, storage, and disposal practices and an assessment of compliance with PCB regulations (40 *Code of Federal Regulation* s [CFR] 761). 2. The report describes four PCB-containing transformers. It contains soil/sludge sampling results for samples collected on the de-inking slip in 1985, and reports high concentrations near Outfall 5. 3. The report contains industrial wastewater surveys from 1968, 1973, 1974, 1977, 1984, and 1981 Michigan Department of Natural Resources (MDNR) studies. 4. It contains the Residuals Management Plan prepared by Manistique Papers, Inc., showing landfill for sludge disposal, sludge characteristics, wastewater processes. 5. It contains a letter describing disposal issues from the lawyer of a landowner adjacent to the landfill.
7	U.S. Army Corps of Engineer Manistique Harbor Navigation Map	USACE Manistique Harbor Navigation Map 1986.pdf	U.S. Army Corps of Engineers	1986	1. It includes a cmp of the Manistique River Harbor. 2. Projected and maintained navigation channel depths are provided. 3. Details of the surrounding areas (that is, street names, locations of boat and ferry slips, and business, including Manistique Pulp & Paper Company) are also shown.
8	Replicate sampling results for split samples collected from de-inking lagoon area in 1985 and 1986	1986_Replicate_Sample_Summary.pdf	Michigan Department of Natural Resources	1986	1. It contains a transmittal of soil sampling results from MDNR to Manistique Papers, Inc., for samples collected near the former de-inking facility in 1985 and 1986. 2. It provides useful information on the soil PCBs results in the areas surrounding the de-inking lagoon. 3. Samples are replicates from the 1985 sampling by MDNR and 1986 sampling by Bittner Engineering.
9	Figures from the 1987 *Michigan Department of Natural Resources Remedial Action Plan for the Manistique River Area of Concern*	1987_RAP_Figures.pdf	Michigan Department of Natural Resources	1987	1. They are duplicates of 1987 Remedial Action Plan figures. 2. They provide useful information on the soil PCBs results in the areas surrounding the de-inking lagoon.
10	*Michigan Department of Natural Resources Remedial Action Plan for the Manistique River Area of Concern*	1987_RAP.pdf	Michigan Department of Natural Resources	1987	1. The document describes the AOC, environmental setting, beneficial use impairments, pollutants of concern, potential sources, historical remedial actions and programs and participants.
11	*Report of Soil Sampling in the Bank of the Manistique River*	BittnerSoilSamplingDeInkingArea.pdf	Bittner Engineering, Inc.	1987	1. It is a soil investigation to assess soil PCB concentrations at the former de-inking facility. 2. Samples were collected after paper storage sheds were constructed. 3. Soil PCB concentrations were found at a high of 73 ppm east of the emergency overflow pond. 4. High concentrations were found in two samples collected just above bedrock in borings between paper sheds Nos. 2 & 3 and sheds Nos. 3 & 4. 5. No other samples were collected just above bedrock. 6. Boring logs contain soil lithology.
12	*Hydrogeological Study for Manistique Paper's Inc. Residuals Management Site Section 36, T42N, R16W Hiawatha Township Schoolcraft, Michigan*	1988_ManistiquePapersInc_HydrogeologicStudy.pdf	Bittner Engineering, Inc.	1988	1. The document is a hydrogeologic investigation of the paper mill landfill site located approximately 1.5 miles north of the paper mill location. 2. The landfill received "residuals" from the paper mill starting in 1973. 3. Soil borings and groundwater monitoring wells were installed near the landfill. 4. It concluded that residual material was suitable for placement at the site because it met the definition of "inert" based on the MDNR Solid Waste Guidelines from February 1987, and that the materials have been placed at the site for approximately 15 years without creating any adverse environmental impacts.

S.No	Document Title	File Name	Document Author(s)	Year	Summary of Information
13	Historical sampling tables and maps	Historic Sampling Tables and Maps.pdf	Unknown	1988	1. Select excerpts from various sampling and analysis reports for sampling events from 1976 through 1988. 2. Some information not legible. Attachments not complete. Information provided in other reports. 3. USACE 1988 4. MDNR 1986 5. MDNR 1985 6. Missouri Department of Transportation (MDOT) 1982 7. Great Lakes National Program Office (GLNPO) 1981 8. MDNR 1976
14	*PCB Results and Results of Benthos Collections, Manistique Harbor, July 1988*	USACE_Historic_Benthos_Data.pdf	U.S. Army Corps of Engineers	1988	1. Transmittal from USACE to USEPA of benthos data collected from Manistique Harbor by on July 27, 1988. 2. Letter discusses elevated PCB concentrations but mapping showing sampling locations and results is not provided. 3. Taxa, common name, density (number / square meter), and pollution tolerance rating provided for each sample. 4. Sampling location map not included. 5. Pollution tolerance reference not provided.
15	Draft Screening Site Inspection Report for Manistique Papers, Inc. Manistique Michigan U.S. EPA ID: MID981192628	1991_Screening_Site_Inspection.pdf	Michigan Department of Natural Resources	1991	1. Report describing sediment, surface water, and soil sampling and results for samples collected in 1990. 2. Elevated PCB concentrations in sediments near de-inking lagoon (up to 100 ppm). 3. Report includes PCB data collected by the USACE in 1990. USACE reports harbor samples up to 338 ppm PCBs. 4. No contaminants of concern found in surface water samples. 5. Pages 3-2 through 3-6 containing most of the study methods are missing.
16	MDNR Expanded Site Inspection Data	1992_ERD_Data.pdf	Michigan Department of Natural Resources	1992	1. MDNR transmission to MPI of invalidated data from 1992 MDNR soil sampling of former de-inking lagoon area and surface water and sediment samples throughout AOC. 2. Split samples were provided to Bittner Engineering. 3. Full report name is 1992 Expanded Site Inspection.
17	December 1993 Sediment Sample Descriptions	1993_SedimentSampleDescriptions.pdf	Unknown	1993	1. Table 1 from the Manistique Harbor Engineering Evaluation/Cost Analysis. 2. Table summarizes the December 1993 Sediment Sampling performed at the site. 3. Lists the sample IDs, sample intervals, time and date collected, depth of water, sediment penetration and sediment recovered measurements, and descriptions of the sample material. 4. Photocopies do not include all of the information. 5. Analytical results not provided for samples.
18	Results of April 20, 1994, Sediment Probing and Sampling	1994_Sampling_Survey_TechMemo.pdf	Blasland, Bouck, and Lee, Inc.	1993	1. Technical memorandum presents the sample locations, probe locations, sampling methodology, sediment thickness, and sediment trap placement information. 2. Field activities including sediment trap placement are described in detail. 3. River sediment probing results summary table along with description of the sediment material is provided. 4. River sediment thickness ranged from 0 to 8 feet. 5. PCB results not provided.

