REVISED DRAFT
FOCUSED FEASIBILITY STUDY
FOR
DIVISION STREET OUTFALL

MUSKEGON, MICHIGAN

Prepared for

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Great Lakes National Program Office
77 West Jackson Boulevard
Chicago, Illinois 60604

Prepared by

WESTON SOLUTIONS, INC.
750 East Bunker Court, Suite 500
Vernon Hills, Illinois 60061

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START Project Manager	Tonya Balla
Telephone No.	(847) 918-4000
U.S. EPA Task Monitor	Scott Cieniawski

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ACRONYMS

AOC	Area of Concern
ARAR	Applicable or Relevant and Appropriate Requirement
AWRI	Annis Water Resource Institute
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	Contaminant of Concern
CY	Cubic Yard
DRO	Diesel Range Organics
DSO	Division Street Outfall
ENR	Enhanced Natural Recovery
FFS	Focused Feasibility Study
GLLA	Great Lakes Legacy Act
GLNPO	Great Lakes National Program Office
GLWQA	Great Lakes Water Quality Agreement
GRA	General Response Actions
IC	Institutional Control
MDEQ	Michigan Department of Environmental Quality
MNR	Monitored Natural Recovery
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPDES	National Pollution Discharge Elimination System
ORO	Oil Range Organics
O&M	Operation and Maintenance
OSWER	Office of Solid Waste and Emergency Response
PAC	Public Advisory Committee
PAH	Polyaromatic Hydrocarbons
POTW	Publicly Owned Treatment Works
RAO	Remedial Action Objectives
RI/FS	Remedial Investigation/Feasibility Study
START	Superfund Technical Assessment and Response Team
SARA	Superfund Amendments and Reauthorization Act
SOW	Statement of Work
TCLP	Toxicity Characteristic Leaching Procedure
U.S. EPA	United States Environmental Protection Agency

1. INTRODUCTION

The United States Environmental Protection Agency (U.S. EPA) tasked the Weston Solutions, Inc., (WESTON®) Superfund Technical Assessment and Response Team (START) with preparing a Focused Feasibility Study (FFS) for the Division Street Outfall (DSO) Site of Muskegon Lake in Muskegon, Michigan. The U.S. EPA Great Lakes National Program Office (GLNPO) issued a Scope of Work (SOW), dated October 2007, to prepare the FFS for remedial alternatives to address contaminated sediment at the DSO (Site) (Figure 1-1). Work is being conducted at the Site under a project agreement between GLNPO and the Michigan Department of Environmental Quality (MDEQ) under the Great Lakes Legacy Act.

WESTON® has prepared this FFS in accordance with the *Draft Work Plan for a Focused Feasibility Study for Remedial Alternatives for Contaminated Sediments* (WESTON, 2007). WESTON has based this FFS on the initial screening results for the remedial alternatives presented in the *Technical Memorandum – Initial Screening of Remedial Alternatives for Division Street Outfall, Muskegon, Michigan* (WESTON, 2008) and on conference calls held between GLNPO, MDEQ, and WESTON. The Draft Technical Memorandum was issued as a standalone document; the Final Technical Memorandum, which incorporates GLNPO's and MDEQ's comments, is presented in Appendix A of this report.

1.1 PURPOSE AND ORGANIZATION OF REPORT

WESTON has prepared the FFS to present a detailed analysis of the remedial alternatives that were retained from the initial screening process of proposed alternatives and to present a recommended remediation alternative for the Site.

The FFS contains 5 sections and 4 appendices. Section 1 presents an introduction, including the scope, purpose, background information, remedial action objectives (RAOs), the nature and extent of contamination, summary of Site risks and exposure pathways, and the Applicable or Relevant and Appropriate Requirements (ARARs). Section 2 summarizes the results of the initial screening of remedial alternatives, which are presented in more detail in Appendix A.

Section 3 presents the detailed analysis of alternatives based on the screening criteria selected by GLNPO and MDEQ, including detailed descriptions, cost estimates, and screening results of each alternative. Section 4 compares the remedial alternatives based on the selected screening criteria and presents the recommended alternative for the Site. Section 5 includes references cited in this FFS.

1.2 BACKGROUND INFORMATION

1.2.1 Site Location and Description

The Site is located within the Muskegon Lake Area of Concern (AOC) and within the Muskegon River watershed. Figure 1-2 shows the location of the Site and the surrounding area. The AOC program is part of the Great Lakes Water Quality Agreement (GLWQA; Annex 2 of the 1987 Protocol) that was established between the United States (U.S.) and Canada. An AOC is defined as *geographic areas that fail to meet the general or specific objectives of the agreement where such failure has caused or is likely to cause impairment of beneficial use of the area's ability to support aquatic life*.

Muskegon Lake empties into Lake Michigan approximately five miles west of the Site. The DSO, located on the southern shore of Muskegon Lake, is the location of historic releases of contamination to Muskegon Lake. Storm water from industrial facilities was reportedly discharged into the Division Street Outfall from 1900 through 1975. Due to an apparent reduction in point source pollution, it is believed the DSO currently releases only storm water to Muskegon Lake.

1.2.2 Site Reconnaissance Visit

In accordance with the *Draft Work Plan for a Focused Feasibility Study for Remedial Alternatives for Contaminated Sediments* (WESTON, 2007), WESTON personnel attended a Site reconnaissance visit to the DSO area and the shoreline of Muskegon Lake. This visit was conducted on November 14, 2007 and included representatives from WESTON, GLNPO, MDEQ, city officials, and other stakeholders. The purpose of the Site visit was to identify logistical considerations on which to evaluate the remedial alternatives. Logistical considerations included but were not limited to access to the work areas, available areas for staging material, and local businesses surrounding the Site. A summary of the Site reconnaissance visit is included in Appendix B.

1.2.3 Site History

Over the past several years, state and federal agencies have worked with the local public advisory committee (PAC) to evaluate and address potential risks posed by sediment in Muskegon Lake near the DSO. Several investigations have been conducted by various agencies since the 1990's to evaluate the concerns associated with the DSO area.

The following information on previous sampling activities was obtained from reports provided by the MDEQ –Water Bureau, including *Preliminary Investigation of the Extent of Sediment Contamination in Muskegon Lake* (Rediske et. al., 2002) and *Sediment Survey of Three Tributaries of Muskegon Lake* (Gannett Fleming of Michigan, Inc., August 2004).

U.S. EPA conducted an initial investigation as summarized in *Muskegon Lake Area of Concern: Division Street Outfall, 1994 Sediment Assessment* (U.S. EPA, 1995). Sample results from the U.S. EPA investigation indicated high levels of lead, mercury, cadmium, copper, and zinc in the sediment at the DSO.

A second investigation, *White Lake and Muskegon Lake Watershed Study* (Rediske, 1995), detected similar levels of metals as the initial U.S. EPA investigation; as well as elevated concentrations of polycyclic aromatic hydrocarbon (PAH) compounds. Laboratory bioassays were conducted using DSO sediment and showed toxicity to amphipods. In addition, the study noted an impaired benthic macroinvertebrate community.

Additional sediment sampling in Muskegon Lake near the DSO occurred in 1999, and elevated levels of metals, including mercury, and sediment toxicity were documented in the *Preliminary Investigation of the Extent of Sediment Contamination in Muskegon Lake* (Rediske et. al., 2002).

From 2005 through 2008, GLNPO and MDEQ conducted sampling to further define the extent of contamination in Muskegon Lake sediment near the DSO. Locations of sediment samples collected throughout this investigation period are shown on Figure 1-3. During the 2005 investigation, GLNPO and MDEQ collected surficial sediment samples, sub-surficial sediment samples, and storm sewer water samples to further delineate the extent of contamination near the DSO. The sediment samples were analyzed for PAHs, PCBs, Michigan 10 Metals, oil and grease, percent (%) solids, total organic carbon (TOC), geotechnical parameters, and tested for toxicity. Data collected during the 2005 investigation activities are summarized in the *Final Data Evaluation Report for Ryerson Creek and Division Street Outfall* (WESTON, August 2006). The results of the 2005 investigation indicated elevated metals and PAH contaminant concentrations in sediment above the effects-based Sediment Quality Guidelines as well as toxicity to benthic organisms.

