An Assessment of Sediment Injury in the Grand Calumet River, Indiana Harbor Canal, Indiana Harbor, and the Nearshore Areas of Lake Michigan

Volume I

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Executive Summary

This investigation was conducted to determine if sediments within the Grand Calumet River, Indiana Harbor Canal, Indiana Harbor, or the nearshore areas of Lake Michigan (i.e., the Assessment Area) have been injured due to discharges of oil or releases of other hazardous substances. If the results of this assessment indicated that sediment injury has occurred within the Assessment Area, then the subsequent objectives of this investigation were to identify contaminants of concern in the Assessment Area and to evaluate the areal extent of sediment injury.

In this report, sediment injury was defined as the presence of conditions that have injured or are sufficient to injure sediment-dwelling organisms and/or fish and wildlife resources. As such, this assessment of sediment injury was intended to provide the information needed to evaluate injury to surface water resources and biological resources within the Assessment Area. Contaminants of concern were defined as those toxic or bioaccumulative substances that occur in sediments at concentrations that are sufficient to cause or substantially contribute to sediment injury, including injury to sediment-dwelling organisms, and/or fish and wildlife resources.

In accordance with the Assessment Plan (Natural Resources Trustees 1997), this assessment of sediment injury was focused on evaluating the effects on natural resources that have occurred due to discharges of oil or releases of other hazardous substances. The chemicals of concern in the Assessment Area include polychlorinated biphenyls (PCBs), oil and oil-related compounds (including alkanes, alkenes, naphthalenes, and polycyclic aromatic hydrocarbons; PAHs), and metals (Natural Resources Trustees 1997). The other substances that were considered in this study include various pesticides, phenols, and conventional variables [such as total organic carbon (TOC), sediment oxygen demand (SOD), and unionized ammonia (NH_3)]. As many of these substances tend to become associated with sediments upon release into aquatic ecosystems, sediment contamination represents a concern with respect to the restoration of beneficial uses in the Assessment Area (IDEM 1991).

To facilitate this evaluation, the Assessment Area was divided into nine separate reaches, including the Grand Calumet River Lagoons (GCRL), East Branch Grand Calumet River-I (EBGCR-I), East Branch Grand Calumet River-II (EBGCR-II), West Branch Grand Calumet River-I (WBGCR-I), West Branch Grand Calumet River-II (WBGCR-II), Indiana Harbor Canal (IHC), Lake George Branch (LGB), US Canal (USC) and Indiana

Harbor/Lake Michigan (IH/LM). In each of these reaches, the available sediment quality and related information was collected, evaluated, compiled, and used to assess injury to sediments and associated biological resources. The results of these assessments are presented in Sections 5 to 13 of this report. A summary of these results is presented below to provide an overview of sediment quality and related conditions within the Assessment Area.

Injury to Sediment-Dwelling Organisms

In total, four primary indicators were used to assess injury to sediment-dwelling organisms within the Assessment Area. These indicators included whole sediment chemistry, pore water chemistry, sediment toxicity (including whole sediment, pore water, and/or elutriates), and benthic invertebrate community structure. The status of physical habitats in each reach of the Assessment Area was also described.

Information on the concentrations of sediment-associated contaminants has been gathered for the entire Assessment Area. Collectively, these sediment chemistry data indicate that both surficial and sub-surface sediments in all of the reaches have been injured as a result of discharges of oil or releases of other hazardous substances (Figure ES.1 and ES.2). The highest frequencies of exceedance of the chronic toxicity threshold for amphipods (i.e., mean probable effect concentration-quotients; PEC-Q of $ 0.7; USEPA 2000a) were observed in the WBGCR-I (90%; n=31 samples), IHC (89%; n=36 samples) and, USC (89%; n=215 samples; Table ES.1). The frequency of exceedance of the chronic toxicity threshold ranged from 72% to 86% in the EBGCR-I, EBGCR-II, WBGCR-II, LGB, and the IH segment of the IH/LM reach (Table ES.1). By comparison, only one of 33 samples (3%) from the nearshore areas of the LM segment of the IH/LM reach, had chemical characteristics sufficient to cause or substantially contribute to injury to sediment-dwelling organisms. Relatively lower levels of sediment contamination were also observed in the Lake George wetlands and in the Roxana Marsh portion of the WBGCR-II (Table ES.2 and ES.3). The contaminants of concern in whole sediments from the Assessment Area included metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc), PAHs (13 individual PAHs and total PAHs), and total PCBs.

The available information on pore water chemistry confirms that sediments within the Assessment Area have been injured due to discharges of oil or releases of other hazardous substances. In particular, the levels of metals, phenol, and unionized ammonia (NH_3) frequently exceeded published toxicity thresholds for sediment-dwelling organisms. The levels of simultaneously extracted metals (SEM) frequently exceeded the concentrations of acid volatile sulfides (AVS) in sediments, indicating that elevated levels of metals are likely to occur in pore water (in 70 of 169 sediment samples in which these variables were measured; Table ES.4). The concentrations of contaminants in pore water were sufficient to cause or substantially contribute to sediment toxicity in sediments from the EBGCR-I, EBGCR-II, WBGCR-I, WBGCR-II, IHC, LGB, and IH (i.e., two or more samples had contaminant concentrations in excess of the published toxicity thresholds; Table ES.1). Insufficient data were available to characterize contaminant concentrations in pore water from GCRL, USC, and LM sediments.

Information on the toxicity of whole sediments, pore water, or elutriates was available for all of the reaches in the Assessment Area. The results of the laboratory toxicity tests demonstrate that whole sediments, pore water, and elutriates were frequently toxic to aquatic organisms throughout the Assessment Area (Table ES.1; Figure ES.3). Among the various reaches that were investigated, the frequency of sediment toxicity ranged from 33% in LM to 100% in the WBGCR-I. The frequency of sediment toxicity equaled or exceeded 50% in all nine of the reaches, including GCRL (50%; n=12), EBGCR-I (73%; n=44), EBGCR-II (88% n=52), WBGCR-I (100%; n=2), WBGCR-II (83%; n=18), IHC (80%; n=5), LGB (57%; n=7), USC (80%; n=90) and IH/LM (74%; n=38; Table ES.1). The frequency of sediment toxicity tended to be lowest in the Middle and East Lagoons (GCRL), Roxana Marsh (WBGCR-II), Lake George wetlands (LGB), the wetlands associated with the IHC, and the nearshore areas of Lake Michigan. Collectively, the sediment toxicity data demonstrate that sediments and sediment-dwelling organisms have been injured throughout the Assessment Area.

Information on the structure of benthic invertebrate communities is available for all of the reaches within the Assessment Area. Evaluation of these data relative to conditions in the nearshore areas of LM indicate that the structure of benthic invertebrate communities has been altered throughout the Assessment Area (Table ES.1; Figure ES.4). In the EBGCR-I (n=14), EBGCR-II (n=5), WBGCR-I (n=3), IHC (n=6), and LGB (n=4), 100% of the samples that have been collected had characteristics that were indicative of altered benthic invertebrate communities (Table ES.1). A somewhat lower frequency of benthic community alteration was observed in the WBGCR-II (71% of samples; n=14), USC (96%; n=25 samples), IH (81%; n=16 samples), and LM (43%; n=56). Overall, average macroinvertebrate index of biotic integrity (mIBI) scores for the various reaches ranged from 0.7 to 1.4 (Table ES.5). Benthic invertebrate communities were typically dominated by pollution-tolerant species, primarily oligochaetes, throughout much of the Assessment Area. Pollution-sensitive species, such as the EPT taxa (mayflies, stoneflies, and caddisflies) were rarely present in any of the reaches within the Assessment Area. Collectively, these data confirm that environmental conditions in the Assessment Area are sufficient to injure sediments and sediment-dwelling organisms.