S.No	Document Title	File Name	Document Author(s)	Year	Summary of Information
19	Manistique Harbor Maps Sediment Survey	Harbor_maps.pdf	U.S. Environmental Protection Agency	1993	1. Figures depicting sediment thickness contours representing shallow zone, intermediate zone and the bottom zone in the Manistique Harbor. 2. Figure depicting maximum PCB concentrations at each sample location and concentration contours in the harbor area. 3. Table showing arithmetic and geometric mean PCB concentrations. 4. Presents summary statistics table for the PCB data and oil and grease data collected during the 1993 sediment survey. Presents a table with PCB data compared with surface sediment TOC. 5. Table with estimated sediment volumes, average sediment thickness, surface area, and PCB concentration range within the Manistique Harbor. 6. Presents principal conclusions of the review.
20	Time of Travel Dye Study on the Manistique River at Manistique Papers August 25, 1993	1995_Dye_Study.pdf	Michigan Department of Environmental Quality	1993	1. Study conducted in response to a proposal to discharge more wastewater into the river from the paper mill. 2. Preliminary models indicated that the river was not meeting the dissolved oxygen requirements at the exit. 3. Report provides the sampling methodology, sample locations, and analytical results. 4. Dye released at discharge required 2 hours and 42 minutes to reach the inner harbor area.
21	*An Assessment of the Sources and Distribution of PCBs in the Manistique River*	1993_TERRAInc. An Assessment of the Sources and Distribution of PCBs in the Manistique River.pdf	Toxilogical Evaluations, Research, and Risk Assessment, Inc.	1993	1. Report that reviews the available information collected at the site from 1973-1992, including spatial and temporal analytical results of soils, sediments, wastewater, and sludge sampling. 2. Detailed chemical characteristics and historical uses for PCBs. Potential sources of PCBs other than MPI are reviewed including wastewater treatment plant, Edison Sault Electric Co, Warshawsky Junkyard, and Michigan Dimension Co. 3. Report purports that the data support the conclusion that Manistique Papers, Inc., is not the source of PCBs in the Manistique River.
22	*Manistique Harbor 1993 Sediment Survey*	1993_ManistiqueHarbor_SedimentSurvey.pdf	Blasland, Bouck, and Lee, Inc.	1993	1. Report for sediment sampling within Manistique Harbor and near combined sewer overflow. 2. Sediment in harbor sampled on 75-foot by 75-foot grid. 3. Divers sampled in 12 locations where split-spoons did not recover sediment. 4. Results analyzed using kriging technique. 5. Sediment volumes for various PCB concentrations were estimated. 6. PCB concentrations generally increased with increasing sediment depth. 7. Generally higher PCB concentrations for silt than sawdust/wood.
23	*Accelerated Engineering Evaluation/Cost Analysis*	1994_AcceleratedEngineering_CostEvaluation.pdf	Blasland, Bouck, and Lee, Inc.	1994	1. Feasibility Study conducted in 1994 under the Superfund Accelerated Cleanup Model. 2. This report presents general site characterization of the AOC, identifies the goals and potential applicable or relevant and appropriate requirements, presents six alternative evaluations for the remedial action, cost estimate, and conclusions. 3. Three main methods were evaluated for remedial action alternatives: (1) No action/monitoring controls, (2) Sediment removal, and (3) Treatment and disposal and in situ containment/treatment. 4. Each of the six alternatives was evaluated against technical feasibility, cost implementability, and community acceptance. 5. Sections of this report present the sediment data and survey conducted from 1985 through 1993. 6. Also discusses history of previous studies, possible exposure pathways, source, nature and extent of contamination, and streamlined risk assessment.