During the 2006 and early 2007 investigation, GLNPO and MDEQ collected additional sediment samples near the DSO to further determine contaminant levels both at the outfall and lakeward of the outfall. Later in 2007, additional investigative work was conducted to further delineate the lateral and horizontal extent of mercury contamination in sediment, classify the sediment as hazardous or non-hazardous based on Toxicity Characteristic Leaching Procedure (TCLP) metals analysis, and gather geotechnical data. The 2006 samples were analyzed for PAHs and Michigan 10 Metals. The 2007 samples were analyzed for PAHs, Michigan 10 Metals, oil and grease, % solids, TOC, TCLP PAHs, TCLP semi-volatile organic compounds (SVOCs), and TCLP metals.

In 2008, GLNPO and MDEQ continued the investigation at the Site to delineate the full horizontal and vertical extent of contaminants of concern (COCs) in sediment; evaluate the presence and levels of ongoing sources of sediment contamination through collection of box core samples; and evaluate background, surficial sediment concentrations for the Site. The sediment samples were analyzed for PAHs, Oil Range Organics (ORO), Diesel Range Organics (DRO), oil and grease, and TOC.

The aforementioned investigations narrowed down the primary DSO COCs to be the following:

- Mercury; and,
- Total PAHs.

Although there is reportedly no on-going point source contamination at the DSO, the MDEQ is conducting an evaluation to refute the existence of continued point source contamination. The MDEQ will provide a source control evaluation report; the source control evaluation report will be included as Appendix C of this FFS.

1.3 DEVELOPMENT OF REMEDIAL ACTION OBJECTIVES

Remedial Action Objectives (RAOs) are specific goals for protecting human health and the environment that typically specify the contaminant(s) and media of concern, the potential exposure pathway, and an acceptable contaminant concentration or range of concentrations for each exposure pathway. RAOs developed for the protection of environmental receptors typically seek to restore or preserve a resource; therefore, these RAOs apply target contaminant levels to each medium of interest. RAOs can be achieved by limiting or eliminating the exposure pathway and/or by reducing contaminant concentrations. GLNPO has developed Site-specific RAOs for the major COCs in sediment at the Site, which are listed in the table below.

Table 1-1. Remedial Action Objectives

CONTAMINANT	PROPOSED TARGET
Mercury	1 mg/kg
Total PAHs	48 mg/kg

Notes:
mg/kg - Milligram per kilogram

The rationale for selecting these RAOs is presented in the January 15, 2008 Memorandum from GLNPO to MDEQ, which is included in Appendix A. The values included in Table 1-1 are final values for mercury and PAHs. The RAOs are consistent with the delisting goals for the Muskegon Lake AOC and are protective of human health and the environment.

1.4 EXTENT OF CONTAMINATION

The approximate extent of contamination was determined using the analytical results from the 2005 through 2008 sampling events. The sampling locations are shown on Figure 1-3. The areal extent of mercury contamination above the cleanup objective is estimated to be 46.4 acres. Figure 1-4 presents the mercury exceedances. Figure 1-5 presents the PAH exceedances. Based on information provided by GLNPO, the mercury RAO was used to calculate the total mass and area for removal. Based on the extent of mercury contamination, the total volume of contaminated sediment at the Site is estimated to be 161,760 cubic yards (cy), which includes a 25% contingency.

The analytical results and RAO exceedances for the 2005 - 2008 investigations are included in Table 1-2.

It should be noted that sampling location HSM 7, which is identified on Figure 1-5, exceeds the PAH RAO but did not exceed the mercury RAO. Sampling location HSM 7 should be considered for remedial action, even though it is not in an area exceeding mercury RAOs.

1.5 SUMMARY OF SITE RISKS AND EXPOSURE PATHWAYS

Exposure pathways at the Site include surface water, lake sediment, and fish consumption.

1.5.1 Human Health Risks

The COC concentrations at the Site do not pose an imminent human health risk. Ingestion of contaminated fish from Muskegon Lake poses a human health risk due to the accumulation and magnification of some COCs in fish tissue (fat, skin, and/or muscle); as such, fish consumption advisories are currently in place and published yearly.

1.5.2 Ecological Risk

The investigations discussed in Subsection 1.2.3 documented metals and PAH contaminant concentrations in DSO area sediment above effects-based Sediment Quality Guidelines. The concurrent and subsequent laboratory bioassays documented toxicity to benthic organisms as a result of contamination in DSO area sediment. The compromised health of the benthic community, the availability and persistence of the COCs, and the bioaccumulation/magnification of mercury in the food chain pose a risk to the overall aquatic health of the DSO area and Muskegon Lake.

GLNPO developed the RAO targets based on the adverse effects on aquatic life from the two primary COCs. GLNPO considered the need for protection of the benthic community; toxicity thresholds for mercury and bioaccumulation in fish species; and previously established guidance in developing the RAO targets to be protective of the overall aquatic health.

1.6 REGULATORY AND PERMITTING REQUIREMENTS

Actions conducted under the Great Lakes Legacy Act (GLLA) must comply with all applicable federal environmental or state environmental or facility citing laws.

Regulatory and permitting requirements governing remedial action at the Site are presented in detail in Appendix D.

2. IDENTIFICATION AND INITIAL SCREENING OF REMEDIAL ALTERNATIVES

2.1 GENERAL RESPONSE ACTIONS

General response actions (GRAs) are actions that will satisfy the RAOs described previously, which are then used to develop the remedial alternatives. The GRAs for the Site are listed below. A more detailed description of the GRAs is given in the *Draft Technical Memorandum – Initial Screening of Remedial Alternatives for Divisions Street Outfall* (WESTON, 2008), which is included as Appendix A.

- ***No Action*** – provides a baseline for comparison with other alternatives and is required by the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) for the FS process.
- ***Institutional Controls*** – minimize human exposure to the identified COCs through actions such as legal controls to ensure appropriate land or resource use but do not address reducing the toxicity, mobility, or volume of contamination.
- ***Containment*** – limits or controls the migration of contaminants beyond the present area of contamination into adjacent areas but does not contribute to reducing the toxicity or volume of contamination.
- ***Collection*** – removes contaminated media to facilitate treatment or disposal actions but does not contribute to reducing the toxicity, mobility, or the volume of contamination.
- ***Treatment*** – uses processes implemented in-situ, ex-situ, onsite, or offsite to reduce the toxicity, mobility, or volume of contaminants in the affected media.
- ***Disposal*** (in association with collection and/or treatment actions) – determines the ultimate location of treated or untreated media in an environmentally sound, publicly acceptable, and cost-effective manner.

2.2 SCREENING CRITERIA

The criteria that were used for the initial screening of alternatives consisted of effectiveness, implementability, and cost, although the screening was weighted towards the first two criteria. Cost was not a significant factor for eliminating alternatives during the initial screening. A summary of these criteria is provided below and presented in the *Draft Technical Memorandum – Initial Screening of Remedial Alternatives for Division Street Outfall* (WESTON, 2008) (Appendix A).

The initial screening criteria included:

- Effectiveness Criterion – was used to evaluate the short- and long-term effectiveness of the alternatives in protecting human health and the environment. Short-term effectiveness refers to the construction and implementation period; long-term effectiveness refers to the period after the remedial action is complete.

- Implementability Criterion – was used to evaluate each alternative with respect to its technical and administrative feasibility and the availability of necessary technologies and services. Technical feasibility refers to the ability to construct, reliably operate, and meet technology-specific regulations for process options. Administrative feasibility refers to the ability to obtain approvals from other offices and agencies; the availability of treatment, storage, and disposal services and capacity; and the requirements for and availability of specific equipment and technical specialists. Public acceptance may also factor in to the administrative feasibility of an alternative.

- Cost Criterion – was used to identify alternatives that are significantly more costly than other alternatives that achieve the same effectiveness. Absolute accuracy of cost estimates during this stage of screening is not essential. Rather, costs for each alternative are relative to the other alternatives. For preliminary screening purposes, the costs were qualitatively classified as low, moderate, or high. The cost estimates for the various alternatives during this stage were based on engineering judgment, unit costs provided by vendors, and costs of other similar projects.

2.3 INITIAL SCREENING OF ALTERNATIVES

The initial screening of alternatives based on the criteria of effectiveness, implementability, and cost is presented in the *Draft Technical Memorandum – Initial Screening of Remedial Alternatives for Division Street Outfall* (WESTON, 2008), which is included in this FFS as Appendix A.

Based on the results of the initial screening, the remedial alternatives listed below were retained for detailed analysis, which is presented in the following section.

- Alternative 1 – No Action
- Alternative 2 – Institutional Controls (IC) and Monitored Natural Recovery (MNR)
- Alternative 3 – Enhanced Natural Recovery
- Alternative 4 – In-Situ Capping
- Alternative 5a – Mechanical Dredging and Disposal

- Alternative 5b – Hydraulic Dredging and Disposal
- Alternative 6 – Dredging, Soil Washing, and Beneficial Reuse
- Alternative 7 – Dredging and Enhanced Natural Recovery

The alternative screening was performed consistently with the "Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA" (Office of Solid Waste and Emergency Response [OSWER] Directive 9355.3-01, 1998).

3. DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

This section presents the detailed analysis of the remedial alternatives that were developed and retained from the *Draft Technical Memorandum – Initial Screening of Remedial Alternatives for Division Street Outfall* (WESTON, 2008). The objective of the detailed analysis is to present sufficient information to compare the remedial alternatives and provide a basis for remedy selection consistent with the selection criteria. This analysis follows the format of the U.S. EPA Remedial Investigation/Feasibility Study (RI/FS) guidance (U.S. EPA, 1988).

3.1 DESCRIPTION OF ALTERNATIVES

Remedial alternatives were described as part of the initial screening process in the *Draft Technical Memorandum – Initial Screening of Remedial Alternatives for Division Street Outfall* (WESTON, 2008). Those alternatives that were retained from the initial screening are developed in further detail in the subsections below. As mentioned in the *Draft Technical Memorandum – Initial Screening of Remedial Alternatives for Division Street Outfall* (WESTON, 2008), only technologies that would remediate or control contaminated media remaining at the Site (i.e. sediment) or associated technologies were included in the remedial alternatives, with the exception of No Action. Examples of associated technologies would include dewatering and water treatment.

3.1.1 Alternative 1 – No Action

The No Action alternative is carried forward to the detailed analysis phase to provide a baseline comparison with the other alternatives. The no action alternative means that no remedial action would be undertaken at the Site. The Site would remain in its current state, and no actions would be conducted to remove, isolate, or remediate the contamination. Under the no action response, long-term monitoring would not be used to assess changes in contaminant concentrations within affected media. No additional access or deed restrictions would be implemented.

3.1.2 Alternative 2 – Institutional Controls and Monitored Natural Recovery

Alternative 2 consists of ICs and MNR. MNR is a remedy that typically uses known, ongoing, naturally occurring processes to contain, destroy, or otherwise reduce the bioavailability or toxicity of contaminants in sediment (U.S. EPA, 2005). MNR is based on risk management to permanently reduce risk to the environment. Although burial by clean sediment is often the dominant process relied upon for natural recovery, multiple physical, biological, and chemical mechanisms frequently act together to reduce risk. During MNR, natural sedimentation occurs by various processes to isolate the contaminated sediment. These processes occur through the following media (Davis et al, 2004):

- ***Water:*** surface water hydraulics and hydrodynamics, groundwater flow, and pore water flow.
- ***Solids:*** deposition, consolidation, burial, re-suspension, vertical mixing, advection, and decay.
- ***Contaminants:*** advection, dispersion, partitioning, decay/transformation, volatilization, diffusion, and biological processes.

Several components are recommended to evaluate the effectiveness of MNR, including data assessment, modeling, and site monitoring (Davis et al, 2004). These components would provide the appropriate empirical evaluation of the remedy. As part of Alternative 2, sediment sampling would periodically be performed to monitor contaminant concentrations and sediment depths. In addition, a Site model would be developed using the collected data. Data analysis and calculations and the Site model would then be used to assess the continued effectiveness of MNR as a permanent alternative as well as reducing the remaining risk to the environment.

In accordance with the U.S. EPA's *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites*, evaluation of MNR for this alternative would be based on Site-specific data, including multiple lines of evidence. Such evidence could include trends of decreasing contaminant levels in fish, surface water, and sediment. Long-term stability of the sediment bed and the mobility of contaminants within it would also be evaluated. Contingency measures would be included as part of this Alternative if there is significant uncertainty that the RAOs would be achieved within the predicted time frame.

ICs would be included with Alternative 2 to limit human exposure to contaminants. Common institutional controls at sediment sites include fish consumption advisories, commercial fishing bans, and waterway use restrictions (U.S. EPA, 2005). For costing purposes, an IC plan was added to the operational costs under MNR. There currently are fish consumption advisories in Muskegon Lake for the following fish: carp, largemouth bass, northern pike, smallmouth bass, and walleye.

Typically, source control may also be necessary to meet the requirements of the GLLA. MDEQ is reviewing historic land use maps and aerial photographs to determine if there are any likely ongoing sources of contamination to the Site. Although there is reportedly no on-going point source contamination at the DSO, the MDEQ is conducting an evaluation to refute the existence of continued point source contamination. The MDEQ will provide a source control evaluation report; the source control evaluation report will be included as Appendix C of this FFS.

3.1.3 Alternative 3 – Enhanced Natural Recovery

In some instances, MNR may be the most appropriate remedy, however, the rate of sedimentation or other natural processes may be insufficient to reduce risks within an acceptable time frame. Where this is the case, the recovery process may be accelerated by engineering means, such as adding a thin layer of clean sand or sediment over the contaminated sediment. This process is called Enhanced Natural Recovery (ENR). ENR is typically different than in-situ caps because it is not designed to provide long-term isolation of contaminants from benthic organisms (U.S. EPA, 2005).

Alternative 3 is similar to MNR and contains the same basic components as part of the remedy; these include sampling, data assessment, and modeling. However, ENR also includes the addition of a 12-inch sand layer, or other comparable barrier, to the existing sediment layer. This sand cover would physically isolate the contaminated sediment from the surrounding environment once it is placed, instead of waiting for natural environmental processes to deposit a layer of sediment. The sand cover would be added over the entire area that has sediment concentrations exceeding the RAOs. Additional contaminated material could be deposited on top of the sand cover if a point source remains. Although there is reportedly no on-going point source contamination at the DSO, the MDEQ is conducting an evaluation to refute the existence of continued point source contamination.

For the purpose of this report, a 12-inch sand layer was assumed for use as the sand layer for ENR. The sand cap would be installed using mechanical means and would be placed in lifts of 2-inches to prevent settling in preferential areas. A pre-cover and post-cap survey would also be conducted to determine the bathymetry of the lake bed prior to sand cap installation and after the installation is complete. Macro invertebrate sampling would be conducted along with toxicity testing to monitor the effectiveness of the sand cap. An annual survey would be performed to determine if the sand cap is eroding. If erosion has occurred, sand cap replacement would be conducted and a post survey would also be conducted to illustrate final bathymetry. The sand cover erosion factor could be influenced by marina traffic and/or anchoring causing movement of the cover. Annual surveys should be conducted to evaluate the thickness of remaining cover.

3.1.4 Alternative 4 – In-Situ Capping

The in-situ capping alternative involves placement of a covering or cap of clean isolating material over a deposit of contaminated sediment to isolate it physically and chemically from the aquatic environment. Caps are typically constructed of clean sediment, sand, or gravel. However, geotextiles or liners can also be included. Reactive material, such as organic carbon, can also be added to attenuate the flux of contaminants into the overlying water (U.S. EPA, 2005). Depending on the contaminants and sediment conditions present, a cap is generally designed to reduce risk through the following functions:

- Physical isolation of the contaminated sediment to reduce direct contact and ability of burrowing organisms to move contaminants to the cap surface;
- Stabilization of contaminated sediment and protection from erosion to reduce re-suspension and transport of contaminants into the water column; and
- Chemical isolation of contaminated sediment to reduce exposure from dissolved contaminants that may be transported into the water column.

As part of Alternative 4, a low-permeability, sub-aqueous cap would be placed over the areas of sediment that have concentrations exceeding the RAOs. The cap material investigated for this report is called AquaBlok. The intent of the cap is to minimize the potential for contact with the contaminated sediment, either by human or ecological receptors, as well as reducing the contaminant flux from the sediment to the overlying water column within Muskegon Lake. The AquaBlok is installed and then a sand cap is placed over the AquaBlok. A pre-cap and post-cap survey would be conducted prior to and after the installation of the AquaBlok and sand cap to show the new bathymetry after installation. Macro invertebrate sampling would be conducted along with toxicity testing to monitor the effectiveness of the sand cap. Institutional controls would be implemented at the Site in the form of craft advisories to prevent potential damage to the cap.

3.1.5 Alternative 5a – Mechanical Dredging and Disposal

Dredging is one of the most common means of removing contaminated sediment from a water body. Dredging refers to the removal of sediment from the bottom of a body of water, typically using floating cranes and/or excavators called dredges. Dredging involves mechanically grabbing, raking, cutting, or hydraulically scouring the bottom of a waterway to dislodge the sediment. Once dislodged, the sediment may be removed from a waterway either mechanically with buckets or hydraulically by pumping. Therefore, dredging may be categorized as either mechanical or hydraulic, depending on the basic means of removing the dredged material. Dredging requires transporting sediment to a location for treatment and/or disposal, and frequently includes treatment of water from dewatered sediment prior to discharge to an appropriate receiving water body (U.S. EPA, 2005).

