Delisting the Restrictions on Dredging Activities Beneficial Use Impairment in the Presque Isle Bay Area of Concern

December 10, 2006

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Acknowledgements

The delisting of the restrictions on dredging activities beneficial use impairment at the Presque Isle Bay Area of Concern would not have been possible without the combined efforts of a number of individuals and organizations. It is a direct result of collaboration between government, academia, and the public.

This work could not have been completed without the partnership of Eric Obert, Pennsylvania Sea Grant, and the financial support of the United States Environmental Protection's Great Lakes National Program Office.

Special thanks to the members of the Sediment Advisory Group: Chris Ingersoll, United States Geological Survey (USGS); Niles Kemble, USGS; Dan Button, USGS; Walter Berry, USEPA; Peter Landrum, National Oceanic and Atmospheric Administration; Jim Smith, Indiana Department of Environmental Protection; Scott Ireland, USEPA.; and Scott Pickard of the United States Army Corp of Engineers.

Thanks also to the members of the Presque Isle Bay Public Advisory Committee and its Sediment Subcommittee members: Rick Diz, Bob Wellington, Jim Rutkowski, Doug Ebert, Sean Rafferty, Ed Kissel, and Mike Campbell.

The contributions of MacDonald Environmental Sciences, Ltd were invaluable to this effort. Many thanks to Don MacDonald, Dawn Smorong, Yvonne Muirhead, and Mary Lou Haines.

Many other individuals provided support for this work. Thanks in particular to Jim Grazio, Rich Neville, Don Luttman, Rob Wood, and Judy Taylor of Pennsylvania's Department of Environmental Protection; Marti Martz of PA Sea Grant; Jerry Covert of the Regional Science Consortium at the Tom Ridge Environmental Center; and Mark Elster, Mike Russ, and Denise Hakowski of USEPA.

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Executive Summary

This report presents specific targets and supports a petition for delisting the restrictions on dredging activities beneficial use impairment in the Presque Isle Bay Area of Concern (AOC). At the time of listing, the Pennsylvania Department of Environmental Protection (PADEP) made a commitment to the Presque Isle Bay Public Advisory Committee (PAC) to evaluate sediment quality in areas being dredged and throughout the AOC. PADEP and the PAC have worked together to identify a primary delisting target related to dredging and disposal activities, and secondary ecosystem health targets related to sediment quality. In 2005 and 2006 the Environmental Protection Agency's Great Lakes National Program Office sponsored a series of workshops to assist in the development of specific targets. The targets identified in this report were developed in consultation with sediment experts during these workshops.

The ecosystem health targets looked at the impact of toxic and bioaccumulative contaminants in sediment on benthic organisms, fish, and aquatic-dependent wildlife. Measures of chemical contamination, bioavailability, and direct toxicity were used to evaluate these targets.

Contaminants were detected in the sediment at concentrations greater than sediment quality guidelines associated with increased toxicity to benthic organisms. In particular, cadmium, nickel, lead, and a number of polycyclic aromatic hydrocarbon (PAH) compounds, most notably dibenzo (a, h) anthracene, were present throughout the AOC and study area. However, when the overall contamination resulting from the combined concentrations of metals, PAHs, and polychlorinated biphenyls (PCBs) was considered, none of the whole-sediment samples exceeded levels that are linked with reduced survival or growth of benthic organisms. Bioavailability measurements indicated that metals are likely binding with sulfides or organic carbon and not available for uptake by benthic organisms. PAHs, on the other hand, were potentially bioavailable at almost 20% of the sampling locations and could contribute to sediment toxicity.

Direct whole-sediment toxicity tests did not correlate with measured contaminant concentrations in the sediment samples or confirm predicted toxicity. Although limited toxicity was observed the samples with the highest levels of PAHs, and all but one location where PAHs were predicted to be bioavailable, were not designated toxic. Therefore, it is unlikely that PAHs caused the limited toxicity that was observed with the bay's sediments.

With regard to the fish and aquatic-dependent wildlife, the levels of measured contaminants in sediments are not sufficient to adversely affect them in the AOC. Additionally, the concentrations of mercury and PCBs in tissue from Presque Isle Bay fish were similar to that found in Lake Erie fish indicating a lake-wide rather than AOC-specific problem.

The evaluation of sediment quality in Presque Isle Bay indicates that factors other than the contaminants in the sediment may be contributing to the limited toxicity to benthic organisms that was observed. Analysis of the data shows that metals and PAHs, while present, do not or rarely occur in the AOC or study area sediments at concentrations sufficient to adversely affect benthic organisms, fish, or aquatic dependent wildlife. Existing sediment quality conditions are sufficient to support benthic invertebrate communities and risks to fish and aquatic-dependent wildlife using habitats in Presque Isle Bay are unlikely to be higher than those for fish or aquatic-dependent wildlife using habitats elsewhere in Lake Erie. Ecosystem health targets are being met in the AOC

and there is no evidence that the moderate amount of contamination found is responsible for degrading the ecosystem.

The restriction on dredging beneficial use impairment was assessed from both practical and ecological perspectives. The practical restriction is based on Pennsylvania's laws and regulations, which preclude the disposal of dredged material in the open lake regardless of the presence or absence of contaminants. This restriction is due to the fact that dredged material is defined as a solid waste and there are limitations on locating a disposal facility in Waters of the Commonwealth. Even if the sediments being dredged showed no contamination, current DEP regulations would prohibit their placement in the open lake. Disposal to the CDF or an upland site are the only allowable options. Because the restrictions on disposal are not related to sediment contamination, the beneficial use should not be considered impaired.

From an ecological perspective, the sediment in the Presque Isle Bay AOC was evaluated against a delisting target based on discharges from the disposal of dredged material. The target takes into account the limitation on disposal options and current permitting practices by evaluating discharges from the CDF. Material can be placed in the CDF when the concentrations of contaminants of potential concern (COPCs) in the CDF mixing zone are below Pennsylvania's Water Quality Standards at the 15-minute compliance point for acute criteria and 12-hour compliance point for chronic criteria. At least 90% of samples must meet this target.

Using elutriate data from areas routinely dredged from within the AOC, it was determined that the primary delisting target for the restrictions on dredging beneficial use impairment is being met for areas currently being dredged within the AOC. In addition, calculations were done to estimate the predicted concentrations of COPCs in the CDF discharge based on concentrations detected in the sediment. If dredging were required in any location in the AOC, the material could be placed in the CDF. Given that the only "restriction" on dredging activities is regulatory and sediment from any location within the AOC can meet those requirements, the restrictions on dredging beneficial use is no longer considered impaired.

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Acronyms

AOC	Area of Concern
AVS	Acid Volatile Sulfides
BUI	Beneficial Use Impairment
CDF	Confined Disposal Facility
CERCLIS	Comprehensive Environmental Response and Liability Information System
COPC	Chemical of Potential Concern
CSO	Combined Sewer Overflow
DDT	Dichloro-Diphenyl-Trichloroethane
ERM	Effects Range Median
ESB-TU	Equilibrium Partitioning Sediment Benchmark Toxic Unit
EWPPA	Erie Western Pennsylvania Port Authority
GLWQA	Great Lakes Water Quality Agreement
IJC	International Joint Commission
MGD	Million Gallons per Day
NPDES	National Pollution Discharge Elimination System
NPL	National Priorities List
OC	Organic Carbon
PAC	Public Advisory Committee
PADEP	Pennsylvania Department of Environmental Protection
PAHs	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
PEC	Probable Effects Concentration
PEC-Q	Probable Effects Concentration Quotient
RCRA	Resource Conversation and Recovery Act
SAG	Sediment Advisory Group
SEM	Simultaneously Extracted Metals
TOC	Total Organic Carbon
USACE	United States Army Corp of Engineers
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service

Chapter 1 Presque Isle Bay Area of Concern

1.0 Introduction

In 2002, Presque Isle Bay became the first American Area of Concern (AOC) listed under the Great Lakes Water Quality Agreement (GLWQA) to be designated in the Recovery Stage. This designation means that all active remediation is complete and that the ecosystem is responding to the actions taken (United States Policy Committee 2001). During this recovery period, monitoring of beneficial use impairments (BUI) is the focus to ensure that delisting targets are met.

Since the Recovery Stage designation, Pennsylvania's Department of Environment Protection (PADEP) and the Presque Isle Bay Public Advisory Committee (PAC) have worked together to develop delisting targets for the AOC's two beneficial use impairments. This report focuses on one of those impairments: restrictions on dredging activities. A two-step approach was taken to assess the beneficial use impairment. First, the process and chemical analyses used to make decisions related to dredging in the AOC were reviewed. This evaluation focused on whether limitations or additional requirements are or should be placed on dredging or disposal activities due to contaminants in the sediment.

Second, the assessment looked at whether the contaminants in the sediment were toxic to benthic (i.e., sediment-dwelling) organisms or negatively impacting fish or aquatic-dependent wildlife. Calculations based on the concentration and interactions of the contaminants in the sediment were used to predict the potential for negative affects. Direct toxicity tests were conducted on benthic organisms with whole-sediment samples to confirm what was predicted. Additionally, tissue data for fish sampled in the bay were compared to Lake Erie data to decide whether contaminant impacts on fish communities were different in the bay and lake.

This report provides the results of those assessments. It also presents specific targets and supports a petition to delist the restrictions on dredging beneficial use impairment in the Presque Isle Bay AOC.

1.1 Background

The Presque Isle Bay AOC is located in northwestern Pennsylvania on the southern shore of Lake Erie (Figure 1). It is 4.5 miles long, 1.5 miles across at its widest point, and has an average depth of 13 feet. A seven-mile long, re-curved sand spit named Presque Isle forms the bay. The Isle is composed of beach sand and reworked glacial sediments and has a continuous series of ponds and lagoons some of which connect directly with the bay. The southeastern end of the bay connects to Lake Erie through a narrow channel that is maintained by the U.S. Army Corp of Engineers (USACE). This channel allows commercial shipping traffic and recreational boaters to enter the bay from the lake.

The Presque Isle Bay drainage basin is about 25 square miles in area, and includes much of the City of Erie as well as portions of Millcreek, Summit, Greene, and Harborcreek townships. The Presque

Isle Bay watershed consists of the bay itself, the Mill Creek watershed including Garrison Run, the Cascade Creek watershed, the Scott Run watershed, and the aquatic habitats within Presque Isle State Park. Mill Creek drains an area of about 13 square miles, while Cascade Creek drains an area of roughly six square miles, which together account for about two thirds of the water flowing into the bay.

Over time, much of the watershed draining into the bay has become urbanized, with heavy manufacturing industries coexisting within residential and commercial neighborhoods. Past waste disposal practices resulted in the discharge of industrial and domestic wastewater to the bay and tributaries draining into the bay. Until recent changes were made to the City of Erie's wastewater treatment, collection, and conveyance system, untreated industrial, commercial, and residential wastewater escaping from combined sewer overflows discharged to the bay and it's tributaries. Since about 80% of the watershed is urbanized, the bay received high concentrations of pollutants from stormwater runoff. Additionally, the geography and geology of the bay make it a natural "settling" basin for solids. Pollutants that enter the bay in runoff generally become entrapped in the sediments. While many pollutants released to the bay from such past practices have decayed through natural biodegradation processes, substances like heavy metals and more persistent organics remain in the sediment.

1.2 History

The GLWQA defines criteria for identifying geographic AOCs based on the presence of conditions that impair the beneficial uses of aquatic ecosystems. The Agreement defines an impairment as "a change in the chemical, physical, or biological integrity" of the system that causes one or more of fourteen listed impairments. The International Joint Commission (IJC) established guidelines for evaluating these fourteen beneficial use impairments (IJC 1991; 1997). The guidelines are intended to serve as an initial reference point from which appropriate restoration criteria could be developed for each AOC.

In 1984, the United States Fish and Wildlife Service (USFWS) received reports of brown bullhead catfish (*Ameiurus nebulosus*) with external sores and tumors being caught in Presque Isle Bay. In January 1988, members of the Erie County Environmental Coalition, a partnership of local organizations concerned about the health of the bay, consulted with the Science Advisory Board of the IJC on the appropriateness of designating the bay as an AOC. A petition was sent to the United States Department of State which designated Presque Isle Bay as the 43rd AOC in 1991.

The reasons for listing the bay were not cited in the designation so the first step was to determine which of the fourteen beneficial uses were impaired. Analysis of existing data and PADEP's1993 Remedial Action Plan identified chemicals of potential concern (COPCs) in the sediment. The COPCs included ten heavy metals, nutrients, chemical oxygen demand, cyanide, oil and grease, and polycyclic aromatic hydrocarbons (PAHs). No impairments to the water column or fish and wildlife were indicated. Based upon this analysis of existing data, PADEP believed that two of the fourteen beneficial uses were impaired: (1) fish tumors or other deformities; and, (2) restrictions on dredging activities.

The IJC Guidelines define the restrictions on dredging activities beneficial use to be impaired when contaminants in sediments exceed standards, criteria, or guidelines such that there are restrictions on dredging or disposal activities (IJC 1991). PADEP interpreted this impairment to mean that sediments were so contaminated that they should not be disturbed. If, however, dredging were needed for navigational or recreational purposes, restrictions would be required during the actual dredging to prevent re-suspension of the material into the water column. Once removed, the material would be considered a solid waste and may need treatment before disposal or there may be limitations on disposal options.

In 1991 when Presque Isle Bay was listed as an AOC, there was very little data to assess sediment quality. Anecdotal evidence and knowledge of historical industrial activities along the bayfront indicated that contaminated sediments would be a problem. To assess the restrictions on dredging activities impairment, PADEP compared whole-sediment chemistry data from three studies to the Environmental Protection Agency's (EPA) Guidelines for Pollutional Classification of Great Lakes Harbor Sediments (USEPA 1977a). PADEP considered these guidelines to be the only "currently-available applicable and appropriate measure of the dredging restrictions with which sediment quality data may be effectively compared" (PADEP 1993). Based on this comparison, the bay's sediments ranged from moderately to heavily polluted for most of the parameters. There was no guideline for PAHs but it was determined that the level present was elevated but typical of urbanized areas in the Great Lakes. PADEP looked at all of the beneficial uses that tied contaminated sediment to ecosystem health and concluded that while the sediment did contain contaminants, the effects of those contaminants were not being seen in the water column, benthos, or plankton populations.

There was, however, dredging of the bay's entrance channel for navigation by the USACE and maintenance dredging of marinas and docks along the bayfront by the Erie Western Pennsylvania Port Authority (EWPPA) (Figure 2). Sediments dredged by the USACE from the entrance channel were determined to meet Federal guidelines for open-lake placement and were placed at a designated, authorized area in Lake Erie. Those from the bayfront were considered unsuitable for open lake disposal and used by a local landfill as daily cover material. In 1998 the EWPPA's permit was amended to require disposal in the Confined Disposal Facility (CDF) located to the south of the bay's entrance channel.

Materials from the EWPPA maintenance dredging are classified as a solid waste under Pennsylvania's Solid Waste Management Act (P.L. 380, *as amended*, 35 P.S. §§6018.101-6018.1003). The Act and its implementing regulations prohibit the disposal of dredged material in the waters of the Commonwealth without a permit. Permitting a solid waste disposal site in the open lake is practically impossible due to disposal siting regulations and requirements. Based upon this "restriction" and the need to continue evaluating the sediment, PADEP listed the restrictions on dredging activities beneficial use as impaired. PADEP also made a commitment to the bay's PAC to evaluate sediment quality throughout the bay and not just in the areas where dredging occurs.

Since the 1980s, PADEP and its partners collected information on sediment quality conditions within the bay. Sediment chemistry data were collected at a number of locations in the bay in 1982, 1986, 1990, 1992, 1993, 1994, 2000, and 2001 (PADEP 2002). In addition, whole-sediment toxicity tests were conducted on samples collected within the AOC in 1982, 1986, 1994, and 2000 (PADEP 2002). The sediments were found to contain broad, low level contamination, primarily metals and PAHs, spread throughout the bay. The investigations also indicated that sediment quality conditions were improving in the bay. As a result, PADEP, in conjunction with the AOC's PAC, determined that monitored natural attenuation, rather than active remediation within the AOC, would provide the most cost-effective and practical method for restoring the restrictions on dredging beneficial use. Based upon this conclusion and a decade-long downward trend in fish tumors, Presque Isle Bay was re-designated as an AOC in the Recovery Stage in 2002.

Following this change in designation, PADEP and the PAC focused on the development of delisting targets and long-term monitoring plans for the bay's fish, sediment, and the watershed. With funding from the EPA's Great Lakes Nation Program Office, PADEP partnered with Pennsylvania Sea Grant to form a Sediment Advisory Group of nationally known sediment experts and host a series of workshops, bringing these sediment experts together with the PAC. The first workshop in May 2005, concentrated on developing and working through a process for identifying appropriate delisting criteria. Following an ecosystem approach, workshop participants developed a conceptual site model for the AOC connecting contaminants in the sediment and the animals and plants that could be exposed to them. Building on that model, participants created a framework to describe goals and objectives for managing the sediment and indicators to measure progress. The indicators and specific metrics form the basis for the bay's proposed sediment delisting targets.

A second workshop in June 2005 focused on finalizing the delisting targets, reviewing existing data, and planning for a comprehensive sediment quality survey, which was implemented in September 2005. Work also began on identifying the components of the long-term sediment-monitoring plan. A third workshop in May 2006, gave participants the opportunity to review the survey data, evaluate the delisting targets, and continue to work on the monitoring plan. The results of the three workshops are summarized in the following chapters.

Chapter 2 An Ecosystem-Based Framework for Managing Contaminated Sediments

2.0 Introduction

The ecosystem approach to planning, research, and management considers the impacts of human activities on the environment and the people who live there. The AOC program as described in the GLWQA is premised on a "systematic and comprehensive ecosystem approach to restoring and protecting beneficial uses". A broad overview of the ecosystem approach applied during the 2005 workshops to the management of Presque Isle Bay's contaminated sediment is described below.

2.1 A Framework for Implementing Ecosystem-Based Management

Implementing the ecosystem approach requires a framework in which to develop and implement management policies for the ecosystem. This framework consists of five main elements (Environment Canada 1996):

• Identify and assess existing information on the ecosystem;
• Develop ecosystem health goals and objectives;
• Select ecosystem health indicators to measure progress toward ecosystem health goals and objectives;
• Conduct directed research and monitoring; and,
• Make informed decisions on the assessment, conservation, protection, and restoration of natural resources.

The first element of the framework is the site conceptual model, which provides a common understanding of the key issues and the existing knowledge base. The second step of the process involves the development of a series of broad management goals (i.e., ecosystem goals) to describe the long-term vision for the ecosystem. A set of objectives for the various components of the ecosystem is also created to clarify the scope and intent of the ecosystem goals. The third element of the ecosystem management framework involves the selection of a suite of ecosystem health indicators, which provide a means for measuring the level of attainment of the ecosystem goals and objectives.

Each of the ecosystem health indicators must be supported by specific metrics and targets, which identify the acceptable range for each of the variables that will be measured to provide information on the status of the indicator. If the measured metrics fall within acceptable ranges for the indicators, then the ecosystem as a whole would be considered to be healthy and vital. In the fourth step of the process, monitoring and directed research are conducted to evaluate the status of the ecosystem and to fill any data gaps that have been identified. The relationship between ecosystem goals, ecosystem health objectives, ecosystem health indicators, metrics, and targets, within the context of the ecosystem approach to environmental management, is illustrated in Figures 3 and 4.

Overall, this framework for implementing ecosystem-based management is intended to support informed decision-making. The ecosystem goals and objectives establish the priorities that need to be reflected in decisions regarding the conservation of natural resources, protection of the environment, and socioeconomic development. As a final step in the process, decision-makers use the information on the status of the ecosystem health indicators to evaluate the effectiveness of their management activities and to refine their approaches, if necessary.

2.2 Application of the Ecosystem Approach to Contaminated Sediment Management

Application of the ecosystem-based framework to Presque Isle Bay's contaminated sediment required development of more specific sediment management objectives (i.e., in addition to ecosystem goals and objectives) and key indicators of sediment quality conditions. Specific measures that apply to each indicator and the corresponding targets for each measurement were then selected. Chapters 3 and 4 describe the framework developed for Presque Isle Bay.

Chapter 3 Conceptual Site Model for the Presque Isle Bay Area of Concern

3.0 Introduction

The first element of the ecosystem management framework is the conceptual site model. It combines what is already known about a site and serves as a framework for identifying what additional information and data are needed. The conceptual site model developed for the Presque Isle Bay AOC identifies known sources and releases of contaminants in the watershed, chemicals of potential concern and how they are expected to impact the environment, and possible pathways that tell how aquatic-dependent wildlife could come into contact with the contaminants. This information forms the basis for a series of questions that need to be answered and reflected in the ecosystem goals, objectives, and indicators to assess environmental conditions in the AOC.

3.1 Sources and Releases of Contaminants

There are a number of natural and man-made sources of toxic and bioaccumulative substances in the Presque Isle Bay watershed. Historical and current man-made sources of environmental contaminants in the watershed include industrial wastewater discharges, municipal wastewater treatment plant discharges, stormwater discharges, non-point source discharges, spills associated with production and transport activities, and deposition of substances that were originally released into the atmosphere.

To support the development of the 1993 Stage I Remedial Action Plan for Presque Isle Bay, an evaluation of pollutant sources and transport mechanisms was conducted for the PADEP (Potomac-Hudson 1991). The results of this evaluation indicated:

- Six industrial point source dischargers permitted under the National Pollutant Discharge Elimination System (NPDES) released, on average, 124 million gallons per day (MGD) of runoff, wastewater, and/or cooling water directly to Presque Isle Bay, to storm sewers, or tributaries to Presque Isle Bay;
- Three NPDES permitted municipal wastewater or water treatment plants released, on average, 1.3 MGD of treated wastewater or filter backwash water to Presque Isle Bay;
- A total of 47 combined sewer overflows released 3.1 million gallons of raw sanitary sewage and untreated industrial effluent during an average storm event to the Mill Creek/Garrison Run drainage system (i.e., 38 combined sewage outflows; CSOs), to Cascade Creek (i.e., 1 CSO), or to Presque Isle Bay via small, unnamed tributaries, drainage ways, or outfall sewer lines (i.e., 8 CSOs); and
- Roughly 18.6 MGD of industrial effluent were discharged to the City of Erie's wastewater treatment plant from 39 industrial users (Potomac-Hudson 1991).

Additionally, two properties (Lord-Shope Landfill and Mill Creek Dump) in the vicinity of Presque Isle Bay were included on the federal National Priorities List as containing potentially uncontrolled hazardous wastes that require investigation and cleanup. Physical cleanup has been completed at both of these sites. Seven sites listed under the Pennsylvania Hazardous Site Control Act are also located within the watershed. Cleanup is complete at three of these sites (Fairview Castings, Filmore Site, and RSR Jones Chemical) and nearing completion at one site (Currie Landfill). The remaining three sites (Cohen/A-1 Auto, Erie Resistor, and Bizzaro Junkyard) were investigated by PADEP and did not require any cleanup actions. At least one facility in the area, Safety Cleen, is subject to regulation and monitoring under the Resource Conservation and Recovery Act (RCRA) for storage of solvents and solvent wastes.

While these and other historic sources of contamination have contributed to the pollutant loading, a lot of cleanup and other work have been done which has greatly reduced the quantity of contaminants entering the bay. Upgrades and improvements to the City of Erie's wastewater collection, conveyance, and treatment system have reduced the number of CSOs in the bay's watershed to four. All of these CSOs discharge into the bay via the Mill Creek tube and have screening devices to remove flotables and are flow monitored.

Changes in the bayfront from an industrial center to a recreation area have also reduced the amount of contaminants entering the system. Currently, there are nine permitted NPDES discharges to the bay and its tributaries. Five of the nine are industrial waste or non-contact cooling water (Erie Forge and Steel, GAF Corporation, Transportation Investment Group/Union Electric Steel, United Erie/Interstate Chemical, and Urick Foundry). Two facilities (Presque Isle State Park and the Ramada Inn) discharge treated domestic wastewater into the bay. The City of Erie also has two NPDES permits for filter backwashes from the Chestnut Street and Summerheim drinking water treatment plants. While both facilities are connected to the City's wastewater treatment plant, these permits are maintained for emergency situations such as a failure of pumps or when maintenance is needed on the filters. The nine dischargers are permitted for 3.27 MGD and actually discharge an average of 0.229 MGD. None of the discharges are permitted for bioaccumulative contaminants.

Although it is difficult to evaluate contributions of contaminants from other sources, surface run-off, groundwater contamination, and atmospheric deposition have all been identified as potential sources of contaminants to Presque Isle Bay (Potomac-Hudson 1991).

3.2 Identification of Chemicals of Potential Concern

Information on historic and current land uses within the AOC's watershed, regional land use patterns, and the characteristics of effluent and stormwater discharges in the vicinity of the site provided the basis for developing the preliminary list of COPCs in Presque Isle Bay (Potomac-Hudson 1991). The COPCs considered to be causing or contributing to beneficial use impairments in Presque Isle Bay included metals (arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, nickel, and zinc), chemical oxygen demand, total kjeldahl nitrogen, total phosphorus, cyanide, polycyclic aromatic hydrocarbons (PAHs), oil and grease, and volatile solids. A review of the sediment quality investigations conducted since the 1991 background report indicates that other contaminants should be evaluated as part of the conceptual site model for Presque Isle Bay. During the 2005 workshops, the initial list of COPCs was expanded to include mercury, Polychlorinated Biphenyls (PCBs)and organochlorine pesticides (i.e., Dichloro-Diphenyl-Trichloroethane (DDT), chlordane, dieldrin, and endrin).

3.3 Environmental Fate of Chemicals of Potential Concern

Upon release into aquatic ecosystems, the COPCs partition into the water and sediment depending on their physical and chemical properties and the characteristics of the receiving water body. Aquatic organisms may be exposed to the COPCs in the water or sediment. . As a result, information on how specific chemicals partition in the environment was used to classify the COPCs into two non-exclusive groups: bioaccumulative substances (i.e., substances that build up in the tissues of aquatic organisms) and toxic substances that partition into sediment.

Toxic COPCs that Partition in Sediment:

- Metals (arsenic, barium, cadmium, chromium, copper, iron, mercury, lead, manganese, nickel, and zinc);
- Cyanide;
- PAHs;
- Oil and grease;
- PCBs; and,
- Organochlorine pesticides (DDTs, chlordane, dieldrin, endrin).

Bioaccumulative COPCs:

- Metals (Cadmium, Mercury, and Lead);
- PCBs; and
- Organochlorine pesticides (DDTs, chlordane, dieldrin, endrin);

3.4 Potential Exposure Pathways

Once released to the Presque Isle Bay ecosystem, there are several pathways through which aquatic organisms and aquatic-dependent wildlife can be exposed to COPCs: direct contact with contaminated sediment, direct contact with contaminated water, ingestion of contaminated sediment, and ingestion of contaminated organisms. For bioaccumulative chemicals, eating contaminated prey species represents the most important route of exposure for the majority of aquatic organisms and aquatic-dependent wildlife species.

For toxic substances that partition into sediments, direct contact with contaminated sediments and pore-water represents the most important route of exposure for aquatic organisms. However, ingestion of contaminated sediments can also represent an important exposure pathway for certain aquatic organisms that process sediments to obtain food and for aquatic-dependent wildlife species.

3.5 Ecological Receptors Potentially at Risk

There are a wide variety of ecological receptors that could be exposed to contaminated sediment in Presque Isle Bay. The aquatic species that occur in the bay include microbiota (e.g., bacteria, fungi and protozoa), aquatic plants, aquatic invertebrates, fish, amphibians, reptiles, bird and mammals.

As discussed earlier, the COPCs in Presque Isle Bay were classified into toxic and/or bioaccumulative categories based on their predicted environmental fate (MacDonald *et al.* 2000). Using this information and the exposure pathways that apply to these COPCs, it is possible to identify the receptors that are potentially at risk due to exposure to contaminated sediment. For bioaccumulative substances, benthic invertebrates, piscivorous fish, amphibians, and reptiles are most likely to be exposed. Decomposers (i.e., microbiota), aquatic plants, benthic invertebrates, benthic fish, and amphibians are most likely to be exposed to toxic substances that partition into sediments. The focus in Presque Isle Bay was on benthic organisms, fish, and aquatic-dependent wildlife as the primary receptors because they are most likely to be exposed to contaminated sediment in the bay.

3.6 Risk Questions

Using the framework provided by the conceptual site model for the Presque Isle Bay AOC, a series of questions was developed. The questions provide the basis for selecting indicators of sediment quality conditions in Presque Isle Bay. These indicators are the foundation for specific delisting and ecosystem health targets developed for assessing and managing the contaminated sediment and the restrictions on dredging activities beneficial use impairment. Although microorganisms, aquatic plants, amphibians, and reptiles are important receptor groups in Presque Isle Bay, insufficient information on the toxicity of sediment-associated COPCs is available to determine the risks that bay's COPCs pose to these species. However, information from other studies shows that these species are likely to be protected if conditions sufficient to support benthic organisms and fish are maintained and/or restored (MacDonald et al 2002; 2004). Additionally, standard methods are available to determine if contaminants in sediment adversely affect survival and growth of sensitive aquatic organisms (ASTM 2006; USEPA 2000). These toxicity tests can be used to assess the ecosystem health (MacDonald and Ingersoll 2002; Ingersoll and MacDonald 2002). The following questions need to be answered to properly assess the health of the Presque Isle Bay ecosystem in terms of contaminated sediment:

1. Survival or Growth of Benthic Organisms

• Are the levels of contaminants in whole sediments from Presque Isle Bay greater than benchmarks for the survival or growth of benthic organisms?

• Is the survival or growth of benthic organisms exposed to whole sediments from Presque Isle Bay significantly lower than that in control or reference sediments?

2. Health of fish

• Are the levels of contaminants in whole sediments from Presque Isle Bay greater than benchmarks for the health of fish?

• Are the levels of contaminants in fish tissues from Presque Isle Bay greater than the levels of contaminants in fish from elsewhere in Lake Erie?

3. Health of Aquatic-Dependent Wildlife

• Are the levels of contaminants in whole sediments from Presque Isle Bay greater than benchmarks for the health of aquatic-dependent wildlife?

Chapter 4 Ecosystem Goals, Objectives, and Indicators for Contaminated Sediment Management in the Presque Isle Bay Area of Concern

4.0 Introduction

Once information is collected and the Conceptual Site Model developed, a framework is constructed by describing the desired future state of the ecosystem and identifying goals and objectives necessary to achieve it. Development of the second and third elements of the framework, ecosystem goals, objectives, and indicators, for the Presque Isle Bay AOC is described below.