S.No	Document Title	File Name	Document Author(s)	Year	Summary of Information
24	MDNR Intraoffice Communication RE: Hydrogeologic study of the Manistique Papers Company with respect to the River	1994_MDNR_Hydrogeologic_Evaluation.pdf	Michigan Department of Natural Resources	1994	1. Compilation of information regarding general geology and hydrogeologic conditions at and around the immediate vicinity of the Manistique River PCB contamination area. 3. Provides a detailed summary of the site and surrounding geology. Soil boring logs from a MDNR hydrogeologic investigation site are included as an attachment to the report. 4. Provides a detailed summary of the site hydrology. 5. Hydrogeologic investigation concluded that groundwater generally flows toward the Manistique River at the lower river east side, and that shallow groundwater within the glacial drift flows parallel with the river; groundwater levels are influenced by the river hydraulic conditions. 6. Evaluates the potential for PCB migration—Concludes that dredging in 1960-1970 period could have caused PCB-laden sediments to be transported downstream to the harbor. 7. Suggests performing a study of the mill lagoon hydraulics to assess whether PCB laden sediment could flow through more permeable bed material and discharge to the river.
25	1994 BB&L Letter RE: R20 Area Sediment Sampling	1994_US2BridgeSite_Sampling_Summary.pdf	Blasland, Bouck, and Lee, Inc.	1994	1. Bittner Engineering, Blasland, Bouck, and Lee, Inc., Ecology and Environment (for USEPA) conducted sediment probing and sampling in December 1993 and April 1994. 2. Total PCBs (TPCB) detected in all stations and most depth intervals. 3. PCBs exceeded 50 ppm at three locations in North Bay. 4. Relatively low TPCB (6.5 ppm) in West Bay 5. Low TPCB east of former de-inking area and upstream of North Bay.
26	"EPA Selects Response Action and Completes the Majority of Dredging Activities"	1995_EPA_ManistiqueDredging_FactSheet.pdf	U.S. Environmental Protection Agency	1995	1. USEPA fact sheet describing the response action selected for the Manistique River and Harbor site, the status of dredging activities in the North Bay area, future dredging activities, and how to obtain additional information. 2. The document is incomplete—This is only the first page of the fact sheet and only provides the first few elements of the remedy selected for the site. 3. A map of the North Bay area of the site is shown, depicting the progress of the dredging activities including areas already dredged, areas to be dredged, and areas that do not need dredging.
27	Blasland, Bouck, and Lee, Inc., Letter to USEPA RE: Manistique Harbor and River	BBL Letter to EPA RE Dec 1993 and Spring 1994 sampling results.pdf	Blasland, Bouck, and Lee, Inc.	1995	1. Figures presenting thickness and concentration of sediment present beneath and immediately downstream to the U.S. Highway 2 bridge and nearby streams. 2. Hand markups of the PCB isoconcentration levels. 3. PCB results table with concentrations at corresponding depth intervals of the three sediment samples collected. 4. Sediment thickness ranged up to 46 inches. 5. PCB concentrations up to 630 ppm in the downstream portion of North Bay.
28	*USEPA Administrative Record Removal Action Manistique River and Harbor Site Manistique, Michigan Update #12 10/21/96*	MRH Administrative Record Update 12.pdf	U.S. Environmental Protection Agency	1996	1. Administrative Record Updates for Manistique River and Harbor; Updates 4, 5, 6, 9, 10, 11, and 12. 2. Listings of reports and other documentation (for example, public comments, letters, memoranda, and journal and newspaper articles, etc.) relevant to the Manistique River and Harbor Site. 3. The list includes the document title, date, author(s), document recipient(s), and general description of the document.
29	2001 Bathymetric Survey	2001_Manistique_Bathymetric_Survey.jpg	U.S. Environmental Protection Agency	2001	1. Map showing the bathymetry of the Manistique Harbor in 2001. 2. Legend not provided, although relative depths seem intuitive with darker areas being relative deeper than lighter areas. 3. Background is an aerial photograph of Manistique, Michigan.

S.No	Document Title	File Name	Document Author(s)	Year	Summary of Information
30	*Final Comprehensive Post-Removal Summary Report*	2002 Final Post-Removal Summary.pdf	Weston Solutions, Inc	2002	1. Post-dredging summary report that calculated whether dredging removed 95% of total PCB mass and resulted in average concentration of <10 ppm in sediment. 2. Developed EQuIS database of all sampling results collected over 5 years of operation of water treatment system. 3. Dredging removed 187,500 cubic yards and 82-97% of PCBs. 4. Contains Screening-Level Ecological Risk Assessment that concluded all sediments contain PCB concentrations that exceed the no observable adverse effect level cleanup goals. 5. Contains Streamlined Human Health Risk Assessment that concluded some risk-based cleanup goals were exceeded.
31	Presence of Wood or Sawdust in Manistique AOC Sediments in 2004	2004_Sawdust&Wood_map.pdf	Unknown	2004	1. Map showing the presence of sawdust or wood in the sediment samples collected in the Manistique AOC and harbor in 2004. 2. Sawdust and wood samples are predominantly present in the harbor and de-inking lagoon.
32	*Field Summary Report Manistique Harbor and River Site Manistique, Michigan*	2004_Weston_FieldSummary_Abridged.pdf	Weston Solutions, Inc	2004	1. Field summary of resident fish sampling, sediment and water sampling, caged fish study, and semipermeable membrane devices (SPMD)s. 2. Filet and carcass adult fish and composite for yearling fish. 3. Caged fish study conducted. 4. SPMDs placed at each caged fish location. 5. Results not provided in this document.
33	Section 4—Statistical Evaluation from *Final Evaluation Report*	StatisticalAnalysisExcerpt_2005_WestonFinalEvaluationReport .pdf	Weston Solutions, Inc	2005	1. Section 4—Statistical Evaluation from the Final Evaluation Report (Weston 2005). 2. Presents information on the different statistical evaluations such as ANOVA, ANACOVA, regression analysis, etc., of the PCB data collected during the period 2000-2004 performed to investigate the occurrence of PCBs in sediment, fish, and surface water and to explain the factors that influence their occurrence. 3. Presents analysis on the distribution of PCBs in sediment using geostatistics. Table 4-2 in the report presents the comparison of the 2001, 2003, and 2004 sampling rounds. Figure 4-9 shows the frequency distribution of surface residuals in the data set. 4. Section 4.1.2 discussed the factors that affect the PCB concentrations and the analysis conducted to determine that. 5. Figure 4-13 in the report presents the relationship between the PCBs and sediment texture. 6. Sections of the report also discusses the analysis of PCB concentration in the fish samples and their feeding behaviors. 7. Sections of this report discusses the statistical analysis conducted to compare between test sites, sediment transportation and PCB content in the sediment.
34	Presence of Wood or Sawdust in Manistique AOC Sediments in 2005	2005_Sawdust&Wood_map.pdf	Unknown	2005	1. Map showing the presence of sawdust or wood in the sediment samples collected in the Manistique AOC and harbor in 2005. 2. Number of sample locations analyzed are much less than collected in 2004. Also, the presence of sawdust and wood in the harbor and deinking lagoon is less than that observed in 2004.
35	Section 4—Statistical Evaluation from *Final Evaluation Report*	StatisticalAnalysisExcerpt_2005_WestonFinalEvaluationReport .pdf	Weston Solutions, Inc	2005	1. Statistical analysis of available sediment data from 2001 to 2004. 2. Four main areas of PCB concentrations include North Bay area (includes marina) and three locations in the harbor. 3. PCB maximum, median, and average concentrations decreased from 2000 to 2004. 4. Analyses to assess factors affecting PCB concentrations. 5. Caged fish study indicated no detectable PCBs in composite fish samples. 6. Statistical analysis to determine whether SPMDs had different total PCB concentrations based on various environmental factors.