Most of the reaches in the Assessment Area were characterized as having altered habitats. Qualitative habitat evaluation index (QHEI) scores ranged from 16 to 65.5 within the Assessment Area, with the lowest scores reported for IHC, LGB, USC, and IH (Simon *et al.* 2000; Table ES.6). Elevated levels of TOC were observed throughout the Assessment Area; the upper limit of the 95% confidence interval of TOC for reference sites (i.e., 3.4% TOC) was frequently exceeded in the EBGCR-II, WBGCR-I, WBGCR-II, LGB, USC, and IH. The lowest levels of TOC were observed in the sediments collected from the nearshore areas of LM. Based on the levels of oil and grease and the levels of PAHs that have been measured in sediments, oil and oil-related compounds comprise much of the TOC that occurs within the Assessment Area. Together, these data confirm that sediments within the Assessment Area have been contaminated due to discharges of oil or releases of other hazardous substances.

Overall, there was a high level of concordance among the four primary indicators of sediment injury (i.e., whole sediment chemistry, pore water chemistry, sediment toxicity, and benthic invertebrate community structure; Table ES.1). All four lines of evidence indicated that conditions sufficient to injure sediment-dwelling organisms occurred within the EBGCR-I, EBGCR-II, WBGCR-I, WBGCR-II, IHC, LGB, USC, and IH/LM. In the GCRL, two lines of evidence – sediment chemistry and sediment toxicity – indicated the presence of conditions sufficient to injure sediments and sediment-dwelling organisms. These conditions were most prevalent in the West Lagoon. Evaluation of the available data indicates that sediment injury is less likely to occur in the nearshore areas of LM (i.e., two lines of evidence indicate that sediment injury has occurred). Within the LM segment of the IH/LM reach, sediment toxicity and alteration of the benthic invertebrate community occurred most frequently within 0.5 miles from the entrance to IH. Collectively, this information indicates that benthic habitats throughout the Assessment Area, with a few exceptions, have been degraded due to discharges of oil or releases of other hazardous substances. Benthic habitats located in areas farther removed from the harbor entrance tended to reflect uninjured conditions.

Effects on Fish and Wildlife Resources

A total of five lines of evidence were used to assess effects on fish and wildlife resources that are associated with sediment contamination (i.e., related to the sediment injury that was demonstrated within the various reaches of the Assessment Area. The primary indicators that were used in this report to assess sediment injury relative to fish and wildlife resources included toxicity to fish, fish health, fish community structure, whole sediment chemistry, and tissue chemistry (Table ES.7).

Information of the toxicity of whole sediments, pore water, and/or elutriates to fish (i.e., fathead minnows; *Pimephales promelas*) are available for four reaches within the Assessment Area, including the GCRL, EBGCR-I, EBGCR-II, and WBGCR-II. The results of such laboratory toxicity tests demonstrate that sediments from the EBGCR-I, EBGCR-II, and WBGCR-II are frequently acutely toxic to fish. The incidence of sediment toxicity ranged from 57% (n=23) in the EBGCR-I to 100% (n=7) in the WBGCR-II (Table ES.7). In contrast, only one sample from the GCRL was toxic to fish, which indicates that conditions sufficient to cause acute toxicity to fish were observed only in the western portion of the West Lagoon.

In this report, information on incidence of deformities, fin erosion, lesions, and tumors (i.e., DELT abnormalities) in fish was used to assess fish health in the Assessment Area (Table ES.8). Based on the information that was collated for this area, fish health has been compromised (i.e., incidence of DELT abnormalities > 1.3%) in several of the reaches including the EBGCR-I, EBGCR-II and the WBGCR-I. The average incidence of DELT abnormalities ranged from 0% in the GCRL to 12.8% in IH/LM. The highest incidence of DELT abnormalities (17.4%) was observed in the EBGCR-I.

A number of field surveys have been conducted over the past 15 years to evaluate the status of fish communities in the Assessment Area. The results of these surveys demonstrate that the integrity of fish communities has been impaired (i.e., relative to reference sites in Indiana) in all of the reaches that have been examined (Table ES.9). Overall, index of biotic integrity (IBI) scores ranged from 0 to 43 in the various stream reaches, which classifies fish communities as “fair”, “poor”, “very poor”, or as having no fish (Table ES.9). The lowest average IBI scores were reported for IH/LM (14; n=1); WBGCR-II (15.9 ± 9.8; n=17); WBGCR-I (16.5 ± 10.4; n=12); IHC (17.5 ± 4.4; n=4). Based on these IBI scores, the integrity of fish communities in these four reaches would be classified as “very poor”. Somewhat higher average IBI scores were reported for the

EBGCR-I, EBGCR-II, LGB, and USC; average IBI scores in these reaches ranged from 23 to 26. As such, fish communities in these four reaches would be classified as having "poor" to "very poor" integrity. Within the LGB, the wetland areas that are located to the west of the Lake George Canal had the highest IBI score (38; Simon *et al.* 2000). Relatively higher IBI scores were also reported for the GCRL, with IBI scores ranging from 31 to 43 (mean IBI score of 38.1 ± 5.0; n=13). In the GCRL, the lowest IBI scores (i.e., 31 to 38) were reported for the West Lagoon (which is located closest to an iron and steel manufacturer's slag landfill; Simon and Stewart 1998). In contrast, IBI scores for the Middle Lagoon averaged 42 (Simon and Stewart 1998).

In this report, the sediment injury relative to wildlife was also evaluated using sediment chemistry data. More specifically, the measured concentrations of bioaccumulative substances in whole sediments were compared to bioaccumulation-based sediment quality guidelines (SQGs) for the protection of wildlife (NYSDEC 1994). The results of this evaluation demonstrated that the concentrations of various sediment-associated contaminants were sufficient to adversely affect wildlife species that utilize habitats within the Grand Calumet River watershed (i.e., through bioaccumulation of contaminants in sediment-dwelling organisms and subsequent food web transfer to wildlife species, such as green herons). Among the various reaches, the frequency of exceedance of one or more of the bioaccumulation-based SQGs ranged from 18% to 93% of the sediment samples (Table ES.7), indicating that all of the reaches have levels of bioaccumulative substances in sediments that are sufficient to cause or substantially contribute to adverse effects on wildlife. The highest incidences of exceedance of the bioaccumulation-based SQGs were observed in the GCRL (84%; n=58), IHC (93%; n=15) LGB (83%; n=29), USC (84%; n=37) and IH/LM (88%; n=33). Total PCBs represented the only bioaccumulative contaminants of concern in the Assessment Area; however, chlordane, total DDTs, endrin, heptachlor, heptachlor epoxide, lindane, and 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD) also exceeded the bioaccumulation-based SQGs in many sediment samples. Bioaccumulation-based SQGs were not available for metals or PAHs, which precluded an evaluation of the potential for bioaccumulation of these chemical classes.

Tissue chemistry data provide important information for determining if bioaccumulative substances pose unacceptable hazards to wildlife species. In this report, the measured concentrations of bioaccumulative substances in the tissues of fish and other aquatic organisms were compared to the tissue residue guidelines (TRGs) that have been established for the protection of piscivorus wildlife species (Newell *et al.* 1987). The results of this evaluation indicate that tissue residue levels in fish and invertebrates from the Assessment Area frequently exceeded the TRGs for piscivorus wildlife. The concentrations of one or more bioaccumulative substances exceeded the TRGs in 50% to 100% of the tissue samples, depending on which reach of the Assessment Area was considered. The highest frequencies of exceedance of the TRGs (i.e., 100%) were reported for the GCRL, EBGCR-I, EBGCR-II, WBGCR-I, WBGCR-II, IHC, and USC. Eighty-six percent (n=21) of the tissue samples from IH/LM had tissue residue levels in excess of the TRGs. Total PCBs represented the bioaccumulative contaminants of concern in the tissues of aquatic organisms; however, chlordane, total DDTs, dieldrin + aldrin, and endrin were also measured at elevated levels in fish and invertebrate tissues.