4.1 Development of Candidate Ecosystem Goals and Objectives for the Presque Isle Bay AOC

In the second step of the framework, broad narrative statements are developed that define the management goals for a specific ecosystem. For the Presque Isle Bay AOC, this step was focused on identification of ecosystem goals and objectives that were most closely linked to the bay's beneficial use impairments. Work done in the broader Great Lakes context for Lake Superior, Lake Ontario, and Lake Erie, identified a common ecosystem goal for freshwater ecosystems, which was recommended and adopted for the AOC.

Ecosystem Goal for the Presque Isle Bay AOC

To protect, sustain, and, where necessary, restore a healthy, functioning aquatic ecosystem that is capable of supporting current and future uses.

While this statement expresses the overarching goal for the AOC, it is too general to support the development of meaningful planning, research, and management initiatives. Participants of the sediment workshops used this goal to identify a set of ecosystem objectives that clarified the scope and intent of the overarching goal and are more closely linked with ecological science. These objectives reflect the desired uses of Presque Isle Bay that require protection and/or restoration.

Ecosystem Objectives for the Presque Isle Bay AOC

• Protect and preserve recreational uses;
• Maintain and protect the benthic invertebrate community;
• Maintain a quality fishery;
• Protect and improve the near-shore habitat;
• Maintain the aesthetic qualities (e.g., prevent algal blooms, unpleasant odors, visual impairments, etc.);• Maintain and improve water quality conditions; and,
• Eliminate the restrictions on dredging.

These AOC-wide ecosystem objectives were then used to propose more specific objectives to support the management of the bay's contaminated sediment. Sediment management objectives describe the desired future sediment quality conditions in terms of specific ecological functions. The objectives are also based on the risk questions developed through building the conceptual site model (Chapter 3) for Presque Isle Bay. The conceptual site model identified pathways and plant and animal species that could be exposed to contaminated sediment. Coupling the desired conditions with the risk questions posed by the model, the sediment management objectives listed below were selected to meet the ecosystem goal and objectives for the AOC.

Sediment Management Objectives for the Presque Isle Bay AOC

• Maintain and/or restore sediment quality conditions such that human health is protected and the human uses of the aquatic ecosystem (e.g., fish and wildlife consumption; navigation and shipping, etc.) are protected and, where necessary, restored.
• Maintain and/or restore sediment quality conditions such that benthic communities, including epibenthic and infaunal species, are protected and where necessary, restored.
• Maintain and/or restore sediment quality conditions such that the health of fish populations is protected and, where necessary, restored.
• Maintain and/or restore sediment quality conditions such that the health of aquatic-dependent wildlife populations is protected and, where necessary, restored.

These sediment management objectives clearly recognize that there are multiple uses of the bay's aquatic ecosystem that can be affected by sediment quality conditions. These objectives also recognize that plant and animal species identified in the conceptual site model as potentially at risk can be exposed to sediment-associated contaminants in three ways: 1) direct exposure to *in situ* sediments and pore-water, 2) through transfer of sediment-associated contaminants into the water column, and 3) through the consumption of contaminated food organisms. The sediment management strategy for Presque Isle Bay considered these three exposure routes, in order to protect, maintain, and restore the designated uses of aquatic ecosystems.

4.2 Sediment Quality Indicators

Sediment quality as defined by the sediment management objectives cannot be measured directly. To do so requires the identification of indicators of sediment quality conditions. In Presque Isle Bay, indicators were defined to provide the information needed to determine if sediment quality and related conditions have improved to such an extent that PADEP could recommend delisting the restrictions on dredging activities beneficial use impairment. The selected indicators were also used to assess the current status of sediment quality and develop the framework for a long-term sediment-monitoring plan for the AOC. By themselves, however, the selected indicators do not provide a comprehensive basis for making sediment management decisions. Metrics were also identified that can be measured to provide information on the status of a sediment quality indicator.

In evaluating the restrictions on dredging activities impairment, the key sediment quality indicator for assessing compliance with Pennsylvania's regulations is elutriate chemistry. However, several other sediment quality indicators and associated metrics were used, including whole-sediment testing guidance from the Great Lakes Dredged Material Testing and Evaluation Manual (USEPA/USACE, 1998), and fish tissue chemistry.

Sediment Quality Indicators and Metrics for the Presque Isle Bay AOC

Sediment Quality Indicator	Metric
Elutriate Chemistry	Concentrations of chemicals of potential concern in elutriate[1] samples
Whole sediment chemistry	Concentrations of chemicals of potential concern in whole sediment samples
Whole sediment toxicity	Survival and growth of amphipods (Hyallela azteca) in 10-day or 28-day whole-sediment toxicity tests
	Survival and growth of midges (Chironomus dilutus) in 10-day whole-sediment toxicity tests
Fish Tissue chemistry	Concentrations of chemicals of potential concern in fish tissue

[1]Note: an elutriate sample is obtained by mixing a sample of sediment with a specific quantity of receiving water. After waiting for the sediment particles to settle, the overlying water is sampled and chemically evaluated to determine elutriate chemistry.

Chapter 5 Identification of Delisting Targets for Presque Isle Bay

5.0 Introduction

Developing delisting targets for Great Lakes AOCs is a site-specific exercise. The IJC and the United States Policy Committee, however, have provided general guidance to assist state agencies and their partners in this process. As mentioned in Chapter 1, the IJC (1991) established a series of listing and delisting guidelines to assist in making recommendations regarding the listing of new AOCs, reviewing all stages of Remedial Action Plans, and delisting. The guidelines were intended to serve as an initial reference point from which to base site-specific restoration criteria.

In addition to the general guidance provided by the IJC, the United States Policy Committee (USPC 2001) has established more specific guidance for developing delisting targets. The principles and criteria for delisting include establishing ecosystem goals and objectives and identifying measurable indicators, as was done for the Presque Isle Bay AOC during the 2005 workshops.

Building on the framework of the ecosystem approach, workshop participants developed site-specific delisting targets for each sediment management objective (Table 1). The primary delisting target relates directly to the restrictions on dredging activities beneficial use impairment. Secondary ecosystem health targets to assess the impact of the sediments in-place were also identified. These secondary targets would not necessarily need to be met to proceed with the delisting process, but provide a basis for implementing ecosystem-based management actions, monitoring, and protecting key beneficial uses in Presque Isle Bay.

5.1 Restriction on Dredging Delisting Target for Presque Isle Bay

To make decisions regarding disposal of material dredged from within the AOC boundary, PADEP follows the procedures outlined in the USACE's Great Lakes Testing and Evaluation Manual (USEPA/USACE 1998). A tiered approach is outlined in the Manual to evaluate the contaminant-related impacts of dredged material discharges. Once enough information is known to make a decision, there is no need for further investigation. To evaluate potential water column impacts from disposal of sediments, the Manual recommends that a suspension of water and sediment known as an elutriate sample be prepared. The elutriate sample represents the expected release of contaminants during the dredging and disposal operations. The elutriate concentrations are adjusted to reflect the dilution from mixing and dispersion at the disposal site (USEPA/USACE, 1998). The adjusted chemical concentrations are then compared to Pennsylvania's Water Quality Standards (25 Pa. Code Chapters 16 and 93; Table 2).

The target for delisting the restrictions on dredging activities beneficial use impairment in Presque Isle Bay is based on the evaluation of COPCs in elutriate samples following this process. The USACE's CDFate model was used to estimate the amount of dilution and dispersion expected in the vicinity of the CDF. The CDF mixing zone or the area in which the initial dilution of a discharge occurs and water quality standards may be exceeded was defined consistent with PADEP's Water Quality Toxics Management Strategy. The Strategy provides a conservative approach to defining compliance points in the mixing zone for toxics in permitted discharges under the National Pollutant Discharge Elimination System program. This policy requires discharges to meet Pennsylvania's acute water quality criteria at the 15-minute compliance point. It also requires chronic criteria to be met at the 12-hour compliance point. The delisting target for the restrictions on dredging activities beneficial use impairment is met when the concentrations of COPCs at the edge of the mixing zone, as calculated by CDFate, are below acute criteria at 15 minutes and below chronic criteria at 12 hours.

5.2 Ecosystem Health Targets for Presque Isle Bay

As described in Chapter 4, workshop participants identified sediment management objectives to evaluate and monitor the risks posed by contaminated sediment to ecological receptors. The Conceptual Site Model (Chapter 3) identified three primary receptor groups most likely to be impacted by contaminated sediment in the bay: benthic organisms, fish, and aquatic-dependent wildlife. These receptor groups were selected because they are the most likely to be adversely impacted by toxic and/or bioaccumulative substances that accumulate in bed sediments. The PAC and Sediment Advisory Group developed specific ecosystem health targets based on information published in peer-reviewed literature to meet the sediment management objectives and ensure the protection of these receptors. The specific targets and metrics are discussed below.

5.2.1 Benthic Organisms

For benthic organisms, quantitative ecosystem health targets (Table 1) were identified using established sediment quality guidelines, measures of chemical contamination in the sediment, and an assessment of the bioavailability of COPCs. Two key indicators of sediment quality conditions, whole-sediment chemistry and whole-sediment toxicity, provide the information needed to assess whether the ecosystem health targets are being met. For whole-sediment chemistry, the concentrations of the toxic and bioaccumulative COPCs in whole-sediment samples are the metrics of primary interest. For whole-sediment toxicity, the survival or growth of the amphipod *Hyalella azteca* in 28-day toxicity tests and the survival or growth of the midge *Chironomus dilutus* in 10-day toxicity tests are the metrics of primary interest.

Sediment quality guidelines are a screening tool that indicates whether individual COPCs are present at levels that could negatively affect the ecosystem. The information provided by this initial evaluation may identify potential "hot spots" or areas needing further investigation. For this initial assessment of Presque Isle Bay sediment, consensus-based probable effects concentrations (PECs) or equivalent sediment quality guidelines were used (Table 3). These selected toxicity thresholds were developed using matching sediment chemistry and toxicity data from field studies conducted throughout the United States (MacDonald, et al, 2000). The resulting consensus-based sediment quality guidelines are a screening tool to predict whether sediments are likely to be toxic to benthic organisms.

While this screening is useful, it does not take into account the mixture of contaminants actually present in the sediment. Calculating the mean PEC-quotient provides a measure for assessing whole-sediment chemistry that considers complex mixtures of contaminants. The PEC quotient or

PEC-Q for a chemical is a measure of the level of contamination in sediment relative to the sediment quality guideline for that substance. Mean PEC-Qs are calculated for each sample by dividing the concentration of a chemical by its PEC, adding those quotients for metals, PAHs, and PCBs, and dividing by three. The resulting number is a unit less measure of the overall level of chemical contamination in the sediment. The mean PEC-quotient is well correlated with sediment toxicity, based on the information contained in the national database (USEPA 2000). For sediment with a mean PEC-Q greater than 1.0, the probability of observing significantly reduced survival or growth of the amphipod *Hyallela azteca* in 10- to 28-day toxicity tests is above 50% (based on data summarized in USEPA 2000 and in subsequent applications of mean PEC-Q at other sites across North America; Ingersoll et al 2005; Long et al 2006).

Although COPCs may be detected in sediments, adverse impacts on benthic organisms may not be observed depending on the bioavailability of the chemical. Bioavailability refers to the extent to which contaminants are available for uptake by benthic organisms. It depends on the presence of other substances in the sediment and the potential for a contaminant to partition into the water between sediment particles. Contaminants may be present in the sediment at concentrations exceeding toxicity thresholds but not bioavailable to benthic organisms. In such cases, sediment samples predicted to be toxic based on whole-sediment chemistry may not be toxic when toxicity test are conducted. The presence of organic carbon and/or acid volatile sulfides in sediments can bind COPCs, making them less available to benthic organisms. To assess bioavailability, two measures were evaluated.

The first measure considers the dissolved metal concentration in the water between sediment particles or pore-water. Heavy metals can bind with sulfur to form sulfides that are not soluble in water. To measure this, simultaneously extracted metals (SEM) and acid volatile sulfides (AVS) were quantified to determine if sediment pore-water concentrations for cadmium, copper, nickel, lead, and zinc were likely to contribute to sediment toxicity. When the amount of AVS exceeds the amount of SEM, the concentrations of metals in the sediment pore-water are likely to be low due to the limited solubility of the metal sulfides formed. As a result, the metals are predicted to be less available for uptake by organisms.

In addition, metals can also be bound up by the organic carbon in the sediment, which results from the decomposition of leaf litter or other organic matter. For this reason, the SEM-AVS tool has been further modified to account for the amount of organic carbon (OC) in the sediment (i.e., fraction OC or f_{oc}). Metals are not expected to be toxic when the SEM-AVS/f_{oc} is less than 3,000 umol/g OC (USEPA 2005).

The second measure of bioavailability considers the concentration of PAHs in the pore-water. The equilibrium partitioning sediment benchmarks toxic units (ESB-TUs) are used to predict the bioavailability of non-polar organic chemicals such as PAHs. ESB-TUs are based on the partitioning of organic chemicals between sediment and the pore-water. The concentrations of various semi-volatile organics in the pore-water are predicted based on the concentrations of these substances in whole sediment, the physical-chemical properties of each substance, and the fraction of organic carbon in the sediment. The benchmark for ESB-TUs is based on 34 PAHs. Sediment with low total organic carbon concentrations generally does not bind the PAHs and result in higher ESB-TU values. Sensitive benthic organisms may be negatively affected by non-polar organic chemicals when ESB-TUs are greater than 1.0 (USEPA 2003).

The accuracy of the predictions of sediment toxicity using the mean PEC-Q, AVS/SEM, and ESB-TU measures can be confirmed with a direct evaluation of the effects of the sediments on benthic organisms. Ten-day and 28-day toxicity tests conducted with the midge *Chironomus dilutus* and the amphipod *Hyalella azteca* respectively, are direct measures of whole-sediment toxicity. Samples are designated as toxic by comparison of the response of the test organisms in control samples. For Presque Isle Bay, sediment samples were designated as toxic to amphipods or midges if control-adjusted survival was less than 75% (USEPA 2004)[1]. Sediment samples were also designated as toxic if control-adjusted growth was less than 70% for midges or less than 90% for amphipods (USEPA, 2004).

5.2.2 Ecosystem Health Targets for Benthic Organisms

In evaluating sediment quality it is important to understand the relationships between the metrics and the magnitude of any exceedences. Sediment contamination and bioavailability measures predict toxicity based upon the concentrations of COPCs in the sediment. These measures look at different aspects of sediment quality and each can be an indicator of the potential for conditions to negatively impact benthic organisms. When the benchmarks for individual COPCs or COPC mixtures are not met, sediment may be toxic to benthic organisms. However, the measures need to be considered together to draw a more complete picture of the interactions taking place between the contaminants and the sediment. The extent to which any benchmark is being exceeded also needs to be evaluated. Whenever possible, these measures should be coupled with direct toxicity testing to confirm predicted results.

The ecosystem health target is met if at least 90% of the sediment samples from Presque Isle Bay have the conditions necessary to support healthy benthic invertebrate communities, as indicated by:

• A mean PEC-Q less than 1.0

• The molar concentration of simultaneously extracted divalent metals is less than the molar concentration of acid volatile sulfide (SEM-AVS<0.0)

• SEM-AVS/f_{oc} is less than 3,000

• ESB-TUs less than 1.0

• Toxicity to the freshwater amphipod *Hyalella azteca* or the midge *Chironomus dilutus* for the survival or growth endpoints:

- Control-adjusted survival of amphipods $\geq$ 75%
- Control-adjusted growth of amphipods $\geq$90%
- Control-adjusted survival of midges $\geq$ 75%
- Control-adjusted growth of midges $\geq$70%

[1] Control-adjusted survival of midges >75% means that the test results must be more than 25% different from the control result to be considered toxic.

5.2.3 Fish and Aquatic-Dependent Wildlife

The ecosystem health target for fish and aquatic-dependent wildlife relies on whole-sediment chemistry and fish tissue chemistry. These indicators allow the assessment of both direct and indirect exposure of fish and aquatic-dependent wildlife to contaminated sediment. Additionally, comparisons between Presque Isle Bay and Lake Erie data indicate whether sediment quality conditions in the AOC are having a greater impact on the fish relative to those in Lake Erie.

To assess potential impacts of exposure to contaminated sediment on fish, the effects range median (ERM) sediment quality guidelines developed by Long *et al.* (1995) and Long and Morgan (1991) (Table 4) were selected as the toxicity threshold values. The ERMs were selected for several reasons. First, although the ERMs were developed primarily to evaluate the effects of sediment-associated COPCs on benthic organisms, the underlying database that was used to derive the ERMs included matching data on sediment chemistry and adverse effects in fish. Second, the results of toxicity tests conducted on invertebrates and fish using splits of samples from the same sampling sites indicate that fish may exhibit similar or lower levels of sensitivity to sediment-associated COPCs than do invertebrates. When ERMs were not available for a specific COPC, probable effect levels (PELs; CCME 1999) were substituted as they were assumed to be functionally equivalent to the ERMs.

In evaluating Presque Isle Bay whole-sediment, samples with concentrations of six or more COPCs exceeding the selected toxicity thresholds were designated as having conditions sufficient to injure fish. Long and MacDonald (1998) reported that more than 50% of the sediment samples with these chemical characteristics in the national database were toxic to benthic invertebrates in 10-day toxicity tests.

Information on the concentrations of certain bioaccumulative COPCs in the tissues of fish from Presque Isle Bay provides a more direct measure of the potential exposure to contaminated sediment. Pennsylvania monitors the concentration of mercury, PCBs, and other contaminants in fish tissue from Presque Isle Bay and Lake Erie as part of its ongoing fish consumption advisory program. Mercury and PCBs frequently exceed the levels that have been established for the protection of human health (PADEP 1993) and advisories are in effect for a number of species in both the lake and bay (Table 5). To determine if elevated levels of these COPCs represents an AOC-specific or a lake-wide issue, an evaluation was conducted to compare the concentrations of PCBs and mercury in fish collected from the bay to the same species collected from Lake Erie.

If the concentrations of PCBs and mercury are higher in the bay's fish tissue, then a comparison is made to toxicity thresholds for fish and for fish-eating birds and mammals. The toxicity thresholds for fish that can be used to assess risks to the fish community associated with the accumulation of COPCs in their tissues are presented in Table 6. The corresponding toxicity thresholds for aquatic-dependent wildlife are presented in Table 7.

5.2.4 Ecosystem Health Targets for Fish

• At least 90% of the sediment samples from Presque Isle Bay should have conditions necessary to support healthy fish communities, as indicated by less than six ERMs exceeded in a sample.

• The concentrations of COPCs in the tissue of fish from Presque Isle Bay are not significantly higher than the levels in fish tissues from the same species in Lake Erie.

• If COPC concentrations are elevated in Presque Isle Bay fish tissue, then the levels should be lower than the toxicity thresholds for fish.

5.2.5 Ecosystem Health Targets for Aquatic-Dependent Wildlife

• Concentrations of bioaccumulative COPCs in the tissues of fish from Presque Isle Bay are not significantly higher than the levels in fish tissue from the same species in Lake Erie.

• If bioaccumulative COPC concentrations are elevated in Presque Isle Bay fish tissue, the levels should be lower than the toxicity thresholds for fish-eating birds and mammals.

Chapter 6 – Evaluation of Ecosystem Health in the Presque Isle Bay AOC

6.0 Introduction

As noted earlier, Presque Isle Bay became the first AOC to be designated in the Recovery Stage in 2002. Data collected over a twenty-year period was used to recommend this designation. PADEP and its partners conducted two subsequent sediment surveys in 2003 and 2005 in the AOC. The data from the surficial sediment collected during these surveys (see Appendix A) as well as fish tissue data collected in the post-Recovery period were used to evaluate ecosystem health.

6.1 2003 Sediment Survey

In August 2003, PADEP, Pennsylvania Sea Grant, and Gannon University collected surficial sediment samples from eleven locations within the AOC boundary (Figure 5). The survey focused on resampling historical sites. A sample was also collected from Canadohta Lake in Crawford County. Composite samples of the top four inches of sediment were collected at each location using a petite ponar dredge. The EPA's Fort Meade lab analyzed samples for the primary COPCs including metals (antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, mercury, nickel, and zinc), total PAHs, and a suite of sixteen PAH compounds. Total organic carbon and grain size were also measured.

6.2 2005 Sediment Survey

In September 2005, PADEP, Pennsylvania Sea Grant, Gannon University, the Regional Science Consortium at the Tom Ridge Environmental Center, and the Erie County Department of Health implemented a comprehensive sediment survey. The study was funded with a grant from the EPA's Great Lakes National Program Office, developed during the workshops with the PAC, and directed by MacDonald Environmental Sciences Ltd. The survey was designed to provide the data and information needed to assess temporal trends in sediment quality and determine if the proposed delisting and ecosystem health targets were being met.

To assess temporal trends in sediment quality, core samples were collected from four locations (Figure 6). Two of the cores (PIB-07 and PIB-14) were processed for analysis and the remaining two archived. The cores were cut into 5 cm sections to a depth of 80 cm. Each section was dated using Pb^{210} and Cs^{135} isotopes. To assess compliance with ecosystem health targets, surficial sediment samples were collected from 32 locations (Figure 7). Twelve samples were collected from directed point sampling stations based on historical sampling locations and twenty samples were collected from computer-selected locations. The top four inches of sediment were collected using a Van Veen grab sampler.

Surficial and core section samples were analyzed for whole sediment chemistry including metals, a suite of 34 PAHs, pesticides, PCBs, acid volatile sulfides, and simultaneously extracted metals.

Whole sediment toxicity was evaluated using 28-day *Hyallela azteca* and 10-day *Chironomus dilutus* tests with survival and growth endpoints. Total organic carbon and grain size were also measured.

6.3 Evaluation of Ecosystem Health Targets

PADEP, the Sediment Advisory Group, and the PAC's Sediment Subcommittee used the quantitative measures of the ecosystem health targets presented in Chapter 5 to evaluate sediment quality conditions since the Recovery Stage designation. The 2003 and 2005 surficial sediment survey data were combined, whenever possible and appropriate, for this analysis. Whole-sediment chemistry and toxicity data were used to determine if toxic substances contaminate the bay's sediments and to assess the potential for adverse affects on benthic organisms, fish, and aquatic dependent wildlife.

6.3.1 Initial Screening of Post Recovery Studies

As described in Chapter 5, comparing concentrations of COPCs to consensus-based PECs or other selected guidelines provides a preliminary evaluation of sediment quality. The purpose of this screening is to identify potential areas of contamination or "hot spots" within the AOC and study area. A summary of the comparison is presented in Table 8 and Figure 8. Data are grouped by sampling locations within the AOC boundary, the Presque Isle Ponds, Nearshore Areas, and for the entire study area.

The number of samples that contained individual COPCs at concentrations greater than the selected sediment quality guidelines varied among the contaminants measured. For metals, PECs were not exceeded for arsenic, chromium, mercury, or zinc at any locations while barium concentrations in samples from the 2003 survey were higher than the PEC in 92% of the samples. Cadmium and nickel concentrations were greater than the associated guidelines in 45% and 55% of the AOC samples, respectively (Figures 9 and 10). Lead concentrations were also higher than the PEC in six samples (Figure 11).

Only two samples within the AOC had total PAH concentrations greater than the PEC, although the frequency of exceedance was $\geq$20% for six individual PAHs. It is important to note that dibenzo (a, h) anthracene concentrations were above the PEC of 135 parts per billion for 35 of the 47 samples collected from within the AOC.

The concentrations of total PCBs exceeded sediment quality guidelines in two samples collected from the bayfront just west of Cascade Creek. By comparison, the guidelines for organochlorine pesticides were never exceeded.

This preliminary screening indicates that there are areas within the AOC needing further evaluation. Sampling locations close to the mouths of Cascade Creek and Mill Creek and along the City's bayfront had one or more COPC detected in concentrations greater than the associated sediment quality guideline. The data indicate that a small number of metals and several PAH compounds occur in the bay's sediments at concentrations that have the potential to cause or contribute to sediment toxicity

6.3.2 Ecosystem Health for Benthic Organisms

The quantitative ecosystem health targets for benthic organisms described in Chapter 5 evaluate the impact of contaminant mixtures in the sediment, the bioavailability of metals and organics, and the direct toxicity to sediment-dwelling midges and amphipods. The first two measures predict sediment toxicity and the third is direct testing.

The mean PEC-Q considers the effect of contaminant mixtures in the sediment and was calculated for each sample using the concentrations of metals, PAHs, and, when measured, PCBs. Consistent with the target, individual sediment samples were designated as having COPC concentrations sufficient to result in significantly reduced survival or growth of freshwater amphipods if the mean PEC-Q was greater than 1.0. The calculated mean PEC-Q did not exceed 1.0 for any sample in the entire study area (Table 8). This suggests that the mixture of COPCs in the sediment is below levels that would be expected to adversely affect benthic organisms in 50% of the sediment samples. Based upon this measure, the concentrations of contaminants in the sediment would not be expected to result in a high frequency of toxicity to benthic organisms.

Bioavailability measures the extent to which contaminants are available for uptake by benthic organisms and was assessed for metals and organics using SEM and AVS measurements and by calculating ESB-TUs, respectively. Metals present in the sediment are considered to be potentially bioavailable when SEM minus AVS is greater than zero. Only two samples within the AOC, both located near the mouth of Mill Creek (Figure 12), exceeded this target. These results indicate that while metals such as cadmium, nickel, and lead are present at concentrations exceeding sediment quality guidelines; they may be present in an insoluble form and not readily bioavailable to sediment-dwelling organisms. None of the samples from the study area had SEM-AVS/f_{OC} of greater than 3,000 umol/g OC, indicating that metals present may also be binding with organic carbon and not available to benthic organisms. These bioavailability measures confirm that metals are unlikely to cause or substantially contribute to sediment toxicity in the Presque Isle Bay AOC.

Organics like PAHs in the sediment were considered to be potentially bioavailable when ESB-TUs were greater than 1.0. Within the AOC, nine samples from locations along the bayfront including the mouths of Mill Creek, Cascade Creek, and Scott Run, had a calculated ESB-TU greater than one. Both of the samples from the nearshore areas of Lake Erie exceeded this target (Figure 13). These results suggest that PAHs could contribute to sediment toxicity in 19% of the AOC samples. The bioavailability measures predict that PAHs partition into the pore-water and could result in toxicity to benthic organisms.

To determine whether the calculated predictions of sediment toxicity based on contaminant mixtures and bioavailability were accurate, a direct evaluation of the effects of the sediments on benthic organisms was done. Ten-day and 28-day whole-sediment toxicity tests were conducted with the midge *Chironomus dilutus* and the amphipod *Hyalella azteca* respectively. The toxicity of the 34 sediment samples collected during the 2005 survey was evaluated with these species. The studies looked at two specific endpoints survival and growth. None of the samples were toxic to amphipods for either endpoint. The results were different for the midges (Table 9). One sediment sample from the center of the AOC (PIB-20) was toxic to midges when the survival endpoint was considered. Three samples were designated toxic using the growth endpoint. These samples were all located within the AOC (Figure 14).

The results of the direct toxicity evaluation did not confirm the predictions made by the initial screening or bioavailability measures but were basically consistent with the mean PEC-Q calculations. For example, two samples from the mouth of Mill Creek (PIB-23 and PIB-27) had concentrations of individual PAHs greater than the selected sediment quality guidelines in the initial screening and were predicted to be toxic to benthic organisms using the AVS/SEM and ESB-TU measures of bioavailability. Samples from these locations, however, were not found to be toxic to midges or amphipods in the direct toxicity testing.

Conversely, three of the four samples (PIB-01, PIB-20, and PIB-33), which were toxic to midges, did not have measured concentrations of contaminants that would be expected to be toxic to benthic organisms. Additionally, the measures of metal and PAH bioavailability indicated that those contaminants were not readily available to exposed organisms in these samples. At these locations, factors such as ammonia or hydrogen sulfide in the pore-water, unmeasured contaminants, or other causes not related to chemical contaminants in the sediment may be causing the observed toxicity. One sample (PIB-22) had an ESB-TU>1.0 and was toxic to the midge. This is the only instance in 34 tests where predicted toxicity was confirmed.

The ecosystem health target for benthic organisms is met when at least 90% of the sediment samples have the conditions necessary to support healthy benthic communities in Presque Isle Bay. Using the mean PEC-Q, measures of bioavailability, and direct toxicity testing, it is concluded that this ecosystem health target is being met in the AOC. Although concentrations of cadmium, lead, nickel, and a number of PAH compounds were detected at levels above selected sediment quality guidelines, the limited toxicity found did not correlate with chemistry. With the exception of one sample, toxicity did not correlate with bioavialibilty measures either. This suggests that organic carbon and/or sulfides may be limiting the bioavailability of sediment contaminants to aquatic life. Given these results, it appears factors other than COPCs in the sediment are most likely causing the limited toxicity measured in the AOC and study area samples.

6.3.3 Ecosystem Health for Fish and Aquatic-Dependent Wildlife

The ecosystem health target for fish and aquatic-dependent wildlife is met when concentrations of COPCs are below levels that are associated with acute or chronic effects on fish. The target also includes a comparison of the concentrations of bioaccumulative COPCs in fish tissue in Presque Isle Bay fish to Lake Erie fish. Whole-sediment chemistry and fish tissue data were used to evaluate this target.

As discussed in Chapter 5, the effects range median (ERM) was selected to assess the potential impacts of exposure to contaminated sediment on benthic fish using whole-sediment chemistry data. The ecosystem health target is met when 90% of the sediment samples have the conditions necessary to support a healthy fish community. For the Presque Isle Bay AOC, whole-sediment samples with concentrations of six or more COPCs exceeding the ERMs were designated as having conditions sufficient to injure fish. Three of the 51 samples evaluated (6%) (Figure 15) met this criterion. All of these samples were collected near areas of urban inputs within the AOC; one near the mouth of Mill Creek and the other two in the proximity of the mouth of Cascade Creek. Although a small number of sediment samples had contaminant concentrations that could potentially have a negative impact on fish; overall, exposure to the bay's contaminated sediment is not predicted to injure fish. Therefore, the ecosystem health target is being met within the AOC and study area.

Data from Pennsylvania's fish consumption advisory program were used to compare mercury and PCB concentrations found in the tissue of fish from Presque Isle Bay and Lake Erie (Table 10). A limited amount of matching data on the concentrations of these COPCs in the muscle tissues of fish from Lake Erie and Presque Isle Bay were located for six species, including brown trout, common carp, freshwater drum, smallmouth bass, white perch, and yellow perch. The results of these analyses showed that the levels of mercury and total PCBs were similar in fish from both areas. This may be in part because some of these species may migrate between the bay and the lake. Even so, there were no statistically significant differences in the levels of these substances observed between these two areas.