Mechanical dredging removes the sediment at nearly the same solids content and volume as the in-situ material. Minimal amounts of water become entrained with the sediment as it is removed. Therefore, the volume of contaminated sediment and process water to be disposed, managed, and/or treated is minimized. However, the water that is present in the bucket with the sediment must either be collected or be permitted to be discharged from the bucket. If the water is collected, it must be managed, treated, and disposed. If the water is permitted to discharge from the bucket, higher contaminant losses occur during dredging (U.S. EPA, 2005).

As part of Alternative 5a, all contaminated sediment having concentrations exceeding mercury RAOs would be mechanically dredged and disposed-of at an offsite location. GLNPO used areas that exceeded the mercury RAO to calculate an approximate contaminant volume and area for the FFS, areas onsite that exceed mercury RAOs also exceed RAOs for PAHs (with the exception of location HSM 7), and include the majority of the contaminant mass.

For the purpose of this report, the sediment removal method evaluated for mechanical dredging was removal with a clam shell bucket, polymer addition, and gravity dewatering. Water collected during sediment dewatering was assumed to be treated using carbon filtration and disposed of into the local publicly owned treatment works (POTW) or through obtaining a National Pollutant Discharge Elimination System (NPDES) permit. After dewatering, the sediment would be shipped to a Type II Landfill and disposed of as a regulated Type II non-hazardous waste, assuming the dewatered sediment samples meet the disposal criteria. A conceptual process flow diagram of mechanical dredging is included in Figure 3-1. Landfill requirements include TCLP sampling and a moisture content requirement prior to disposal at the landfill. Sampling requirements during dredging operations would include landfill disposal sampling, POTW/NPDES-required discharge sampling, and monitoring, including confirmation sampling, and site inspections. A pre- and post-treatment survey would be conducted at the Site to confirm that the desired depths had been reached during dredging. Figure 3-2 shows a conceptual plan of dredge areas based on the mercury RAO.

<u>Monitoring Plan</u>

The monitoring that would be required for the Site following dredging would include:

- Grided confirmation sampling for mercury and PAHs; and
- Site inspections.

The monitoring would be conducted at the Site to assess the following criteria (U.S. EPA, 2005):

- Compliance with design and performance standards;
- Short-term remedy performance and effectiveness in meeting sediment cleanup levels; and
- Long-term effectiveness in achieving RAOs and in reducing risk to human health and the environment.

Following the dredging, confirmation sampling would be conducted to verify that RAOs have been met in the dredged areas. Long-term monitoring after dredging would include site visits and invertebrate sampling. Additional long-term monitoring could include the collection of chemical and/or physical field data to determine if there is residual contamination at the Site.

3.1.6 Alternative 5b – Hydraulic Dredging and Disposal

Alternative 5b is similar to Alternative 5a, except that as part of Alternative 5b, all contaminated sediment having concentrations exceeding RAOs would be hydraulically dredged instead of mechanically dredged. The extent of dredging for Alternative 5b would be the same extent as for Alternative 5a (Figure 3-2) to provide an accurate comparison of methods. All components of the two alternatives would remain the same, except the dredging method and associated technologies related to the method of dredging. For example, both alternatives would include performance monitoring but the methods for sediment handling, staging, and dewatering may also differ due to the varying solids content of the sediment produced by each method.

Hydraulic dredging removes and transports sediment as a slurry by adding water during the removal process. As a result, the total volume of material processed may be greatly increased and the solids content of the slurry may be considerably less than that of the in-situ sediment (U.S. EPA, 1994). The excess water would be treated and discharged as effluent through the POTW or NDPES permit. Hydraulic dredges may be equipped with rotating blades, augers, or high-pressure water jets to loosen the sediment (U.S. EPA, 1995).

For the purpose of this report hydraulic dredging was evaluated using two different sediment dewatering methods. Dewatering with Geotubes ® and dewatering using a DEL Tank screening system. Geotubes were used for the purpose of the cost estimate. The FFS assumes that the location of the dewatering and staging area would be the same as mechanical dredging, thereby ensuring comparable cost estimating. Water treatment and disposal, sediment transportation, and disposal methods are also considered to be the same. A conceptual flow diagram of the hydraulic dredging process is illustrated in Figure 3-3. The monitoring plan for hydraulic dredging would be the same as mechanical dredging. Though the methods for removing the sediment differ, there is still the risk of suspended sediment recontaminating remediated areas; therefore post-dredging confirmation sampling is required.

3.1.7 Alternative 6 – Dredging, Soil Washing, and Beneficial Reuse

Alternative 6 consists of dredging all contaminated sediment having concentrations exceeding mercury RAOs and treating the sediment ex-situ by soil washing. Mechanical dredging was chosen to be representative of dredging for this alternative. However, hydraulic dredging could also be considered. Other ex-situ treatments may also be considered during the design phase; however, soil washing was chosen because it is currently the most likely ex-situ treatment method to be implemented for the Site.

Generally, sediment washing is an ex-situ, water-based, extraction technology that is capable of removing organic pollutants and metals from sediment. Sediment washing is generally considered a media transfer technology. The contaminated water generated from sediment washing is further treated with technologies suitable for the contaminants. This process can be implemented using an on-site mobile treatment system. The material that can be treated includes gravel, sand, silt, and clay. Sediment washing can be effective on a range of contaminants, including metals, and other organic and inorganic pollutants. The cleaning process can remove 85% to 99% of the contamination.

Chemicals, surfactants, air, and water are added during various stages of the washing process to destroy or separate out contaminants from the sediment. The end result is treated sediment that can be backfilled or reused elsewhere. For Alternative 6, treated sediment would be considered for beneficial reuse. Some examples of beneficial reuse include backfill, highway berm placement, and road subgrade.

Byproducts of the process include oversized materials from screening, sludges from treatment, floatable organic contaminants, and contaminated water. The contaminated water, which carries the remaining contaminants separated from the sediment, can be treated through various other ex-situ treatment methods or sent to a POTW for treatment.

Typical equipment for sediment washing include a truck mounted washing unit, sediment processor, sediment washing unit, hydrocyclones, shaker screens, water treatment equipment, tanks, water blasters, compressors, and earth moving equipment. Figure 3-4 presents a conceptual flow diagram of the sediment washing process. A complete bench scale treatability study is recommended before applying this technology as a remedial solution (Federal Remediation Technologies Roundtable).

The FFS assumes that mechanical dredging would be used for Alternative 6, soil washing would be performed by BioGenesis, and the transportation and beneficial reuse would be neither a cost savings nor a cost sink for this work. Therefore, no cost is provided for the beneficial reuse portion of the alternative. All other assumptions remain the same for monitoring as discussed in the dredging section.

3.1.8 Alternative 7 – Dredging and Disposal with Enhanced Natural Recovery

Alternative 7 is a combination of previous alternatives (i.e. mechanical dredging, off-site disposal, and ENR). As part of Alternative 7, the contaminated sediment with mercury concentrations greater than 2 mg/kg would be mechanically dredged and disposed at an off-site location, followed by placement of a 6-inch sand cover over the dredged area. Alternative 7 also includes a 12-inch sand cover over the areas having sediment concentrations that exceed the mercury RAO of 1 mg/kg that were not removed through dredging. A conceptual plan for Alternative 7 is illustrated in Figure 3-5.

For brevity, all possible combinations of alternatives are not presented (e.g. dredging method and treatment versus disposal). However, hydraulic dredging could also be considered. Alternatives 5a and 5b present a comparison of mechanical and hydraulic dredging. In addition, the sediment could be considered for ex-situ treatment and beneficial reuse. Alternative 6 presents an analysis of ex-situ treatment of sediment and beneficial reuse.

The monitoring for the area after remedial activities are complete would be a combination of confirmation sampling in dredged areas and macro invertebrate sampling, surveying, and monitoring in all areas. The monitoring plan would be a combination of the plans used for dredging and ENR.

3.2 SCREENING CRITERIA

The screening criteria selected for the detailed analysis of the alternatives were based on the nine criteria developed as part of the NCP and are also included in the U.S. EPA RI/FS guidance document (U.S. EPA, 1988) as well as guidance from GLNPO and MDEQ. The evaluation criteria selected for the detailed analysis of the alternatives include the following:

- Short-Term Effectiveness;
- Long-Term Effectiveness and Permanence;
- Implementability;
- Cost;
- Short-Term Impacts;
- Long-Term Impacts; and
- Community Acceptance.