In this report, five separate lines of evidence were used to assess sediment injury relative to wildlife species. Overall, the results of this assessment indicate that conditions within the GCRL, EBGCR-I, EBGCR-II, WBGCR-I, WBGCR-II, IHC, LGB, USC, and IH/LM are sufficient to adversely affect wildlife species (i.e., one or more lines of evidence demonstrate effects on wildlife, including, amphibians, reptiles, fish, birds, and mammals; Table ES.7). More specifically, sediments have been demonstrated to be toxic to fish in three reaches of the Assessment Area. In addition, fish health has been compromised in three reaches of the Assessment Area. As would be expected in areas that have impaired fish health and toxic conditions, the integrity of fish communities was “poor” to “very poor” (as measured using IBI scores) throughout most of the Assessment Area (i.e., in seven of nine reaches). Finally, the available sediment chemistry data indicate that the concentrations of bioaccumulative substances are high enough to pose hazards to wildlife (i.e., as a result of bioaccumulation in the sediment-dwelling organisms and subsequent food web transport to piscivorus wildlife species) in all nine reaches. The available data on tissue chemistry confirm that bioaccumulation is occurring throughout the Assessment Area and that the concentrations of bioaccumulative substances in the tissues of aquatic organisms are sufficient to adversely affect piscivorus wildlife species (i.e., in eight of nine reaches). Therefore, sediment injury relative to wildlife resources has been demonstrated throughout the Assessment Area.

Overall Assessment of Injury to Sediments

An evaluation of the harmful effects of sediment-associated contaminants in the Assessment Area was conducted. To support this assessment, the study area was divided into nine separate reaches, including GCRL, EBGCR-I, EBGCR-II, WBGCR-I, WBGCR-II, IHC, LGB, USC, and IH/LM. The results of this evaluation demonstrate that sediments throughout the Assessment Area have been injured due to discharges of oil or releases of other hazardous substances. This conclusion is supported by up to nine of the following separate lines of evidence:

- Concentrations of metals, PAHs, and/or PCBs, in whole sediments frequently exceeded the consensus-based probable effect concentrations (PECs) throughout the Assessment Area;
- Concentrations of metals, phenol, and/or ammonia in pore water from Assessment Area sediments exceeded published toxicity thresholds at various locations;
- Whole sediments, pore water, and/or elutriates from the Assessment Area were frequently toxic to aquatic organisms, including sediment-dwelling species;
- The structure of benthic invertebrate communities throughout the Assessment Area has been severely altered relative to communities in the nearshore areas of LM or elsewhere in Indiana;
- The health of fish in the Assessment Area has been compromised, as indicated by a high incidence of deformities, fin erosion, lesions, and tumors;
- Whole sediments, pore water, and/or elutriates from the Assessment Area were frequently toxic to fish;
- The integrity of fish communities in the Assessment Area has been frequently degraded relative to reference sites in Indiana;
- Concentrations of total PCBs in sediments frequently exceeded the bioaccumulation-based SQGs for the protection of wildlife; and,
- Concentrations of total PCBs in the tissues of aquatic organisms frequently exceeded the TRGs for the protection of wildlife.

Any one of these independent lines of evidence could be used alone to support the conclusion that sediment injury has occurred in the Assessment Area. When taken together, however, these nine separate lines of evidence provide an indisputable weight-of-evidence for concluding that discharges of oil or releases of other hazardous substances have created conditions that are sufficient to severely injure sediments and the organisms that depend on these critical habitats. The levels of metals, PAHs, PCBs, unionized ammonia and phenols in whole sediments, pore water, and/or fish tissues were sufficient to cause or substantially contribute to the injury of sediments, sediment-dwelling organisms, and/or fish and wildlife resources.

Various metals (arsenic, cadmium, chromium, copper, lead, nickel, and zinc), PAHs (anthracene, fluorene, 2-methylnaphthalene, naphthalene, phenanthrene, benz(a)anthracene, dibenz(a,h)anthracene, benzo(a)pyrene, chrysene, fluoranthene, pyrene, and total PAHs), PCBs (total PCBs), phenols (phenol) and unionized ammonia are considered to be the toxic and/or bioaccumulative contaminants of concern in the Assessment Area. All of these substances frequently exceeded the chemical benchmarks in surficial and sub-surface sediments throughout the Assessment Area. In addition, the concentrations of these substances in sediments often exceeded the chemical benchmarks by substantial margins, frequently by more than a factor of 100. Therefore, all of these substances were present in whole sediment and/or pore water at concentrations that are sufficient to cause or substantially contribute to injury to sediment-dwelling organisms, and/or adversely affect fish and wildlife resources. It is important to note, however, that this assessment was restricted by the availability of PECs, published bioaccumulation-based SQGs, and other benchmarks that are relevant for assessing sediment quality conditions. In certain reaches of the Assessment Area, this assessment was also restricted by limitations on the availability of data on the concentrations of chemical analytes in whole sediments and/or pore waters. Therefore, substances not included on the list of contaminants of concern can not necessarily be considered to be of low priority with respect to sediment injury.

The levels of sediment-associated contaminants are sufficient to cause or substantially contribute to injury to surficial sediments throughout most of the Assessment Area (Table ES.2). In surficial sediments, the highest levels of sediment contamination occur in the GCRL, with mean PEC-Qs of up to 23,800 calculated for this reach; the average mean PEC-Q for this reach was approximately 160. These chemical characteristics make these sediments the most contaminated and toxic surficial sediment samples that we have ever evaluated. The average mean PEC-Q in the EBGCR-II was similar (i.e., 126; range of 1.4 to 987). Lower average mean PEC-Qs were calculated for the WBGCR-I and the WBGCR-II (i.e., 29.5 and 22.6, respectively). The EBGCR-I and USC had average mean PEC-Qs of 14.0 and 11.7, respectively. Lower levels of contamination were reported in the IHC (average mean PEC-Q of 5.2), LGB (average mean PEC-Q of 4.3), and IH/LM (average mean PEC-Q of 4.4). The lowest levels of contamination in surficial sediments were observed in Roxana Marsh (in the WBGCR-II; average mean PEC-Q of 0.4), Lake

George wetlands (in the LGB; average mean PEC-Q of 0.9), East Lagoon (in the GCRL; average mean PEC-Q of 0.6), Little West Pond (in the GCRL; average mean PEC-Q of 0.3), Little East Pond (in the GCRL; average mean PEC-Q of 0.1), IHC wetlands (in the IHC; average mean PEC-Q of 0.7) and the nearshore areas of LM (in the IH/LM; average mean PEC-Q of 0.2). By comparison USEPA (2000a) reported that acute and chronic toxicity to sediment-dwelling organisms is likely to be observed when mean PEC-Qs are $ 4.0 and $ 0.7 respectively.

The levels of chemical contamination in sub-surface sediments were similar to those that were observed in surficial sediments (Table ES.3). The highest mean PEC-Qs in sub-surface sediments occurred in the EBGCR-II and the GCRL, with mean PEC-Qs of up to 937 and 2,560, respectively, calculated for these reaches (with average mean PEC-Qs of approximately 98 and 197, respectively). Based on these chemical characteristics, these sub-surface sediment samples are among the most contaminated and toxic that we have ever evaluated. Lower average mean PEC-Qs were calculated for the EBGCR-I (12.7), WBGCR-II (19.3), and USC (17.0). Indiana Harbor and the nearshore areas of LM had the lowest average mean PEC-Qs (2.4). While most of the sub-surface sediments in the Assessment Area had levels of contaminants that were sufficient to cause or substantially contribute to sediment injury, relatively low levels of contamination were observed in Roxana Marsh (in WBGCR-II; average mean PEC-Q of 0.05), Lake George wetlands (LGB; average mean PEC-Q of 0.1), Middle Lagoon (in GCRL; average mean PEC-Q of 0.03), and the nearshore areas of LM (IH/LM average mean PEC-Q of 0.1).