Additionally, specific sources for the contaminants in Presque Isle bay fish (e.g., pockets of PCB-contaminated sediment) were not identified within the AOC. Therefore, consumption of fish in Presque Isle Bay does not appear to pose incremental risks to fish-eating birds or mammals compared to consumption of fish from Lake Erie. The Lake Erie Lakewide Management Plan (LaMP) monitors fish consumption advisories across the open waters and nearshore areas. As the consumption advisories are not unique to the Presque Isle Bay AOC, the bioaccumulation of PCBs and mercury in fish tissues represents a lake-wide issue that cannot be addressed only in the AOC. The larger LaMP is the appropriate environmental program to provide a forum for addressing fish consumption issues.

6.4 Sediment Quality Following the Recovery Stage Designation

The evaluation of sediment quality in Presque Isle Bay conducted in the post-Recovery Stage used multiple lines of evidence to examine the effects of toxic and bioaccumulative COPCs on benthic organisms, fish, and aquatic-dependent wildlife. It shows that the moderately contaminated sediment is not adversely impacting ecosystem health.

Looking first at the screening exercise, contaminants were detected in the sediment at concentrations greater than sediment quality guidelines associated with increased toxicity to benthic organisms. In particular, cadmium, nickel, lead, and a number of PAH compounds, most notably dibenzo (a, h) anthracene, were present throughout the AOC and study area. However, when the overall contamination resulting from the combined concentrations of metals, PAHs, and PCBs was considered by calculating the mean PEC-Q, none of the whole sediment samples exceeded levels that are linked with reduced survival or growth of benthic organisms. Bioavailability measurements indicated that metals are likely binding with sulfides or organic carbon and not available for uptake by benthic organisms. PAHs, on the other hand, were potentially bioavailable at almost 20% of the sampling locations and could contribute to sediment toxicity.

Whole-sediment toxicity tests, however, did not correlate with measured COPC concentrations in the sediment samples or confirm predicted toxicity. Although limited toxicity to midges was observed, the samples with the highest levels of PAHs in all but one location where PAHs were predicted to be bioavailable were not designated toxic. Therefore, it is unlikely that PAHs caused the limited toxicity that was observed with the bay's sediments.

With regard to the fish and aquatic-dependent wildlife, the levels of COPCs in sediments are not sufficiently elevated to adversely affect them in the AOC. Additionally, the concentrations of bioaccumulative COPCs in tissue from Presque Isle Bay fish were similar to that found in Lake Erie fish indicating a lake-wide rather than AOC-specific problem.

The evaluation of sediment quality in Presque Isle Bay indicates that factors other than the COPCs in the sediment may be contributing to the limited toxicity to the benthic organisms that was observed. Analysis of the data shows that metals and PAHs, while present, do not or rarely occur in the AOC or study area sediments at concentrations sufficient to adversely affect benthic organisms, fish, or aquatic dependent wildlife. Existing sediment quality conditions are sufficient to support benthic invertebrate communities and risks to fish and aquatic-dependent wildlife using habitats in Presque Isle Bay are unlikely to be higher than those for fish or aquatic-dependent wildlife using habitats elsewhere in Lake Erie. Ecosystem health targets are being met in the AOC and there is no evidence that the moderate amount of contamination found is degrading the ecosystem.

Chapter 7 – Evaluation of the Restrictions on Dredging Beneficial Use Impairment at the Presque Isle Bay AOC

7.0 Introduction

The IJC guideline for the restrictions on dredging beneficial use impairment compares contaminants in sediment to standards, criteria, or guidelines. Pennsylvania does not have sediment quality criteria to use in such an evaluation. State law does, however, regulate the disposal of contaminated material including sediment. There are also state water quality criteria that can be used to evaluate the potential impacts of the contaminated sediment. The assessment of the restrictions on dredging beneficial use impairment uses the state water quality criteria to evaluate elutriate test data from historical dredging operations and an analysis of the 2005 sampling survey data to estimate the potential impacts of dredging within the AOC.

7.1 State and Federal Authorities

In Pennsylvania, dredged material is regulated as a solid waste under the Solid Waste Management Act (P.L. 380, *as amended*, 35 P.S. §§6018.101-6018.1003). Dredged material is considered a demolition or construction waste and depending on its characteristics, may be either a residual waste or a hazardous waste under the Act. The disposal of dredged material requires a permit, and the material must be disposed of in a permitted residual or hazardous waste facility.

Open lake disposal of dredged material also requires a permit under Pennsylvania's Clean Streams Law, (Act of June 22, 1937 P.L. 1987, *as amended*, 35 P.S. §§691.1-691.1001). Again, the dredged material must be disposed in a permitted facility. Regulatory siting limitations (25 Pa. Code §277.202) make it virtually impossible to site a residual or hazardous waste disposal facility in a body of water. For all practical purposes, there is a restriction on disposal of dredged material in the open waters of Lake Erie, as Pennsylvania's legal requirements cannot be met for construction or operation of aquatic disposal facilities.

Federal authority under Section 404 of the Clean Water Act, also allows permitting for the discharge of dredged materials into the navigable waters. There is specific Federal legislation authorizing confined disposal facilities in the Great Lakes. Section 123 of the Rivers and Harbors, Flood Appropriations Act of 1970 (33 U.S.C. §1293a.), authorizes the construction of confined disposal facilities including the facility located to the south of the Presque Isle Bay entrance channel. The facility is operated and maintained by the USACE. Federal permits under Section 404 for discharges of dredged material require certification by PADEP that the permitted discharge will comply with state water quality standards. A permit under Pennsylvania's Dam Safety and Encroachments Act (P.L. 1375, *as amended*, 32 P.S. §§693.1-693.27) is also required which may impose additional limitations on the disposal of dredged materials in the waters of the Commonwealth. PADEP and the USACE coordinate permit review and water quality certification. In developing the delisting target for the restrictions on dredging BUI in Presque Isle Bay, the evaluations required under both Federal and state permitting processes were considered.

7.2 Dredging Activities in Presque Isle Bay

Dredging for both recreation and navigation activities has been permitted within the AOC (Figure 2). The entrance channel connecting the bay to the outer harbor and Lake Erie as well as a turning basin within the bay is maintained by the USACE. Historically, material dredged by the USACE was disposed at a site in the open waters of Lake Erie. Although the channel has not been dredged since 1998, the USACE routinely samples the entrance channel and outer harbor to determine whether the material continues to meet the specifications for open lake disposal.

The Presque Isle Bay AOC contains a number of public and private marinas and boat launches. Maintenance dredging of the public areas is done by the EWPPA (Erie Western Pennsylvania Port Authority) under both federal and state permits. Prior to 1998, dredged material was used as daily cover at the Lake View Landfill. In 1999, the permits were amended to allow disposal in the confined disposal facility (CDF) located south of the entrance channel.

The CDF is operated and regulated by the USACE. The 26-acre CDF was built in 1979 by the USACE as a disposal facility for Lake Erie dredged materials. It is located on EWPPA property, which is encumbered by the USACE until the CDF is filled, at which time it will revert to EWPPA. The CDF has a capacity for 420,000 cubic yards of material and is about 15% full. A portion of the CDF was capped and developed into a campground facility, which is operated by the EWPPA.

Dredging has also taken place in locations adjacent to the AOC. In 2003, the US Coast Guard received a permit authorizing action to rehabilitate and maintain the Guard's existing boat basin along the entrance channel to Presque Isle Bay. Materials from these activities were disposed of in the CDF. This permit expired in December 2005.

The Pennsylvania Department of Conservation and Natural Resources is also permitted to perform maintenance dredging of accumulated sand in Lake Erie at the entrance to Thompson Bay to maintain Beach #11 of Presque Isle State Park. The permit allows the material to be used as beach nourishment on the Park's Beach #10.

7.3 Water Quality Certification

As described in Chapter 5, PADEP follows the procedures outlined by the USACE to make decisions regarding disposal of dredged material and issuance of water quality certification. Historically, PADEP used elutriate data to make these decisions. Composites of ten samples were required for every 500 cubic yards of material to be dredged. The concentrations of contaminants in the prepared elutriate were compared to concentrations in a sample of the receiving waters of Lake Erie. If the concentration of any chemical in the elutriate was more than 1.5 times the concentration of that same chemical in the receiving waters, then the material was sent to the CDF.

Under its 404 authorities, the USACE issues permits for discharges of dredged or fill material into the navigable waters of the United States at specified disposal sites. Regulations implementing this portion of the Clean Water Act require an evaluation of the short and long-term effects of the proposed discharge. As part of that evaluation, a determination of the impacts of contaminants in the disposed material is made. In 1998, the USACE issued the Great Lakes Dredged Materials Testing and Evaluation Manual (USEPA/USACE 1998), which describes a tiered approach to making "contaminant determinations" for evaluating proposed discharges of dredged material in the Great Lakes basin. It is also intended to provide guidance to states in making decisions regarding water quality certification.

As part of the tiered approach, the Manual recommends the standard elutriate test to evaluate water quality compliance for section 401certification. As described earlier, the elutriate test represents the expected release of contaminants during dredging and disposal operations. It is intended to evaluate the potential water quality impacts of the dredged material discharge at the disposal site. In this type of evaluation, the concentrations of contaminants in the elutriate are adjusted to reflect dilution from mixing and dispersion at the disposal site (USEPA/USACE, 1998) and then compared to state water quality standards.

In developing delisting targets for the restrictions on dredging beneficial use impairment, PADEP reviewed its historical process for making water quality certification decisions and the approach recommended in the USACE's 1998 Manual. A decision was made to be consistent with the Manual's procedure for evaluating discharges and use elutriate data as the primary sediment quality indicator for the beneficial use impairment.

7.4 Evaluation of Existing Elutriate Data

Using the quantitative delisting target for the restrictions on dredging beneficial use impairment described in Chapter 5, PADEP evaluated elutriate data collected between 1999 and 2005. Sixteen samples from five locations within the AOC covered by the EWPPA's maintenance dredging permit were evaluated. Due to their proximity to historical and current industrial activities, areas covered by these samples are likely to be the most contaminated in the AOC and represent worst case conditions. Consistent with the federal regulations implementing Section 404 of the Clean Water Act (The requirements for disposal sites for dredged or fill material are found under Section 404(b)(1) of the Federal Clean Water Act, 33 U.S.C. §1344(b)(1), and the implementing regulations at 40 CFR Part 230) and the guidance provided in the Great Lakes Dredged Material Testing and Evaluation Manual (USEPA/USACE, 1998), the delisting target compares concentrations of COPCs in the elutriate to water quality standards allowing for dilution and dispersion at the disposal site.

The USACE's CDFate model was used to estimate the size, location, and movement of discharges from the CDF. The model uses elutriate data and specific information on the CDF (Table 11) to calculate the concentration of COPCs in the adjacent receiving waters as a function of time. The concentration after mixing is compared to water quality standards to determine whether the discharge would be in compliance. Water quality criteria were calculated in accordance with Pennsylvania's Chapter 93 and Chapter 16 (25 Pa. Code Chapters 16 and 93) using data collected over a five-year period from a Water Quality Network station adjacent to the CDF (Table 2).

The CDFate model was run for each of the contaminants exceeding water quality standards in at least one elutriate sample. The highest detected concentration of the contaminant was used to determine the rate of dilution (Table 12). The model predicts how long in terms of time and distance from the point of discharge it will take to meet water quality standards. For example, the highest detected concentration of cadmium in an elutriate sample was 0.073 mg/L. Using acute and chronic water quality standards of 0.0052 mg/L and 0.0026 mg/L, respectively, the model predicts the acute standard will be met in 1minute or 10.5 feet from the point of discharge and the chronic standard in 2.4 minutes or 24 feet.

The delisting target requires discharges to meet acute water quality criteria at the 15-minute compliance point and chronic water quality criteria at the 12-hour compliance point. The CDFate model predicts a dilution of 170:1 at 15 minutes and 617:1 at 12 hours (Table 13). Taking the cadmium example, the concentration at 15 minutes is predicted to be 0.00043 mg/L and at 12 hours is 0.00012 mg/L. The calculated values are considerably lower than the acute and chronic water quality standards. The model predicts acute, chronic, and human health criteria would be met for all COPCs in the elutriate within 67 feet of the CDF and in under 10 minutes of mixing with the water in the outer harbor. This is well within the 15-minute and 12 hour timeframe required by the delisting target. Based upon this analysis, the disposal of the sediments from areas currently dredged within the AOC in the CDF would not result in exceedences of state water quality standards outside the mixing zone. Additionally, there have not been any instances of fish kills or demonstrated toxicity to aquatic life attributable to the CDF. For these areas, then the delisting target is being met.

7.5 Effluent Modeling

Presque Isle Bay is approximately 3700 acres in size and permitted dredging activities take place in a very small portion of the AOC along the bayfront. The elutriate data used to evaluate the restrictions on dredging beneficial use impairment provides the most relevant data in that it is from those areas where future dredging will occur. Even though dredging in areas other than those already permitted is not expected, it is important to evaluate the delisting target at sampling locations throughout the AOC. Because elutriate analysis was not included in the 2003 or 2005 sediment surveys, a screening methodology developed by the USACE was used to predict the concentration of COPCs in the CDF effluent.

The methodology uses whole sediment chemistry data to conduct an initial screening based on equilibrium partitioning (i.e., the partitioning of contaminants between the sediment and pore water) and the bioavailability of the contaminants. It is a conservative approach to estimating the concentration of COPCs in the discharge from the CDF. The evaluation used whole sediment chemistry from the 2005 survey and default values for other parameters to calculate predicted effluent quality at the edge of the mixing zone for a given sediment contaminant concentration.

The methodology was applied to data from eighteen sampling locations. These locations were chosen because the concentrations of one or more COPCs exceeded the consensus based probable effects concentrations used to evaluate ecosystem health (Table 14). The expected concentration of the contaminant was calculated at the 15-minute acute and 12-hour chronic mixing zones. This concentration was compared to Pennsylvania's water quality standards (Table 2). The spreadsheet calculates a ratio of the predicted concentration to the appropriate water quality standard. When the ratio is greater than one, the concentration of the contaminant in the sediment is predicted to exceed water quality standards in the discharge from the CDF. Using the nickel concentration of 55.15 mg/kg detected at PIB-16P, the methodology calculates the concentration at 15-minute compliance point would be 49.989ug/L and 49.997 ug/L at the 12-hour chronic compliance point. The ratios are less than one in both cases and the predicted concentrations in the discharge are below the standards the 550 ug/L acute and 61 ug/L chronic water quality standards for nickel. This conservative methodology does predict some exceedences. Concentrations of benzo (a) anthracene and benzo (a) pyrene from PIB-27 near Mill Creek are predicted to exceed human health water quality criteria at the point of discharge.

Because contaminant concentrations across the AOC are relatively homogeneous, the methodology was applied to a hypothetical sample containing the mean concentration for each of the COPCs. No exceedences of chronic, acute, or human health water quality criteria were predicted in the discharge from the CDF (see Appendix B). While this methodology is used to conservatively predict the concentration of the COPCs in the CDF discharge, it shows that sediment from the AOC would not be expected to exceed water quality standards should dredging and disposal in the CDF be required. Therefore, delisting targets would be met for disposal of the sediment from areas within the AOC that are not currently dredged in the CDF.

7.6 Evaluation of the Restrictions on Dredging Beneficial Use

The restriction on dredging beneficial use impairment was assessed from both practical and ecological perspectives. The practical restriction is based on Pennsylvania's laws and regulations, which preclude the disposal of dredged material in the open lake regardless of contaminant presence or absence. This restriction is due to the fact that dredged material is defined as a solid waste, and there are limitations associated with locating a disposal facility in Waters of the Commonwealth. Even if the sediments being dredged showed no contamination, current DEP regulations would prohibit their placement in the open lake. Disposal to the CDF or an upland site are the only allowable options. Because the restrictions on disposal are not related to sediment contamination, the beneficial use should not be considered impaired.

From an ecological perspective, the sediment in the Presque Isle Bay AOC was evaluated against a delisting target based on discharges from the disposal of dredged material. The target takes into account the limitation on disposal options and current permitting practices by evaluating discharges from the CDF. Material can be placed in the CDF when the concentrations of COPCs in the CDF mixing zone are below Pennsylvania's Water Quality Standards at the 15-minute compliance point for acute criteria and 12-hour compliance point for chronic criteria. At least 90% of samples must meet this target.

Using elutriate data from areas routinely dredged from within the AOC, it was determined that the primary delisting target for the restrictions on dredging beneficial use impairment is being met for areas currently being dredged within the AOC. In addition, calculations were done to estimate the predicted concentrations of COPCs in the CDF discharge based on concentrations detected in the sediment. If dredging were required in any location in the AOC, the material could be placed in the CDF. Given that the only "restriction" on dredging activities is regulatory and sediment from any location within the AOC can meet those requirements, the restrictions on dredging beneficial use is not longer considered impaired.

Chapter 8 – Proposed Components of a Long-Term Sediment Monitoring Plan for the Presque Isle Bay Area of Concern

1. Sediment Quality as related to delisting requirements

   <u>Question to answer</u>: Is the primary delisting target for the restrictions on dredging beneficial use being met?

   Target: In at least 90% of samples, the concentrations of chemicals of potential concern in the confined disposal facility mixing zone are below Pennsylvania's Water Quality Standards at the 15-minute compliance point for acute criteria and the 12-hour compliance point for chronic criteria.

   To evaluate the delisting target, PADEP will use elutriate data from sediment samples collected by parties permitted under PA's Chapter 105 program to perform dredging within the AOC.

   The frequency of monitoring will depend on when permitted dredging activities occur. Monitoring data and the status of dredging activities will be reviewed annually.

2. Sediment Quality as related to the ecosystem health of Presque Isle Bay

   <u>Question to answer</u>: Is ecosystem health showing any change?

   A. Benthos

   Target: In at least 90% of sediment samples, the concentrations of chemicals of potential concern are below levels that are associated with acute or chronic toxicity in sediment-dwelling organisms.

   Whole sediment chemistry and whole sediment toxicity tests will be used to evaluate ecosystem health. Sampling locations will include sites within the AOC, the study area, and areas adjacent to the AOC. Specifically,

   - samples will be collected from up to eight locations within the AOC. The locations include the areas adjacent to the mouths of Scott Run (SR-25), Mill Creek (MC-23/MC-27), and Cascade Creek (CC-26); one location in the center of the Bay (PIB-07), and one in Misery Bay (PIB-46);
   - an additional sample will be collected from the ponds within Presque Isle State Park (i.e., study area);
   - a sample will also be collected from the Outer Harbor and one from Thompson Bay; and
   - a reference sample (TBD).

   Samples will be analyzed for PCBs, 34 PAHs, metals, AVS/SEM, total organic carbon, and grain size.

   - toxicity testing using the freshwater amphipod *Hyallela azteca* or the midge *Chironomus dilutus* will also be done.

Monitoring will occur every three years beginning in 2008 until 2018 and every five years thereafter.

B. Fish and Wildlife Health

Target: In at least 90% of samples, the concentration of six or more chemicals of potential concern do not exceed Effects Range Median.

Whole sediment chemistry will be used to evaluate this ecosystem health target.

Target: The concentration of mercury and PCBs in tissues of fish from Presque Isle Bay should not be significantly higher than levels in fish tissue from Lake Erie.

PADEP's fish consumption advisory sampling program will be used to evaluate this target.

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Figures

Figure 1. Map of the Presque Isle Bay Area of Concern (AOC) Boundary

Figure 2: Dredging in Presque Isle Bay

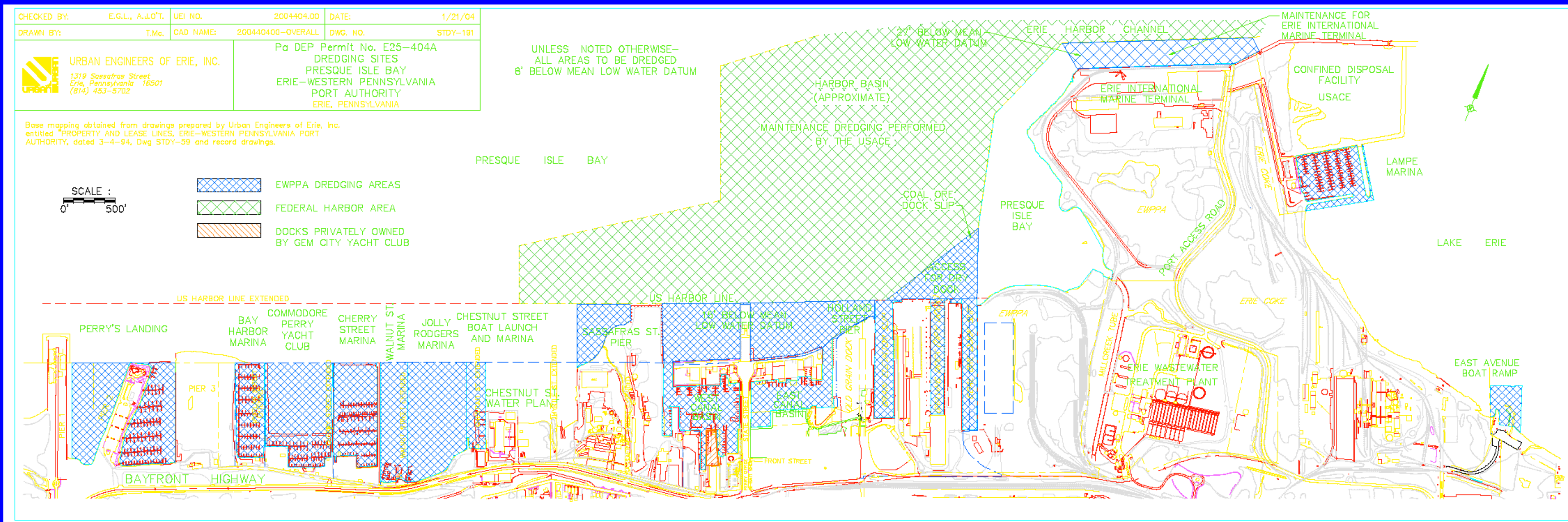


Figure 3. Relationship between ecosystem goals, objectives, indicators, metrics, and targets

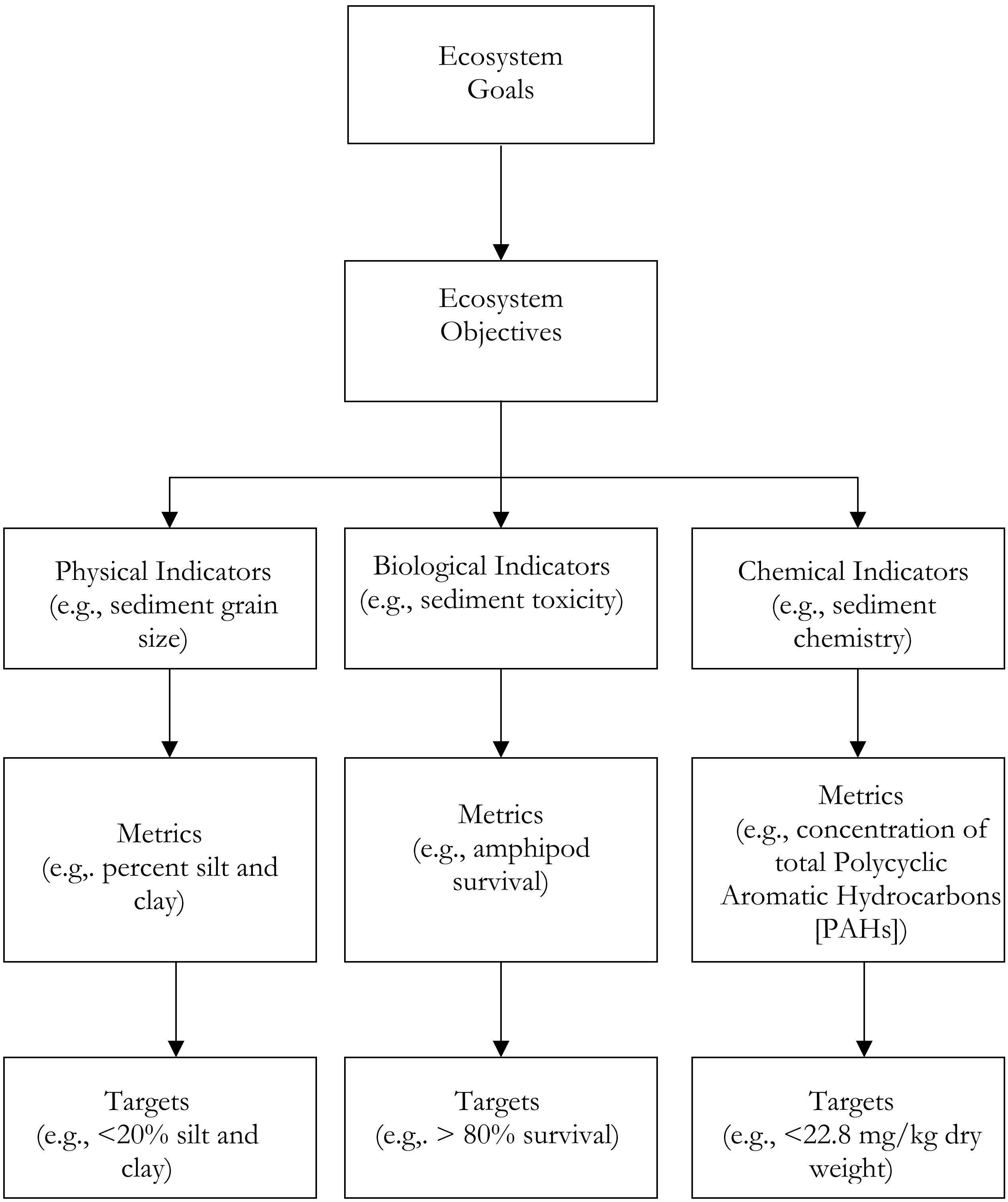


Figure 4. Overview of the implementation process for the ecosystem approach to environmental management

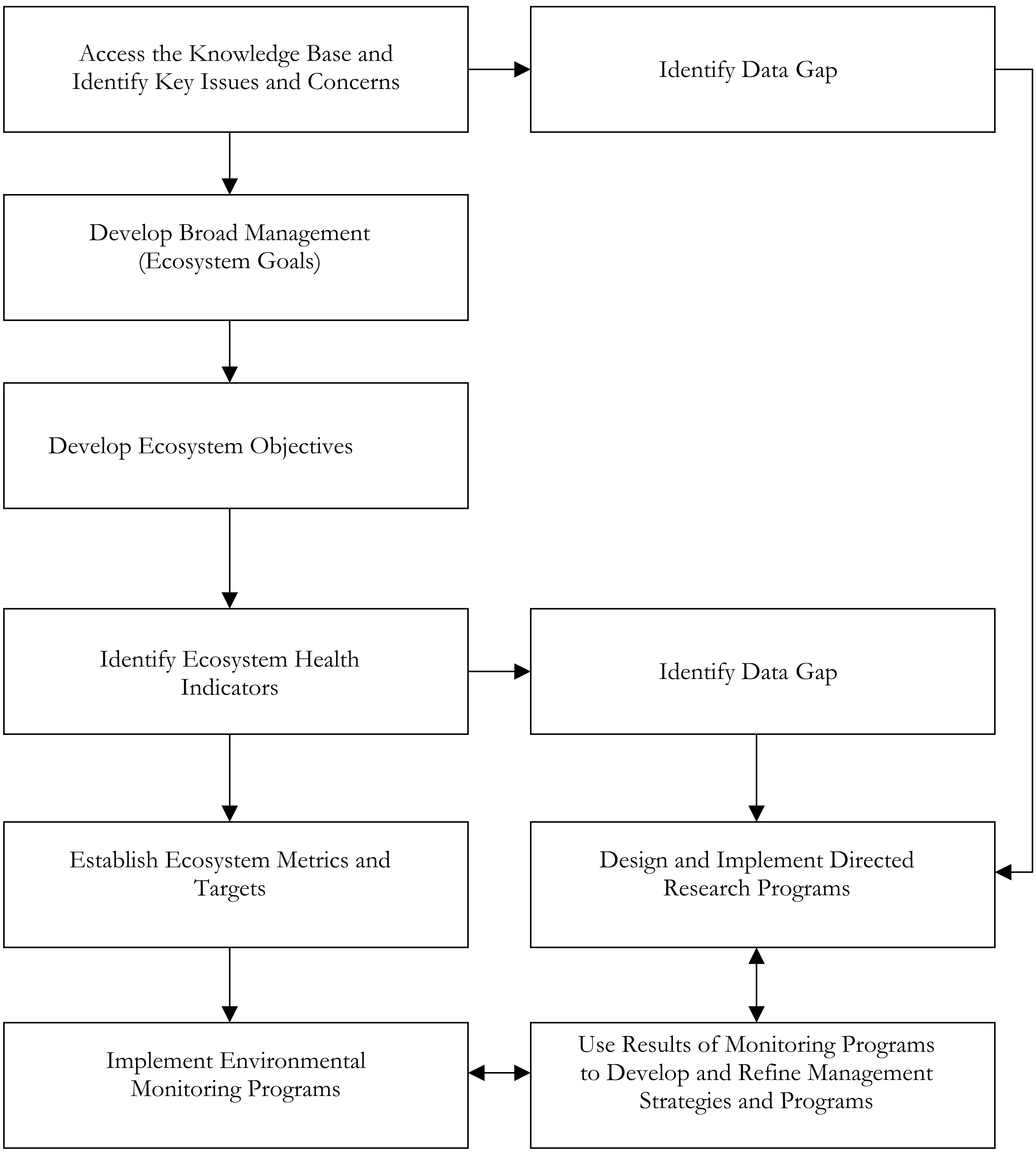


Figure 5. 2003 Survey Sampling Locations

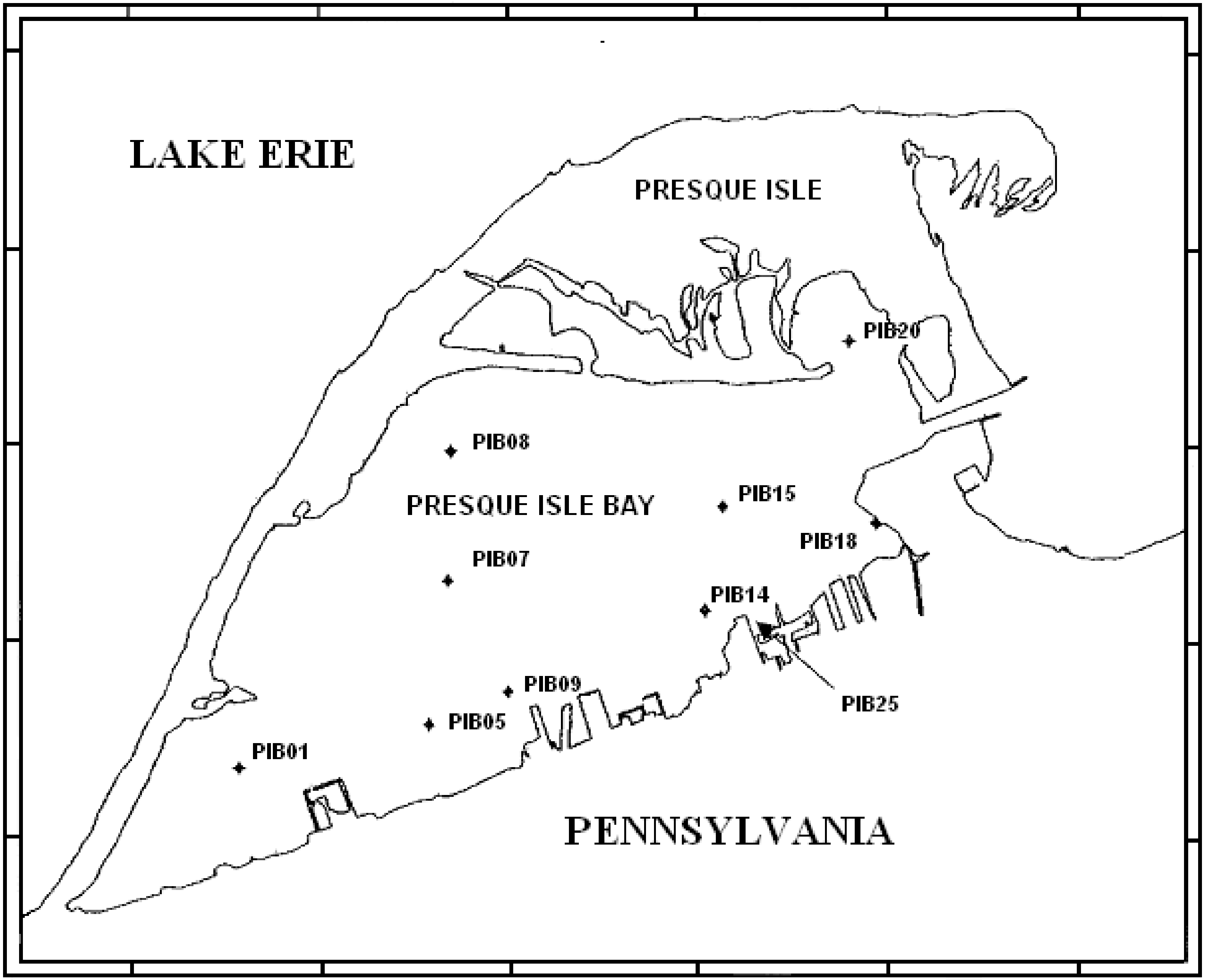


Figure 6. Location of the four core samples from the 2005 survey.