3.2.1 Short-Term Effectiveness

This evaluation criterion examines the effectiveness of the alternatives in protecting human health and the environment during the construction and implementation of a remedy until RAOs have been met. This criterion also evaluates the time required to implement and achieve the RAOs. The following considerations can be applied to each alternative:

- Protection of the community from any risk that results from implementation of proposed remedial actions.
- Protection of workers from any threats that may be posed during remedial actions and the effectiveness and reliability of protective measures that would be taken.
- Environmental impacts that may result from the implementation of an alternative and a corresponding evaluation of available mitigation measures.
- The time required to achieve RAOs.

3.2.2 Long-Term Effectiveness and Permanence

This criterion evaluates the long-term effectiveness of alternatives in maintaining protection of human health and the environment after the remedial action has been implemented and the RAOs have been achieved. The following factors are considered in the long-term effectiveness:

- Magnitude of the residual risks remaining at the completion of remedial activities.
- Adequacy and long-term reliability of management and technical controls for providing continued protection from the residual risks.

3.2.3 Implementability

The implementability criterion evaluates the technical and administrative feasibility of the alternatives as well as the availability of goods and services that are required to implement the remedy. This criterion involves analysis of the alternatives for the following factors:

- Ability to construct the technology and the reliability of its operation.
- Ease of undertaking additional remediation, if necessary.
- Ability to adequately monitor migration and exposure pathways.
- Availability of services and materials.
- Coordination between agencies.

3.2.4 Cost

This assessment evaluates the capital cost and operation and maintenance (O&M) costs of each alternative. In addition, the present worth of annualized costs associated with each alternative is calculated using an annualized discount rate of 7% before taxes and after inflation. Costs are compared on a present-worth basis in year 2008 dollars. The level of detail employed in developing these estimates is appropriate for comparison of alternatives, but the estimates are not intended for use in budgetary planning.

Cost estimates for the alternatives were prepared primarily by contacting potential materials suppliers and other contractors and by using construction estimating resources. The costs were estimated from the information available at the time of the estimate. Whenever possible, more than one supplier was contacted to estimate the costs; therefore, the costs would be within the desired range of accuracy of +50 to -30 % of the actual final cost. Final costs would depend on actual labor and material costs, actual Site conditions, market conditions, final project scope, engineering between the feasibility study and final design, final project schedule, productivity, and other variable factors. As a result, the final costs would vary from the estimates presented in this report; however, most of these factors should not affect the relative cost differences between the alternatives.

Total capital costs consist of the direct and indirect costs required to initiate and implement a remedial action. Direct costs include costs for construction, labor, and materials. Indirect costs consist of engineering, permitting, supervising, and other similar services. Construction contingencies account for unknown costs, which include a variety of factors that would tend to increase costs associated with a given project scope, such as bidding climate, adverse weather conditions, availability of materials, contractors' uncertainty regarding liability and insurance, regulatory or policy changes that may affect FFS assumptions, and geotechnical unknowns. Contingencies do not include allowances for price inflation and unforeseeable, abnormal technical difficulties.

The present-worth cost represents the amount of money that, if invested in the current year and disbursed as needed, would be sufficient to cover all costs associated with the remedial action over its planned life. In conducting the present-worth analysis, the FFS assumes a discount rate of 7% and operating life of 30 years or less (depending on the time required for an alternative to achieve the RAOs). The 30-year period is based on the U.S. EPA RI/FS guidance (U.S. EPA, 1988). For perpetuity, the present worth of the incremental cost after 30 years is very small.

3.2.5 Short-Term Impacts

Short-term impacts evaluate the impact of the remedial alternative that directly affects human health or the environment. The short-term impacts can be physical, chemical, and ecological.

3.2.6 Long-Term Impacts

Long-term impacts evaluate the impact of the remedial alternative that can affect human health or the environment long after the work has been completed. The long-term impacts can be physical, chemical, and ecological.

3.2.7 Community Acceptance

The community acceptance criterion evaluates the community's apparent preferences and/or concerns regarding the alternatives. The community is provided with an opportunity to review the FFS Report during a 30-day public comment period. During and after the public comment period, U.S. EPA and/or MDEQ typically receive comments by mail. The public is also given the opportunity to express concerns and comments during a public meeting, which is usually held during the 30-day public comment period.

3.3 ANALYSIS OF ALTERNATIVES

3.3.1 Alternative 1 – No Action

Alternative 1 consists of no action and is assessed based on the screening criteria in the following paragraphs.

3.3.1.1 Short-Term Effectiveness

Alternative 1 would not be effective in the short-term because this alternative does not include institutional controls to prevent the public from being exposed to contaminated sediment or monitoring that would evaluate the effectiveness of the natural recovery processes to ensure protectiveness over time. The sedimentation rate of Muskegon Lake is approximately 1,700 grams per square meter per year ($g/m^2/yr$), which is fairly high compared to other inland lakes in the state of Michigan (Parsons et. al., 2004), natural sedimentation still requires many years for a protective layer of uncontaminated sediment to accumulate over the contaminated sediments and achieve the RAOs. Research for the report titled *Inland Lakes Sediment Trends: Sediment Analysis Results for Five Michigan Lakes* indicates that the minimum number of years needed to deposit approximately 2 centimeters (cm) of new sediment in Muskegon Lake is 2 years (Parsons et. al., 2004), which corresponds to a rate of 1 cm per year (0.4 inches per year). At this rate, it would take 30 years to deposit a 1-foot layer of uncontaminated sediments over the top of the contaminated sediments, which would not be effective in the short-term. Further, Alternative 1 does not include any contingency actions to be implemented if the natural recovery processes are not performing as anticipated, or if Site conditions change to the extent that these processes are no longer protective. Therefore, the short-term effectiveness of this alternative can not be assured.

3.3.1.2 Long-Term Effectiveness and Permanence

Alternative 1 does not provide long-term effectiveness and permanence. Chemical concentrations in the sediment may decrease over time due to natural processes. However, because this alternative does not require any cleanup levels or include monitoring or contingency actions, the long-term effectiveness and permanence of this alternative can not be assured.

3.3.1.3 Implementability

Alternative 1 could be easily implemented because there are no associated activities to perform.

3.3.1.4 Cost

There is no cost associated with Alternative 1 since no remedial activities would be implemented.

3.3.1.5 Short-Term Impacts

There would be no short-term impacts associated with Alternative 1 since no remedial activities would be implemented.

3.3.1.6 Long-Term Impacts

Long-term impacts associated with Alternative 1 would include continued exposure risk for recreational lake users and marine workers. There would be continued ecological risk to benthic organisms and a continued risk to organisms in the food chain.

3.3.1.7 Community Acceptance

Alternative 1 would be evaluated for this criterion following U.S. EPA receipt of formal comments regarding the FFS Report. However, it is unlikely that the community would accept Alternative 1.

3.3.2 Alternative 2 – Institutional Controls and Monitored Natural Recovery

Alternative 2 consists of ICs and MNR and is assessed based on the screening criteria in the following paragraphs.

3.3.2.1 Short-Term Effectiveness

Alternative 2 is not expected to be effective at reducing short-term risk, because MNR monitors the natural recovery of the system, which takes place over many years. Therefore, MNR is not effective in the short-term.

3.3.2.2 Long-Term Effectiveness and Permanence

Alternative 2 is not expected to be effective at reducing long-term risk within an acceptable time period because MNR relies on ongoing, naturally occurring processes to contain, destroy, or otherwise reduce the bioavailability or toxicity of contaminants in sediment. Although the sedimentation rate of Muskegon Lake is approximately 1,700 grams per square meter per year ($g/m^2/yr$), which is fairly high compared to other inland lakes in the state of Michigan (Parsons et. al., 2004), natural sedimentation still requires many years for a protective layer of uncontaminated sediment to accumulate over the contaminated sediment and achieve the RAOs. Research for the report titled *Inland Lakes Sediment Trends: Sediment Analysis Results for Five Michigan Lakes* (Michigan State University [MSU], 2000) indicates that the minimum number of years needed to deposit approximately 2 centimeters (cm) of new sediment in Muskegon Lake is 2 years (Parsons et. al., 2004), which corresponds to a rate of 1 cm per year (0.4 inches per year). At this rate, it would take 30 years to deposit a 1-foot layer of uncontaminated sediment over the top of the contaminated sediment, assuming no ongoing source of contamination is present. Re-suspension of sediment due to heavy use of the harbor and marina may also reduce effectiveness and increase the time to naturally deposit a 1-foot sediment cover. Thirty years or more are unlikely to be an acceptable time frame to meet the RAOs. In addition, the COCs are resistant to degradation.