Summary Matrix and Description of Available Data Sources
Manistique River Area of Concern
September 2012

S.No	Document Title	File Name	Document Author(s)	Year	Summary of Information
36	*The Michigan Department of Environmental Quality Biennial Remedial Action Plan Update for the Manistique River Area of Concern*	2007_MDEQ_FinalRAP_update.pdf	Michigan Department of Environmental Quality	2007	1. This report is a Biennial RAP that documents and communicates progress to the public and agencies. 2. Sections of this report provide the background information, beneficial use impairment (BUI) removal matrix with remaining BUIs, assessment of progress, and BUIs removed. 3. The report in general provides the following: (1)Significance in the Manistique AOC (2) Restoration Criteria (3) Remedial Actions performed in the past (1973-2004) (4) Assessment results for each of the BUIs listed in the BUI matrix table.
37	*Final Close-out Memorandum for Removal Action*	finalcloseoutmemo.pdf	U.S. Environmental Protection Agency	2007	1. USEPA memorandum to file that generally describes the AOC, chronology of sediment and soil sampling and analyses and removal actions, and costs incurred through April 2007. 2. Provides map of temporary capping area and dredged areas.
38	Guidance for Delisting Michigan's Great Lakes Areas of Concern	MDEQ_AOC_Delisting_Guidance.pdf	Michigan Department of Environmental Quality	2008	1. State process to track restoration progress, remove BUIs, and ultimately delist AOCs. 2. Statewide Criteria for Restoration of Beneficial Use Impairments for Michigan's Great Lakes AOCs. 3. Actions and policies for applying restoration criteria to the BUIs in AOCs and documenting progress toward removal. 4. Actions and policies for removing a BUI and documenting these activities. 5. Actions necessary to delist an AOC. 6. Special considerations for shared jurisdictions, use of special designations, source control, and dispute resolution. 7. Specific restoration criteria for each of the 14 BUIs.
39	*PCB Concentrations in Wild-Caught and Caged Fish Samples Collected from the Manistique River Area of Concern Schoolcraft County, Michigan November 2008*	2009_MDEQ_Fish_Report.pdf	Michigan Department of Environmental Quality	2008	1. Caged Fish and Wild Fish Study. 2. Caged fish placed in Manistique River AOC. 3. Wild fish collected from AOC and Little Bay De Noc. 4. Tissue PCB concentrations of all caged fish were nondetect. 5. Except for carp, wild fish from the AOC had significantly higher PCB content than wild fish from Little Bay De Noc. 6. Wild carp tissue PCB concentrations declined from 2004 to 2008 in the AOC. 7. Other wild fish species PCB concentrations did not change from 2004 to 2008.
40	*Sediment Sampling and Analysis Report, Manistique Harbor, Michigan*	2008_SedimentSampling&AnalysisReport (front portion).pdf and 2008_SedimentSampling&AnalysisReport_Draft_Textonly.pdf	U.S. Army Corps of Engineers	2008	1. Sediment sampling at 11 locations in Manistique Harbor. 2. Biological toxicity testing and elutriate testing showed no significant difference in survival or growth between background and test samples. 3. Bioaccumulation study showed PCB concentrations in Lumbriculus was significantly higher for worms held in harbor sediment than lake sediment. 4. Detected PCB concentrations in Manistique Yacht Club Marina sediments and sediments immediately downstream of marina. 5. Nondetect PCBs in all other samples.
41	October 2009 Condition of Channel	Manistique_Harbor_GLRI_Sampling_2011_-_sampling_map.pdf	U.S. Army Corps of Engineers	2009	1. USACE mapping of Manistique Harbor water depths as surveyed in October 2009.
42	October 2009 Condition of Channel	2009_USACE_SurveyMap1.pdf	U.S. Army Corps of Engineers	2009	1. USACE mapping of Manistique Harbor water depths as surveyed in October 2009.
43	October 2009 Condition of Channel	2009_USACE_SurveyMap2.pdf	U.S. Army Corps of Engineers	2009	1. USACE mapping of the "outer" Manistique Harbor (Lake Michigan portion of harbor and immediately inside harbor breakwalls) water depths as surveyed in October 2009.

Summary Matrix and Description of Available Data Sources
Manistique River Area of Concern
September 2012