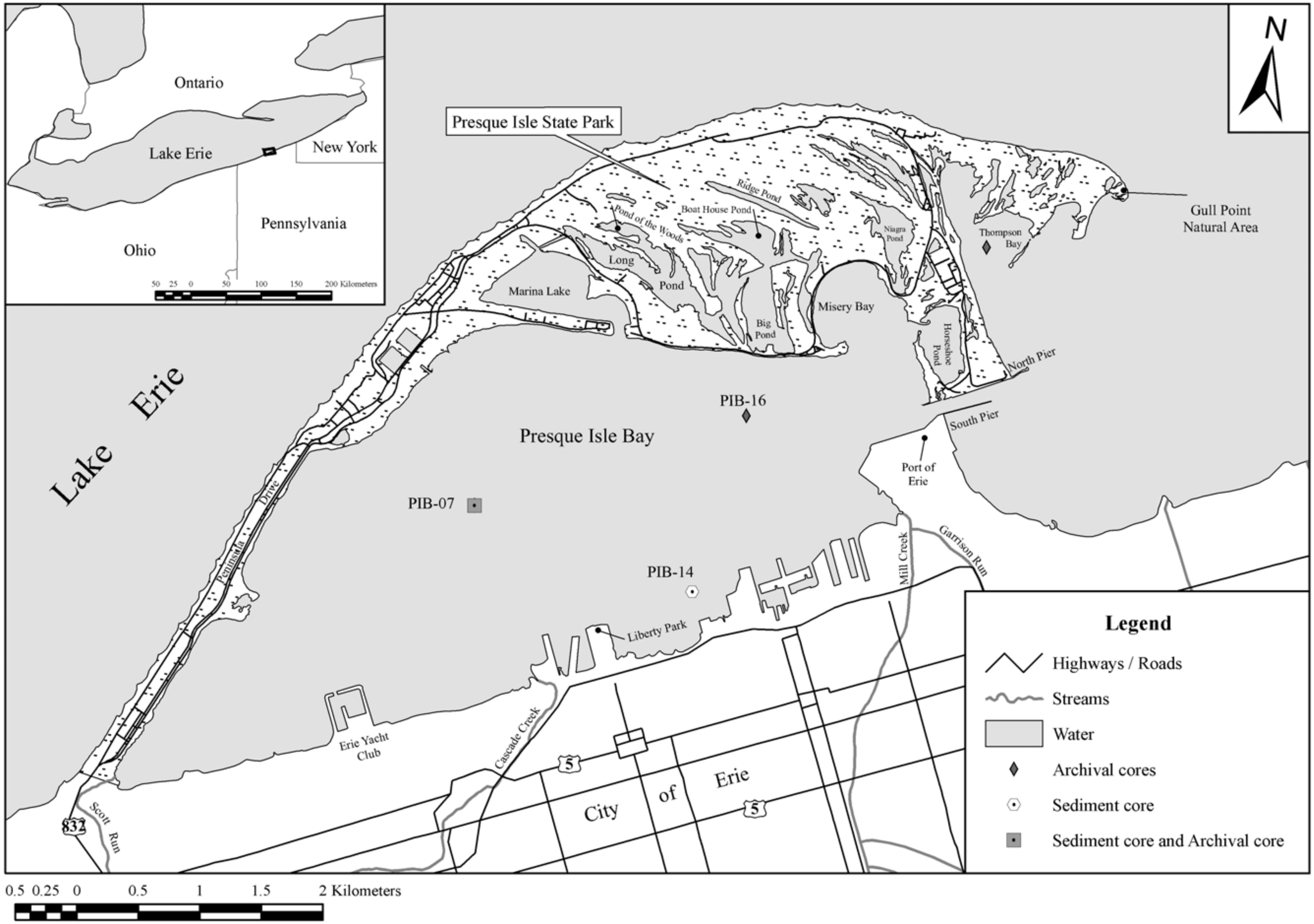


Figure 7. Surficial Sampling Locations - 2005 Sediment Survey

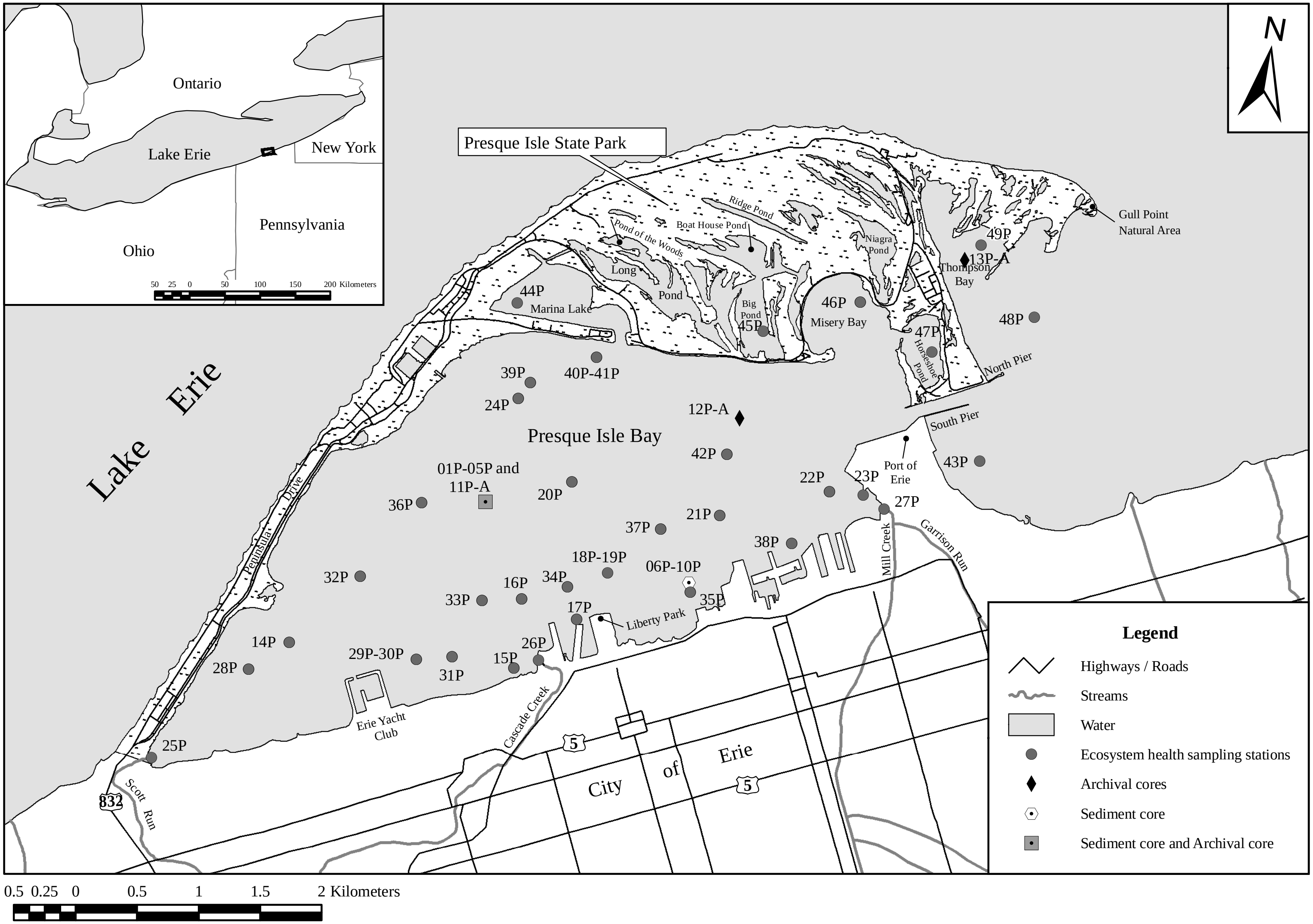


Figure 8. Frequency of exceedences of the selected Individual toxicity thresholds for the protection of the benthic community in surficial sediment samples from the Presque Isle Bay Area of Concern (AOC)

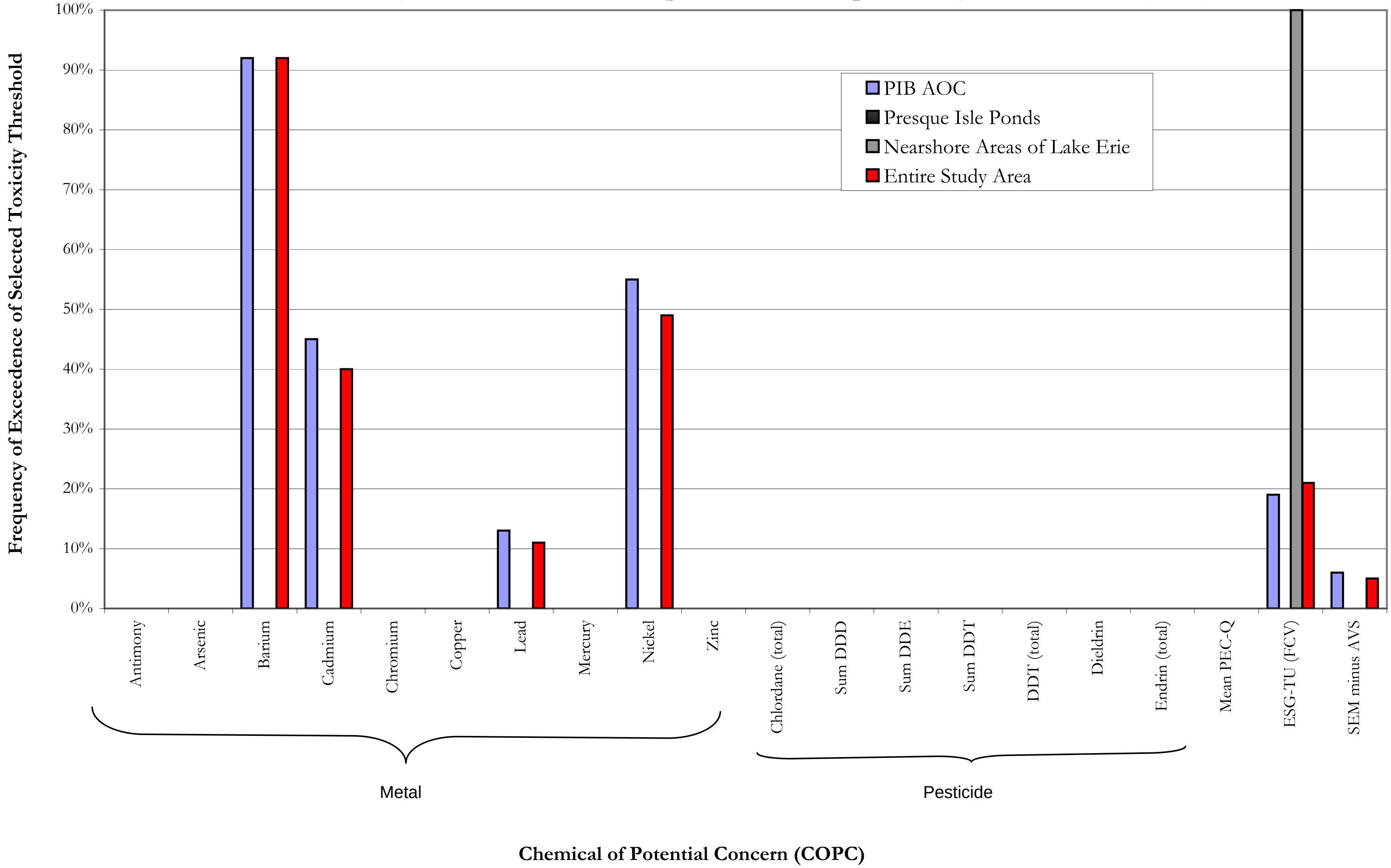
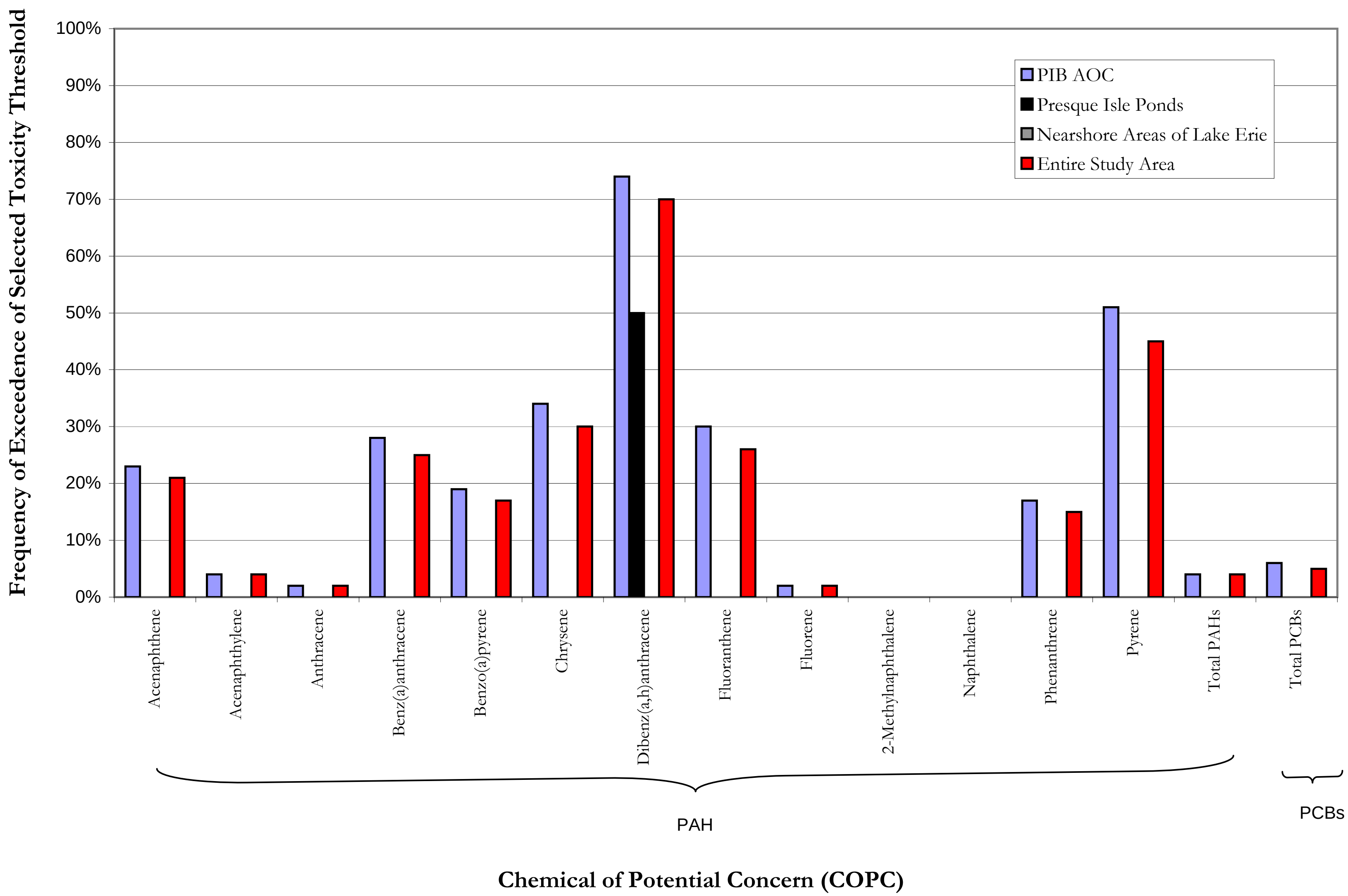


Figure 8 (cont.). Frequency of exceedences of the selected individual toxicity thresholds for the protection of the benthic community in surficial sediment samples from the Presque Isle Bay Area of Concern (AOC)



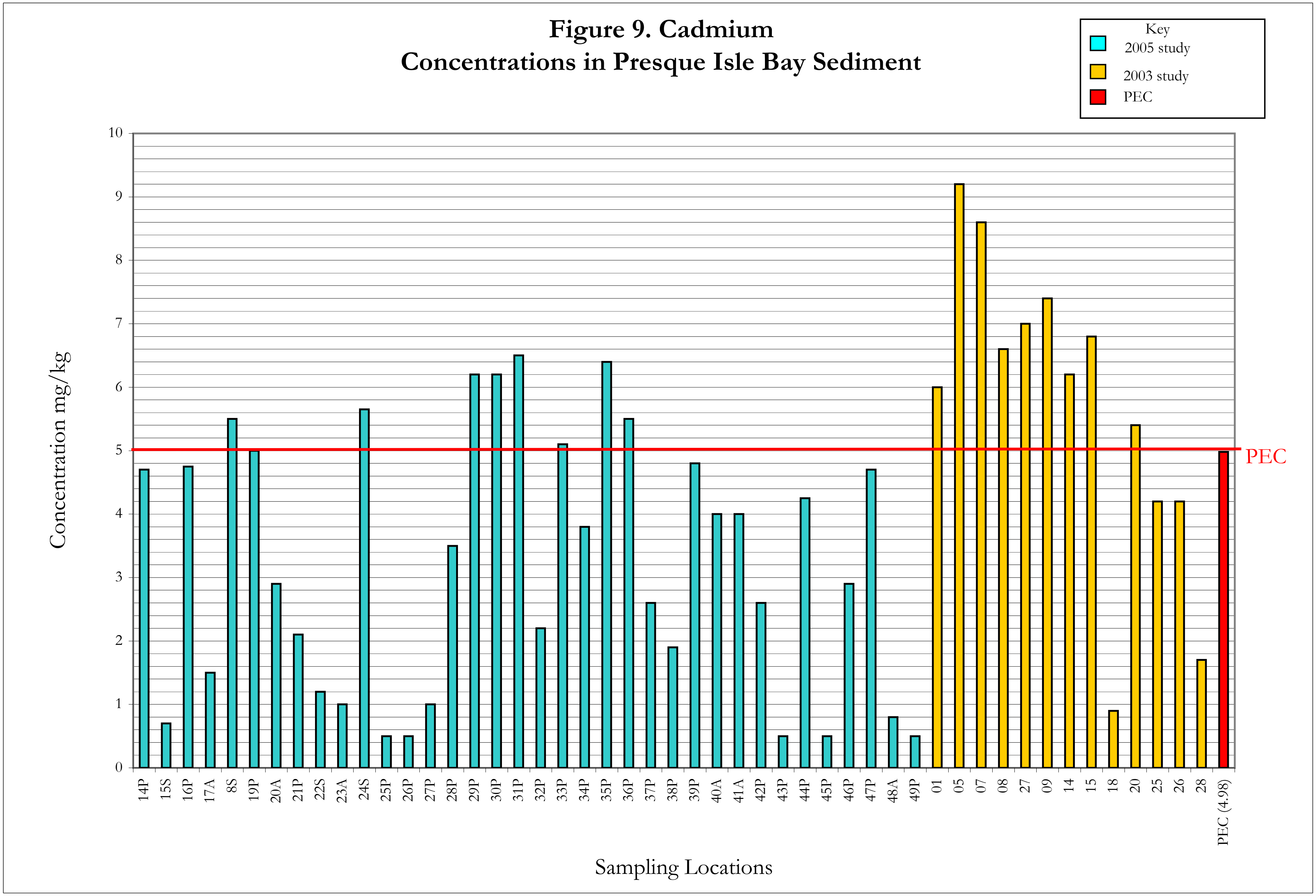


Figure 9. Cadmium
Concentrations in Presque Isle Bay Sediment
Key
2005 study
2003 study
PEC
Concentration mg/kg
0
1
2
3
4
5
6
7
8
9
10
PEC
14P 15S 16P 17A 8S 19P 20A 21P 22S 23A 24S 25P 26P 27P 28P 29P 30P 31P 32P 33P 34P 35P 36P 37P 38P 39P 40A 41A 42P 43P 44P 45P 46P 47P 48A 49P 01 05 07 08 27 09 14 15 18 20 25 26 28 PEC (4.98)
Sampling Locations

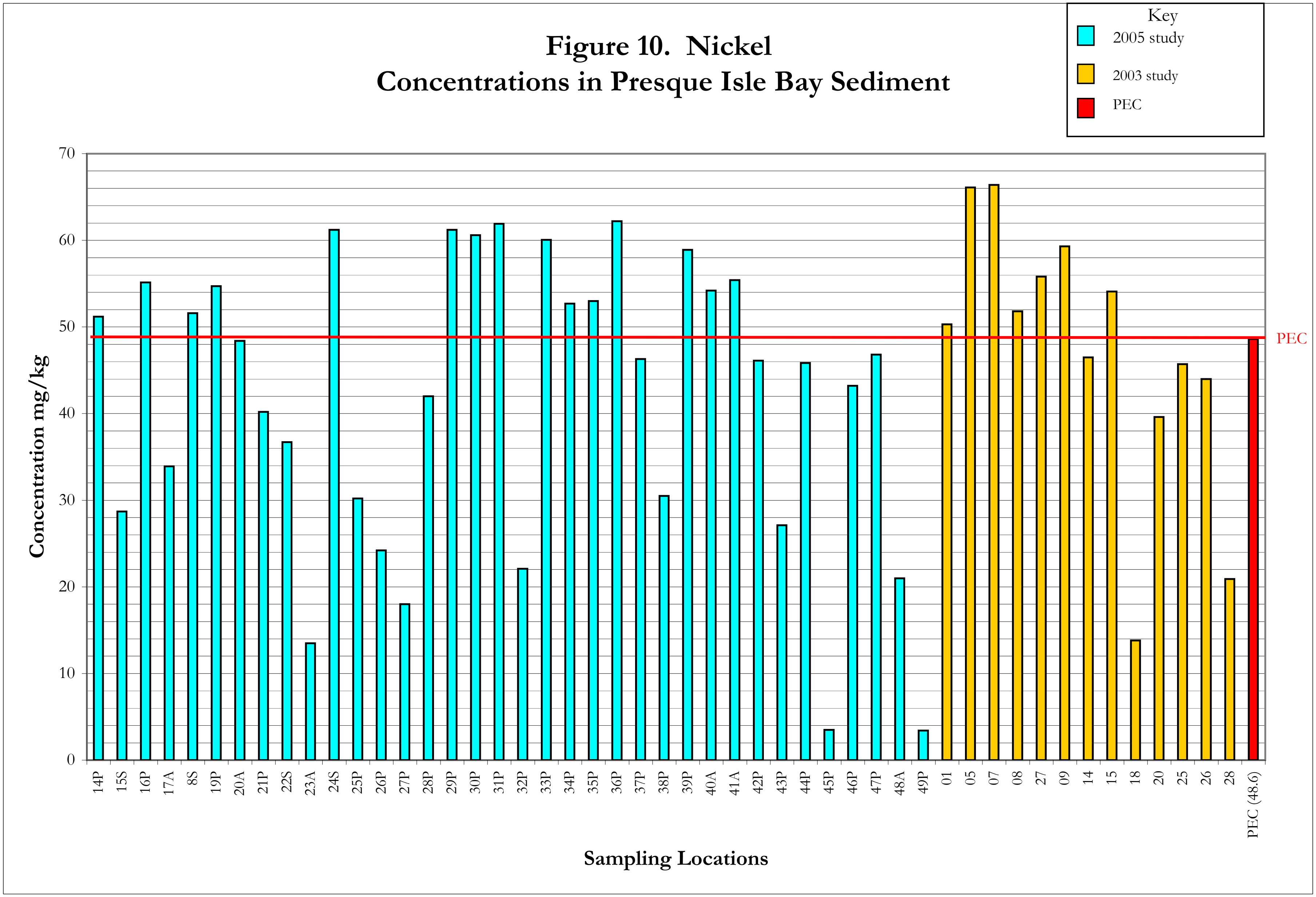


Figure 10. Nickel
Concentrations in Presque Isle Bay Sediment
Key
2005 study
2003 study
PEC
Concentration mg/kg
0
10
20
30
40
50
60
70
PEC
14P
15S
16P
17A
8S
19P
20A
21P
22S
23A
24S
25P
26P
27P
28P
29P
30P
31P
32P
33P
34P
35P
36P
37P
38P
39P
40A
41A
42P
43P
44P
45P
46P
47P
48A
49P
01
05
07
08
27
09
14
15
18
20
25
26
28
PEC (48.6)
Sampling Locations

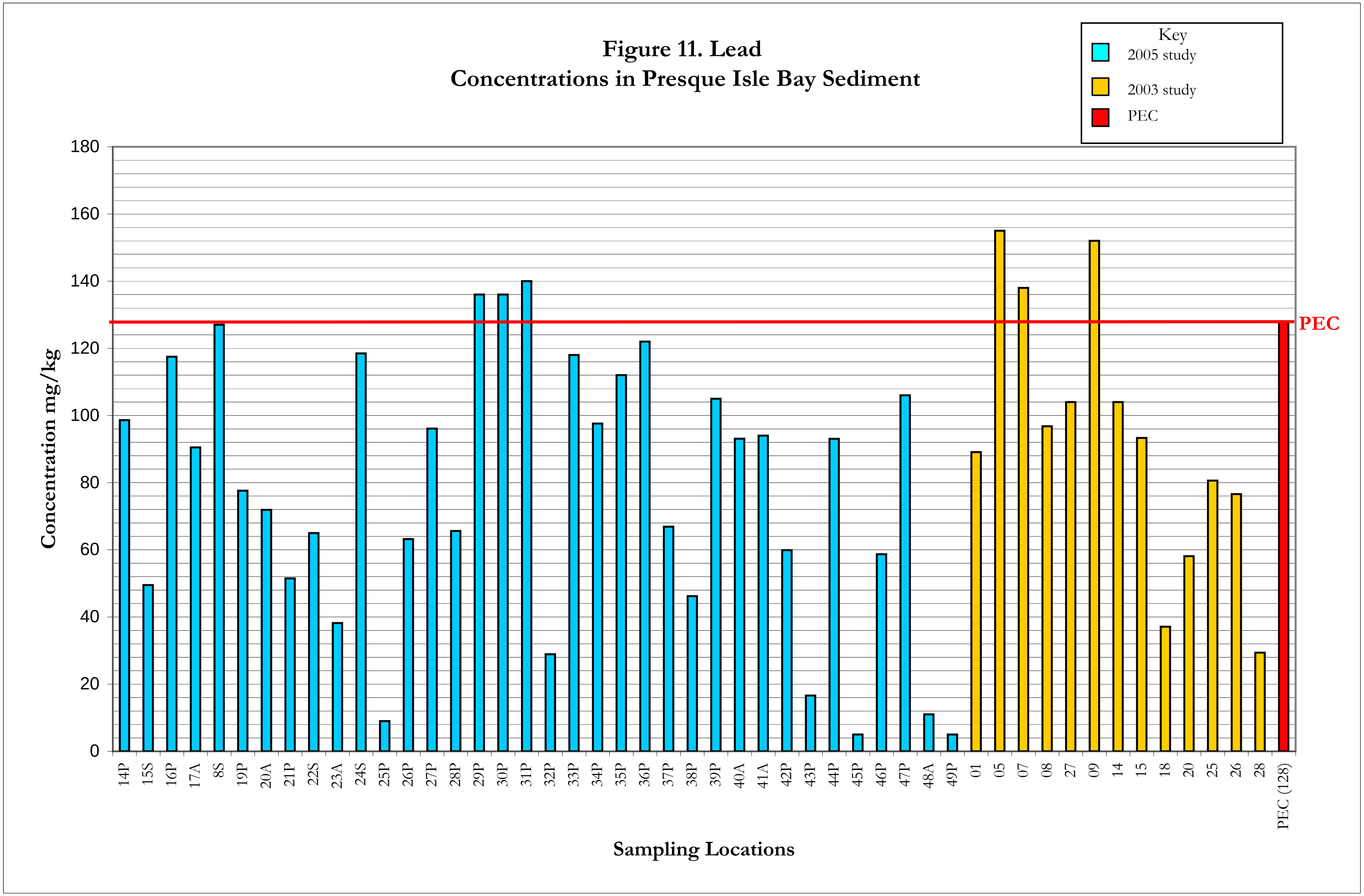


Figure 11. Lead
Concentrations in Presque Isle Bay Sediment
Key
2005 study
2003 study
PEC
Concentration mg/kg
180
160
140
120
100
80
60
40
20
0
PEC
14P
15S
16P
17A
8S
19P
20A
21P
22S
23A
24S
25P
26P
27P
28P
29P
30P
31P
32P
33P
34P
35P
36P
37P
38P
39P
40A
41A
42P
43P
44P
45P
46P
47P
48A
49P
01
05
07
08
27
09
14
15
18
20
25
26
28
PEC (128)
Sampling Locations

Figure 12. Map of the Presque Isle Bay Area of Concern (AOC), showing the frequency of exceedences of the simultaneously extracted metals minus acid volatile sulfides (SEM-AVS) toxicity threshold in whole-sediment samples.