The results of this investigation indicated that sediments and associated sediment-dwelling organisms throughout the Assessment Area have been injured by discharges of oil or releases of other hazardous substances. Similarly, fish and wildlife resources have been adversely affected by ambient conditions within the Assessment Area. Restoration of natural resources in the Assessment will necessitate the development and implementation of a restoration plan that will improve the quality of bed and bank sediments (Natural Resource Trustees 1997).

Restoration planning is likely to involve, among other activities, the development of target clean-up levels for the various contaminants of concern. While this task was beyond the scope of this investigation, the sediment effect concentrations that were employed in this assessment represent relevant tools for deriving such target clean-up levels. More specifically, the PECs and associated mean PEC-Qs were used to identify the concentrations of sediment-associated contaminants that are likely to cause or substantially contribute to sediment toxicity. Therefore, target clean-up levels would need to be lower than the PECs to ensure that bed sediments would once again support healthy and diverse populations of sediment-dwelling organisms and associated fish and wildlife communities. USEPA (2000a) reported that the incidence of toxicity to freshwater amphipods is generally less than 20% at mean PEC-Qs of < 0.1 and increases with increasing levels of sediment contamination. If virtual elimination of sediment toxicity and restoration of the benthic invertebrate community were primary restoration goals, then target clean-up levels for sediments might be in the order of 0.25 for mean PEC-Qs. Such a level of sediment contamination would be predicted to be associated with roughly a 20% incidence of toxicity to freshwater amphipods (USEPA 2000a).

As certain contaminants of concern have the potential to bioaccumulate in the food web, target clean-up levels should be established to facilitate the restoration of fish and wildlife resources. New York State Department of Environmental Conservation (NYSDEC 1994) derived numerical sediment quality criteria for the protection of wildlife. Such criteria could be used to establish target clean-up levels for bioaccumulative substances within the Assessment Area.

Table ES.1. Summary of assessment of sediment injury to sediment-dwelling organisms.

Reach/Segment	Indicator of Injury to Sediment-Dwelling Organisms[1] Sediment Chemistry[2]	Pore Water Chemistry[3]	Sediment Toxicity[4]	Benthic Community[5]	Number of Lines of Evidence for Demonstrating Injury to Sediment-Dwelling Organisms
Grand Calumet River Lagoons	27% (n=215)*	0% (n=5)	50% (n=12)*	ID (n=0)	2
East Branch Grand Calumet River-I	83% (n=269)*	55% (n=20)*	73% (n=44)*	100% (n=14)*	4
East Branch Grand Calumet River-II	72% (n=131)*	100% (n=2)*	88% (n=52)*	100% (n=5)*	4
West Branch Grand Calumet River-I	90% (n=31)*	100% (n=2)*	100% (n=2)*	100% (n=3)*	4
West Branch Grand Calumet River-II	76% (n=172)*	88% (n=8)*	83% (n=18)*	71% (n=14)*	4
Indiana Harbor Canal	89% (n=36)*	60% (n=5)*	80% (n=5)*	100% (n=6)*	4
Lake George Branch	82% (n=33)*	83% (n=6)*	57% (n=7)*	100% (n=4)*	4
US Canal	89% (n=215)*	67% (n=3)*	80% (n=90)*	96% (n=25)*	4
Indiana Harbor / Lake Michigan	61% (n=111)*	100% (n=3)*	74% (n=38)*	51% (n=72)*	4
Overall	**70% (n=1213)***	**65% (n=54)***	**78% (n=268)***	**72% (n=143)***	**4**

[1] For each line of evidence, sediment injury is indicated if two or more samples have conditions sufficient to cause or substantially contribute to sediment injury. Evidence of sediment injury is denoted with an asterisk (*).

[2] Percent of sediment samples with mean PEC-Qs of $\geq$ 0.7.

[3] Percent of pore water samples with chemical concentrations > published toxicity thresholds.

[4] Percent of sediment samples that are toxic to aquatic organisms in laboratory tests.

[5] Percent of samples with altered benthic invertebrate community structure.

ID = insufficient data; n = number of samples.

Table ES.2. Summary of the distribution of mean PEC-Qs in surficial sediments in the Assessment Area.

Reach Segment	Number of Samples	Average of Mean PEC-Q	Minimum Mean PEC-Q	Maximum Mean PEC-Q	10th Percentile	90th Percentile	Median
Grand Calumet River Lagoons							
West Lagoon	58	555	0.0556	23800	0.146	26.6	1.04
Middle Lagoon	49	0.941	0.0914	16.1	0.101	2.18	0.290
East Lagoon	47	0.558	0.0768	2.30	0.106	1.28	0.376
Little West Pond	25	0.326	0.0646	2.51	0.0937	0.425	0.178
Little East Pond	23	0.111	0.0639	0.220	0.0668	0.141	0.0995
Overall	**202**	**160**	**0.0556**	**23800**	**0.0925**	**3.19**	**0.289**
East Branch Grand Calumet River-I							
EB and WB Confluence to Kennedy Avenue	29	8.34	0.112	77.4	0.255	25.9	2.88
USS Lead Canal	17	27.7	3.60	72.6	5.45	65.3	13.0
Kennedy Avenue to Cline Avenue	51	7.20	0.457	58.2	1.20	12.3	4.61
Cline Avenue to Cline/I-90 Ramps	15	4.59	0.104	12.1	1.31	7.29	3.73
Cline/I-90 Ramps to Industrial Highway	21	28.9	0.71	184	2.12	45.4	5.94
Industrial Highway to ConRail Bridge	12	36.8	1.92	357	2.24	18.9	3.58
EB Wetland	17	3.99	0.0655	15.7	0.208	6.88	3.23
Overall	**162**	**14.0**	**0.0655**	**357**	**0.875**	**30.3**	**4.58**
East Branch Grand Calumet River-II							
EB II Wetland	55	1.12	0.000636	16.0	0.0901	2.75	0.230
ConRail Bridge to Bridge Street	8	25.3	13.1	51.9	13.1	38.3	22.5
Bridge Street to Grant Street	6	10.7	2.58	17.6	2.58	13.4	11.1
Grant Street to I-90	3	30.0	4.66	68.8	4.66	16.6	16.6
I-90 to Broadway	9	52.1	1.54	375	1.54	39.5	6.44
Broadway to Virginia Street	4	27.5	2.59	63.4	2.59	29.9	22.1
Virginia Street to Tennessee Street	4	473	87.2	821	87.2	705	492
Tennessee Street to Lagoon Culvert	9	286	1.43	987	1.43	589	9.25
Overall	**98**	**55.7**	**0.000636**	**987**	**0.0986**	**63.4**	**2.42**

Table ES.2. Summary of the distribution of mean PEC-Qs in surficial sediments in the Assessment Area.

Reach Segment	Number of Samples	Average of Mean PEC-Q	Minimum Mean PEC-Q	Maximum Mean PEC-Q	10th Percentile	90th Percentile	Median
West Branch Grand Calumet River-I							
EB and WB Confluence to Indianapolis Boulevard	**19**	**29.5**	**1.13**	**231**	**1.35**	**56.9**	**11.7**
West Branch Grand Calumet River-II							
Indianapolis Boulevard to I-90	14	15.5	0.149	75.3	0.243	35.3	6.22
Roxana Marsh	5	0.428	0.123	0.603	0.123	0.595	0.515
I-90 to Columbia Avenue	22	12.3	0.0395	76.0	1.01	16.2	6.53
Columbia Avenue to Calumet Avenue	2	3.71	0.259	7.17	NA	NA	NA
Calumet Avenue to Hohman Avenue	9	37.6	0.311	210	0.311	88.6	6.85
Hohman Avenue to State Line Avenue	21	47.5	0.875	304	2.51	94.9	28.7
Illinois Portion	11	6.00	2.71	10.1	2.97	9.65	4.89
Overall	**84**	**22.6**	**0.0395**	**304**	**0.347**	**67.1**	**6.71**
Indiana Harbor Canal							
EB and WB Confluence to 151st Street	7	5.44	2.10	10.4	2.10	8.21	4.85
151st Street to Chicago Avenue	10	3.00	0.191	8.84	0.191	7.19	2.29
Chicago Avenue to Columbus Drive	12	7.29	1.09	25.9	1.69	11.5	5.34
IHC Wetland	1	0.718	0.718	0.718	NA	NA	NA
Overall	**30**	**5.21**	**0.191**	**25.9**	**0.491**	**10.4**	**4.08**
Lake George Branch							
Indianapolis Boulevard to B & O Railroad Bridge	7	4.81	1.75	14.5	1.75	6.00	2.91
B & O Railroad Bridge to Fill Area	4	13.9	3.13	31.5	3.13	16.4	10.5
Lake George Wetlands	12	0.870	0.0786	1.67	0.0916	1.60	0.729
Overall	**23**	**4.33**	**0.0786**	**31.5**	**0.484**	**6.00**	**1.67**

Table ES.2. Summary of the distribution of mean PEC-Qs in surficial sediments in the Assessment Area.