S.No	Document Title	File Name	Document Author(s)	Year	Summary of Information
44	2009 Bathymetric Survey	2009_Manistique_Bathymetric_Survey.jpg	U.S. Environmental Protection Agency	2009	1. Map showing the bathymetry of the Manistique Harbor in 2009. 2. Legend not provided, although relative depths seem intuitive with darker areas being relative deeper than lighter areas. 3. No specific sample location IDs or concentration values identified on the map. 4. Total PCB results for sediment samples collected from North Bay and harbor in 2008. 5. Sample depths not provided.
45	Location of Wood Chip Samples on Beach Manistique, Michigan	Sept2010_WoodChip_SampleLocations&Results_map.pptx	Unknown	2010	1. Excerpt from map of Manistique Harbor highlighting the beach sampling locations on the Lake Michigan shoreline. 2. Labels appear to provide total PCB concentrations at specified depths. 4. Sample IDs match labeling from USEPA 2010 sampling; however, TPCB values do not match 2011 report.
46	*Manistique Sea Lamprey Barriers*	ManistiqueAttachments.pdf	Unknown	2010	1. Document composed of site location map, photographs of existing dam upstream of facility, and drawings of alternative sea lamprey barriers. 2. Two design drawings for Alternative 1—Cantilever steel sheet pile wall. 4. Design drawing for Alternative 2—Post and panel wall.
47	Figure 3 Maximum TPCB Values—Surface and Subsurface Samples Manistique Harbor Manistique, Schoolcraft County, Michigan	2010_Max_TPCB_Values_map.pdf	Weston Solutions, Inc.	2010	1. Map presenting the analytical results for 2010 sediment sampling within harbor and river. 2. Elevated PCB concentrations in North Bay (490 ppm), West Bay (48 ppm), harbor (35 ppm), and beach (6.3 ppm).
48	Manistique Sampling Data: 2010 Maximum PCB Concentration	2010_PCB_Concentration_Maps.pdf	U.S. Environmental Protection Agency/Fields Program	2010	1. Sediment sample location map for samples collected in Manistique Harbor and upstream to the paper mill. 2. Maximum Total PCB concentrations in 0- to 6-inch interval , 6- to 12-inch intervals, and at all depths for each location. 3. One sediment sample, located in North Bay, exceeded 50 ppm PCBs. 4. Few samples exceeded 1 ppm Total PCB.
49	Maximum TPCB Values—Surface & Subsurface Samples	Manistique_Maps.pptx	Weston Solutions, Inc.	2010	1. PowerPoint presentation with three maps created using analytical results for sediment collected in 2010 by USEPA. 2. Map presenting the sediment sample locations with maximum surface concentrations in the Manistique River and Harbor areas. 3. Map presenting the sediment sample locations with maximum subsurface concentrations in the Manistique River and Harbor areas. 4. Map presenting the sediment sample locations with maximum surface and subsurface PCB concentrations in the Manistique River and Harbor areas.
50	2011_ManistiqueWaterDepth_Figure	2011_ManistiqueWaterDepth_Figure.jpg	Unknown	2011	1. Map showing the water depths in the Manistique River AOC in 2011. The water depth ranges from less than 1 meter to over 7 meters.
51	*Stage 2 Remedial Action Plan Manistique River Area of Concern*	2011_RAP_Stage2.pdf	Michigan Department of Environmental Quality	2011	1. RAP Update provides the following: (1) Significance in the Manistique AOC, (2) Restoration Criteria, and (3) Current status and action to be undertaken for each of the five BUIs listed in the RAP 2. 2. Report presents the purpose of the Stage 2 RAP. 3. Presents the BUI tracking matrix table with list of actions/tasks, target BUI start and removal dates, etc.
52	*A Brief History of Manistique Papers, Inc.*	MPIHistory.pdf	Unknown	2011	1. General overview of the history of Manistique Papers, Inc., from 1914 to 2011. 2. The overview describes major milestones of the facility, including construction dates, opening date, ownership changes, upgrades, USEPA settlement, and filing for bankruptcy. 3. No quantitative information is provided.

S.No	Document Title	File Name	Document Author(s)	Year	Summary of Information
53	*Draft Data Evaluation Report for Manistique River Sediment Investigation Manistique, Schoolcraft County, Michigan*	2011_Weston_Draft_2010SedimentInvestigation_DataEvaluation.pdf	Weston Solutions, Inc.	2011	1. Sediment cores collected from 63 locations in Manistique River and Harbor. 2. Surface sediment samples collected from 23 locations. 3. Five areas of interest were the focus of the sampling. 4. All core locations were analyzed for PCB aroclors, total organic carbon, grain size, and bulk density. 5. PCB congeners analyses on 10% of samples. 6. Four samples collected for bioaccumulation study.
54	Manistique Harbor Sediment Bioaccumulation Testing	2011_EPA_ManistiqueHarborBioaccumulationPresentation.pdf	U.S. Environmental Protection Agency	2011	1. PowerPoint presentation of 2011 bioaccumulation study. Author and year of study not presented. 2. Sediments collected from four locations for PCB congener analysis. 3. 28-day Lumbriculus variegatus bioaccumulation test. 4. Biota-Sediment Accumulation Factors (BSAFs) calculated and compared to other sites in Great Lakes. 5. BSAFs slightly, but not significantly higher than other sites. 6. Concluded that Manistique River AOC contaminant bioaccumulation is not unusual.
55	Manistique Harbor Sediments: Sediment Bioaccumulation Test Results	2011_ManistiqueHarbor_LumbriculusB_BioaccumulationSummaryReport.docx	U.S. Environmental Protection Agency	2011	1. Document presents results of 2011 bioaccumulation study. 2. Minimal interpretation of results.
56	National Oceanic and Atmospheric Administration's Enhanced Great Lakes Mussel Watch Program: Monitoring Contaminant Levels in Mussels from Historic Mussel Watch Sites and Areas of Concern	NOAA_MusselWatch_FinalPresentation.ppt	National Oceanic and Atmospheric Administration	2011	1. PowerPoint presentation of National Oceanic and Atmospheric Administration's Mussel Watch Program. 2. Slight mention of Manistique. 3. Information not specific to Manistique River AOC.
57	Detroit District 5 Jan 2012 Manistique Harbor Dredging Records Sediment Testing	2010-2011_USACE_SedimentDredging&Sampling_presentation.pptx	U.S. Army Corps of Engineers	2012	1. PowerPoint presentation describing the 2010 dredging activities—Provides photographs of the mechanical dredging equipment and barge used during the activities. 2. Photographs of the dredging operation. 4. Presents information regarding the Fall 2011 sediment sampling activities—Figure showing the sampling transects, photos of sediment cores collected, and a figure showing PCB concentrations at specific locations. 5. Concluded that PCBs were not found in the water fraction of the sediment. 6. Appears to be a draft presentation as it contains blank slides and red text indicating tables and data to be inserted.
59	Birds as Indicators of Contaminant Exposure and Effects in the Great Lakes	USGS_GLRIProject80_Presentation.pptx	U.S. Geological Survey	2012	1. PowerPoint presentation about the use of birds as indicators of contaminant exposure. 2. Explains why swallows are useful indicators of contaminant exposure. 3. Nest boxes deployed near de-inking lagoon, boat launch, and outer harbor. 4. Five nests built. 5. Swallows in nests contained PCBs near the mean levels for U.S. and Canada. 4. Additional monitoring is planned for 2012.