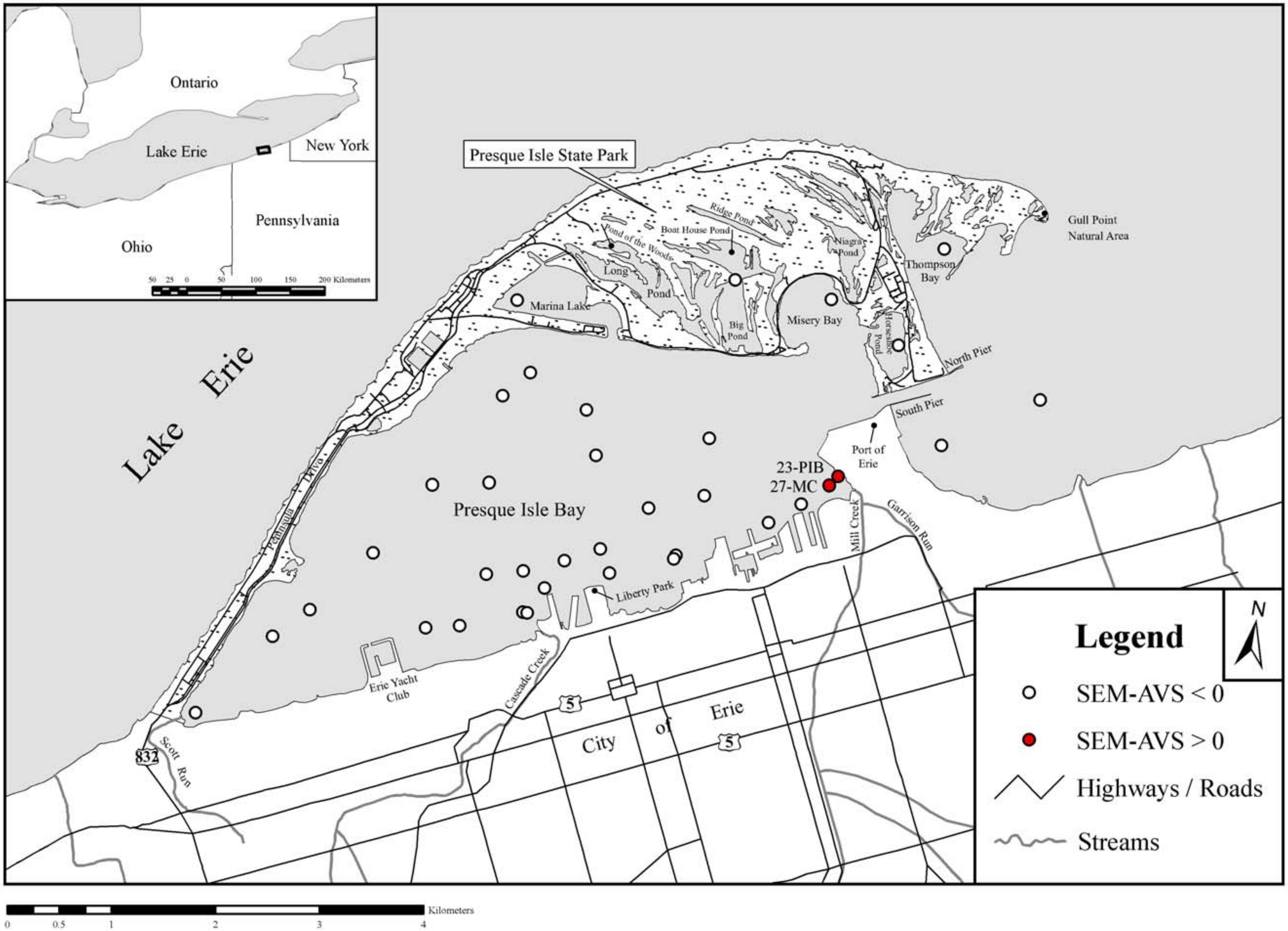


Figure 13. Map of the Presque Isle Bay Area of Concern (AOC), showing the location of samples found to be toxic to *Chironomus dilutus*, in 10-day toxicity tests.

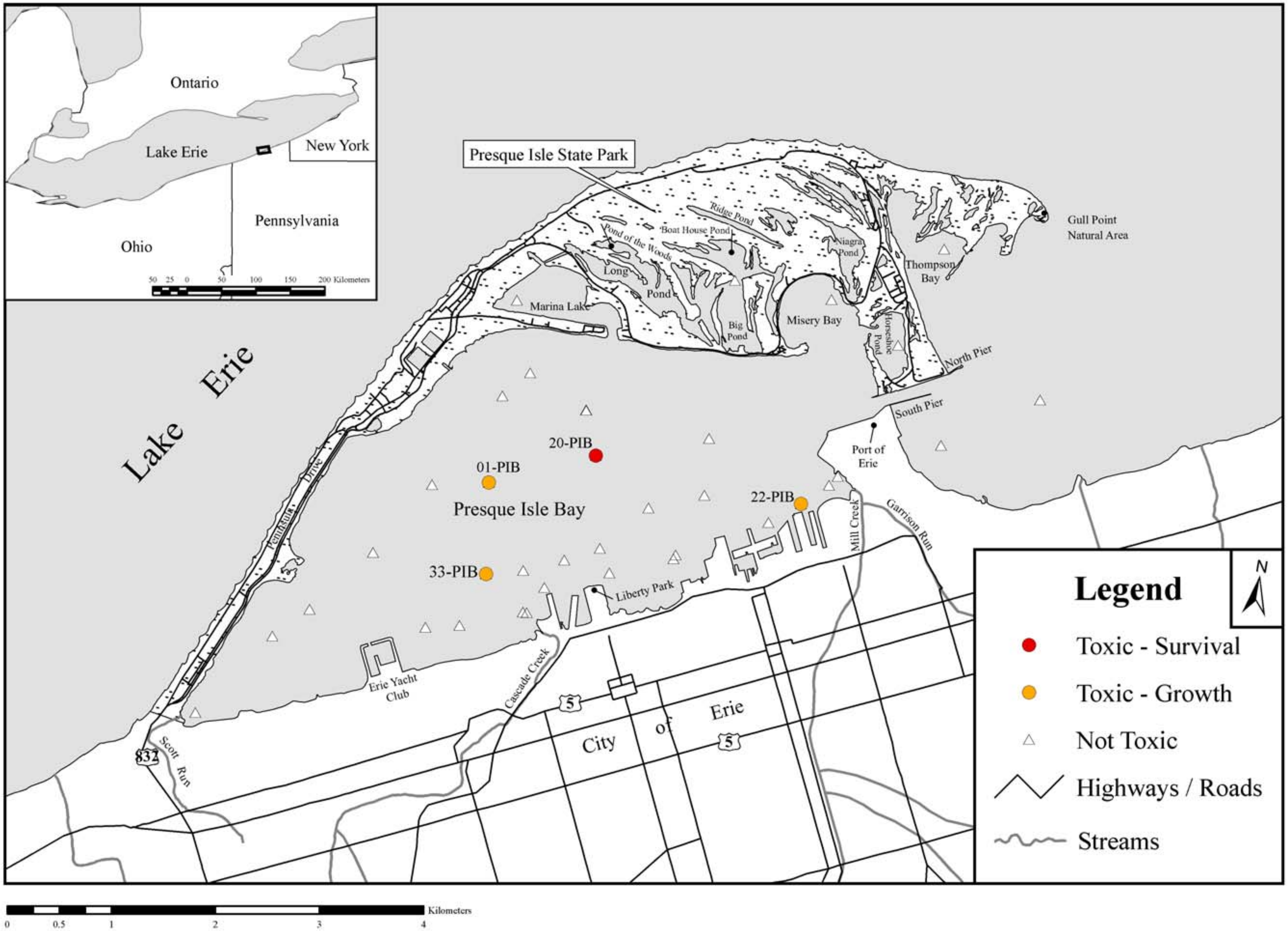


Figure 14. Map of the Presque Isle Bay Area of Concern (AOC), showing the frequency of exceedences of the equilibrium partitioning sediment benchmarks final chronic value (ESBTU-FCV) toxicity threshold in whole-sediment samples.

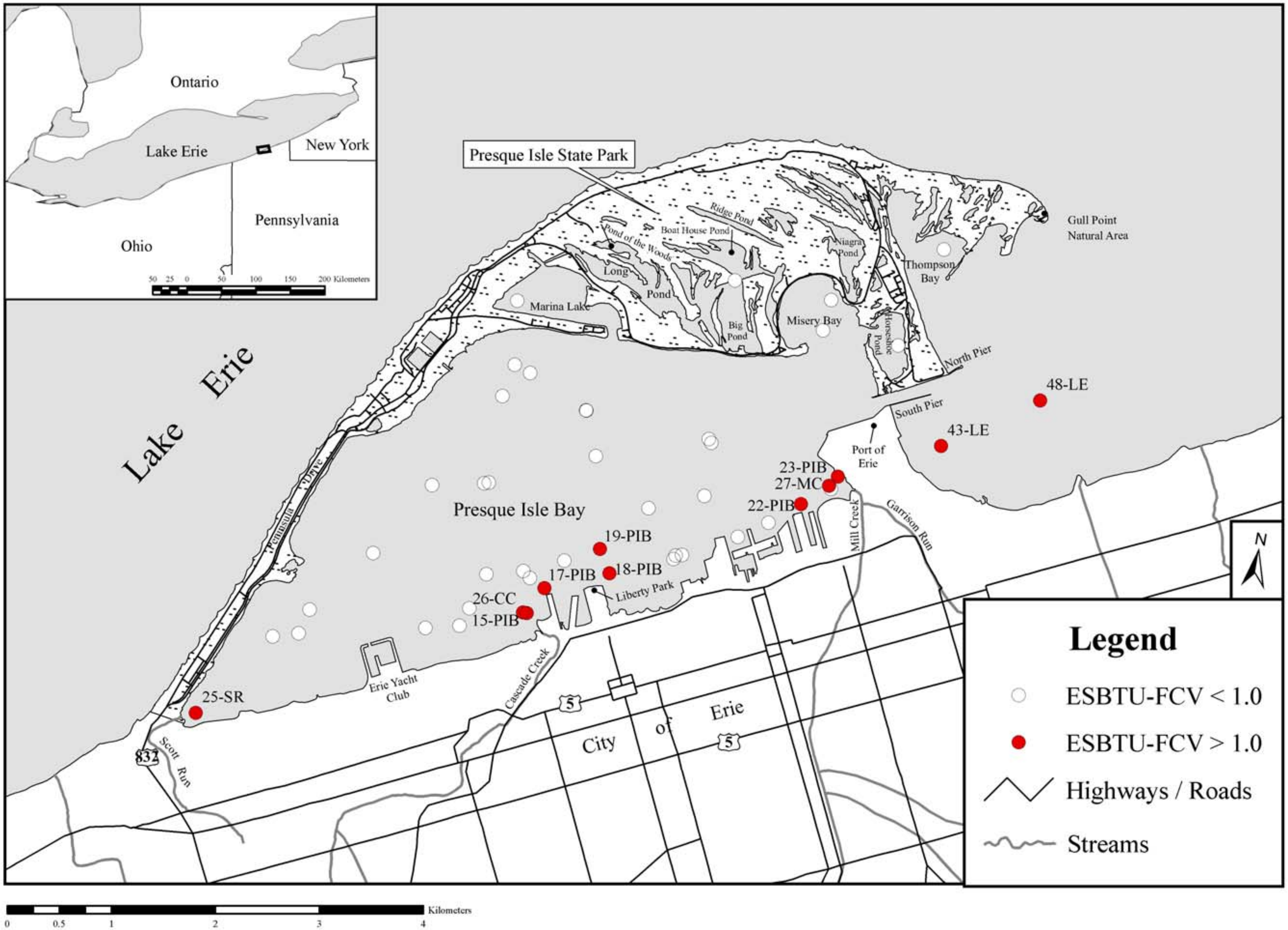
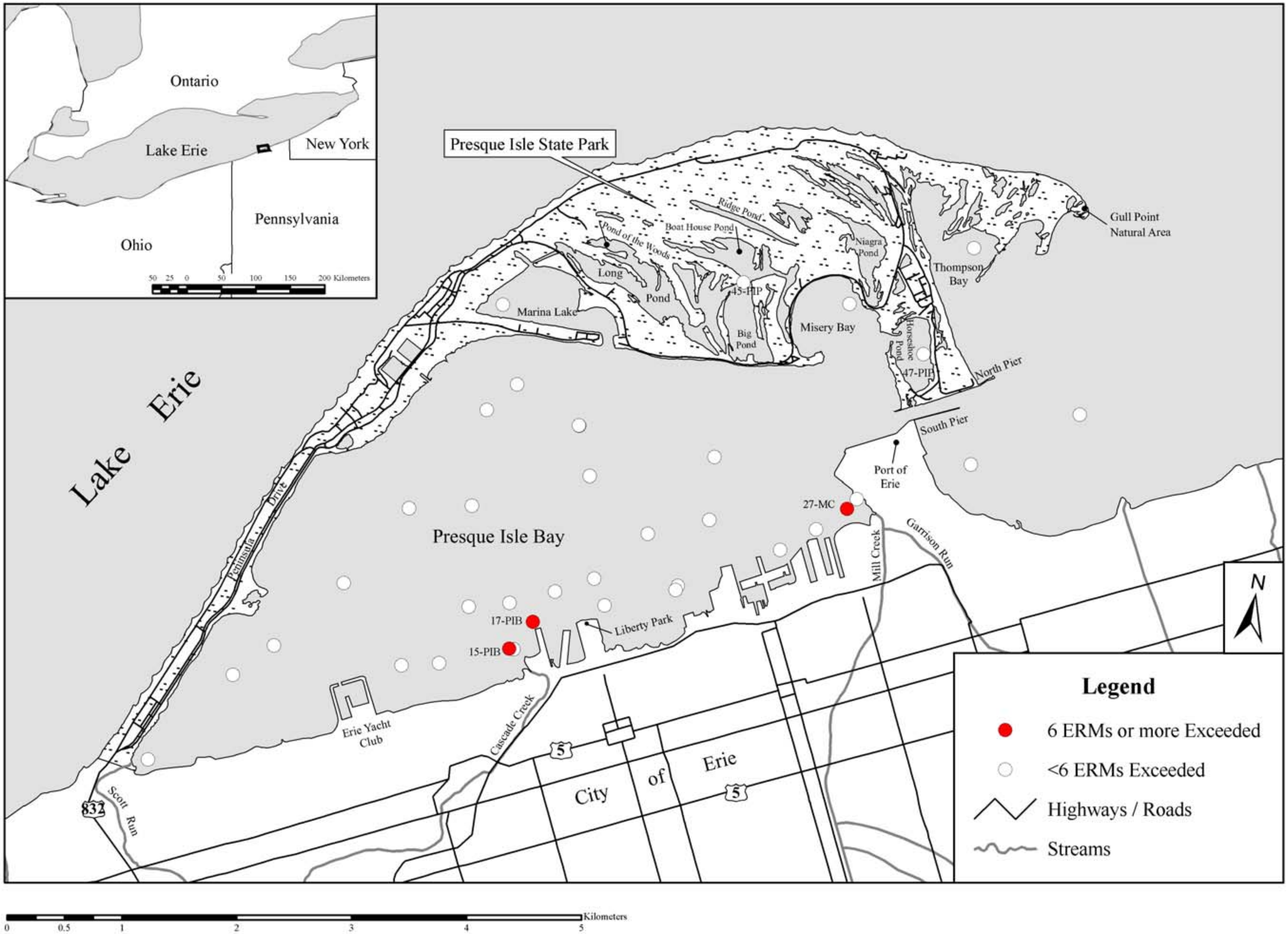


Figure 15. Map of the Presque Isle Bay Area of Concern (AOC), showing the surficial whole-sediment samples with conditions sufficient to potentially injure fish [i.e., concentrations of six or more chemicals of potential concern (COPCs) exceed the effects range median (ERMs)].



Tables

Table 1. Proposed Delisting and Ecosystem Health Targets for the Restrictions On Dredging Beneficial Use Impairment At the Presque Isle Bay Area of Concern

Ecosystem Goal for Presque Isle Bay Sediment: Maintain and/or restore sediment quality conditions such that human health is protected and the human uses of the aquatic ecosystem (e.g., fish and wildlife consumption; navigation and shipping, etc.) are protected and, where necessary, restored.

Ecosystem Objective for Presque Isle Bay Sediment: Maintain and protect the benthic invertebrate, fish, and wildlife communities of Presque Isle Bay.

Beneficial Use Impairment	Management Objective, Indicators, Metrics, and Targets
Restrictions On Dredging	
Sediment Management Objective	Protect human uses of the aquatic ecosystem (e.g., navigation, shipping, and recreation) and minimize the impact of dredged material discharge on water quality.
Sediment Quality Indicator	Whole sediment chemistry Elutriate test data
Metrics	Concentrations of COPCs in the confined disposal facility mixing zone as determined by application of the USACE's CDFate model using elutriate data or other model using whole-sediment chemistry data from Presque Isle Bay sediment samples.
Narrative Delisting Target	The concentrations of COPCs in the CDF mixing zone are below Pennsylvania Water Quality Standards at the 15-minute compliance point for acute criteria and the 12-hour compliance point for chronic criteria.
Numeric Delisting Target	Pennsylvania Chapter 16 and Chapter 93 Water Quality Standards.
Assumptions	No more than 10% of samples will exceed the target.

Table 1. Proposed Delisting and Ecosystem Health Targets for the Restrictions
On Dredging Beneficial Use Impairment
At the Presque Isle Bay Area of Concern (cont.)

Ecosystem Health Target	Management Objective, Indicators, Metrics, and Targets
Ecosystem Health for Benthos	
Sediment Management Objective:	Maintain and/or restore sediment quality conditions such that benthic communities, including epibenthic and infaunal species, are protected and, where necessary, restored.
Sediment Quality Indicator:	Whole-sediment chemistry Whole-sediment toxicity
Metrics:	Concentrations of COPcs in whole-sediment samples Whole sediment toxicity tests 1. 28-d *Hyallela azteca* survival and growth 2. 10-d *Chironomus dilutus* survival and growth
Narrative Ecosystem Health Target:	The concentrations of COPCs (metals, PAHs, and PCBs) are below the levels that are associated with acute or chronic toxicity in sediment-dwelling organisms; The survival and growth of freshwater amphipods, *H.azteca* and midges, *C. dilutus*, exposed to sediment samples from Presque Isle Bay should be greater than or equal to the normal range of survival rates observed for appropriately selected control or reference sediment samples.
Numeric Ecosystem Health Target:	At least 90% of the sediment samples from Presque Isle Bay have the conditions necessary to support healthy benthic invertebrate communities, as indicated by: mean PEC-Q l<1.0; SEM-AVS<0.0; SEM-AVS/f_{oc} <3,000; ESB-TUs <1.0; toxicity to the freshwater amphipod *Hyalella azteca* or the midge *Chironomus dilutus* for the survival or growth endpoints: - Control-adjusted survival of amphipods $\geq$ 75% - Control-adjusted growth of amphipods $\geq$90% - Control-adjusted survival of midges $\geq$ 75% - Control-adjusted growth of midges $\geq$70%

Table 1. Proposed Delisting and Ecosystem Health Targets for the Restrictions On Dredging Beneficial Use Impairment At the Presque Isle Bay Area of Concern (cont.)

Ecosystem Health Target	Management Objective, Indicators, Metrics, and Targets
Ecosystem Health for Fish and Wildlife	
Sediment Management Objective	Maintain and/or restore sediment quality conditions such that fish and wildlife communities, including aquatic dependent amphibians, reptiles, birds, and mammals, are protected and, where necessary, restored.
Sediment Quality Indicator	Whole-sediment chemistry Fish health Fish tissue chemistry
Metrics	Concentrations of COPCs in whole-sediment samples Concentrations of bioaccumulative COPCs in fish tissue
Numeric Ecosystem Health Target	The concentrations of six or more COPCs in a sample do not exceed Effects Range Median as calculated by Long, et al. (1996); or The concentrations of bioaccumulative COPCs in tissues of fish from Presque Isle Bay should not be significantly higher than the levels in fish tissue from Lake Erie; if COPC concentrations are elevated in PIB fish, then the levels should be lower than the toxicity thresholds for fish and aquatic-dependent wildlife.
Assumptions	No more than 10% of samples will exceed the target.

Table 2: Pennsylvania Water Quality Standards [1]

Chemical		Criteria		
		mg/l		
	Chronic	**Acute**	**Human Health**	
Aluminum	N/A	0.75	N/A	Ch. 16 Appendix A
Antimony	0.22	1.1	0.014	Ch. 16 Appendix A
Arsenic	0.148	0.34	N/A	Ch. 16 Great Lakes Criteria
Barium	4.1	21	2.4	Ch. 16 Appendix A
Beryllium	N/A	N/A	N/A	Ch. 16 Appendix A
Cadmium	0.0026	0.0052	N/A	Ch. 16 Great Lakes Criteria
Calcium	NC	NC	NC	
Chromium	NC	NC	NC	
Cobalt	0.019	0.095	N/A	Ch. 16 Appendix A
Copper	0.0105	0.016	N/A	Ch. 16 Great Lakes Criteria
(T) Iron	1.5			Chapter 93
Lead	0.0031	0.079	N/A	Ch. 16 Appendix A
Magnesium	NC	NC	NC	
Manganese		1		Chapter 93
Mercury	0.00077	0.00144	0.0000031	Ch. 16 Great Lakes Criteria
Nickel	0.061	0.55	N/A	Ch. 16 Great Lakes Criteria
Potassium	NC	NC	NC	
Selenium	0.00461	N/A	N/A	
Silver	N/A	0.0056	N/A	Ch. 16 Appendix A
Sodium	NC	NC	NC	
Thallium	0.013	0.065	0.0017	Ch. 16 Appendix A
Vanadium	0.1	0.51	N/A	Ch. 16 Appendix A
Zinc	0.139	0.138	N/A	Ch. 16 Appendix A
Phosphorus				
Oil and Grease				
Total Organic Carbon	NC	NC	NC	
Hardness	NC	NC	NC	
Nitrogen K	NC	NC	NC	
Acenapthene	0.017	0.083	1.2	Ch. 16 Appendix A
Acenapthlylene	N/A	N/A	N/A	Ch. 16 Appendix A
Anthracene	N/A	N/A	9.6	Ch. 16 Appendix A
Benzo(a)anthracene	0.0001	0.0005	0.0000044	Ch. 16 Appendix A
Benzo(b)fluoranthene	NC	NC	NC	
Benzo(k)fluoranthene	N/A	N/A	0.0000044	Ch. 16 Appendix A
Benzo(a)pyrene	N/A	N/A	0.0000044	Ch. 16 Appendix A
Benzo(a,h)anthracene	NC	NC	NC	
Benzo(g,h,I)perlene	N/A	N/A	N/A	Ch. 16 Appendix A
Chrysene	N/A	N/A	0.0000044	Ch. 16 Appendix A
Dibenzo(a,h)anthracene	N/A	N/A	0.0000044	Ch. 16 Appendix A
Fluoranthene	0.04	0.2	0.3	Ch. 16 Appendix A
Fluorene	N/A	N/A	1.3	Ch. 16 Appendix A
Indeno(1,2,3-cd)pyrene	N/A	N/A	0.0000044	Ch. 16 Appendix A
Napthalene	0.043	0.14	N/A	Ch. 16 Appendix A
Phenanthrene	0.001	0.005	N/A	Ch. 16 Appendix A
Pyrene	N/A	N/A	0.96	Ch. 16 Appendix A
PCB	0.014	N/A	0.000000044	Ch. 16 Appendix A
Sulfide	NC	NC	NC	

H = Hardness bases (121mg/l)
N/A = Not Available

N/C = No Criteria

[1] Calculated with 5 years of data from Water Quality Network Station 632

Table 3. Selected toxicity thresholds for whole sediment for evaluating the effects of chemicals of potential concern on the benthic invertebrate community.

Chemical of Potential Concern (COPC)	Selected Toxicity Thresholds	Type	Source
Metals (mg/kg DW)			
Aluminum	58000	ERM	Ingersoll et al. 1996
Antimony	25.0	SEL	NYSDEC 1999
Arsenic	33.0	PEC	MacDonald *et al.* 2000
Barium	60	HTP	USEPA 1977
Cadmium	4.98	PEC	MacDonald *et al.* 2000
Chromium	111	PEC	MacDonald *et al.* 2000
Copper	149	PEC	MacDonald *et al.* 2000
Iron	250000	PEL	Ingersoll et al. 1996
Lead	128	PEC	MacDonald *et al.* 2000
Manganese	1200	PEL	Ingersoll et al. 1996
Mercury	1.06	PEC	MacDonald *et al.* 2000
Nickel	48.6	PEC	MacDonald *et al.* 2000
Silver	2.2	SEL	NYSDEC 1999
Zinc	459	PEC	MacDonald *et al.* 2000
SEM-AVS	0.0		Ankley *et al.* 1996
Polycyclic Aromatic Hydrocarbons (PAHs; µg/kg DW)			
Acenaphthene	88.9	PEL	CCME 1999
Acenaphthylene	128	PEL	CCME 1999
Anthracene	845	PEC	MacDonald *et al.* 2000
Benz(a)anthracene	1050	PEC	MacDonald *et al.* 2000
Benzo(a)pyrene	1450	PEC	MacDonald *et al.* 2000
Chrysene	1290	PEC	MacDonald *et al.* 2000
Dibenz(a,h)anthracene	135	PEL	CCME 1999
Fluoranthene	2230	PEC	MacDonald *et al.* 2000
Fluorene	536	PEC	MacDonald *et al.* 2000
2-Methylnaphthalene	201	PEL	CCME 1999
Naphthalene	561	PEC	MacDonald *et al.* 2000
Phenanthrene	1170	PEC	MacDonald *et al.* 2000
Pyrene	1520	PEC	MacDonald *et al.* 2000
Total PAHs	22800	PEC	MacDonald *et al.* 2000
ESBTUs[1]	1.0	FCV	USEPA 2003
Polychlorinated Biphenyls (PCBs; µg/kg DW)			
Total PCBs	676	PEC	MacDonald *et al.* 2000
Aroclor 1248	600	TET (@ 1% OC)	MEQ/EC 1992
Aroclor 1254	340	PEL	CCME 1999

Organochlorine Pesticides (µg/kg DW)

Table 3. Selected toxicity thresholds for whole sediment for evaluating the effects of chemicals of potential concern on the benthic invertebrate community.

Chemical of Potential Concern (COPC)	Selected Toxicity Thresholds	Type	Source
Chlordane (total)	17.6	PEC	MacDonald *et al.* 2000
Sum DDD	28.0	PEC	MacDonald *et al.* 2000
Sum DDE	31.3	PEC	MacDonald *et al.* 2000
Sum DDT	62.9	PEC	MacDonald *et al.* 2000
DDT (total)[2]	572	PEC	MacDonald *et al.* 2000
Dieldrin	61.8	PEC	MacDonald *et al.* 2000
Endrin (total)[3]	207	PEC	MacDonald *et al.* 2000
Phthalates (µg/kg DW)			
Bis(2-ethylhexyl)phthalate	119700	SC (@ 100% OC)	Newell 1989
Other COPCS (µg/kg DW)			
Cyanide	0.25	HTP	USEPA 1977
Mean PEC-Q			
50% probability of toxicity	0.63	FTT	USEPA 2000; Ingersol et al. 2005; Long et al. 2006

DW = dry weight; NB = no benchmark available; ERM = effects range median;
SEL = severe effect level; PEC = probable effect concentration; HPT = heavily polluted threshold;
PEL = probable effect level; FCV = final chronic value; OC = organic carbon; TET = toxic effect threshold;
SQAL = sediment quality advisory level; FTT = freshwater toxicity threshold; SC = sediment criterion.

SEM-AVS = Simultaneously Extracted Metals minus Acid Volatile Sulphides
ESBTU = Equilibrium Partitioning Sediment Benchmark Toxic Units; BHC = Benzene hexachloride;
DDD = Dichlorodiphenyldichloroethane; DDE = Dichlorodiphenyldichloroethylene; DDT = Dichlorodiphenyltrichloroethane.
PEC-Q = Probable Effect Concentration Quotient

NYSDEC = New York State Department of Environmental Conservation; USEPA = United States Environmental Protection Agency
CCME = Canadian Council of Ministers of the Environment; MEQ/EC = Ministere de l'Environnement du Quebec/Environment Canada

[1]For a list of substances that should be used to calculate ESBTUs see Table 3. In this study, ESBTUs were calculated using data on 34 parent PAHs.

[2]Total DDT is the sum of 6 isomers.

[3]Total endrin is the sum of endrin aldehyde and ketone.

Table 4. Selected toxicity thresholds for whole sediment for evaluating the effects of chemicals of potential concern on the fish communnity.