Reach Segment	Number of Samples	Average of Mean PEC-Q	Minimum Mean PEC-Q	Maximum Mean PEC-Q	10th Percentile	90th Percentile	Median
US Canal							
Columbus Drive to Forks	12	5.99	2.25	22.0	2.25	7.98	4.41
Indianapolis Boulevard to Forks	11	13.2	3.51	35.2	4.10	24.9	8.18
Forks to Highway 912	21	10.5	0.61	61.3	3.07	23.7	5.21
Highway 912 to Dickey Road	18	5.72	0.0652	29.3	0.55	12.6	3.14
Dickey Road to B & O Railroad Bridge	36	18.8	0.0395	177	1.17	29.7	9.90
B & O Railroad Bridge to IH	16	7.04	0.233	25.2	0.691	10.8	6.33
Overall	**114**	**11.7**	**0.0395**	**177**	**1.11**	**24.9**	**5.16**
IH and Nearshore Areas of Lake Michigan							
Indiana Harbor	55	6.81	0.0699	90.1	0.652	6.84	2.35
Nearshore areas of Lake Michigan	32	0.215	0.0447	1.31	0.0523	0.379	0.142
Overall	**87**	**4.4**	**0.0447**	**90.1**	**0.104**	**4.92**	**1.27**

NA = not applicable.

Table ES.3. Summary of the distribution of mean PEC-Qs in sub-surface sediments in the Assessment Area.

Reach Segment	Number of Samples	Average of Mean PEC-Q	Minimum Mean PEC-Q	Maximum Mean PEC-Q	10th Percentile	90th Percentile	Median
Grand Calumet River Lagoons							
West Lagoon	6	427	0.0185	2560	0.0185	0.317	0.0964
Middle Lagoon	3	0.0336	0.0147	0.0600	0.0147	0.0260	0.0260
East Lagoon	0	NA	NA	NA	NA	NA	NA
Little West Pond	2	0.120	0.0675	0.172	NA	NA	NA
Little East Pond	2	0.0412	0.0334	0.0490	NA	NA	NA
Overall	**13**	**197**	**0.0147**	**2560**	**0.0185**	**0.172**	**0.0490**
East Branch Grand Calumet River-I							
EB and WB Confluence to Kennedy Avenue	18	3.51	0.0692	13.1	0.193	8.30	2.77
USS Lead Canal	9	24.2	5.64	80.8	5.64	54.4	12.1
Kennedy Avenue to Cline Avenue	54	16.9	0.0286	497	0.0887	16.9	3.06
Cline Avenue to Cline/I-90 Ramps	7	1.47	0.0555	4.20	0.0555	2.63	1.21
Cline/I-90 Ramps to Industrial Highway	12	3.55	0.0847	13.6	0.123	5.50	2.78
Industrial Highway to ConRail Bridge	6	18.6	0.593	99.1	0.593	5.15	2.98
EB Wetland	1	0.627	0.627	0.627	NA	NA	NA
Overall	**107**	**12.7**	**0.0286**	**497**	**0.107**	**16.9**	**2.98**
East Branch Grand Calumet River-II							
EB II Wetland	0	NA	NA	NA	NA	NA	NA
ConRail Bridge to Bridge Street	9	14.1	2.55	65.3	2.55	19.1	7.21
Bridge Street to Grant Street	4	4.94	2.47	6.58	2.47	5.89	5.36
Grant Street to I-90	4	4.43	2.09	7.19	2.09	6.28	4.21
I-90 to Broadway	6	29.1	2.13	116	2.13	36.2	7.84
Broadway to Virginia Street	0	NA	NA	NA	NA	NA	NA
Virginia Street to Tennessee Street	3	450	118	937	118	296	296
Tennessee Street to Lagoon Culvert	7	218	2.80	765	2.80	458	66.3
Overall	**33**	**97.6**	**2.09**	**937**	**2.47**	**188**	**7.21**

Table ES.3. Summary of the distribution of mean PEC-Qs in sub-surface sediments in the Assessment Area.

Reach Segment	Number of Samples	Average of Mean PEC-Q	Minimum Mean PEC-Q	Maximum Mean PEC-Q	10th Percentile	90th Percentile	Median
West Branch Grand Calumet River-I							
EB and WB Confluence to Indianapolis Boulevard	**12**	**4.80**	**0.139**	**13.7**	**0.368**	**8.80**	**3.77**
West Branch Grand Calumet River-II							
Indianapolis Boulevard to I-90	10	0.191	0.0976	0.357	0.0976	0.278	0.205
Roxana Marsh	5	0.0905	0.0652	0.111	0.0652	0.101	0.0919
I-90 to Columbia Avenue	25	8.18	0.0658	30.2	0.128	16.9	3.34
Columbia Avenue to Calumet Avenue	3	3.21	0.215	5.89	0.215	3.53	3.53
Calumet Avenue to Hohman Avenue	13	13.1	0.109	97.3	0.325	17.9	3.78
Hohman Avenue to State Line Avenue	25	51.0	0.0712	193	2.47	129	33.4
Illinois Portion	7	4.69	0.148	13.3	0.148	8.45	3.74
Overall	**88**	**19.3**	**0.0652**	**193**	**0.101**	**51.7**	**3.84**
Indiana Harbor Canal							
EB and WB Confluence to 151st Street	4	2.90	0.434	4.36	0.434	4.12	3.41
151st Street to Chicago Avenue	0	NA	NA	NA	NA	NA	NA
Chicago Avenue to Columbus Drive	2	5.87	2.09	9.64	NA	NA	NA
IHC Wetland	0	NA	NA	NA	NA	NA	NA
Overall	**6**	**3.89**	**0.434**	**9.64**	**0.434**	**4.36**	**3.41**
Lake George Branch							
Indianapolis Boulevard to B & O Railroad Bridge	3	5.88	2.66	11.8	2.66	3.19	3.19
B & O Railroad Bridge to Fill Area	6	6.15	0.367	14.2	0.367	9.87	5.40
Lake George Wetlands	1	0.0457	0.0457	0.0457	NA	NA	0.0457
Overall	**10**	**5.46**	**0.0457**	**14.2**	**0.0457**	**11.8**	**3.20**

Table ES.3. Summary of the distribution of mean PEC-Qs in sub-surface sediments in the Assessment Area.