S.No	Document Title	File Name	Document Author(s)	Year	Summary of Information
60	Conceptual Design for Manistique River Source Tracking	Conceptual Design for Manistique Source Tracking.ppt	U.S. Environmental Protection Agency/U.S. Geological Survey	2012	1. Short PowerPoint presentation outlining a general sampling approach to identify potential PCB source near the Manistique Paper facility. 2. Approach includes groundwater-surface water interface sampling, water column-bivalve deployment, surface water sampling, and pore water sampling.
61	Riparian indicators of contaminant exposure in Manistique River and Harbor	MSQ_USGS_ContaminantExposureIndicators.pptx	U.S. Environmental Protection Agency/U.S. Geological Survey	2012	1. PowerPoint presentation of spider and sediment sampling results. 2. River, harbor, and beach sampling schemes presented. 3. PCBs detected in sediment and spiders. 4. Sediment and spiders collected from backwater and harbor sites had highest PCB concentrations. 5. Results show shift in homolog distribution to lower chlorination congeners in spiders from upstream to downstream. The biggest shift occurs between the above dam sample and the de-inking lagoon area sample.
62	Maps and Figures of AOC and its surroundings	20120214132143073.pdf	Unknown	1971, 1976, and 1985	1. Series of five figures excerpted from historical documents. 2. Figure showing area upstream of US-2 Bridge. 3. Figure showing areas dredged in 1990s. 4. Figure showing area upstream of US-2 Bridge, dated 1971. 5. Figure showing sediment sampling locations, dated 1985. 6. Figure showing sediment sampling locations from 1976 and 1978.
63	Presentation with PCB trends over time	Manistique_bathymetry_extra_info.pptx	Unknown	1996-2008	1. PowerPoint presentation with table showing general decline in PCB concentration from 1996 until 2008. 2. 2009 bathymetry map of the Manistique River AOC with PCB sample locations and their corresponding concentrations collected in 2008. Two samples in harbor channel contains TSCA level PCBs. 3. Map showing sediment deposit patterns and surface elevations changes from 2001 to 2009. Greater than 4 meters of sediment deposition in portions of harbor.
64	Sediment Changes from 2001 to 2009	2001 to 2009_Manistique_SedimentChanges.jpg	Unknown	2001-2009	1. Map showing sediment deposit patterns and surface elevations changes from 2001 to 2009. Greater than 4 meters of sediment deposition in portions of harbor. 2. Most of the AOC experienced an increase in sediment deposits. Very few areas experienced erosion/scour of sediment. 3. A small portion on the east side of the harbor channel (north of the east harbor wall) experienced scour up to 4 feet since 2001 until 2009. 4. Most sediment deposition occurred in the harbor (4+ meters).
65	Manistique River Sediment PCB data analyses	Manistique_SFdata_presentation.pptx	U.S. Environmental Protection Agency/Great Lakes National Program Office	2004-2008	1. PowerPoint presentation provides a brief overview of the PCB sediment analyses conducted during the period 2004-2008 in the Manistique Harbor. Also presents statistical analysis conducted on the PCB results collected between 2004-2008. 2. Presents exoplots of the sediment PCB concentrations from 2004, 2005, 2006, and 2007 and compares mean and median of PCB concentrations. 3. Significant decrease in sediment PCB levels over the 5-year period (downward trend) in the harbor areas but insignificant decrease in sediment PCB levels (downward trend) in the river areas. 4. Mann-Kendall test shows a negative trend for PCB levels. 5. Figure presenting the sampling trend locations in the Manistique River and Harbor.

S.No	Document Title	File Name	Document Author(s)	Year	Summary of Information
66	Manistique Sampling Data: 2008 - 2010 Inverse Distance Weighted Interpolation	2008-2010_ManistiqueSamplingData.pdf	U.S. Environmental Protection Agency/Fields Program	2008-2010	1. Maps presenting the Inverse distance weighted interpolation of the PCB concentration in the 0 to 6 inches of sediment samples collected between 2008-2010. 2. Two surface samples exceeding 50 ppm of PCBs were found in the harbor and the interpolated area exceeding 50 ppm of PCBs were found in the stream just south of the de-inking lagoon.
67	Fish Contaminant Monitoring Manistique River AOC	MDEQ_FishContaminantMonitoring_presentation.pptx	Michigan Department of Environmental Quality	Unknown	1. PowerPoint presentation of the fish contaminant monitoring conducted in the Manistique AOC for the past years. 2. Presents caged fish sampling locations for studies in 1990, 2002, and 2008. 3. Compares the fish PCB concentrations for each type of fish species (scattered plots) with respect to the size, sampled year, and the site location. 4. Caged fish study indicates low PCBs in water and indication that PCB concentrations in Manistique river fish are declining. 5. Fish collected from the Manistique River tend to have higher PCB concentration than fish collected from Little Bay De Noc.
68	Slides of Manistique River maps and sediment thickness changes	Manistique_Maps_Overview.pptx	U.S. Environmental Protection Agency	Unknown	1. PowerPoint presentation with maps of the AOC, sediment elevation changes (2010-2011), PCB sample locations and concentrations, and woodchip photographs. 2. Slide 1 presents the USEPA/State-approved AOC area map. 3. Slide 2 presents the changes in sediment elevations between 2010 and 2011. 4. Slide 3 presents the Superfunds/Fields most recent PCB data collected in the AOC. Surficial sediment concentrations going down over the years. 5. Slide 4 presents dredge Areas B, C, and D that were dredged in the 1990s. 6. Slide 5 presents shows proposed sediment sampling locations. 7. Slide 6 presents the bathymetry map showing the sediment elevation changes from 2001 to 2009. 7. Slide 7 presents the changes/difference in the sediment elevations between 2010 and 2011. 8. Slide 8 presents data showing general decline in surficial PCB concentration from 1996 until 2008. 9. Slide 9 presents the map with maximum PCB concentrations in surface and subsurface samples present in the AOC (from 2011 USEPA sediment investigation).
69	Superfund Surficial Sediment Data Total PCB Concentrations	Manistique_PCB by sample_range.jpg	Unknown	Unknown	1. Figure presenting total PCB concentrations for samples collected in 2008. 2. Results color-coded to differentiate the surface concentrations ranging from 10 ppb up to TSCA levels. 3. Two surface sediment samples contained PCBs concentrations greater than 50 ppm. Both samples are located in the harbor area.
70	Figure 1-2, Manistique River and Harbor Areas Designations	BBL Figure 1_2 MRH Area Designations.pdf	Blasland, Bouck, and Lee, Inc.	1994	1. Figure 1-2 from Accelerated Engineering Evaluation/Cost Analysis (Blasland, Bouck, and Lee, Inc. 1994).
71	Manistique River Hydrogeological Review	GLNPO_Manistique_Hydrogeological_Review_v1.doc	U.S. Environmental Protection Agency/GLNPO	Unknown	1. GLNPO technical memorandum summarizing findings of the review conducted on several documents (MDNR 1994 & U.S. Geological Survey 2011). 2. Evaluated potential for migration of PCBs from contaminated areas facility through groundwater and surface water. 3. Groundwater likely discharges to the river downstream of the mill dam. 4. Potential exists for contaminant migration via groundwater that migrates through contaminated materials and discharges to the river.
72	Manistique River , Michigan Area of Concern	Final_ManistiqueAOC_StateApproved.pdf	U.S. Environmental Protection Agency	Unknown	1. Map depicting Manistique River AOC. 2. Inset shows approximate Manistique River Watershed boundaries.