Chemicals of Potential Concern (COPCs)	Selected Benchmarks	Type	Source
Metals (mg/kg DW)			
Aluminum	NB		
Antimony	25	ERM	Long and Morgan 1991
Arsenic	70	ERM	Long *et al*. 1995
Barium	NB		
Cadmium	9.6	ERM	Long *et al*. 1995
Chromium	370	ERM	Long *et al*. 1995
Copper	270	ERM	Long *et al*. 1995
Iron	NB		
Lead	218	ERM	Long *et al*. 1995
Manganese	NB		
Mercury	0.71	ERM	Long *et al*. 1995
Nickel	51.6	ERM	Long *et al*. 1995
Silver	3.7	ERM	Long *et al*. 1995
Zinc	410	ERM	Long *et al*. 1995
Polycyclic Aromatic Hydrocarbons (PAHs; µg/kg DW)			
Acenapthene	500	ERM	Long *et al*. 1995
Acenapthylene	640	ERM	Long *et al*. 1995
Anthracene	1100	ERM	Long *et al*. 1995
Benz(a)anthracene	1600	ERM	Long *et al*. 1995
Benzo(a)pyrene	1600	ERM	Long *et al*. 1995
Chrysene	2800	ERM	Long *et al*. 1995
Dibenzo(a,h)anthracene	260	ERM	Long *et al*. 1995
Fluoranthene	5100	ERM	Long *et al*. 1995
Fluorene	540	ERM	Long *et al*. 1995
2-Methylnapthalene	670	ERM	Long *et al*. 1995
Napthalene	2100	ERM	Long *et al*. 1995
Phenanthrene	1500	ERM	Long *et al*. 1995
Pyrene	2600	ERM	Long *et al*. 1995
Total PAHs	44792	ERM	Long *et al*. 1995
ESBTUs[1]	1.0	ERM	USEPA 2003
Polychlorinated Biphenyls (PCBs; µg/kg DW)			
Total PCBs	180	ERM	Long *et al*. 1995
Aroclor 1248	NB		
Aroclor 1254	340	PEL	CCME 1999
Organochlorine Pesticides (µg/kg DW)			
Chlordane (total)	6	ERM	Long and Morgan 1991
Sum DDD	20	ERM	Long and Morgan 1991
Sum DDE	15	ERM	Long and Morgan 1991

Table 5. COMMONWEALTH OF PENNSYLVANIA
FISH CONSUMPTION ADVISORIES - 2006

LAKE ERIE BASIN

Water Body	Area Under Advisory	Species	Meal Frequency	Contaminant
Lake Erie (Erie Co.)	Open Waters	Walleye under 23"	2 meals/month	Mercury
		Walleye over 23" Coho salmon* Steelhead* (Rainbow trout) Smallmouth bass White perch White bass Lake whitefish Carp under 20" Freshwater drum Lake trout Channel catfish	1 meal/month	PCB
		Carp over 20"	Do Not Eat	
Lake Erie (Erie Co.)	Presque Isle Bay	Largemouth bass	2 meals/month	Mercury
		Smallmouth bass Northern pike White perch Freshwater drum Bowfin Carp Coho salmon* Steelhead* (Rainbow Trout)	1 Meal/Month	PCB

* Salmon and trout are migratory. They may be found seasonally in Presque Isle Bay or Lake Erie tributary streams. Trout, salmon and other fish, whether caught in the lake or elsewhere, should be treated as Lake Erie fish.

Table 6. Summary of critical body burdens of selected chemicals of potential concern in fish tissues. These toxicity thresholds identify concentrations of COPCs that are associated with adverse effects in freshwater, estuarine, or marine fish species (Source: Jarvinen and Ankley 1999).

Chemical of Potential Concern (COPC)	Lowest Observed Adverse Effect Level in Fish Tissue							
	Whole Body		Liver		Muscle		Fish eggs	
Metals (mg/kg WW)								
Antimony	9.0	(1)						
Arsenic	3.0	(2)	47[a]	(3)	6[a]	(3)		
Cadmium	0.14	(4,5)	1.37[a]	(6)	0.029[a]	(6)		
Copper	11.1[a]	(7)	5.8	(8)	0.50	(9)		
Lead	0.40[a]	(10)	26.8[a]	(10)				
Mercury	0.04	(11)	18	(12)	0.7	(12)		
Methyl mercury	0.04	(11)			0.7	(12)		
Nickel			82.2	(13)	118.1	(13)		
Selenium	0.92[a]	(14)	9.56[a]	(14)	3.8	(15)		
Vanadium	3.12[a]	(16,17)						
Zinc	44[a]	(18)	48.5[a]	(19)	13.6[a]	(19)		
Polychlorinated Biphenyls (PCBs; µg/kg WW)								
Total PCBs	2700	(A)						
Aroclor 1016	200000	(22)						
Aroclor 1242	2700	(23)						
Aroclor 1254	1530	(24)	27100	(25)			500	(B)
Aroclor 1260	5200	(26)						
Aroclor 1268	2500	(26)						
Organochlorine Pesticides (µg/kg WW)								
BHC-gamma (lindane)	7900	(35)	3400	(36)	590	(37)		
Sum DDE	290	(24)						
DDT (total)[1]	475	(27)	7760	(28)	170	(28)		
Dieldrin	1480	(29)						
Endosulfan (total)[2]	30	(30)	3100	(31)	115	(32)		
Endrin	11.5	(33)	1000	(34)	120	(34)		
Methoxychlor	1640	(38)						
Toxaphene	400	(39,40,41)						
Organotins (µg/kg WW)								
Tributyltin	5660	(20,21)						
Chlorinated Benzenes (µg/kg WW)								
1,4-Dichlorobenzene	47000	(43)						
1,2,4-Trichlorobenzene	182000	(26)						
Hexachloro-1,3-butadiene	34800	(44)						
Chlorinated Phenols (µg/kg WW)								
2-Chlorophenol	128000	(48)						
2,4-Dichlorophenol	18000	(47)						
2,4,5-Trichlorophenol	66000	(45)						
2,4,6-Trichlorophenol	51	(46)						
Pentachlorophenol	17800	(49)						

Table 6. Summary of critical body burdens of selected chemicals of potential concern in fish tissues. These toxicity thresholds identify concentrations of COPCs that are associated with adverse effects in freshwater, estuarine, or marine fish species (Source: Jarvinen and Ankley 1999).

Chemical of Potential Concern (COPC)	Lowest Observed Adverse Effect Level in Fish Tissue							
	Whole Body		Liver		Muscle		Fish eggs	
PCDDs and PCDFs (ng/kg)								
2,3,7,8-TCDD Toxic Equivalents (TEQs; ng/kg WW)					116	(42)	40	(42, 51)
2,3,7,8-TCDD TEQs (ng/kg lipid)	321	(C)					321	(C)
2,3,7,8-TCDD TEQs (ng/kg DW)			409	(D)				

WW = wet weight; DW = dry weight.

...footnotes continued on next page

BHC = Benzene hexachloride; DDD = Dichlorodiphenyldichloroethane; DDE = Dichlorodiphenyldichloroethylene; DDT = Dichlorodiphenyltrichloroethane; TCDD = Tetrachlorodibenzo-*p*-dioxin; TCDF = Tetrachlorodibenzofuran; PCDD = Polychlorinated dibenzo-*p*-dioxin; PCDF = Polychlorinated dibenzofuran; HxCDF = Hexachlorodibenzofuran.

[a]Converted from dry weight to wet weight (0.2 factor, Stephen *et al.,* 1985; Ref 50).

[1]Total DDT is the sum of 6 isomers.

[2]Total endosulfan is the sum of mixed isomers (interpreted as alpha + beta in this study).

[3]Total heptachlor is the sum of heptachlor and heptachlor epoxide.

References from Jarvinen and Ankley 1999:

Ref 1 = Doe *et al.* 1987
Ref 2 = McGeachy and Dixon 1990
Ref 3 = Sorensen 1976
Ref 4 = Hamilton *et al.* 1987a
Ref 5 = Hamilton *et al.* 1987b
Ref 6 = Westernhagen *et al.* 1980
Ref 7 = Stouthart *et al.* 1996
Ref 8 = Brungs *et al.* 1973
Ref 9 = Handy 1992
Ref 10 = Holcombe *et al.* 1976
Ref 11 = Birge *et al.* 1979
Ref 12 = Niimi and Kissoon 1994
Ref 13 = Sreedevi *et al.* 1992
Ref 14 = Hilton *et al.* 1982
Ref 15 = Coughlan and Velte 1989
Ref 16 = Holdway and Sprague 1979
Ref 17 = Holdway *et al.* 1983
Ref 18 = Spehar 1976
Ref 19 = Flos *et al.* 1979
Ref 20 = Tas *et al.* 1993
Ref 21 = Tas *et al.* 1996
Ref 22 = Hansen *et al.* 1975
Ref 23 = Hogan and Brauhn 1975
Ref 24 = Berlin *et al.* 1981
Ref 25 = Sangalang *et al.* 1981
Ref 26 = van Wezel *et al.* 1995a
Ref 27 = Cuerrier *et al.* 1967
Ref 28 = Pandian and Bhaskaran 1983
Ref 29 = Smith and Cole 1973
Ref 30 = Schimmel *et al.* 1977a
Ref 31 = Matthiessen *et al.* 1982
Ref 32 = Herzberg 1986
Ref 33 = Fabacher 1976
Ref 34 = Bennett and Day 1970
Ref 35 = Schimmel *et al.* 1977b
Ref 36 = Tooby and Durbin 1975
Ref 37 = Marcelle and Thome 1983
Ref 38 = Lee *et al.* 1975
Ref 39 = Mayer and Mehrle 1977
Ref 40 = Mayer *et al.* 1975
Ref 41 = Mehrle and Mayer 1975
Ref 42 = Walker *et al.* 1994
Ref 43 = van Wezel *et al.* 1995b
Ref 44 = Leeuwangh *et al.* 1975
Ref 45 = Kishino and Kobayashi 1995
Ref 46 = Virtanen and Hattula 1982
Ref 47 = Hattula *et al.* 1981
Ref 48 = Kobayashi *et al.* 1979
Ref 49 = Thomas *et al.* 1981
Ref 50 = Stephen *et al.* 1985
Ref 51 = Spitsbergen *et al.* 1991

Other references:

Ref A = Orn *et al.* 1998
Ref B = Jensen *et al.* 1970
Ref C = Steevens *et al.* 2004
Ref D = Black *et al.* 1998

Table 7. Summary of toxicity thresholds for aquatic-dependent wildlife for chemicals of potential concern in the Passaic River Newark Bay complex. Toxicity thresholds identify the concentrations of COPCs in prey organisms that represent lowest observed adverse effect levels (LOAELs) for various groups of wildlife receptors (with focal species in parentheses; from Sample *et al.* 1996).

Chemical of Potential Concern (COPC)	Avian Receptor Groups				Mammalian Receptor Groups
	Sediment-Probing[1] (*Sandpiper*[6])	Insectivorus[2] (*Swallow*)	Carnivorous Wading[3] (*Heron*)	Piscivorous[4] (*Kingfisher*)	Piscivorus Mammals[5] (*Otter*)
Metals (mg/kg WW)					
Aluminum					
Antimony					2.8
Arsenic	17	17	73	25	2.8
Barium	55	55	240	82	81
Beryllium[7]					
Cadmium	26	27	110	39	39
Chromium					
Cobalt					
Copper	81	82	350	120	81
Lead	15	15	64	22	330
Manganese					1200
Mercury	1.2	1.2	5.1	1.8	0.13
Methyl mercury	0.084	0.085	0.36	0.13	0.13
Nickel	140	140	610	210	330
Selenium	1.3	1.3	5.7	2.0	1.3
Silver					
Thallium					0.30
Titanium					
Vanadium					7.9
Zinc	170	170	750	260	1300
Polycyclic Aromatic Hydrocarbons (PAHs; µg/kg WW)					
Low Molecular Weight (LMW) PAHs					
2-Methylnaphthalene					
Acenaphthene					
Acenaphthylene					

Table 7. Summary of toxicity thresholds for aquatic-dependent wildlife for chemicals of potential concern in the Passaic River Newark Bay complex. Toxicity thresholds identify the concentrations of COPCs in prey organisms that represent lowest observed adverse effect levels (LOAELs) for various groups of wildlife receptors (with focal species in parentheses; from Sample *et al.* 1996).

Chemical of Potential Concern (COPC)	Avian Receptor Groups				Mammalian Receptor Groups
	Sediment-Probing[1] (*Sandpiper[6]*)	**Insectivorus[2] (*Swallow*)**	**Carnivorous Wading[3] (*Heron*)**	**Piscivorous[4] (*Kingfisher*)**	**Piscivorus Mammals[5] (*Otter*)**
LMW PAHs (cont.)					
Anthracene					
Fluorene					
Naphthalene					
Phenanthrene					
High Molecular Weight (HMW) PAHs					
Benz(a)anthracene					
Benzo(a)pyrene					22000
Benzo(b)fluoranthene					
Benzo(g,h,i)perylene					
Benzo(k)fluoranthene					
Chrysene					
Dibenz(a,h)anthracene					
Fluoranthene					
Indeno(1,2,3-cd)pyrene					
Pyrene					
Polychlorinated Biphenyls (PCBs; µg/kg WW)					
Total PCBs					720[A]
Aroclor 1016					18000
Aroclor 1242					1400[B]
Aroclor 1248					600[B]
Aroclor 1254	2400	2400	10000	3600	600[B]
Aroclor 1260					
Aroclor 1268					

Table 7. Summary of toxicity thresholds for aquatic-dependent wildlife for chemicals of potential concern in the Passaic River Newark Bay complex. Toxicity thresholds identify the concentrations of COPCs in prey organisms that represent lowest observed adverse effect levels (LOAELs) for various groups of wildlife receptors (with focal species in parentheses; from Sample *et al.* 1996).

Chemical of Potential Concern (COPC)	Avian Receptor Groups				Mammalian Receptor Groups
	Sediment-Probing[1] (*Sandpiper*[6])	Insectivorus[2] (*Swallow*)	Carnivorous Wading[3] (*Heron*)	Piscivorous[4] (*Kingfisher*)	Piscivorus Mammals[5] (*Otter*)
Organochlorine Pesticides (µg/kg WW)					
Aldrin					4100
Aldrin + Dieldrin					
BHC-alpha					
BHC-beta					
BHC-gamma (lindane)	2600	2700	110000	39000	
BHC (total)					
Chlordane-alpha					
Chlordane-gamma					
Chlordane (total)	14000	14000	61000	21000	20000
2,4'-DDD					
4,4'-DDD					
Sum DDD					
2,4'-DDE					
4,4'-DDE					
Sum DDE					
2,4'-DDT					
4,4'-DDT					
Sum DDT					
DDT (total)[8]	37	37	160	55	16000
Dieldrin					810
Endosulfan (total)[7,9]					
Endrin	130	130	570	200	2000
Heptachlor (total)[10]					
Methoxychlor					33000
Toxaphene[7]					

Table 7. Summary of toxicity thresholds for aquatic-dependent wildlife for chemicals of potential concern in the Passaic River Newark Bay complex. Toxicity thresholds identify the concentrations of COPCs in prey organisms that represent lowest observed adverse effect levels (LOAELs) for various groups of wildlife receptors (with focal species in parentheses; from Sample *et al.* 1996).

Chemical of Potential Concern (COPC)	Avian Receptor Groups				Mammalian Receptor Groups
	Sediment-Probing[1] (*Sandpiper*[6])	Insectivorus[2] (*Swallow*)	Carnivorous Wading[3] (*Heron*)	Piscivorous[4] (*Kingfisher*)	Piscivorus Mammals[5] (*Otter*)
Phthalates (µg/kg WW)					
Bis(2-ethylhexyl)phthalate					400000
Butyl benzyl phthalate					
Di-n-butylphthalate	1500	1500	6300	2200	4000000
Di-n-octylphthalate					
Organotins (µg/kg WW)					
Monobutyltin					
Dibutyltin					
Tributyltin	22000	22000	96000	33000	77000
Chlorinated Benzenes (µg/kg WW)					
1,4-Dichlorobenzene					
1,2,4-Trichlorobenzene					
Hexachloro-1,3-butadiene					
Chlorinated Phenols (µg/kg WW)					
2-Chlorophenol					
4-Chloro-3-methylphenol					
2,4-Dichlorophenol					
2,4,5-Trichlorophenol					
2,4,6-Trichlorophenol					
Pentachlorophenol					9800

Table 7. Summary of toxicity thresholds for aquatic-dependent wildlife for chemicals of potential concern in the Passaic River Newark Bay complex. Toxicity thresholds identify the concentrations of COPCs in prey organisms that represent lowest observed adverse effect levels (LOAELs) for various groups of wildlife receptors (with focal species in parentheses; from Sample *et al.* 1996).

Chemical of Potential Concern (COPC)	Avian Receptor Groups				Mammalian Receptor Groups
	Sediment-Probing[1] (*Sandpiper*[6])	Insectivorus[2] (*Swallow*)	Carnivorous Wading[3] (*Heron*)	Piscivorous[4] (*Kingfisher*)	Piscivorus Mammals[5] (*Otter*)
PCDDs and PCDFs (ng/kg WW)					
2,3,7,8-TCDD	180	190	800	280	41
2,3,7,8-TCDF	13	13	57	20	
1,2,3,7,8-PCDF					6500
2,3,4,7,8-PCDF					650
1,2,3,6,7,8-HxCDF					6500
2,3,7,8-TCDD Toxic Equivalents (TEQs)	60[C]	60[C]	60[C]	60[C]	12.6[A]
Other COPCs (μg/kg WW)					
Dibenzofuran					

WW = wet weight; BW/FIR = body weight/food intake ratio; NOAEL = no observed adverse effect level.

BHC = Benzene hexachloride; DDD = Dichlorodiphenyldichloroethane; DDE = Dichlorodiphenyldichloroethylene; DDT = Dichlorodiphenyltrichloroethane; TCDD = Tetrachlorodibenzo-*p*-dioxin; TCDF = Tetrachlorodibenzofuran; PCDD = Polychlorinated dibenzo-*p*-dioxin; PCDF = Polychlorinated dibenzofuran; HxCDF = Hexachlorodibenzofuran.

[A]This benchmark is from Tillitt *et al.* 1996.

[B]This benchmark is from Chapman 2003.

[C]This benchmark is the high risk thresholds from USEPA 1993 (high risk concentrations were derived from TCDD doses expected to cause 50 to 100% mortality in embryos and young of sensitive species).

[1]Compare to contaminant levels in benthic organism.

[2]Compare to contaminant levels in emergent insects.

[3]Compare to contaminant levels in fish, amphibians, reptiles, crabs, shrimp, etc.

[4]Compare to contaminant levels in fish.

[5]Compare to contaminant levels in fish.

...footnotes continued on next page

Table 7. Summary of toxicity thresholds for aquatic-dependent wildlife for chemicals of potential concern in the Passaic River Newark Bay complex. Toxicity thresholds identify the concentrations of COPCs in prey organisms that represent lowest observed adverse effect levels (LOAELs) for various groups of wildlife receptors (with focal species in parentheses; from Sample *et al.* 1996).

Chemical of Potential Concern (COPC)	Avian Receptor Groups				Mammalian Receptor Groups
	Sediment-Probing[1] (*Sandpiper*[6])	Insectivorus[2] (*Swallow*)	Carnivorous Wading[3] (*Heron*)	Piscivorous[4] (*Kingfisher*)	Piscivorus Mammals[5] (*Otter*)

[6]Toxicity thresholds for sandpipers were adopted directly from the LOAEL for woodcock, because the BW/FIR may be similar for these two species.

[7]LOAELs were not established for these COPCs (i.e., only NOAELs were established).

[8]Total DDT is the sum of 6 isomers.

[9]Total endosulfan is the sum of mixed isomers (interpreted as alpha + beta in this study).

[10]Total heptachlor is the sum of heptachlor and heptachlor epoxide.

Table 8. Frequency of exceedance of the selected toxicity thresholds for the protection of the benthic community, in surficial sediment samples from the Presque Isle Bay Area of Concern (AOC).

Chemical of Potential Concern (COPC)	Selected Toxicity Threshold[1]	Frequency of Exceedance of Selected Toxicity Thresholds			
		PIB AOC	Presque Isle Ponds	Nearshore Areas of Lake Erie	Entire Study Area
Metals (mg/kg DW)					
Antimony	25	0% (0 of 13)	ND	ND	0% (0 of 13)
Arsenic	33	0% (0 of 47)	0% (0 of 4)	0% (0 of 2)	0% (0 of 53)
Barium	60	92% (12 of 13)	ND	ND	92% (12 of 13)
Cadmium	4.98	45% (21 of 47)	0% (0 of 4)	0% (0 of 2)	40% (21 of 53)
Chromium	111	0% (0 of 47)	0% (0 of 4)	0% (0 of 2)	0% (0 of 53)
Copper	149	0% (0 of 47)	0% (0 of 4)	0% (0 of 2)	0% (0 of 53)
Lead	128	13% (6 of 47)	0% (0 of 4)	0% (0 of 2)	11% (6 of 53)
Mercury	1.06	0% (0 of 47)	0% (0 of 4)	0% (0 of 2)	0% (0 of 53)
Nickel	48.6	55% (26 of 47)	0% (0 of 4)	0% (0 of 2)	49% (26 of 53)
Zinc	459	0% (0 of 47)	0% (0 of 4)	0% (0 of 2)	0% (0 of 53)
Polycyclic Aromatic Hydrocarbons (PAHs; µg/kg DW)					
Acenaphthene	88.9	23% (11 of 47)	0% (0 of 4)	0% (0 of 2)	21% (11 of 53)
Acenaphthylene	128	4% (2 of 47)	0% (0 of 3)	0% (0 of 2)	4% (2 of 52)
Anthracene	845	2% (1 of 47)	0% (0 of 4)	0% (0 of 2)	2% (1 of 53)
Benz(a)anthracene	1050	28% (13 of 47)	0% (0 of 4)	0% (0 of 2)	25% (13 of 53)
Benzo(a)pyrene	1450	19% (9 of 47)	0% (0 of 4)	0% (0 of 2)	17% (9 of 53)
Chrysene	1290	34% (16 of 47)	0% (0 of 4)	0% (0 of 2)	30% (16 of 53)
Dibenz(a,h)anthracene	135	74% (35 of 47)	50% (2 of 4)	0% (0 of 2)	70% (37 of 53)
Fluoranthene	2230	30% (14 of 47)	0% (0 of 4)	0% (0 of 2)	26% (14 of 53)
Fluorene	536	2% (1 of 47)	0% (0 of 4)	0% (0 of 2)	2% (1 of 53)
2-Methylnaphthalene	201	0% (0 of 8)	ND	ND	0% (0 of 8)
Naphthalene	561	0% (0 of 47)	0% (0 of 4)	0% (0 of 2)	0% (0 of 53)
Phenanthrene	1170	17% (8 of 47)	0% (0 of 4)	0% (0 of 2)	15% (8 of 53)
Pyrene	1520	51% (24 of 47)	0% (0 of 4)	0% (0 of 2)	45% (24 of 53)
Total PAHs	22800	4% (2 of 47)	0% (0 of 4)	0% (0 of 2)	4% (2 of 53)
Polychlorinated Biphenyls (PCBs; µg/kg DW)					
Total PCBs	676	6% (2 of 34)	0% (0 of 4)	0% (0 of 2)	5% (2 of 40)
Organochlorine Pesticides (µg/kg DW)					
Chlordane (total)	17.6	0% (0 of 34)	0% (0 of 4)	0% (0 of 2)	0% (0 of 40)
Sum DDD	28	0% (0 of 34)	0% (0 of 4)	0% (0 of 2)	0% (0 of 40)
Sum DDE	31.3	0% (0 of 34)	0% (0 of 4)	0% (0 of 2)	0% (0 of 40)
Sum DDT	62.9	0% (0 of 34)	0% (0 of 4)	0% (0 of 2)	0% (0 of 40)
DDT (total)	572	0% (0 of 34)	0% (0 of 4)	0% (0 of 2)	0% (0 of 40)
Dieldrin	61.8	0% (0 of 34)	0% (0 of 4)	0% (0 of 2)	0% (0 of 40)
Endrin (total)	207	0% (0 of 34)	0% (0 of 4)	0% (0 of 2)	0% (0 of 40)

Table 8. Frequency of exceedance of the selected toxicity thresholds for the protection of the benthic community, in surficial sediment samples from the Presque Isle Bay Area of Concern (AOC).

Chemical of Potential Concern (COPC)	Selected Toxicity Threshold[1]	Frequency of Exceedance of Selected Toxicity Thresholds			
		PIB AOC	Presque Isle Ponds	Nearshore Areas of Lake Erie	Entire Study Area
Mixture Models					
Mean PEC-Q	1	0% (0 of 47)	0% (0 of 4)	0% (0 of 2)	0% (0 of 53)
ESG-TU (FCV)	1	19% (9 of 47)	0% (0 of 4)	100% (2 of 2)	21% (11 of 53)
SEM minus AVS	0 μmol/g	6% (2 of 34)	0% (0 of 4)	0% (0 of 2)	5% (2 of 40)
SEM minus AVS/F_{OC}	3000 μmol/g OC	0% (0 of 34)	0% (0 of 4)	0% (0 of 2)	0% (0 of 40)

ND = no data.

[1]Selected toxicity thresholds apply to whole-sediment samples.

Table 9. Proportion of sediment samples from the Presque Isle Bay Area of Concern with conditions sufficient to potentially injure sediment-dwelling organisms, based on the results of 28-day whole-sediment amphipod and 10-day whole-sediment midge toxicity tests (endpoints: survival and growth).

Species	Endpoint	Duration	PIB AOC	Presque Isle Ponds	Nearshore Areas of Lake Erie	Entire Study Area
Chironomus dilutus	Survival	10-d	3% (1 of 34)	0% (0 of 4)	0% (0 of 2)	3% (1 of 40)
Chironomus dilutus	Growth(AFDW)	10-d	9% (3 of 34)	0% (0 of 4)	0% (0 of 2)	8% (3 of 40)
Chironomus dilutus	Survival and growth	10-d	12% (4 of 34)	0% (0 of 4)	0% (0 of 2)	10% (4 of 40)
Hyalella azteca	Percent survival	28-d	0% (0 of 34)	0% (0 of 4)	0% (0 of 2)	0% (0 of 40)
Hyalella azteca	Growth (length)	28-d	0% (0 of 34)	0% (0 of 4)	0% (0 of 2)	0% (0 of 40)
Hyalella azteca	Survival and growth	28-d	0% (0 of 34)	0% (0 of 4)	0% (0 of 2)	0% (0 of 40)
Overall Toxicity			12% (4 of 34)	0% (0 of 4)	0% (0 of 2)	10% (4 of 40)

Table 10. Comparison of the concentrations of PCBs and mercury in fish[1] collected from PIB and from Lake Erie.

Location	Statistics	Mercury						PCB[3]
		Brown Trout	Common Carp	Freshwater Drum	Small Mouth Bass[2]	White Perch	Yellow Perch	Common Carp
Lake Erie	**N**	1	4	4	8	1	16	2
	Mean	0.071	0.107	0.144	0.186	0.091	0.081	12.739
	SD	NA	0.025	0.120	0.064	NA	0.037	7.596
Presque Isle Bay	**N**	1	2	1	1	1	4	1
	Mean	0.17	0.093	0.190	0.140	0.160	0.061	6.09
	SD	NA	0.067	NA	NA	NA	0.037	NA
	P-value	NA	0.181	NA	NA	NA	0.895	NA
	F-value	NA	0.692	NA	NA	NA	0.357	NA
	F-critical	NA	7.71	NA	NA	NA	4.41	NA
	Significantly Different	NA (2.39)	NO	NA (1.32)	NA (0.753)	NA (1.76)	NO	NA (0.477)

NA=not applicable (statistical comparison not possible because sample size equals one); number in paraentheses is the factor by which the Presque Isle Bay fish tissue concentration exceeded the Lake Erie fish tissue concentrations.

[1] Fish tissue analyzed was fillets with skin on.

[2] Small mouth bass are known to travel in and out of the harbour and thus may be the same population.

[3] Lipid normalized concentration.

Table 11. CDFate Model Parameters

The CDFATE model was utilized with the following scenario and inputs:

I. Discharge Case = CDF Dike Leakage
A. Estimate Dike Leakage = 0.53. 10,000 cubic yards disposed in 24 hours would equal 0.53 cubic yards. The example case in the model used 0.1.
B. Water Depth along Dike Face. Used height of dike face which is 3.6 m.
C. Dike length over which discharge occurs.The length of the east and south sides, 270m + 330m = 600m was used.
D. Depth of water in CDF = 3.6m –0.54m = 3.06m. 0.54m is the depth of sediment in the CDF estimated as 15%.
E. Maximum dike extends into water = 330m.
F. Minimum dike extends into water = 0m.
G. Angle dike makes with current = 180.

II. Receiving Water Data
n Uniform density. Density of water at 50 degrees Fahrenheit was used, which is 1000.6 kilograms/cubic meter.
n Channel velocity. Estimated value of 0.05 meters per second was used.
n Bottom roughness – Manning's Roughness value of 0.025 – natural channel, good condition was used.
n Wind Speed of Low < 1 meter per second was used.

III. Effluent Density and Modeling Parameters
The model was used to calculate effluent density by using 2% solids by volume with 100% fine silt. This calculated effluent density of 1033.59 kilograms per cubic meter.
The distance of mixing zone used was 2160m. This is the distance the plume would travel in chronic criteria compliance time of 12 hours.
Using the above modeling scenario, the model calculated the dilution of the plume at the 15 minute travel time for acute criteria would be approximately 170:1. The dilution at the 12 hour time period was calculated to be 617.3:1.