Reach Segment	Number of Samples	Average of Mean PEC-Q	Minimum Mean PEC-Q	Maximum Mean PEC-Q	10th Percentile	90th Percentile	Median
US Canal							
Columbus Drive to Forks	33	20.9	4.35	57.9	4.90	43.0	13.8
Indianapolis Boulevard to Forks	18	12.8	0.178	37.8	0.207	34.4	6.72
Forks to Highway 912	23	14.9	0.0557	45.3	0.222	36.5	6.71
Highway 912 to Dickey Road	6	2.45	0.0522	5.28	0.0522	5.18	2.08
Dickey Road to B & O Railroad Bridge	12	34.2	0.222	170	0.256	67.9	8.21
B & O Railroad Bridge to IH	9	3.23	0.225	5.04	0.225	4.96	3.47
Overall	**101**	**17.0**	**0.0522**	**170**	**0.245**	**38.8**	**7.25**
IH and nearshore areas of Lake Michigan							
Indiana Harbor	23	2.45	0.0412	7.19	0.0607	5.90	1.81
Nearshore areas of Lake Michigan	1	0.136	0.136	0.136	NA	NA	NA
Overall	**24**	**2.35**	**0.0412**	**7.19**	**0.0607**	**5.90**	**1.75**

NA = not applicable.

Table ES.4. Summary of the available information on SEM-AVS in the Assessment Area.

Reach/Segment	n	Number of Samples with SEM > AVS[1]	Percent Samples with SEM > AVS[1]
Grand Calumet River Lagoons	5	0	0%
East Branch Grand Calumet River-I	105	51	49%
East Branch Grand Calumet River-II	0	NA	NA
West Branch Grand Calumet River-I	9	5	56%
West Branch Grand Calumet River-II	0	NA	NA
Indiana Harbor Canal	11	10	91%
Lake George Branch	30	4	13%
US Canal	5	0	0%
Indiana Harbor / Lake Michigan	2	0	0%
Overall	**169**	**70**	**41%**

[1]As determined using the molar concentrations of simultaneously extracted metals (SEM) and acid volatile sulfides (AVS).
n = number of samples.
NA = not applicable.

Table ES.5. Summary of mIBI scores for the various reaches in the Assessment Area, 1993-1998.

		Reach								
Date	**Sample**	**Grand Calumet River Lagoons**	**East Branch Grand Calumet River-I**	**East Branch Grand Calumet River-II**	**West Branch Grand Calumet River-I**	**West Branch Grand Calumet River-II**	**Indiana Harbor Canal**	**Lake George Branch**	**US Canal**	**Indiana Harbor/ Lake Michigan**
October, 1993	1								2.8	
September, 1994	1								2.2	
October, 1996	1		2.1	1.3		1.1			1.7	
	2		2.4			1.7				
August, 1998	1		1.40		0.87		1.13	0.87	0.33	0.8
	2		1.13		0.53		1.07	0.40	0.20	
	3		1.67				1.07	0.87		
	4		1.13							
	5		0.87							
	6		0.87							
Average mIBI Score		NA	1.4	1.3	0.7	1.4	1.1	0.7	1.4	0.8
Standard Deviation		NA	0.57	NA	0.24	0.42	0.03	0.27	1.15	NA
Number of Samples		0	8	1	2	2	3	3	5	1

Sources: Sobiech *et al.* (1994); Simon and Stewart (1998); Simon *et al.* (2000).
NA = not applicable.

Table ES.6. Summary of QHEI scores for the various reaches in the Assessment Area, 1993-1998.

		Reach								
Date	**Sample**	**Grand Calumet River Lagoons**	**East Branch Grand Calumet River-I**	**East Branch Grand Calumet River-II**	**West Branch Grand Calumet River-I**	**West Branch Grand Calumet River-II**	**Indiana Harbor Canal**	**Lake George Branch**	**US Canal**	**Indiana Harbor/ Lake Michigan**
September, 1992	1				65.5	57.9				
	2					50.7				
	3					54.7				
	4					51.8				
	5					56.9				
	6					46.0				
June-July 1994	1		48	22						
	2			41						
	3			46						
	4			51						
1998	1		47.4		48.6	49.7	16	16	18	17
	2		41.3		49.7		24	45.2	21	
	3		45.2				24			
	4		42.8							
	5		48.8							
	6		43.0							
	7		39.5							
	8		42.5							
	9		48.6							
Average QHEI Score		NA	44.7	40	54.6	52.5	21.3	30.6	19.5	17
Standard Deviation		NA	3.34	12.68	9.46	4.23	4.62	20.65	2.12	NA
Number of Samples		0	10	4	3	7	3	2	2	1

Sources: Sobiech *et al.* (1994); Simon and Stewart (1988); Simon *et al.* (2000).
NA = not applicable.

Table ES.7. Summary of assessment of effects on fish and wildlife resources.

Reach/Segment	Indicator of Effects on Fish and Wildlife Resources[1] Toxicity to Fish[2]	Fish Health[3]	Fish Community[4]	Whole Sediment Chemistry[5]	Tissue Chemistry[6]	Number of Lines of Evidence for Demonstrating Ecosystem Impacts
Grand Calumet River Lagoons	14% (n=7)	0% (n=12)	38% (n=13)*	84% (n=58)*	100% (n=18)*	3
East Branch Grand Calumet River-I	57% (n=23)*	40% (n=10)*	100% (n=29)*	74% (n=110)*	100% (n=22)*	5
East Branch Grand Calumet River-II	85% (n=40)*	75% (n=4)*	100% (n=22)*	66% (n=90)*	100% (n=5)*	5
West Branch Grand Calumet River-I	ID (n=0)	100% (n=3)*	100% (n=12)*	29% (n=7)*	100% (n=7)*	4
West Branch Grand Calumet River-II	100% (n=7)*	100% (n=1)	100% (n=17)*	18% (n=17)*	100% (n=5)*	4
Indiana Harbor Canal	ID (n=0)	33% (n=3)	100% (n=4)*	93% (n=15)*	100% (n=7)*	3
Lake George Branch	ID (n=0)	50% (n=2)	50% (n=2)	83% (n=29)*	ID (n=0)	1
US Canal	ID (n=0)	50% (n=2)	100% (n=8)*	84% (n=37)*	100% (n=18)*	3
Indiana Harbor / Lake Michigan	ID (n=0)	100% (n=1)	100% (n=1)	88% (n=33)*	86% (n=21)*	2
Overall	**71% (n=77)***	**39% (n=38)***	**92% (n=108)***	**74% (n=396)***	**97% (n=103)***	**5**

[1] For each line of evidence, sediment injury is indicated if two or more samples have conditions sufficient to cause or substantially contribute to sediment injury. Evidence of sediment injury is denoted with an asterisk (*).

[2] Percent of sediment samples that were toxic to fish in laboratory tests.

[3] Percent of fish samples with > 1.3% DELT abnormalities.

[4] Percent of fish samples with IBI scores of ≤34 (i.e., poor, very poor, or no fish).

[5] Percent of sediment samples with one or more chemical concentrations in excess of the bioaccumulation SQGs for wildlife.

[6] Percent of fish and invertebrate tissue samples with one or more chemical concentrations in excess of the TRGs for wildlife.

ID = insufficient data; n = number of samples.

Table ES.8. Summary of DELT scores for the various reaches in the Assessment Area, 1993-1998.

Date	Sample	Reach: Grand Calumet River Lagoons	East Branch Grand Calumet River-I	East Branch Grand Calumet River-II	West Branch Grand Calumet River-I	West Branch Grand Calumet River-II	Indiana Harbor Canal	Lake George Branch	US Canal	Indiana Harbor/ Lake Michigan
October, 1993	1	0								
	2	0								
	3	0								
	4	0								
	5	0								
	6	0								
	7	0								
	8	0								
	9	0								
	10	0								
	11	0								
	12	0								
June-July, 1994	1		2.7	5.6						
	2			8.0						
	3			17.4						
	4			0						
September, 1992	1				10.8					
1998	1		0		6.15	2.8	6.15	1.68	0	12.8
	2		0.74		2.8		0	0	3.28	
	3		1.57				0.36			
	4		0							
	5		0.65							
	6		0.7							

Table ES.8. Summary of DELT scores for the various reaches in the Assessment Area, 1993-1998.