3.3.2.3 Implementability

The active components of Alternative 2 mainly consist of sampling, monitoring, and modeling. Therefore, this alternative would be relatively easy to implement technically. However, another important component of Alternative 2 is the implementation of ICs, such as continued fish consumption advisories, commercial fishing bans, and waterway use restrictions. Because these types of institutional controls would most likely restrict future public use of an active marina, the ICs likely would not be acceptable to the public. As a result, this alternative would be difficult to implement administratively.

3.3.2.4 Cost

There are minimal capital costs associated with Alternative 2, such as the costs to implement ICs. O&M costs for this alternative would consist of periodic sediment sampling and analysis, bathymetric surveys, evaluation of data, maintaining sample database, modeling of natural processes, and reporting. O&M costs are anticipated to be moderate.

As shown in Table 3-1, the total present worth for this alternative is $24,300.

3.3.2.5 Short-Term Impacts

Alternative 2 would not have any short-term impacts because there is no construction work associated with this task.

3.3.2.6 Long-Term Impacts

Long-term impacts for Alternative 2 could include reduced usage of the marina due to bans and waterway use restrictions.

3.3.2.7 Community Acceptance

It is likely that Alternative 2 would not be accepted by the public. One important component of Alternative 2 is the implementation of ICs, such as continued fish consumption advisories, commercial fishing bans, and waterway use restrictions. These types of ICs would most likely restrict future public use of an active marina, and therefore, would not be acceptable to the public.

3.3.3 Alternative 3 – Enhanced Natural Recovery

Alternative 3 consists of sampling, data assessment, modeling, and the addition of a 12-inch sand cover (or other comparable barrier) to the existing sediment layer. Alternative 3 is assessed based on the screening criteria in the following paragraphs.

3.3.3.1 Short-Term Effectiveness

A barrier would be installed between contaminated sediment and water/contact, therefore reducing the risk of contact with contaminated sediment and contamination of the water column for the short term. Unlike Alternative 2, which would be minimally effective at reducing short-term risk, Alternative 3 would be moderately effective at reducing short-term risk due to the installation of the sand cover.

3.3.3.2 Long-Term Effectiveness and Permanence

Alternative 3 would be more likely to provide acceptable reduction of long-term risk than Alternative 2 because Alternative 3 includes installation of a sand cover over the contaminated sediment rather than relying completely on natural processes to deposit uncontaminated sediment. However, re-suspension of sediment due to heavy use of the harbor or marina could reduce the effectiveness of Alternative 3. In addition, the COCs are resistant to degradation. Alternative 3 is expected to be minimally to moderately effective at reducing long-term risk.

3.3.3.3 Implementability

Alternative 3 would be easy to implement technically; materials for cover are readily available and easily placed, especially in nearshore ares with shallower water depths. Further, this alternative would likely include the same sampling, monitoring, and modeling that Alternative 2 includes, which is also relatively easy to implement technically.

However, Alternative 3 would be more complicated to implement administratively because adding sand cover would decrease the water depth of the harbor, which could impact future use. In addition, ICs may be required, such as waterway use restrictions to protect the sand cover. ICs could potentially restrict future public use of the marina. As a result, it likely would not be accepted by the public. As a result, this alternative would be difficult to implement administratively.

3.3.3.4 Cost

The capital costs for Alternative 3 would consist of placing a sand cover over the contaminated sediment and possibly implementing ICs. The total capital costs would be relatively low. O&M costs would include periodic maintenance of the sand cover by adding sand, if necessary. Also, many of the O&M costs associated with Alternative 2 would also apply to Alternative 3, including periodic sediment sampling and analysis, bathymetric surveys, evaluation of data, maintaining sample database, modeling of natural processes, and reporting. O&M costs are anticipated to be moderate.

As shown in Table 3-2, the total present worth for this alternative is $8,465,500.

3.3.3.5 Short-Term Impacts

Short-term impacts for Alternative 3 include closing of the cover area to the public during installation and increased turbidity of the water during the cover installation. The work at the Site would close off areas of the lake and use restrictions would start to take affect. The installation of the sand cover could release small amounts of contaminated sediment into the water column and then that sediment could settle on top of the clean sand.

3.3.3.6 Long-Term Impacts

Long-term impacts for Alternative 3 include the formation of ICs for the Site including waterway use restrictions. Based on cap thickness and current use of the waterway, only minor impacts to current navigation use at the site are expected. Due to possible erosion of the sand cap, the risk could increase again over time if the sand cap is not monitored and protected properly.

3.3.3.7 Community Acceptance

ICs may be required, such as waterway use restrictions to protect the sand cover. ICs could potentially restrict future public use of the marina. As a result, it would likely not be accepted by the public.

3.3.4 Alternative 4 – In-Situ Capping

Alternative 4 consists of placing a cover or cap of clean, isolating material over the contaminated sediment to isolate it physically and chemically from the aquatic environment. Alternative 4 is assessed based on the screening criteria in the following paragraphs.

3.3.4.1 Short-Term Effectiveness

Alternative 4 would likely provide a high level of short-term risk reduction during and after the cap is installed, assuming that the cap adequately covers the extent of contaminated sediment. Because the cap is a semi-impermeable layer there will be almost immediate isolation of the contaminated sediment. Additionally, cap materials could be designed with features that enhance the aquatic diversity of the Site, some examples of those features include as seeds to provide vegetation, microbes to expedite biodegradation, and carbon sources to promote a habitat for benthic organisms. These features would be effective in the short-term.

3.3.4.2 Long-Term Effectiveness and Permanence

Alternative 4 would provide an even greater level of reduction of long-term risk than Alternative 3 because Alternative 4 includes installation of a low-permeability, sub-aqueous cap over the contaminated sediment to isolate it physically and chemically from the aquatic environment, whereas Alternative 3 includes installation of just a sand cover. Not only would the cap minimize the potential for contact with the contaminated sediment, but it would also reduce the contaminant flux from the sediment to the overlying water column within Muskegon Lake. The cap may also potentially reduce the methylation of mercury, thus reducing the potential flux of bio-available mercury into the water column, as discussed in *"Observations of Mercury Fate and Transport Beneath a Sediment Cap"* (Liu et al, 2007). Therefore, Alternative 4 would provide moderate to high level of long-term risk reduction, depending upon extent of cap placement, design, construction, and adequacy of long-term maintenance.

3.3.4.3 Implementability

Alternative 4 would be moderately easy to implement technically; cap installation methods are well-established and reliability is generally high. However, Alternative 4 would be difficult to implement administratively; adding a cap would decrease the available depth of the water column for navigation when lake levels are often already low and problematic. Further, installing a cap would limit or prohibit navigational dredging although, given current water depths, there is no current need for navigational dredging at the site. Installing a cap may also impact future recreational use of the marina. As a result, it would likely not be accepted by the public.

3.3.4.4 Cost

The capital costs for Alternative 4 would mainly consist of installing the cap; capital costs would be moderate. O&M costs would consist of periodic maintenance of the cap and performance monitoring to ensure that the cap is still functioning properly; O&M costs are expected to be moderate to high.

As shown in Table 3-3, the total present worth for this alternative is $14,984,100.

3.3.4.5 Short-Term Impacts

Short-term impacts for Alternative 4 include the restricted use of the marina during construction and the use of heavy equipment and machinery in public areas. The installation of the cap could release contaminated sediment into the water column and then that sediment could settle on top of the clean sand.

3.3.4.6 Long-Term Impacts

Long-term impacts for Alternative 4 include the implementation of waterway use restrictions to protect the cap. Waterway use restrictions would impact the local marinas, businesses, and residents that use the waterway in the area of the restriction.

3.3.4.7 Community Acceptance

Installation of a cap would limit or prohibit navigational dredging, although, no navigation currently takes place at the site. Installing a cap may also impact future recreational use of the marina, although, given current water depths, the impacts would be minimal in most areas. However, some members of the public have already expressed opposition to this alternative.

3.3.5 Alternative 5a – Mechanical Dredging and Disposal

Alternative 5a consists of removal of sediment from the bottom of a body of water by mechanical dredging, sediment dewatering, and off-site disposal of the sediment. Alternative 5a is assessed based on the screening criteria in the following paragraphs.