Table 12: CDFate Mixing Zone Calculations

										ACUTE CRITERIA		CHRONIC CRITERIA		HUMAN HEALTH	
							dilution			distance	time to	distance	time to	distance	time to
	(mg/l)		(mg/l)				needed to			to achieve	achieve	to achieve	achieve	to achieve	achieve
	Highest		criteria				achieve criteria			dilution	dilution	dilution	dilution	dilution	dilution
Parameter	Sample	acute	chronic	thh		acute	chronic	thh		(meters)	(minutes)	(meters)	(minutes)	(meters)	(minutes)
cadmium	0.073	0.0052	0.0026			14.038	28.077			3.190	1.063	7.250	2.417		
cobalt	0.559	0.095	0.019			5.884	29.421			1.340	0.447	7.560	2.520		
copper	0.055	0.016	0.0105			3.438	5.238			0.780	0.260	1.190	0.397		
manganese	6.06	1				6.060				1.380	0.460				
lead	0.015	0.079	0.0031			0.190	4.839			0.008	0.003	1.100	0.367		
mercury	0.003	0.00144	0.00077			2.083	3.896			0.474	0.158	0.890	0.297		
nickel	0.97	0.55	0.061			1.764	15.902			0.400	0.133	3.620	1.207		
thallium	0.0098	0.065	0.013	0.0017		0.151	0.754	5.765		0.034	0.011	0.170	0.057	1.31	0.436666667
zinc	11.9	0.138	0.138			86.232	86.232			20.500	6.833	20.500	6.833		
NH3-N	6.2	2.22	0.55			2.793	11.273			0.635	0.212	2.540	0.847		

Table 13: Predicted Dilution of Acute and Chronic Endpoints

						15 minutes	12 hours
						Dilution predicted to be 170:1	Dilution predicted to be 617:1
	(mg/l)		(mg/l)				
	Highest		criteria				
Parameter	Sample	acute	chronic	human health		concentration	concentration
cadnium	0.073	0.0052	0.0026			0.000429412	0.000118314
cobalt	0.559	0.095	0.019			0.01	0.000905997
copper	0.055	0.016	0.0105			0.000323529	0.000089141
manganese	6.06	1				0.04	0.01
lead	0.015	0.079	0.0031			8.82353E-05	2.43112E-05
mercury	0.003	0.00144	0.00077			1.76471E-05	4.86223E-06
nickel	0.97	0.55	0.061			0.01	0.01
thallium	0.0098	0.065	0.013	0.0017		5.76471E-05	1.58833E-05
zinc	11.9	0.138	0.138			0.07	0.019287
NH3-N	6.2	2.22	0.55			0.036471	0.010049

Table 14: Presque Isle Bay – 2005 Surficial Sediment Samples Exceeding PECs

Sampling Location	Nickel > 48.6 ppm	Lead >128 ppm	Cadmium >4.98 ppm	Acenap-thene > 88.9 ppb	Acenap-thylene >128	Anthra-cene >845 ppb	Dibenzo(a,h)anthracene >135 ppb	Pyrene >1520 ppb	Benzo(a) anthracene >1050 ppb	Benzo(a) pyrene >1450 ppb	Chrysene >1290 ppb	Fluoran-thene >2230 ppb	Flourene > 536 ppb	Phenan-threne >1170 ppb	Total PAHs >22800 ppb	Total PCBs >676 ppb
15S				X			X	X	X	X	X	X		X	X	
16P	X						X	X				X				
17A				X			X	X	X	X	X	X		X		
18S	X		X	X			X	X	X	X	X	X		X		
19P	X		X													
20 A							X									
21 P							X									
22S				X			X	X	X	X	X	X		X		
23A				X			X	X	X		X	X		X		
24S	X		X				X	X								
25 P				X										X		
26P				X			X	X	X		X	X		X		
27P				X		X	X	X	X	X	X	X	X	X	x	
29P	X	X	X	X			X	X	X	X	X	X				X
30P	X	X	X				X									X
31P	X	X	X				X	X			X	X				
33P	X		X				X	X			X					
35 P	X		X	X			X	X	X	X	X	X				
36 P							X									
37 P							X									
38 P							X									
39P	X						X									
40A	X						X									
41A	X						X									
42 P							X									
44 P					X		X									
47 P							X									

Appendix A – 2003 and 2005 Sediment Survey Data

Summary of Presque Isle Bay sediment chemistry and toxicity data for the recovery period (file prepared by MESL October 6, 06)

Area	Study Name	Station ID	Sample ID	Field Rep	Sample Depth (cm)	Sample Date	Latitude	Longitude	Conventionals: TOC (%)	Fines (%)	Clay (%)	Silt (%)	Sand (%)	Metals (mg/kg DW): Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc
Toxicity Threshold														**25**	**33**	**60**		**4.98**	**111**	**149**	**128**	**1.06**	**48.6**	**459**
Surficial samples																								
PIB AOC	**PADEP 2003**	01	#	#	0 - 4	20030602	42.1225	-80.140556	4.1810	85.4	14.1	71.3	14.6	1.2	20.4	73.7	0.7	6	41.7	82.7	89.1	0.3	50.3	282
PIB AOC	**PADEP 2003**	05	#	#	0 - 4	20030602	42.12747	-80.121667	4.8485	96.1	22	74.1	4	1.5	23	114	1	9.2	59.2	113	155	0.5	66.1	399
PIB AOC	**PADEP 2003**	07	#	#	0 - 4	20030602	42.13833	-80.122778	4.7200	98	17.4	80.6	2	1.4	23.4	126	1.1	8.6	58.4	102	138	0.4	66.4	370
PIB AOC	**PADEP 2003**	08	#	#	0 - 4	20030602	42.14889	-80.121944	3.3360	77.6	11.7	65.9	22.4	1.3	25.5	105	0.8	6.6	43.6	81.3	96.8	0.3	51.8	272
PIB AOC	**PADEP 2003**	08	#	01	0 - 4	20030602	42.14889	-80.121944	2.4860	82.2	11.9	70.3	17.8	1.5	25.6	112	0.8	7	45.8	84.4	104	0.3	55.8	293
PIB AOC	**PADEP 2003**	09	#	#	0 - 4	20030602	42.13106	-80.115417	4.5630	95.3	25.6	69.7	4.7	1.7	24.5	112	0.9	7.4	48.6	105	152	0.3	59.3	368
PIB AOC	**PADEP 2003**	14	#	#	0 - 4	20030602	42.13556	-80.098611	3.2510	82.8	15	67.8	17.2	1.4	22.1	91.4	0.8	6.2	38.3	82.4	104	0.4	46.5	291
PIB AOC	**PADEP 2003**	15	#	#	0 - 4	20030602	42.14556	-80.097778	3.4520	95.7	25.4	70.3	4.2	0.8	20.5	124	0.9	6.8	44.8	73.9	93.3	0.3	54.1	290
PIB AOC	**PADEP 2003**	18	#	#	0 - 4	20030602	42.14364	-80.083083	2.8960	15.6	3.8	11.8	84.5	1.9	8.6	32	<0.5	0.9	9.6	16.3	37.1	<0.1	13.8	73.3
PIB AOC	**PADEP 2003**	20	#	#	0 - 4	20030602	42.15694	-80.087528	4.1685	71.2	7.9	63.3	28.9	1.4	26.6	107	0.6	5.4	32.1	64.1	58.1	0.2	39.6	230
PIB AOC	**PADEP 2003**	25	#	#	0 - 4	20030602	42.138	-80.092639	3.7200	84.5	12.9	71.6	15.5	0.9	21.7	103	0.8	4.2	37.2	76.3	80.6	0.2	45.7	274
PIB AOC	**PADEP 2003**	25	#	01	0 - 4	20030602	42.138	-80.092639	3.5025	82.4	15.1	67.3	17.5	1	20.4	104	0.8	4.2	36.3	76	76.6	0.2	44	270
PIB AOC	**PADEP 2003**	28REF	#	#	0 - 4	20030602	41.8163	-79.83726	6.2960	88.9	16.2	72.7	11.1	0.3	26.8	140	0.7	1.7	16.8	26.4	29.4	<0.1	20.9	117
PIB AOC	PADEP 2005	01-PIB	01	#	0 - 5	20050914	42.13845	-80.122233	5.104	97.8	17.2	80.6	2.1		8.5			4	45.4	93.3	100	0.4	57.3	324
PIB AOC	PADEP 2005	01-PIB	02	#	5 - 10	20050914	42.13845	-80.122233	4.443	98.5	7.7	90.8	1.5		8.8			5.2	49.5	98.8	114	0.4	61.7	348
PIB AOC	PADEP 2005	02-PIB	01	#	0 - 5	20050914	42.1354	-80.099316	4.031	90.6	9	81.6	9.4		9.3			5.1	47.4	92.5	102	0.3	53.8	325
PIB AOC	PADEP 2005	02-PIB	02	#	5 - 10	20050914	42.1354	-80.099316	4.266	93.3	20.4	72.9	6.8		13.2			6.6	53.3	107	122	0.4	57.6	335
PIB AOC	PADEP 2005	14-PIB	#	#	0 - 10	20050914	42.12469	-80.139833	4.335	89.3	12.3	77	10.7		12.3			4.7	43.4	95.4	98.6	0.4	51.2	305
PIB AOC	PADEP 2005	15-PIB	#	#	0 - 10	20050914	42.12802	-80.115458	2.172	49.9	3.9	46	50.1		4.9			0.7	20.6	58.7	49.5	<0.1	28.7	212
PIB AOC	PADEP 2005	16-PIB	#	#	0 - 10	20050914	42.13155	-80.116353	4.3035	96.35	25.1	71.25	3.65		12.55			4.75	43.75	100	117.5	0.4	55.15	346.5
PIB AOC	PADEP 2005	17-PIB	#	#	0 - 10	20050914	42.13045	-80.113561	3.158	45.4	7.6	37.8	54.5		10.1			1.5	27.1	70	90.5	0.1	33.9	243
PIB AOC	PADEP 2005	18-PIB	#	#	0 - 10	20050914	42.13278	-80.106475	3.912	84.4	3.7	80.7	15.7		11			5.5	43	103	127	0.4	51.6	334
PIB AOC	PADEP 2005	19-PIB	#	#	0 - 10	20050914	42.1347	-80.108092	0.6672	96.8	6.2	90.6	3.1		16.8			5	41.9	93.4	77.6	0.3	54.7	322
PIB AOC	PADEP 2005	20-PIB	#	#	0 - 10	20050914	42.14251	-80.110644	4.364	97.2	16	81.2	2.8		9.6			2.9	37.5	73.6	71.9	0.3	48.4	262
PIB AOC	PADEP 2005	21-PIB	#	#	0 - 10	20050914	42.14094	-80.097386	2.468	83.6	10	73.6	16.3		8.6			2.1	29.7	57.7	51.5	0.2	40.2	216
PIB AOC	PADEP 2005	22-PIB	#	#	0 - 10	20050914	42.14185	-80.086178	3.185	87.7	10.5	77.2	12.4		8			1.2	27.8	58.8	65	0.2	36.7	218
PIB AOC	PADEP 2005	23-PIB	#	#	0 - 10	20050914	42.14478	-80.082581	0.38	6.9	0.8	6.1	93.1		4.2			1	10.8	46.9	38.2	<0.1	13.5	89.7
PIB AOC	PADEP 2005	24-PIB	#	#	0 - 10	20050914	42.14602	-80.122636	4.8135	97.7	12.3	85.4	2.25		13.35			5.65	52.1	101	118.5	0.4	61.2	350
PIB AOC	PADEP 2005	25-SR	#	#	0 - 10	20050914	42.11403	-80.150528	0.7961	27.7	0.9	26.8	72.3		6.3			<0.5	16.1	24.8	9	<0.1	30.2	82.7
PIB AOC	PADEP 2005	26-CC	#	#	0 - 9	20050914	42.12803	-80.114994	2.429	23.2	3.1	20.1	76.8		4.5			<0.5	17.7	46.3	63.2	<0.1	24.2	171
PIB AOC	PADEP 2005	27-MC	#	#	0 - 10	20050914	42.14388	-80.083386	0.4138	4.3	0	4.3	95.7		2.7			1	15	31.1	96.1	<0.1	18	127
PIB AOC	PADEP 2005	28-PIB	#	#	0 - 10	20050914	42.12181	-80.143464	2.824	77.6	6.6	71	22.3		8.3			3.5	32.9	73	65.6	0.2	42	242
PIB AOC	PADEP 2005	29-PIB	#	1	0 - 10	20050914	42.12509	-80.126233	4.88	95.7	11.8	83.9	4.3		11			6.2	51.7	118	136	0.5	61.2	391
PIB AOC	PADEP 2005	30-PIB	#	2	0 - 10	20050914	42.12509	-80.126233	4.583	95.5	23.6	71.9	4.4		10.2			6.2	51.1	116	136	0.6	60.6	388
PIB AOC	PADEP 2005	31-PIB	#	#	0 - 10	20050914	42.12584	-80.1224	4.652	96.2	14.7	81.5	3.8		8.8			6.5	52.6	115	140	0.5	61.9	397
PIB AOC	PADEP 2005	32-PIB	#	#	0 - 10	20050914	42.13056	-80.133875	0.8685	20.7	2.3	18.4	79.3		3.4			2.2	14.2	24.6	28.9	0.2	22.1	138
PIB AOC	PADEP 2005	33-PIB	#	#	0 - 10	20050914	42.13064	-80.1205	4.542	98.2	17.95	80.25	1.8		8.8			5.1	48.75	104.5	118	0.4	60.05	357
PIB AOC	PADEP 2005	34-PIB	#	#	0 - 10	20050914	42.13311	-80.111889	4.16	93.8	16.7	77.1	6.2		7			3.8	40.6	91.6	97.6	0.3	52.7	322
PIB AOC	PADEP 2005	35-PIB	#	#	0 - 10	20050914	42.13506	-80.099472	3.674	86.8	18.8	68	13.2		9.9			6.4	48.4	102	112	0.4	53	336
PIB AOC	PADEP 2005	36-PIB	#	#	0 - 10	20050914	42.13731	-80.128667	4.989	96.8	18.2	78.6	3.3		9.4			5.5	52.2	102	122	0.5	62.2	363
PIB AOC	PADEP 2005	37-PIB	#	#	0 - 10	20050914	42.13894	-80.103478	3.642	92.9	14.2	78.7	7		5.7			2.6	35.2	72.9	66.9	0.2	46.3	256

Summary of Presque Isle Bay sediment chemistry and toxicity data for the recovery period (file prepared by MESL October 6, 06)

									Conventionals					Metals (mg/kg DW)										
Area	**Study Name**	**Station ID**	**Sample ID**	**Field Rep**	**Sample Depth (cm)**	**Sample Date**	**Latitude**	**Longitude**	**TOC (%)**	**Fines (%)**	**Clay (%)**	**Silt (%)**	**Sand (%)**	**Antimony**	**Arsenic**	**Barium**	**Beryllium**	**Cadmium**	**Chromium**	**Copper**	**Lead**	**Mercury**	**Nickel**	**Zinc**
Surficial Samples continued….																								
PIB AOC	PADEP 2005	38-PIB	#	#	0 - 10	20050914	42.13973	-80.089458	2.778	56.7	11.2	45.5	43.3		1.7			1.9	22.8	87.4	46.2	0.2	30.5	187
PIB AOC	PADEP 2005	39-PIB	#	#	0 - 10	20050914	42.14843	-80.119994	5.463	96.1	6.2	89.9	3.9		8.3			4.8	48.2	99.4	105	0.4	58.9	326
PIB AOC	PADEP 2005	40-PIB	#	1	0 - 10	20050914	42.14621	-80.112758	4.43	98.4	20	78.4	1.6		9.4			4	43.8	86.8	93.1	0.3	54.2	315
PIB AOC	PADEP 2005	41-PIB	#	2	0 - 10	20050914	42.14621	-80.112775	4.339	98.2	17.9	80.3	1.8		8.8			4	44.8	87.9	94	0.3	55.4	309
PIB AOC	PADEP 2005	42-PIB	#	#	0 - 10	20050914	42.14583	-80.098128	3.029	91.1	7.8	83.3	8.9		5.1			2.6	33.9	67.5	59.9	0.3	46.1	247
PIB AOC	PADEP 2005	46-MB	#	#	0 - 10	20050914	42.15966	-80.087272	8.914	78.6	12.3	66.3	21.3		20.9			2.9	30.3	71.9	58.7	0.2	43.2	217
PIP	PADEP 2005	44-PIB	#	#	0 - 10	20050914	42.15437	-80.123114	9.0255	85.2	7.2	78	14.75		27.8			4.25	38.75	143.5	93.05	0.3	45.85	299.5
PIP	PADEP 2005	45-PIP	#	#	0 - 5	20050914	42.15971	-80.098692	0.215	NR	NR	NR	NR		7.5			<0.5	1.9	<2.5	<5.0	<0.1	3.5	17.5
PIP	PADEP 2005	47-PIP	#	#	0 - 10	20050914	42.15691	-80.078628	7.18	82.3	8.6	73.7	17.7		30.1			4.7	41.7	101	106	0.3	46.8	385
PIP	PADEP 2005	49-TB	#	#	0 - 10	20050914	42.16583	-80.075556	0.0418	1	0.9	0.1	99		2.2			<0.5	1.7	<2.5	<5.0	<0.1	3.4	14.5
LE	PADEP 2005	43-LE	#	#	0 - 10	20050914	42.14912	-80.071492	0.7926	82.8	3.3	79.5	17.3		7.3			<0.5	16.6	30.9	16.6	<0.1	27.1	122
LE	PADEP 2005	48-LE	#	#	0 - 10	20050914	42.15462	-80.061219	0.6989	48.3	6.6	41.7	51.7		3.8			0.8	13.8	21.7	11	<0.1	21	119
Sub-surface samples																								
PIB AOC	PADEP 2005	01-PIB	03	#	10 - 30	20050914	42.13845	-80.122233	4.314	98.6	28.4	70.2	1.4		21.1			6.9	56.3	121	165	1	58.2	466
PIB AOC	PADEP 2005	01-PIB	04	#	30 - 50	20050914	42.13845	-80.122233	2.378	98.7	36.2	62.5	1.3		16.3			0.7	35.4	75.2	91.5	0.8	43	291
PIB AOC	PADEP 2005	01-PIB	05	#	50 - 80	20050914	42.13845	-80.122233	0.7538	90.4	17	73.4	9.6		7			<0.5	8.2	29.2	6.6	<0.1	15.3	117
PIB AOC	PADEP 2005	02-PIB	03	#	10 - 30	20050914	42.1354	-80.099316	4.225	96.2	25	71.2	3.8		23.4			9.9	111	123	140	0.7	56.4	443
PIB AOC	PADEP 2005	02-PIB	04	#	30 - 50	20050914	42.1354	-80.099316	3.96	94.6	21.8	72.8	5.4		20.1			6.8	65.3	126	150	0.7	52.7	461
PIB AOC	PADEP 2005	02-PIB	05	#	50 - 80	20050914	42.1354	-80.099316	2.523	92.7	22.5	70.2	7.4		14.8			2.3	31.3	111	124	1	39.1	377

LE = nearshore areas of Lake Erie; PIB AOC = Presque Isle Bay AOC; PIP = Presque Isle Ponds; TOC = total organic carbon; AFDW = ash free dry weight; S or G = survival or growth

ICDP = Indeno(1,2,3-c,d)pyrene; BKF = Benzo(k)fluoranthene; BGHIP = Benzo(g,h,i)perylene; BAA = Benzo(a)anthracene; BAP = Benzo(a)pyrene; BBF = Benzo(b)fluoranthene; BAP = Benzo(e)pyrene

Summary of Presque Isle Bay sediment chemistry and t														
					Simultaneously Extracted Metals (µmol/g)									
Area	**Study Name**	**Station ID**	**Sample ID**	**Field Rep**	**SE Cadmium**	**SE Copper**	**SE Lead**	**SE Nickel**	**SE Zinc**	**Sum SEM**	**Acid volatile sulfides**	**SEM - AVS (foc)**	**SEM - AVS**
Toxicity Threshold												**1300**	**0**
Surficial samples													
PIB AOC	**PADEP 2003**	01	#	#									
PIB AOC	**PADEP 2003**	05	#	#									
PIB AOC	**PADEP 2003**	07	#	#									
PIB AOC	**PADEP 2003**	08	#	#									
PIB AOC	**PADEP 2003**	08	#	01									
PIB AOC	**PADEP 2003**	09	#	#									
PIB AOC	**PADEP 2003**	14	#	#									
PIB AOC	**PADEP 2003**	15	#	#									
PIB AOC	**PADEP 2003**	18	#	#									
PIB AOC	**PADEP 2003**	20	#	#									
PIB AOC	**PADEP 2003**	25	#	#									
PIB AOC	**PADEP 2003**	25	#	01									
PIB AOC	**PADEP 2003**	28REF	#	#									
PIB AOC	PADEP 2005	01-PIB	01	#	0.042	1.1	0.46	0.71	3.9	6.212	28.8	-442.5549	-22.588
PIB AOC	PADEP 2005	01-PIB	02	#	0.053	1.2	0.53	0.77	4.2	6.753	45.6	-874.3417	-38.847
PIB AOC	PADEP 2005	02-PIB	01	#	0.049	1.2	0.47	0.66	3.8	6.179	13.3	-176.6559	-7.121
PIB AOC	PADEP 2005	02-PIB	02	#	0.059	1.2	0.54	0.69	3.7	6.189	21.9	-368.2841	-15.711
PIB AOC	PADEP 2005	14-PIB	#	#	0.048	1.3	0.54	0.75	4.3	6.938	29.4	-518.1546	-22.462
PIB AOC	PADEP 2005	15-PIB	#	#	0.011	0.73	0.28	0.29	2.8	4.111	27.2	-1063.029	-23.089
PIB AOC	PADEP 2005	16-PIB	#	#	0.046	1.35	0.59	0.75	4.55	7.286	28.1	-483.6528	-20.814
PIB AOC	PADEP 2005	17-PIB	#	#	0.017	0.95	0.41	0.44	3.2	5.017	17.3	-388.9487	-12.283
PIB AOC	PADEP 2005	18-PIB	#	#	0.054	1.4	0.64	0.71	4.4	7.204	17.4	-260.6339	-10.196
PIB AOC	PADEP 2005	19-PIB	#	#	0.04	1.2	0.48	0.72	4.1	6.54	31.5	-3741.007	-24.96
PIB AOC	PADEP 2005	20-PIB	#	#	0.032	0.98	0.4	0.67	3.5	5.582	14.6	-206.6453	-9.018
PIB AOC	PADEP 2005	21-PIB	#	#	0.025	0.79	0.3	0.58	2.8	4.495	20.6	-652.5527	-16.105
PIB AOC	PADEP 2005	22-PIB	#	#	0.016	0.85	0.35	0.52	3	4.736	13.7	-281.4443	-8.964
PIB AOC	PADEP 2005	23-PIB	#	#	0.01	0.29	0.3	0.14	1.3	2.04	0.68	357.8947	1.36
PIB AOC	PADEP 2005	24-PIB	#	#	0.0565	0.97	0.595	0.655	4.45	6.7265	35	-587.3792	-28.2735
PIB AOC	PADEP 2005	25-SR	#	#	0.0019	0.26	0.051	0.09	1.1	1.5029	2.5	-125.2481	-0.9971
PIB AOC	PADEP 2005	26-CC	#	#	0.0058	0.57	0.23	0.22	2.2	3.2258	6.7	-143.0301	-3.4742
PIB AOC	PADEP 2005	27-MC	#	#	0.0084	0.37	0.39	0.15	1.6	2.5184	0.79	417.6897	1.7284
PIB AOC	PADEP 2005	28-PIB	#	#	0.036	0.95	0.36	0.56	3.2	5.106	36.2	-1101.062	-31.094
PIB AOC	PADEP 2005	29-PIB	#	1	0.063	1.5	0.65	0.8	5	8.013	30.2	-454.6516	-22.187
PIB AOC	PADEP 2005	30-PIB	#	2	0.058	1.4	0.59	0.73	4.6	7.378	28.1	-452.1492	-20.722
PIB AOC	PADEP 2005	31-PIB	#	#	0.063	1.4	0.65	0.77	4.9	7.783	29.6	-468.9811	-21.817
PIB AOC	PADEP 2005	32-PIB	#	#	0.022	0.31	0.15	0.29	1.7	2.472	17	-1672.769	-14.528
PIB AOC	PADEP 2005	33-PIB	#	#	0.05	1.25	0.53	0.725	4.25	6.805	25.85	-419.3087	-19.045
PIB AOC	PADEP 2005	34-PIB	#	#	0.032	1.1	0.45	0.65	3.8	6.032	18.4	-297.3077	-12.368
PIB AOC	PADEP 2005	35-PIB	#	#	0.061	1.3	0.55	0.67	4.1	6.681	22.5	-430.5661	-15.819
PIB AOC	PADEP 2005	36-PIB	#	#	0.058	1.3	0.59	0.82	4.7	7.468	36.9	-589.9379	-29.432
PIB AOC	PADEP 2005	37-PIB	#	#	0.022	0.91	0.34	0.6	3.1	4.972	13.4	-231.4113	-8.428

Summary of Presque Isle Bay sediment chemistry and t

					Simultaneously Extracted Metals (µmol/g)								
Area	**Study Name**	**Station ID**	**Sample ID**	**Field Rep**	**SE Cadmium**	**SE Copper**	**SE Lead**	**SE Nickel**	**SE Zinc**	**Sum SEM**	**Acid volatile sulfides**	**SEM - AVS (foc)**	**SEM - AVS**
Surficial Samples continued….													
PIB AOC	PADEP 2005	38-PIB	#	#	0.018	0.67	0.27	0.4	2.2	3.558	19.2	-563.067	-15.642
PIB AOC	PADEP 2005	39-PIB	#	#	0.044	1.3	0.52	0.79	4.3	6.954	46	-714.7355	-39.046
PIB AOC	PADEP 2005	40-PIB	#	1	0.033	1	0.43	0.7	3.7	5.863	17.5	-262.6862	-11.637
PIB AOC	PADEP 2005	41-PIB	#	2	0.034	1	0.44	0.68	3.6	5.754	18.1	-284.5356	-12.346
PIB AOC	PADEP 2005	42-PIB	#	#	0.026	0.93	0.35	0.68	3.3	5.286	22.5	-568.3064	-17.214
PIB AOC	PADEP 2005	46-MB	#	#	0.033	0.82	0.35	0.46	2.7	4.363	129	-1398.216	-124.637
PIP	PADEP 2005	44-PIB	#	#	0.042	1.95	0.52	0.59	4.15	7.252	91	-927.9043	-83.748
PIP	PADEP 2005	45-PIP	#	#	0.00085	0.025	0.016	0.035	0.2	0.27685	0.71	-201.4651	-0.43315
PIP	PADEP 2005	47-PIP	#	#	0.051	1.2	0.59	0.47	4.5	6.811	43.8	-515.1671	-36.989
PIP	PADEP 2005	49-TB	#	#	0.0003	0.021	0.0083	0.045	0.18	0.2546	<0.63	-144.4976	-0.0604
LE	PADEP 2005	43-LE	#	#	0.0049	0.34	0.082	0.32	1.3	2.0469	3.3	-158.0999	-1.2531
LE	PADEP 2005	48-LE	#	#	0.01	0.24	0.067	0.27	1	1.587	11	-1346.831	-9.413
Sub-surface samples													
PIB AOC	PADEP 2005	01-PIB	03	#	0.064	1.5	0.79	0.74	6	9.094	45.3	-99999	-36.206
PIB AOC	PADEP 2005	01-PIB	04	#	0.008	0.91	0.47	0.52	3.6	5.508	11.6	-99999	-6.092
PIB AOC	PADEP 2005	01-PIB	05	#	<0.0035	0.27	0.068	0.35	0.85	1.53975	3.8	-99999	-2.26025
PIB AOC	PADEP 2005	02-PIB	03	#	0.086	1.6	0.63	0.65	5.3	8.266	21	-99999	-12.734
PIB AOC	PADEP 2005	02-PIB	04	#	0.056	1.6	0.69	0.65	5.8	8.796	40.8	-99999	-32.004
PIB AOC	PADEP 2005	02-PIB	05	#	0.017	1.3	0.52	0.45	4.4	6.687	20.9	-99999	-14.213

LE = nearshore areas of Lake Erie; PIB AOC = Presque Is
ICDP = Indeno(1,2,3-c,d)pyrene; BKF = Benzo(k)fluorant