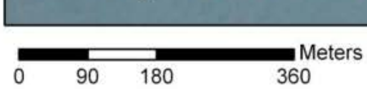
S.No	Document Title	File Name	Document Author(s)	Year	Summary of Information
73	Manistique River AOC Operational Units	2012_Draft_Ous_Aerial.png	Unknown	Unknown	1. Aerial map showing Operational Units of the AOC. 2. OU1 is downstream of Manistique Paper, Inc. 3. OU2 is boat launch area downstream of US-2 Bridge. 4. OU 3 is channel through harbor. 5. OU4 is harbor area outside of channel.
74	Manistique Aerial Photographs	Manistique_aerialphotographs.pdf	Unknown	Various	1. Historical aerial photographs from 1953, 1969, 1971, 1977, 1993, 1998, 2005, 2006, 2009, and 2010. 2. The aerials show changes in the slips, former de-inking lagoon, paper mill areas, and road construction over time.
75	Manistique Site Updates 01, 03, 06, 07, and 08	1995 EPA Manistique Dredging Fact Sheet.pdf	U.S. Environmental Protection Agency	various	1. USEPA yearly updates Nos. 1 (1996), 3 (1996), 6 (1998), 7(1998), and 8 (2000). 2. USEPA descriptions of site activities prepared for public information purposes. 3. Generally describes PCB concentrations detected in various years, proposed and completed remedies including capping and dredging, and schedule of completed and planned activities.
76	Manistique Harbor over 50 ppm PCBs	Manistique_over50_SF data.jpg	Unknown	Unknown	1. Unlabeled map showing sediment sampling results. 2. Locations shown by green and yellow dots—No legend explaining color coding of the figure or locations.
77	Manistique Harbor over 50 ppm PCBs 2	Manistique_over50_SF data2.jpg	Unknown	Unknown	1. Unlabeled map showing sediment sampling results. 2. Locations shown by green and yellow dots—No legend explaining color coding of the figure or locations.
78	Manistique Debris Pictures	Manistique_DebrisPictures.pptx	Unknown	Unknown	1. PowerPoint with six photographs. 2. Two photographs of small woody debris/sawdust along the shore of Lake Michigan. 3. Two photographs of sediment cores collected in the harbor. 5. Two photographs of large woody debris along the shoreline of the river.
81	*Data Evaluation Report for Manistique Harbor and River Site, Manistique, Michigan Revision 1*	Manistique 2008 Data Evaluation Report_Rev1.pdf	SulTRAC	2009	1. Report describing sediment, SPMD, adult and juvenile fish, and bathymetry data collected in 2008. 2. Total sediment in survey area decreased slightly from 2007 volume. 3. Significantly significant reduction in overall sediment total PCB concentration from 2004 to 2008. 4. Sediment PCB concentrations in samples collected from river locations do not show a reduction from 2004-2008. 5. SPMDs indicate that PCBs are available in surface water. 6. Fish tissue concentrations exceeded various benchmark and tolerance limits.
79	Locations of Manistique Papers, the Manistique WWPT, Manistique Marina, and Public Boat Launch within the Manistique River Area of Concern	ManistiqueAOC_OldLagoon_LocationMap.pdf	Michigan Department of Natural Resources	1987	1. Figure 3-9 from 1987 RAP.
80	Manistique Harbor Wood Chip Evaluation	Manistique_WoodChipEvaluation_presentation.pptx	U.S. Army Corps of Engineers	Unknown	1. PowerPoint presentation evaluating the extent to which wood waste influences the concentration and bioavailability of sediments. 2. Correlates wood chip presence with the PCB concentrations and hence the bioavailability of PCBs 3. Quantified presence of wood relative to total organic matter (OM) using a "wood index." 4. Total PCBs strongly related to both total OM and "wood index." 5. OM normalized PCBs poorly related to "wood index" indicating the presence of wood ins not a significant controlling factor of PCBs. 6. Laboratory bioaccumulation tests show a strong relationship between uptake and organic carbon-normalized PCB concentrations.