3.3.5.1 Short-Term Effectiveness

Alternative 5a would be moderately effective at reducing short-term risk because there would be a low to moderate potential for health impacts to community and workers from contaminant exposure during dredging, staging, transport, and disposal of sediment. Further, heavy construction equipment and trucks would be working within heavily used areas by the public, which would present a physical safety hazard to members of the public. However, these risks could be minimized by implementing proper controls, monitoring, and safety plans. Minimizing the potential safety hazard to construction workers and to the public would be a key component of Alternatives 5a, as well as any other alternative involving dredging. Short-term effectiveness could be reduced by sediment suspension caused by dredging activities.

3.3.5.2 Long-Term Effectiveness and Permanence

Alternative 5a would likely provide a high level of reduction of long-term risk because the contaminated sediment exceeding RAOs would be removed from the Site entirely and disposed at an off-site disposal facility. The selected disposal facility would be permitted and have controls in place to ensure that the sediment would not present a risk to human health and the environment in the future. A residual management plan designed to cover or re-dredge residual contamination will substantially reduce the impacts of any residual contamination. However, the long-term effectiveness of these alternatives would be highly dependant on achieving an adequate removal of the contaminated sediment and the degree to which residual contamination remains.

3.3.5.3 Implementability

Alternative 5a would be moderately easy to implement technically; dredging methods are generally well-established. The technical feasibility depends on accessibility of equipment to the Site, the depth of water column, the extent of debris in the sediment, and the ability to over-dredge. Alternative 5a would be moderately difficult to implement administratively; dredging would require coordination with the City of Muskegon and other regulatory entities. Further, these alternatives would likely result in a temporary reduction of recreational and navigational waterway access during dredging. Dredging would cause some disruption to local residents and businesses. Lastly, finding areas for staging and disposal of a large volume of sediment may be difficult.

3.3.5.4 Cost

Alternative 5a would involve high capital cost, but low O&M cost. Capital costs would include the construction costs for a contractor to perform the dredging, staging, and dewatering the sediment, treatment of wastewater from dewatering, and transport and disposal of the sediment. O&M costs would only include periodic performance monitoring, which would consist of sediment sampling, to ensure that the contaminated sediment has been sufficiently removed.

Performance monitoring is also necessary to ensure that sediment that may have been suspended during dredging and resettled has not re-contaminated the Site.

As shown in Table 3-4, the total present worth for this alternative is $20,316,700.

3.3.5.5 Short-Term Impacts

One short-term impact of dredging is suspension of sediment into the water column during dredging activities; this can affect the confirmation sampling after dredging is complete. Another short-term impact is the reduced access to an active marina during dredging.

3.3.5.6 Long-Term Impacts

A long-term impact of Alternative 5a would be the risk of suspended sediment re-contaminating dredged areas. During dredging, sediment becomes suspended in the water column and is then redistributed over the dredged areas. However, dredging practices and controls, and implementation of a sound residual management plan will reduce the potential impacts of resuspension.

3.3.5.7 Community Acceptance

The community would most likely accept this alternative. Although Alternative 5a would restrict access to the marina and dredge area for a period of time, the restriction would not be permanent. Dredging would also remove all of the contaminated sediment exceeding RAOs, thereby, reducing risk greatly in the area over time.

3.3.6 Alternative 5b – Hydraulic Dredging and Disposal

Alternative 5b consists of removal of sediment from the bottom of a body of water by hydraulic dredging, sediment dewatering, and off-site disposal of the sediment. Alternative 5b is assessed based on the screening criteria in the following paragraphs.

3.3.6.1 Short-Term Effectiveness

The short-term effectiveness of Alternative 5b is the same as Alternative 5a, as these are both dredging methods and have similar levels of short-term effectiveness.

3.3.6.2 Long-Term Effectiveness and Permanence

The long-term effectiveness of Alternative 5b is the same as Alternative 5a, as these are dredging methods and do not have a different level of long-term effectiveness.

3.3.6.3 Implementability

The implementability of Alternative 5b has two differences from Alternative 5a: the treatment and discharge of water and dewatering. During hydraulic dredging a large amount of water is generated during removal and results in increased dewatering time and effort due to the low solids content of the slurry. Some technical difficulties exist in treating and discharging the water from the dewatering operations, especially in terms of identifying sufficient vacant property to support dewatering and water treatment operations. However, even with the additional water generation and dewatering time hydraulic dredging would also be moderately easy to implement.

3.3.6.4 Cost

Alternative 5b would incur close to the same capital and O&M costs as Alternative 5a. Differences include the amount of water treated and disposed of and the capability for longer dewatering time.

As shown in Table 3-5, the total present worth for this alternative is $26,841,400.

3.3.6.5 Short-Term Impacts

One short-term impact of dredging is suspension of sediment into the water column during dredging activities; this can affect the confirmation sampling after dredging is complete. Another short-term impact is the reduced access to an active marina during dredging.

3.3.6.6 Long-Term Impacts

A long-term impact of Alternative 5b would be the risk of suspended sediment recontaminating dredged areas. During dredging sediment becomes suspended in the water column and is then redistributed over the dredged areas.

3.3.6.7 Community Acceptance

The community would most likely accept this alternative. Although Alternative 5b would restrict access to the marina and dredge area for a period of time, the restriction would not be permanent. Dredging would also remove all of the contaminated sediment exceeding RAOs, therefore reducing risk greatly in the area over time.

3.3.7 Alternative 6 – Dredging, Soil Washing, and Beneficial Reuse

Alternative 6 consists of mechanically dredging all contaminated sediment having concentrations exceeding RAOs, and treating the sediment *ex-situ* by soil washing. Alternative 6 is assessed based on the screening criteria in the following paragraphs

3.3.7.1 Short-Term Effectiveness

Alternative 6 would be moderately effective at reducing short-term risk because there would be a low to moderate potential for health impacts to community and workers from contaminant exposure during dredging, staging, and treatment of sediment. Heavy construction equipment and trucks would be working within areas used by the public, which would present a physical safety hazard to members of the public. However, these risks could be minimized by implementing proper controls, monitoring, and safety plans. Similar to Alternatives 5a and 5b, minimizing the potential safety hazard to construction works and to the public would be a key component of Alternative 6 since it involves dredging.

3.3.7.2 Long-Term Effectiveness and Permanence

Alternative 6 would likely provide a high level of reduction of long-term risk because the contaminated sediment exceeding RAOs would be removed from the Site, treated ex-situ, and then beneficially reused. Alternative 6 also provides a greater long-term reduction of risk to human health and the environment than Alternatives 5a and 5b because contaminants are removed from the sediment by treatment instead of placing contaminated sediment in off-site disposal facilities that must be monitored, controlled, and maintained. Similar to Alternatives 5a and 5b, the long-term effectiveness of these alternatives would be highly dependant on achieving an adequate removal of the contaminated sediment and the degree to which residual contamination remains.

3.3.7.3 Implementability

Alternative 6 would be moderately easy to moderately difficult to implement technically; although dredging methods are generally well-established, ex-situ treatment for sediment is not as widely used. In addition to the considerations for dredging, technical feasibility would also depend on the ability to identify a process that can treat the sediment adequately enough for reuse. Alternative 6 would be moderately difficult to difficult to implement administratively; in addition to administrative challenges for dredging, specialized vendors and contractors are often required to perform ex-situ treatment. Use of ex-situ sediment treatment by soil washing is limited in the United States; a relatively small number of vendors are available to provide services, as compared to those available for more conventional technologies like dredging.

3.3.7.4 Cost

Similar to Alternatives 5a and 5b, Alternative 6 would involve high capital cost, but low O&M cost. Capital costs would include the construction costs for a contractor to perform the dredging, staging and dewatering the sediment, ex-situ treatment of the sediment, treatment of wastewater from dewatering, and transport of the treated sediment for reuse. O&M costs would only include periodic performance monitoring, which would consist of sediment sampling, to ensure that the contaminated sediment have been sufficiently removed. Performance monitoring is also necessary to ensure that sediment that may have been suspended during dredging and resettled have not re-contaminated the Site.

As shown in Table 3-6, the total present worth for this alternative is $39,457,800.

3.3.7.5 Short-Term Impacts

One short-term impact of dredging is suspension of sediment into the water column during dredging activities; this can affect the confirmation sampling after dredging is complete. Another short-term impact is the reduced access to the active marina during dredging.

3.3.7.6 Long-Term Impacts

A long-term impact of Alternative 6 would be the risk of suspended sediment recontaminating dredged areas. During dredging sediment becomes suspended in the water column and is then redistributed over the dredged areas. Development and implementation of a residual management plan will reduce the long-term impacts of this alternative by reducing the impacts of any residual contamination.