Summary of Presque Isle Bay sediment chemistry and t																									
					Polycyclic Aromatic Hydrocarbons (µg/kg DW)																				
Area	**Study Name**	**Station ID**	**Sample ID**	**Field Rep**	**2-Methyl-naphthalene**	**Acenaph-thene**	**Acenaph-thylene**	**Anthra-cene**	**BAA**	**BAP**	**BBF**	**BEP**	**BGHIP**	**BKF**	**Biphenyl**	**Chrysene**	**Dibenzo(a,h) anthracene**	**Fluoran-thene**	**Fluorene**	**ICDP**	**Naphth-alene**	**Perylene**	**Phenan-threne**	**Pyrene**	**Total PAH**
Toxicity Threshold					**201**	**88.9**	**128**	**845**	**1050**	**1450**						**1290**	**135**	**2230**	**536**		**561**		**1170**	**1520**	**22800**
Surficial samples																									
PIB AOC	**PADEP 2003**	01	#	#		47	68	195	532	626	1026		589	542		653	<17	1189	132	658	105		605	984	5144.5
PIB AOC	**PADEP 2003**	05	#	#		52	95	203	685	866	1470		763	664		784	237	1315	134	823	142		608	1172	6293
PIB AOC	**PADEP 2003**	07	#	#		45	95	181	647	851	1217		751	647		760	208	1294	104	814	136		566	1113	6000
PIB AOC	**PADEP 2003**	08	#	#		15	35	65	245	320	495		310	255		300	<17	485	40	340	60		225	410	2208.5
PIB AOC	**PADEP 2003**	08	#	01		23	52	127	393	526	867		509	382		491	<17	792	92	555	81		353	671	3609.5
PIB AOC	**PADEP 2003**	09	#	#		97	120	311	1199	1521	2528		1262	1045		1468	386	2625	180	1363	176		1075	2217	11375
PIB AOC	**PADEP 2003**	14	#	#		<17	152	297	934	1073	1513		772	797		1025	231	1968	187	854	266		835	1661	8637.5
PIB AOC	**PADEP 2003**	15	#	#		43	86	198	594	733	1056		601	515		716	185	1119	99	663	132		502	1010	5417
PIB AOC	**PADEP 2003**	18	#	#		34	23	109	360	401	596		267	315		447	<17	971	61	288	64		472	757	3707.5
PIB AOC	**PADEP 2003**	20	#	#		26	52	147	405	422	681		345	371		491	<17	784	<17	345	129		379	681	3533
PIB AOC	**PADEP 2003**	25	#	#		73	137	328	1073	1294	1950		969	870		1332	252	2523	195	1031	282		1092	2053	10634
PIB AOC	**PADEP 2003**	25	#	01		69	118	294	931	1121	1781		873	827		1150	229	2173	183	925	239		993	1748	9248
PIB AOC	**PADEP 2003**	28REF	#	#		<17	47	121	282	275	416		195	235		349	<17	463	<17	235	20		181	376	2139.5
PIB AOC	PADEP 2005	01-PIB	01	#		72	48	180	1200	1800	2100	1500	1700	1700		1500	650	2600	120	2200	130	790	990	2200	11490
PIB AOC	PADEP 2005	01-PIB	02	#		58	39	160	760	1100	1100	1000	1100	1300		1200	590	2000	92	1000	58	520	730	1800	8587
PIB AOC	PADEP 2005	02-PIB	01	#		54	23	200	760	1000	1100	900	910	1200		1100	410	2300	89	1300	110	340	770	1900	8716
PIB AOC	PADEP 2005	02-PIB	02	#	140	88	43	190	1100	1300	1400	1100	1000	1000	32	1400	290	2000	130	1500	160	470	780	1800	9421
PIB AOC	PADEP 2005	14-PIB	#	#		36	20	130	450	680	950	620	650	640		730	120	1300	73	830	58	340	570	1100	5267
PIB AOC	PADEP 2005	15-PIB	#	#		270	22	790	2200	2700	2700	2100	2200	2900		3000	400	5800	300	3100	110	870	4200	4500	24292
PIB AOC	PADEP 2005	16-PIB	#	#		61.5	25	255	855	1230	1320	1010	950	1300		1275	200	2350	100	1335	86	440	840	2000	9277.5
PIB AOC	PADEP 2005	17-PIB	#	#		240	27	670	2100	2300	2500	1800	1500	2300		2700	370	5300	290	2200	100	710	2500	4300	20897
PIB AOC	PADEP 2005	18-PIB	#	#		150	34	530	1700	2300	2300	1700	1600	2300		2400	370	4300	210	2300	130	790	1900	3700	17724
PIB AOC	PADEP 2005	19-PIB	#	#		29	16	120	430	580	670	500	460	640		630	100	1200	51	640	51	230	460	1000	4667
PIB AOC	PADEP 2005	20-PIB	#	#		40	24	180	680	960	1100	820	820	1100		990	170	1700	74	1100	65	390	610	1500	6993
PIB AOC	PADEP 2005	21-PIB	#	#		49	24	190	670	850	960	710	650	910		970	140	1700	87	900	79	380	650	1400	6809
PIB AOC	PADEP 2005	22-PIB	#	#		120	26	400	1300	1600	1700	1200	1100	1600		1900	260	3700	180	1600	61	510	1700	3000	14247
PIB AOC	PADEP 2005	23-PIB	#	#		150	28	450	1200	440	1200	940	910	1300		1500	200	3400	180	1300	23	430	2300	2700	12571
PIB AOC	PADEP 2005	24-PIB	#	#		45.5	30	165	725	1100	1340	940	1020	1150		1035	210	1800	74	1300	58.5	475	740	1550	7533
PIB AOC	PADEP 2005	25-SR	#	#		130	3.3	410	550	670	720	500	530	620		750	74	2000	190	630	24	210	1600	1500	7901.3
PIB AOC	PADEP 2005	26-CC	#	#		270	12	790	1200	1200	1300	970	930	1400		1600	210	3300	340	1300	110	390	3400	2600	15032
PIB AOC	PADEP 2005	27-MC	#	#		590	23	1800	2200	2000	2100	1200	1100	1500		2100	280	6200	700	1600	47	590	6400	4700	27040
PIB AOC	PADEP 2005	28-PIB	#	#		28	13	100	380	510	580	440	370	570		570	84	1100	54	480	33	230	440	900	4212
PIB AOC	PADEP 2005	29-PIB	#	1	180	150	80	250	1600	2100	2800	1800	1900	2000	69	2000	380	2700	170	3000	170	890	970	2300	13050
PIB AOC	PADEP 2005	30-PIB	#	2	89	67	32	150	810	1100	1300	960	920	1200	21	1100	250	1700	100	1400	88	480	680	1500	7666
PIB AOC	PADEP 2005	31-PIB	#	#	110	74	39	300	940	1400	1500	1200	1200	1600	23	1400	260	2300	130	1800	120	540	960	2100	10133
PIB AOC	PADEP 2005	32-PIB	#	#	14	9.8	3.8	27	120	160	200	160	140	190	3.1	190	37	280	19	210	13	110	90	250	1213.6
PIB AOC	PADEP 2005	33-PIB	#	#	100	66	34.5	175	955	1350	1650	1150	1150	1350	20.5	1300	250	1900	104	1700	99.5	485	705	1700	8739
PIB AOC	PADEP 2005	34-PIB	#	#		64	32	240	1000	1300	1700	1200	1300	1400		1500	640	2000	110	1100	93	590	880	1700	9559
PIB AOC	PADEP 2005	35-PIB	#	#	99	94	39	180	1300	1600	2000	1300	1300	1500	23	1600	300	2100	130	2000	110	550	840	1800	10192
PIB AOC	PADEP 2005	36-PIB	#	#	82	49	29	130	700	930	1200	840	830	1000	18	950	180	1500	84	1200	79	390	540	1300	6553
PIB AOC	PADEP 2005	37-PIB	#	#		38	22	160	730	1000	1200	910	900	1100		1100	390	2000	86	1300	85	410	580	1700	7891

Summary of Presque Isle Bay sediment chemistry and t

Area	Study Name	Station ID	Sample ID	Field Rep	2-Methyl-naphthalene	Acenaph-thene	Acenaph-thylene	Anthra-cene	BAA	BAP	BBF	BEP	BGHIP	BKF	Biphenyl	Chrysene	Dibenzo(a,h) anthracene	Fluoran-thene	Fluorene	ICDP	Naphth-alene	Perylene	Phenan-threne	Pyrene	Total PAH
					Polycyclic Aromatic Hydrocarbons (µg/kg DW)																				
Surficial Samples continued….																									
PIB AOC	PADEP 2005	38-PIB	#	#		44	21	210	680	840	890	700	660	890		960	280	1900	84	990	63	380	620	1700	7402
PIB AOC	PADEP 2005	39-PIB	#	#		41	29	150	600	880	950	830	890	1100		1000	440	1600	74	800	74	410	680	1400	6968
PIB AOC	PADEP 2005	40-PIB	#	1		41	31	150	660	960	1100	910	1000	1200		1100	470	1600	73	870	88	430	670	1400	7243
PIB AOC	PADEP 2005	41-PIB	#	2		45	29	160	720	1000	1100	970	1100	1200		1200	500	1700	75	920	95	460	750	1500	7774
PIB AOC	PADEP 2005	42-PIB	#	#		51	25	140	700	900	1100	840	810	960		1100	420	1500	86	750	77	500	610	1300	6909
PIB AOC	PADEP 2005	46-MB	#	#		18	24	91	320	450	660	410	430	450		520	100	1000	69	510	47	170	400	800	3839
PIP	PADEP 2005	44-PIB	#	#		23	<170	59.5	270	415	570	395	445	455		505	205	800	48.5	515	50	230	315	660	3351
PIP	PADEP 2005	45-PIP	#	#		<2.9	<2.9	<2.9	4	6.2	11	6.6	6.6	6.9		8.4	<2.9	15	<2.9	8	<2.9	4.7	8.1	13	63.4
PIP	PADEP 2005	47-PIP	#	#		33	39	230	580	720	1200	700	610	720		1000	150	1800	77	760	80	280	650	1500	6859
PIP	PADEP 2005	49-TB	#	#		<2.4	<2.4	<2.4	<2.4	2.4	3.6	2.8	<2.4	<2.4		2.5	<2.4	3.9	<2.4	2.4	<2.4	2.5	<2.4	3.3	21.7
LE	PADEP 2005	43-LE	#	#		30	15	150	360	380	400	310	290	400		510	130	1000	68	430	120	190	480	830	4073
LE	PADEP 2005	48-LE	#	#		20	11	74	230	230	300	210	190	230		330	110	440	39	180	36	190	230	380	2130
Sub-surface samples																									
PIB AOC	PADEP 2005	01-PIB	03	#		42	37	180	480	490	520	480	460	500		630	280	840	74	410	85	670	430	730	4298
PIB AOC	PADEP 2005	01-PIB	04	#		25	20	110	310	380	530	370	380	350		470	190	670	52	350	49	920	310	560	3146
PIB AOC	PADEP 2005	01-PIB	05	#		<23	<23	<23	16	13	29	34	27	22		73	8.7	39	7	17	<23	580	48	37	287.7
PIB AOC	PADEP 2005	02-PIB	03	#		110	54	270	890	1100	1500	1000	920	1000		1400	570	1900	150	870	130	550	1200	1600	9374
PIB AOC	PADEP 2005	02-PIB	04	#		110	85	430	1100	1400	1600	1200	1100	1200		1700	700	2300	230	1000	240	770	1800	1900	11995
PIB AOC	PADEP 2005	02-PIB	05	#		35	30	160	460	470	550	420	430	440		580	270	840	65	390	65	610	450	730	4155

LE = nearshore areas of Lake Erie; PIB AOC = Presque Is

ICDP = Indeno(1,2,3-c,d)pyrene; BKF = Benzo(k)fluorant

Summary of Presque Isle Bay sediment chemistry and t

							PEC Quotients (Ingersoll *et al.* 2001)				Toxicity Results										
Area	**Study Name**	**Station ID**	**Sample ID**	**Field Rep**	**ESG-TUs$_{FCV}$**	**tPCB (µg/kg DW)**	**tPAH-Q**	**tPCB-Q**	**Metals-Q**	**Mean PEC-Q**	***C. dilutus* Survival (%)**		***C. dilutus* Growth (AFDW; mg)**		***H. azteca* Survival (%)**		***H. azteca* Growth (length; mm)**		***C. dilutus* S or G**	***H. azteca* S or G**	**Overall Toxicity**
Toxicity Threshold					**1.0**	**676**				**1.0**											
Surficial samples																					
PIB AOC	**PADEP 2003**	01	#	#	0.417		0.226		0.728	0.477											
PIB AOC	**PADEP 2003**	05	#	#	0.433		0.276		1.04	0.658											
PIB AOC	**PADEP 2003**	07	#	#	0.417		0.263		0.985	0.624											
PIB AOC	**PADEP 2003**	08	#	#	0.227		0.0969		0.779	0.438											
PIB AOC	**PADEP 2003**	08	#	01	0.499		0.158		0.823	0.491											
PIB AOC	**PADEP 2003**	09	#	#	0.814		0.499		0.940	0.719											
PIB AOC	**PADEP 2003**	14	#	#	0.864		0.379		0.745	0.562											
PIB AOC	**PADEP 2003**	15	#	#	0.510		0.238		0.766	0.502											
PIB AOC	**PADEP 2003**	18	#	#	0.418		0.163		0.196	0.179											
PIB AOC	**PADEP 2003**	20	#	#	0.287		0.155		0.626	0.39											
PIB AOC	**PADEP 2003**	25	#	#	0.928		0.466		0.645	0.556											
PIB AOC	**PADEP 2003**	25	#	01	0.866		0.406		0.627	0.516											
PIB AOC	**PADEP 2003**	28REF	#	#	0.112		0.0938		0.342	0.218											
PIB AOC	PADEP 2005	01-PIB	01	#	0.671	190.548	0.504	0.282	0.680	0.489	73	NT	0.21	T	98	NT	3.31	NT	T	NT	T
PIB AOC	PADEP 2005	01-PIB	02	#	0.547	287.3094	0.377	0.425	0.763	0.521	85	NT	0.88	NT	95	NT	3.33	NT	NT	NT	NT
PIB AOC	PADEP 2005	02-PIB	01	#	0.581	230.145	0.382	0.340	0.709	0.477	93	NT	0.97	NT	93	NT	3.09	NT	NT	NT	NT
PIB AOC	PADEP 2005	02-PIB	02	#	0.641	442.803	0.413	0.655	0.827	0.632	80	NT	0.68	NT	93	NT	2.87	T	NT	T	T
PIB AOC	PADEP 2005	14-PIB	#	#	0.376	246.7275	0.231	0.365	0.691	0.429	75	NT	0.89	NT	98	NT	4.07	NT	NT	NT	NT
PIB AOC	PADEP 2005	15-PIB	#	#	2.69	56.2599	1.07	0.0832	0.330	0.493	78	NT	0.93	NT	98	NT	3.53	NT	NT	NT	NT
PIB AOC	PADEP 2005	16-PIB	#	#	0.616	168.30735	0.407	0.249	0.744	0.467	85	NT	1.73	NT	90	NT	3.38	NT	NT	NT	NT
PIB AOC	PADEP 2005	17-PIB	#	#	1.67	151.90575	0.917	0.225	0.465	0.535	95	NT	0.72	NT	98	NT	3.06	NT	NT	NT	NT
PIB AOC	PADEP 2005	18-PIB	#	#	1.24	171.453	0.777	0.254	0.757	0.596	85	NT	0.72	NT	93	NT	3.45	NT	NT	NT	NT
PIB AOC	PADEP 2005	19-PIB	#	#	2.01	268.2345	0.205	0.397	0.707	0.436	98	NT	0.87	NT	98	NT	3.33	NT	NT	NT	NT
PIB AOC	PADEP 2005	20-PIB	#	#	0.469	215.7735	0.307	0.319	0.548	0.391	63	T	0.77	NT	95	NT	3.41	NT	T	NT	T
PIB AOC	PADEP 2005	21-PIB	#	#	0.788	276.7569	0.299	0.409	0.434	0.381	85	NT	0.93	NT	100	NT	3.19	NT	NT	NT	NT
PIB AOC	PADEP 2005	22-PIB	#	#	1.13	114.1881	0.625	0.169	0.409	0.401	80	NT	0.44	T	95	NT	3.47	NT	T	NT	T
PIB AOC	PADEP 2005	23-PIB	#	#	8.33	56.8227	0.551	0.0841	0.216	0.284	100	NT	0.93	NT	88	NT	3.64	NT	NT	NT	NT
PIB AOC	PADEP 2005	24-PIB	#	#	0.469	105.1431	0.330	0.156	0.805	0.43	93	NT	0.72	NT	95	NT	3.22	NT	NT	NT	NT
PIB AOC	PADEP 2005	25-SR	#	#	2.18	26.733	0.347	0.0395	0.203	0.197	73	NT	1.45	NT	98	NT	3.6	NT	NT	NT	NT
PIB AOC	PADEP 2005	26-CC	#	#	1.45	80.5608	0.659	0.119	0.289	0.356	93	NT	0.87	NT	93	NT	3.9	NT	NT	NT	NT
PIB AOC	PADEP 2005	27-MC	#	#	15.8	73.4253	1.19	0.109	0.289	0.528	90	NT	0.83	NT	93	NT	3.82	NT	NT	NT	NT
PIB AOC	PADEP 2005	28-PIB	#	#	0.438	124.3788	0.185	0.184	0.521	0.296	88	NT	0.83	NT	95	NT	3.58	NT	NT	NT	NT
PIB AOC	PADEP 2005	29-PIB	#	1	0.823	483.807	0.572	0.716	0.859	0.716	95	NT	0.85	NT	98	NT	3.23	NT	NT	NT	NT
PIB AOC	PADEP 2005	30-PIB	#	2	0.521	1097.259	0.336	1.62	0.850	0.936	90	NT	0.67	NT	95	NT	3.08	NT	NT	NT	NT
PIB AOC	PADEP 2005	31-PIB	#	#	0.671	678.576	0.444	1.00	0.864	0.771	98	NT	0.97	NT	98	NT	3.27	NT	NT	NT	NT
PIB AOC	PADEP 2005	32-PIB	#	#	0.492	70.7319	0.0532	0.105	0.260	0.139	80	NT	0.74	NT	98	NT	3.65	NT	NT	NT	NT
PIB AOC	PADEP 2005	33-PIB	#	#	0.588	473.2545	0.383	0.700	0.767	0.617	80	NT	0.29	T	98	NT	4.14	NT	T	NT	T
PIB AOC	PADEP 2005	34-PIB	#	#	0.663	365.418	0.419	0.541	0.643	0.534	88	NT	0.93	NT	93	NT	3.42	NT	NT	NT	NT
PIB AOC	PADEP 2005	35-PIB	#	#	0.828	666.315	0.447	0.986	0.772	0.735	75	NT	0.59	T	90	NT	3.51	NT	T	NT	T
PIB AOC	PADEP 2005	36-PIB	#	#	0.412	280.6965	0.287	0.415	0.795	0.499	93	NT	0.75	NT	90	NT	3.51	NT	NT	NT	NT
PIB AOC	PADEP 2005	37-PIB	#	#	0.597	150.1671	0.346	0.222	0.505	0.358	85	NT	1.71	NT	88	NT	3.36	NT	NT	NT	NT

Summary of Presque Isle Bay sediment chemistry and t

							PEC Quotients (Ingersoll *et al.* 2001)				Toxicity Results										
Area	**Study Name**	**Station ID**	**Sample ID**	**Field Rep**	**ESG-TUs$_{FCV}$**	**tPCB (µg/kg DW)**	**tPAH-Q**	**tPCB-Q**	**Metals-Q**	**Mean PEC-Q**	***C. dilutus* Survival (%)**		***C. dilutus* Growth (AFDW; mg)**		***H. azteca* Survival (%)**		***H. azteca* Growth (length; mm)**		***C. dilutus* S or G**	***H. azteca* S or G**	**Overall Toxicity**
Surficial Samples continued….																					
PIB AOC	PADEP 2005	38-PIB	#	#	0.703	113.5449	0.325	0.168	0.374	0.289	93	NT	0.89	NT	95	NT	3.41	NT	NT	NT	NT
PIB AOC	PADEP 2005	39-PIB	#	#	0.373	197.6835	0.306	0.292	0.723	0.44	88	NT	1.62	NT	98	NT	3.33	NT	NT	NT	NT
PIB AOC	PADEP 2005	40-PIB	#	1	0.48	310.5048	0.318	0.459	0.656	0.478	98	NT	0.59	T	93	NT	2.97	T	T	T	T
PIB AOC	PADEP 2005	41-PIB	#	2	0.523	240.597	0.341	0.356	0.659	0.452	83	NT	0.93	NT	95	NT	3.32	NT	NT	NT	NT
PIB AOC	PADEP 2005	42-PIB	#	#	0.649	160.56885	0.303	0.238	0.484	0.342	93	NT	0.89	NT	98	NT	3.33	NT	NT	NT	NT
PIB AOC	PADEP 2005	46-MB	#	#	0.13	31.7781	0.168	0.0470	0.542	0.252	95	NT	0.62	T	85	NT	4.66	NT	T	NT	T
PIP	PADEP 2005	44-PIB	#	#	0.117	215.6127	0.147	0.319	0.762	0.409	95	NT	0.52	T	98	NT	4.37	NT	T	NT	T
PIP	PADEP 2005	45-PIP	#	#	0.105	2.80998	0.00278	0.00416	0.0618	0.0229	93	NT	0.76	NT	95	NT	3.84	NT	NT	NT	NT
PIP	PADEP 2005	47-PIP	#	#	0.28	29.65152	0.301	0.0439	0.791	0.379	88	NT	0.58	T	95	NT	3.53	NT	T	NT	T
PIP	PADEP 2005	49-TB	#	#	0.2	1.07133	0.000952	0.00158	0.0374	0.0133	88	NT	1.31	NT	95	NT	3.88	NT	NT	NT	NT
LE	PADEP 2005	43-LE	#	#	1.41	63.3954	0.179	0.0938	0.226	0.166	95	NT	1.24	NT	100	NT	3.19	NT	NT	NT	NT
LE	PADEP 2005	48-LE	#	#	1.02	67.9782	0.0934	0.101	0.189	0.128	80	NT	0.66	NT	95	NT	3.38	NT	NT	NT	NT
Sub-surface samples											95		0.7		90		3.18				
PIB AOC	PADEP 2005	01-PIB	03	#	0.415	249.843	0.189	0.370	0.978	0.512	95	NT	0.86	NT	98	NT	3.14	NT	NT	NT	NT
PIB AOC	PADEP 2005	01-PIB	04	#	0.53	43.3959	0.138	0.0642	0.527	0.243	73	NT	1.09	NT	90	NT	2.94	T	NT	T	T
PIB AOC	PADEP 2005	01-PIB	05	#	0.414	3.59388	0.0126	0.00532	0.165	0.0609	70	T	1.3	NT	93	NT	3.29	NT	T	NT	T
PIB AOC	PADEP 2005	02-PIB	03	#	0.721	628.929	0.411	0.930	1.11	0.816	90	NT	0.9	NT	95	NT	3.01	T	NT	T	T
PIB AOC	PADEP 2005	02-PIB	04	#	1.02	610.3365	0.526	0.903	0.953	0.794	90	NT	0.77	NT	90	NT	2.94	T	NT	T	T
PIB AOC	PADEP 2005	02-PIB	05	#	0.666	23.8587	0.182	0.0353	0.647	0.288	93	NT	0.79	NT	98	NT	2.88	T	NT	T	T

LE = nearshore areas of Lake Erie; PIB AOC = Presque Is

ICDP = Indeno(1,2,3-c,d)pyrene; BKF = Benzo(k)fluorant

Appendix B – Calculations for Effluent Modeling

AOC avg concentration acute Contaminant	Actual Bulk Sediment Conc q (mg/kg)	Carrier Water Conc. C_c (ug/l)	Back-ground Conc. C_B (ug/l)	Predicted Leachable Sediment Conc q^*_{sed} (mg/kg)	Predicted Slurry Conc including carrier water q^*_{sl} (mg/kg)	Predicted Conc at the point of CDF Discharge $C_{eff\ 1}$ (ug/l)	Predicted Sediment Pore Water Conc C_{sed} (ug/l)	Predicted Conc at the point of CDF Discharge $C_{eff\ 2}$ (ug/l)	Predicted Conc at the point of CDF Discharge C_{eff} (ug/l)	Predicted Conc at the Mixing Zone Boundary C_P (ug/l)	Target Screening Criteria at the Mixing Zone Boundary C_T (ug/l)	Ratio: Effluent at the Mixing Zone to Target Screening Criteria
Entered by user on sheet "ChemData"				Effluent Computations								
Metals												
Barium		17.000	17.000	NA	NA	NA	NA	NA	NA	NA	21000.000	
Cadmium	5.708	13.000	13.000	0.572	0.626	15.788	14.122	13.121	15.788	13.016	13.000	1.001
Lead	79.070	1.000	1.000	7.923	7.927	26.457	26.365	3.745	26.457	1.149	79.000	0.015
Mercury	0.276	1.000	1.000	0.011	0.015	0.153	0.110	0.904	0.904	0.999	1.440	0.694
Nickel	42.754	50.000	50.000	1.714	1.920	27.573	24.306	47.220	47.220	49.984	550.000	0.091
PAH's												
Acenaphthene	0.087	0.000	0.000	0.087	0.087	0.536	0.533	0.058	0.536	0.003	83.000	0.000
Acenaphthylene	29.603	0.000	0.000	29.603	29.603	154.747	154.038	16.667	154.747	0.905	NA	NA
Anthracene	0.272	0.000	0.000	0.272	0.272	0.556	0.555	0.060	0.556	0.003	NA	NA
Benzo(a)anthracene	0.839	0.000	0.000	0.839	0.839	0.559	0.558	0.060	0.559	0.003	0.500	0.007
Benzo(a)pyrene	1.046	0.000	0.000	1.046	1.046	0.644	0.644	0.070	0.644	0.004	NA	NA
Chrysene	1.164	0.000	0.000	1.164	1.164	0.775	0.775	0.084	0.775	0.005	NA	NA
Dibenzo(a,h)anthracene	0.261	0.000	0.000	0.261	0.261	0.152	0.152	0.016	0.152	0.001	NA	NA
Fluoranthene	2.094	0.000	0.000	2.094	2.094	1.787	1.785	0.193	1.787	0.010	200.000	0.000
Fluorene	0.124	0.000	0.000	0.124	0.124	0.435	0.434	0.047	0.435	0.003	NA	NA
Phenanthrene	1.097	0.000	0.000	1.097	1.097	2.397	2.392	0.259	2.397	0.014	5.000	0.003
Pyrene	1.744	0.000	0.000	1.744	1.744	1.643	1.642	0.178	1.643	0.010	NA	NA
Total PAHs	8.847	0.000	0.000	8.847	8.847	5.428	5.426	0.587	5.428	0.032	NA	NA
PCB Congeners												
PCB Total	0.219		0.000	0.219	NA	NA	0.135	NA	NA	NA	NA	NA

Entered by user on sheet "ChemData"				Effluent Computations								Ratio
AOC avg concentration chronic Contaminant	Actual Bulk Sediment Conc q (mg/kg)	Carrier Water Conc. C_c (ug/l)	Back-ground Conc. C_B (ug/l)	Predicted Leachable Sediment Conc q^*_{sed} (mg/kg)	Predicted Slurry Conc including carrier water q^*_{sl} (mg/kg)	Predicted Conc at the point of CDF Discharge $C_{eff\ 1}$ (ug/l)	Predicted Sediment Pore Water Conc C_{sed} (ug/l)	Predicted Conc at the point of CDF Discharge $C_{eff\ 2}$ (ug/l)	Predicted Conc at the point of CDF Discharge C_{eff} (ug/l)	Predicted Conc at the Mixing Zone Boundary C_P (ug/l)	Target Screening Criteria at the Mixing Zone Boundary C_T (ug/l)	Effluent at the Mixing Zone to Target Screening Criteria
Metals												
Barium		17.000	17.000	NA	NA	NA	NA	NA	NA	NA	4100.000	
Cadmium	5.708	0.000	0.000	0.572	0.572	14.436	14.122	1.528	14.436	0.023	2.600	0.009
Lead	79.070	1.000	1.000	7.923	7.927	26.457	26.365	3.745	26.457	1.041	3.100	0.336
Mercury	0.276	1.000	1.000	0.011	0.015	0.153	0.110	0.904	0.904	1.000	1.000	1.000
Nickel	42.754	50.000	50.000	1.714	1.920	27.573	24.306	47.220	47.220	49.996	61.000	0.820
PAH's												
Acenaphthene	0.087	0.000	0.000	0.087	0.087	0.536	0.533	0.058	0.536	0.001	17.000	0.000
Acenaphthylene	29.603	0.000	0.000	29.603	29.603	154.747	154.038	16.667	154.747	0.250	NA	NA
Anthracene	0.272	0.000	0.000	0.272	0.272	0.556	0.555	0.060	0.556	0.001	NA	NA
Benzo(a)anthracene	0.839	0.000	0.000	0.839	0.839	0.559	0.558	0.060	0.559	0.001	0.100	0.009
Benzo(a)pyrene	1.046	0.000	0.000	1.046	1.046	0.644	0.644	0.070	0.644	0.001	NA	NA
Chrysene	1.164	0.000	0.000	1.164	1.164	0.775	0.775	0.084	0.775	0.001	NA	NA
Dibenzo(a,h)anthracene	0.261	0.000	0.000	0.261	0.261	0.152	0.152	0.016	0.152	0.000	NA	NA
Fluoranthene	2.094	0.000	0.000	2.094	2.094	1.787	1.785	0.193	1.787	0.003	40.000	0.000
Fluorene	0.124	0.000	0.000	0.124	0.124	0.435	0.434	0.047	0.435	0.001	NA	NA
Phenanthrene	1.097	0.000	0.000	1.097	1.097	2.397	2.392	0.259	2.397	0.004	1.000	0.004
Pyrene	1.744	0.000	0.000	1.744	1.744	1.643	1.642	0.178	1.643	0.003	NA	NA
Total PAHs	8.847	0.000	0.000	8.847	8.847	5.428	5.426	0.587	5.428	0.009	NA	NA
PCB Congeners												
PCB Total	0.219		0.000	0.219	NA	NA	0.135	NA	NA	NA	n/a	NA

Entered by user on sheet "ChemData"				Effluent Computations								Ratio
AOC avg concentration human health Contaminant	Actual Bulk Sediment Conc q (mg/kg)	Carrier Water Conc. C_c (ug/l)	Back-ground Conc. C_B (ug/l)	Predicted Leachable Sediment Conc q^*_{sed} (mg/kg)	Predicted Slurry Conc including carrier water q^*_{sl} (mg/kg)	Predicted Conc at the point of CDF Discharge $C_{eff\ 1}$ (ug/l)	Predicted Sediment Pore Water Conc C_{sed} (ug/l)	Predicted Conc at the point of CDF Discharge $C_{eff\ 2}$ (ug/l)	Predicted Conc at the point of CDF Discharge C_{eff} (ug/l)	Predicted Conc at the Mixing Zone Boundary C_P (ug/l)	Target Screening Criteria at the Mixing Zone Boundary C_T (ug/l)	Effluent at the Mixing Zone to Target Screening Criteria
Metals												
Barium		17.000	17.000	NA	NA	NA	NA	NA	NA	NA	2400.000	
Cadmium	5.708	0.000	0.000	0.572	0.572	14.436	14.122	1.528	14.436	0.023	NA	NA
Lead	79.070	1.000	1.000	7.923	7.927	26.457	26.365	3.745	26.457	1.041	NA	NA
Mercury	0.276	1.000	1.000	0.011	0.015	0.153	0.110	0.904	0.904	1.000	1.000	1.000
Nickel	42.754	50.000	50.000	1.714	1.920	27.573	24.306	47.220	47.220	49.996	NA	NA
PAH's												
Acenaphthene	0.087	0.000	0.000	0.087	0.087	0.536	0.533	0.058	0.536	0.001	1200.000	0.000
Acenaphthylene	29.603	0.000	0.000	29.603	29.603	154.747	154.038	16.667	154.747	0.250	NA	NA
Anthracene	0.272	0.000	0.000	0.272	0.272	0.556	0.555	0.060	0.556	0.001	9600.000	0.000
Benzo(a)anthracene	0.839	0.000	0.000	0.839	0.839	0.559	0.558	0.060	0.559	0.001	0.004	0.205
Benzo(a)pyrene	1.046	0.000	0.000	1.046	1.046	0.644	0.644	0.070	0.644	0.001	0.004	0.237
Chrysene	1.164	0.000	0.000	1.164	1.164	0.775	0.775	0.084	0.775	0.001	0.004	0.285
Dibenzo(a,h)anthracene	0.261	0.000	0.000	0.261	0.261	0.152	0.152	0.016	0.152	0.000	0.004	0.056
Fluoranthene	2.094	0.000	0.000	2.094	2.094	1.787	1.785	0.193	1.787	0.003	300.000	0.000
Fluorene	0.124	0.000	0.000	0.124	0.124	0.435	0.434	0.047	0.435	0.001	1300.000	0.000
Phenanthrene	1.097	0.000	0.000	1.097	1.097	2.397	2.392	0.259	2.397	0.004	NA	NA
Pyrene	1.744	0.000	0.000	1.744	1.744	1.643	1.642	0.178	1.643	0.003	960.000	0.000
Total PAHs	8.847	0.000	0.000	8.847	8.847	5.428	5.426	0.587	5.428	0.009	NA	NA
PCB Congeners												
PCB Total	0.219		0.000	0.219	NA	NA	0.135	NA	NA	NA	*0.000*	NA