		Reach								
Date	Sample	Grand Calumet River Lagoons	East Branch Grand Calumet River-I	East Branch Grand Calumet River-II	West Branch Grand Calumet River-I	West Branch Grand Calumet River-II	Indiana Harbor Canal	Lake George Branch	US Canal	Indiana Harbor/ Lake Michigan
1998 (cont.)	7		0.15							
	8		2.4							
	9		6.15							
Average DELT Score		0	1.5	7.8	6.6	2.8	2.2	0.8	1.6	12.8
Standard Deviation		NA	1.89	7.25	4.02	NA	3.45	1.19	2.32	NA
Number of Samples		12	10	4	3	1	3	2	2	1

Sources: Sobiech *et al.* (1994); Simon and Stewart (1998); Simon *et al.* (2000); Simon (1993)
NA = not applicable.
DELT score = % incidence of deformities, fin erosion, lesions, and tumors.

Table ES.9. Summary of IBI scores for the various reaches in the Assessment Area, 1985-1998.

Date	Sample	Reach: Grand Calumet River Lagoons	East Branch Grand Calumet River-I	East Branch Grand Calumet River-II	West Branch Grand Calumet River-I	West Branch Grand Calumet River-II	Indiana Harbor Canal	Lake George Branch	US Canal	Indiana Harbor/ Lake Michigan
October, 1985	1		24	24		24				
	2		24			0				
June, 1986	1	32	24	26	22	22			24	
	2		24	24						
October, 1986	1		30	28	20	20			26	
	2		28	28						
April, 1987	1		22	30	24	24	22			
	2		22	32	22	24				
	3		22	24						
April, 1987	1		24	24	22	22			28	
	2		26	26						
November, 1987	1		30	32	0	0			34	
	2		30	30						
May, 1988	1		22	26	0	0				
	2		24	24						
July, 1988	1		32	28	0	0			24	
	2		26	26						
July, 1990	1		20	24	21	21			16	
	2		32	32						

Table ES.9. Summary of IBI scores for the various reaches in the Assessment Area, 1985-1998.

Date	Sample	Reach								
		Grand Calumet River Lagoons	East Branch Grand Calumet River-I	East Branch Grand Calumet River-II	West Branch Grand Calumet River-I	West Branch Grand Calumet River-II	Indiana Harbor Canal	Lake George Branch	US Canal	Indiana Harbor/ Lake Michigan
September, 1992	1				29	24				
	2					24				
	3					12				
	4					12				
	5					19				
June, 1994	1		22	12						
	2			18						
	3			22						
	4			22						
1994	1	42								
	2	42								
	3	42								
	4	34								
	5	32								
	6	31								
	7	38								
	8	32								
	9	43								
	10	43								
	11	42								
	12	42								
1998	1		16		16	22	16	14	12	14
	2		22		22		12	38	18	
	3		16				20			

Table ES.9. Summary of IBI scores for the various reaches in the Assessment Area, 1985-1998.

Date	Sample	Reach: Grand Calumet River Lagoons	East Branch Grand Calumet River-I	East Branch Grand Calumet River-II	West Branch Grand Calumet River-I	West Branch Grand Calumet River-II	Indiana Harbor Canal	Lake George Branch	US Canal	Indiana Harbor/ Lake Michigan
1998 (cont.)	4		18							
	5		20							
	6		24							
	7		24							
	8		26							
	9		18							
Average IBI Score		38.1	23.9	25.5	16.5	15.9	17.5	26.0	22.8	14.0
Standard Deviation		5.0	4.3	4.7	10.4	9.8	4.4	17.0	7.1	NA
Number of Samples		13	29	22	12	17	4	2	8	1
Percent Altered		38%	100%	100%	100%	100%	100%	50%	100%	100%
Classification for Average Score		fair-poor	poor-very poor	poor-very poor	very poor	very poor	very poor	poor-very poor	poor-very poor	very poor

Sources: Sobiech *et al.* (1994); Simon and Stewart (1988); Simon (1993); Stewart *et al* . (1999); Simon *et al.* (2000).

Figure ES.1. Areal extent of injury to surficial sediments in the Assessment Area.

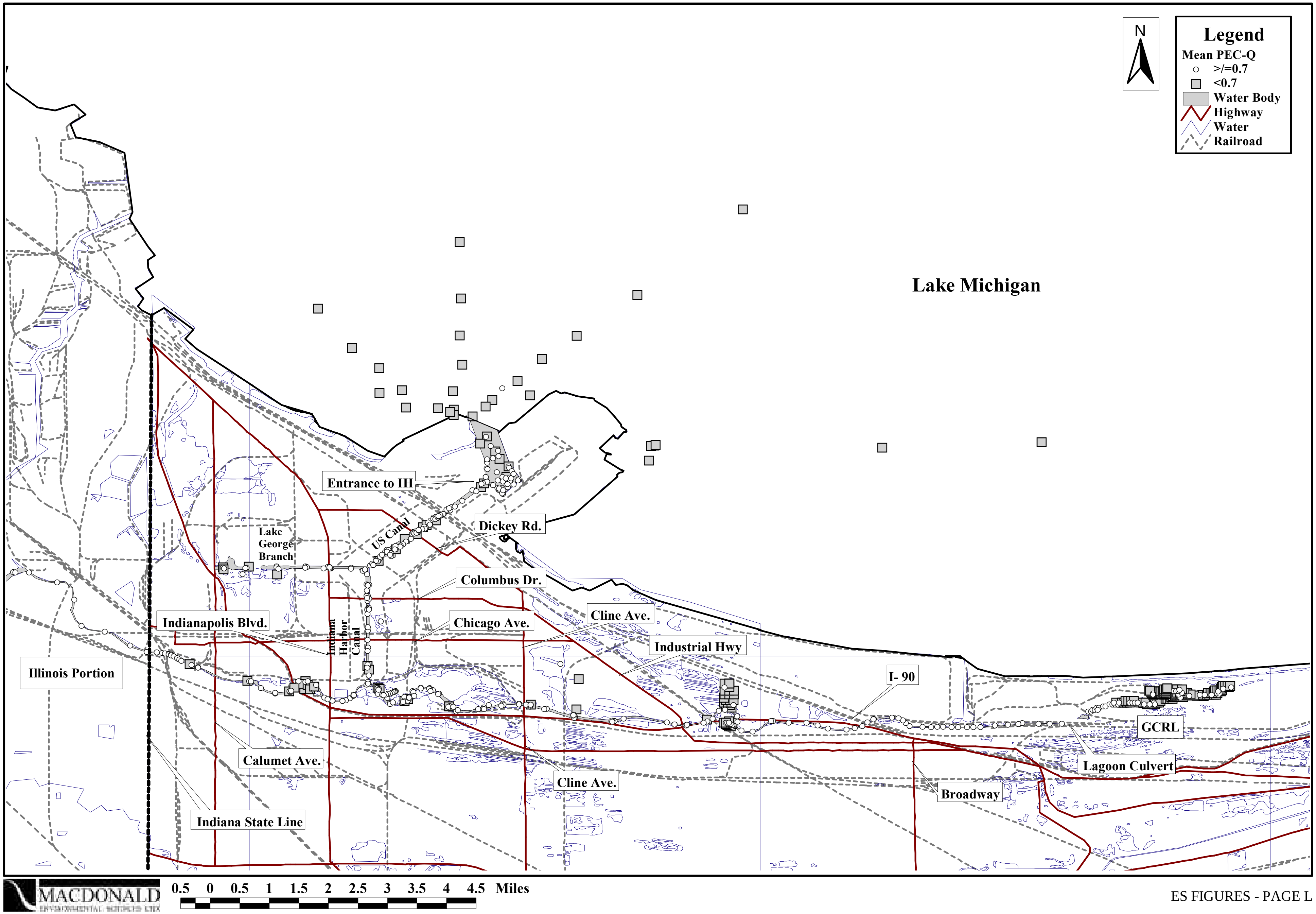

Figure ES.2. Areal extent of injury to sub-surface sediments in the Assessment Area.