Appendix B
Historical Aerial Photographs

Manistique Paper Property

National Agriculture Imagery Program Mosaic
U.S. Department of Agriculture
http://datagateway.nrcs.usda.gov/

Manistique Paper Property



National Agriculture Imagery Program Mosaic
U.S. Department of Agriculture
http://datagateway.nrcs.usda.gov/

Manistique Paper Property

Meters
0 90 180 360

National Agriculture Imagery Program Mosaic
U.S. Department of Agriculture
http://datagateway.nrcs.usda.gov/

Manistique Paper Property

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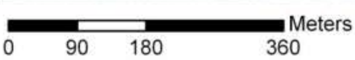
National Agriculture Imagery Program Mosaic
U.S. Department of Agriculture
http://datagateway.nrcs.usda.gov/

Manistique Paper Property



United States Geological Survey
Digital Orthophoto Quadrangle (DOQ)
http://earthexplorer.usgs.gov/

Manistique Paper Property

Meters
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United States Geological Survey
Digital Orthophoto Quadrangle (DOQ)
http://earthexplorer.usgs.gov/

Manistique Paper Property

United States Geological Survey
Project VDZS0, Entity ID Entity ID AR1VDZS00010004
http://earthexplorer.usgs.gov/

Manistique Paper Property

Meters
0 90 180 360

United States Geological Survey
Project VCS0, Entity ID AR1VCSC00040002
http://earthexplorer.usgs.gov/

Manistique Paper Property

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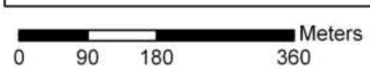
United States Air Force
Project 6830A, Entity ID ARB6830A0080728
http://earthexplorer.usgs.gov/

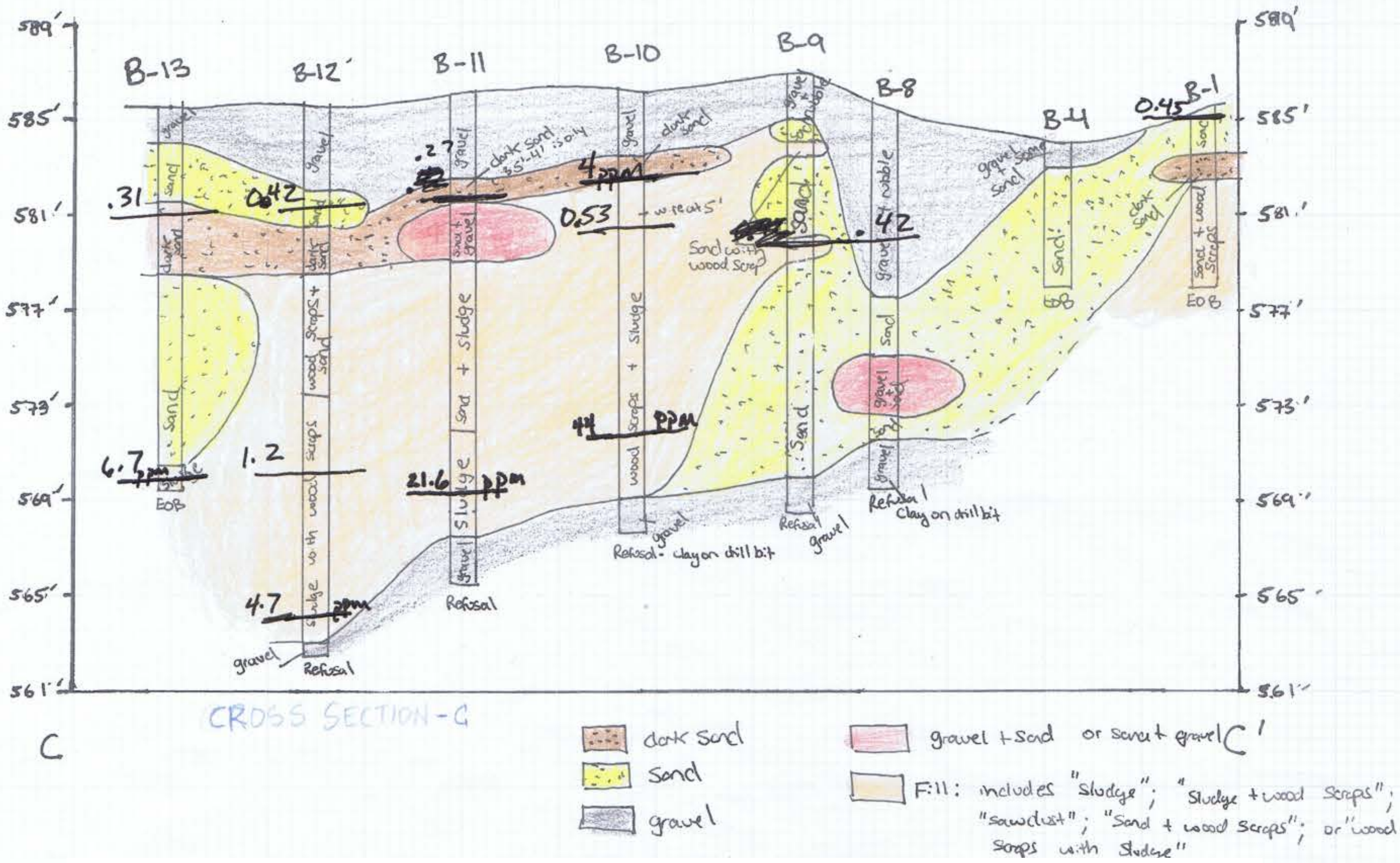
Manistique Paper Property



United States Geological Survey
Project VBL00, Entity ID AR1VBL000020140
http://earthexplorer.usgs.gov/

Appendix C
Cross Section of Former Deinking Lagoon

CH2M HILL SUBJECT Manistique River – De inking Lagoon PLANT SITE BY CRYSTAL NICKEL PROJECT NO. 434422 DATE 5/31/12 SHT 3 OF 3



Developed from soil boring data collected by Bittner Engineering (1987).