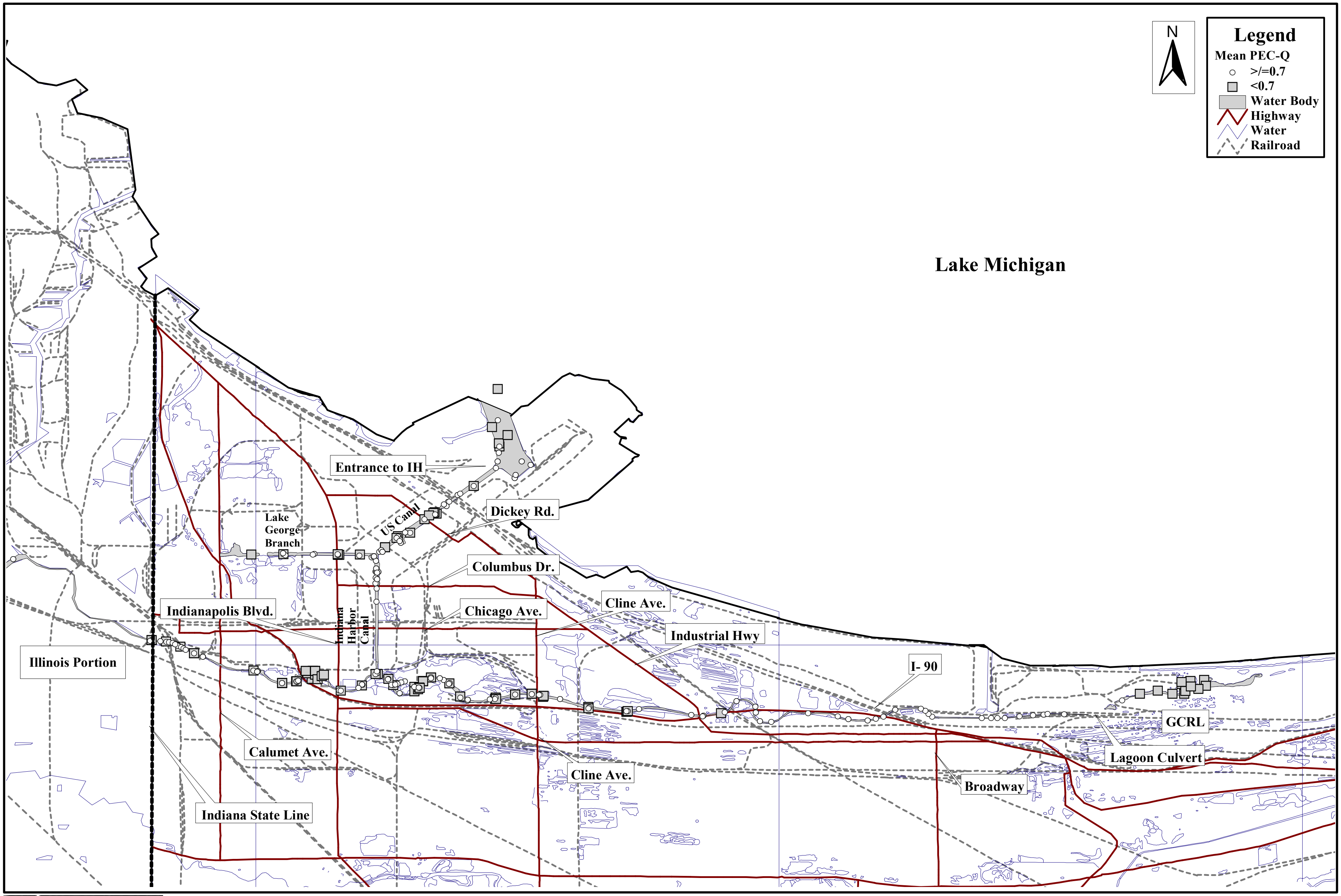

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Figure ES.3. Areal extent of sediment toxicity in the Assessment Area.

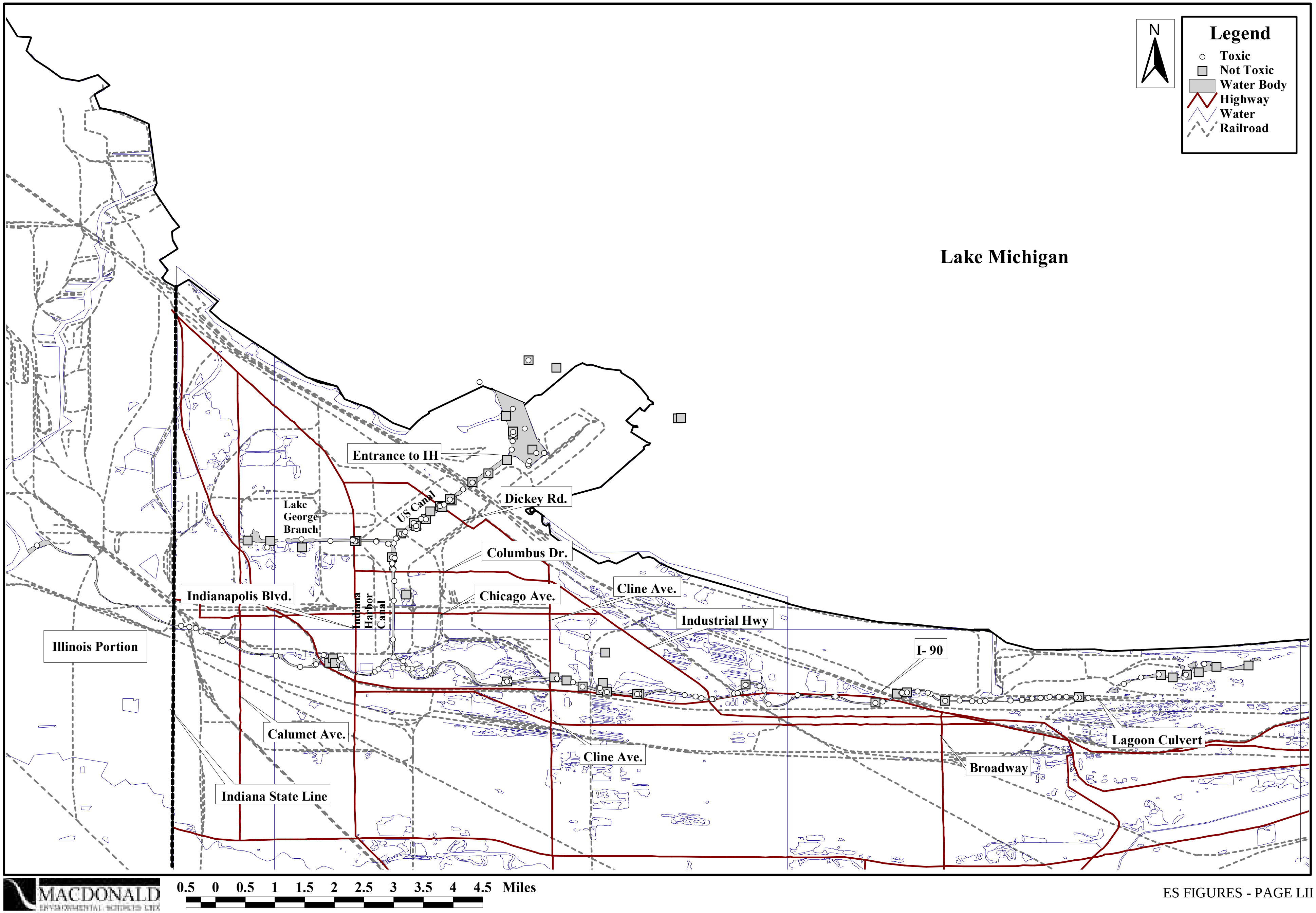

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Figure ES.4. Areal extent of altered and unaltered benthic invertebrate communities in the Assessment Area.