3.3.7.7 Community Acceptance

The community would most likely accept this alternative. Although Alternative 6 would restrict access to the marina and dredge area for a period of time, the restriction would not be permanent. Dredging would also remove all of the contaminated sediment exceeding RAOs, therefore reducing risk greatly in the area over time. Additionally, the sediment could be reused beneficially at another site rather than landfill disposal.

3.3.8 Alternative 7 – Dredging, Disposal, and Enhanced Natural Recovery

Alternative 7 consists of mechanically dredging the most contaminated sediment, disposing of the dredged sediment at an off-site location, placing a 6-inch sand cover over the dredged area, and placing a 12-inch sand cover over the areas having sediment concentrations exceeding RAOs that were not removed through dredging. Alternative 7 also includes sampling, data assessment, and modeling as part of ENR. Alternative 7 is a combination of Alternatives 3 and 5. As a result, the performance of Alternative 7 would likely be between Alternatives 3 and 5. Alternative 7 is assessed based on the screening criteria in the following paragraphs

3.3.8.1 Short-Term Effectiveness

Alternative 7 is expected to have a lower potential for health impacts to community and workers from contaminant exposure during dredging, staging, transport, and disposal than Alternative 5 because the extent of sediment dredged would be less. However, heavy construction equipment and trucks would still be working within areas used by the public. Therefore, proper controls, monitoring, and safety plans to minimize risk to the public would still need to be considered as part of Alternative 7. Alternative 7 is expected to be moderately effective at reducing short-term risk.

3.3.8.2 Long-Term Effectiveness and Permanence

Alternative 7 would provide greater reduction of long-term risk than ENR alone (Alternative 3), but not as much as complete dredging of all areas having sediment concentrations that exceed RAOs (Alternatives 5a and 5b). Alternative 7 is expected to be moderately to highly effective at reducing long-term risk, especially because the most contaminated sediment would be removed from the Site entirely and disposed at an off-site disposal facility. The portion of contaminated sediment remaining would be residual contaminants and would be covered with a sand cover.

3.3.8.3 Implementability

Similar to Alternatives 5a and 5b, Alternative 7 would be moderately easy to implement technically; dredging methods are generally well-established and materials for cover are readily available. Sampling, monitoring, and modeling are also easy to implement technically. The technical feasibility depends on accessibility of equipment to the Site, the depth of water column, the extent of debris in sediment, and the ability to over-dredge.

Alternative 7 would be moderately easy to moderately difficult to implement administratively. Similar to Alternatives 5a and 5b, Alternative 7 includes dredging, which would require coordination with the City of Muskegon and other authorities. Dredging would likely result in a temporary reduction of waterway access and would cause some disruption to local residents and businesses. However, the extent of dredging for Alternative 7 would be less than the extent for Alternatives 5a and 5b. As a result, the dredging could be completed in a shorter time period and would result in less disruption, possibly making it easier to implement administratively. Staging areas and disposal sites would also be easier to find for a smaller volume of sediment.

Similar to Alternative 3, Alternative 7 would require adding a sand cover. The addition of the sand cover would decrease the water depth of the harbor. However, the sand cover would likely be added farther from the shore and in the deeper portions of Muskegon Lake where lower levels of contamination are located. As a result, future use of the harbor might only be minimally impacted, if at all. Therefore, Alternative 7 would likely not be as difficult to implement administratively as Alternative 3. The extent of the difficulty presented by the sand would depend on the areas where the cover is added and the depth of water in those areas. The need for ICs and use restrictions as well as public acceptance would still need to be considered for Alternative 7.

3.3.8.4 Cost

Alternative 7 would involve moderate capital cost. Similar to Alternatives 5a and 5b, capital costs would include the construction costs for a contractor to perform the dredging, staging and dewatering the sediment, treatment of wastewater from dewatering, and transport and disposal of the sediment. Capital costs would also include a sand cover over the contaminated sediment and possibly implementing ICs, similar to Alternative 3. However, the extent of dredging would not be as large as for Alternatives 5a and 5b. Likewise, the extent of sand cover would not be as large of an area as for Alternative 3. Therefore, the capital costs of Alternative 7 can be expected to be between those of Alternative 3 and Alternatives 5a and 5b.

O&M costs of Alternative 7 would include many of the same O&M components from Alternatives 3 and Alternatives 5a and 5b.

As shown in Table 3-7, the total present worth for this alternative is $13,386,500.

3.3.8.5 Short-Term Impacts

One short-term impact of dredging is suspension of sediment into the water column during dredging activities, however, this impact can be reduced by using proper dredging practices and implementing a sound residual management plan. Another short-term impact is the reduced access to an active marina during construction.

3.3.8.6 Long-Term Impacts

A long-term impact of Alternative 6 would be the risk of suspended sediment re-contaminating dredged areas. During dredging, sediment becomes suspended in the water column and is then redistributed over the dredged areas. However, dredging practices and controls and implementation of a sound residual management plan will reduce the potential impacts of resuspention. Long-term impacts for Alternative 7 also include the possible formation of ICs for the Site including waterway use restrictions. Development and implementation of a residual management plan will reduce the long-term impacts of this alternative by reducing the impacts of any residual contamination.

3.3.8.7 Community Acceptance

The community would most likely accept this alternative. Though Alternative 7 would restrict access to the marina and dredge area for a period of time, the restriction would not be permanent as long as the water column is deep enough in the area of the partial sand cover. However, there could also be ICs that would affect the usage of the area, which the community may not accept. The community may not accept an IC that reduces the use of the marina, such as a water use restriction in the area of the sand cover, to protect the integrity of the cover.

4. COMPARATIVE ANALYSIS OF ALTERNATIVES

A comparative analysis of all considered alternatives is presented in this section. Table 4-1 summarizes the criteria used to compare the alternatives. Table 4-2 presents an alternative ranking table.

4.1 SHORT-TERM EFFECTIVENESS

Alternative 1 is not effective in reducing short-term risk to human health and the environment because no action is taken. Alternative 2 would be minimally effective at reducing short-term risk due to slow sedimentation rates and a non-aggressive approach. Alternative 3 would be moderately effective at reducing risk due to the placement of a barrier between contaminated sediment and receptors. Alternative 4 would be highly effective at reducing short-term risk due to the placement of an impermeable barrier between contaminated sediment and receptors. Alternatives 5a, 5b, 6, and 7 would be low to moderately effective at reducing short-term risk due to potential for health impacts to construction workers and the movement of the contaminated material.

4.2 LONG-TERM EFFECTIVENESS AND PERMANENCE

Alternative 1 is not effective in reducing long-term risk to human health and the environment because no action is taken. Alternative 2 may provide acceptable reduction of long-term risk, depending on contaminant/sediment transport mechanisms and the resuspension of sediment due to heavy use of the harbor may reduce effectiveness. Alternative 3 is more likely to provide acceptable reduction of long-term risk than MNR alone due to added sand cover. Alternative 4 may provide moderate-to-high level of long-term risk reduction, depending on extent of cap placement, design, construction, and adequacy of long-term maintenance. Alternatives 5a and 5b are likely to provide moderate-to-high level of protection and risk reduction, depending on adequacy of removal and low residual contamination from dredging. Alternative 6 provides greater long-term reduction of risk because contaminated sediment is treated instead of being placed in disposal sites that must be controlled. Alternative 7 would provide greater long-term risk reduction than ENR alone, but not as much as complete dredging of all areas having sediment concentrations that exceed RAOs.

4.3 IMPLEMENTABILITY

Alternative 1 has no actions to implement; therefore this alternative is most easily implemented. Alternative 2 would be easy to implement technically; the alternative is non-invasive and primarily involves monitoring. It could be difficult to implement administratively; because it would require use restrictions on public access. Alternative 3 would be easy to implement technically; materials for cover are readily available and easily placed. Alternative 3 would be moderately difficult to implement administratively; cover placement would require coordination with the City and other authorities and the temporary reduction of recreational and navigational waterway access during cover placement would need to be considered. Alternative 4 would be moderately easy to implement technically; because cap installation methods are well-established and reliability is generally high. It would be difficult to implement administratively; because adding a cap would decrease the available depth of water column for navigation when lake levels are already low and problematic. Alternatives 5a and 5b are moderately easy to implement technically; dredging methods are generally well-established. Technical feasibility depends on accessibility, depth of water column, extent of debris in sediment, and ability to over-dredge. Alternatives 5a and 5b would be moderately difficult to implement administratively. Dredging would require coordination with the City and other authorities, and the temporary reduction of recreational and navigational waterway access during dredging would need to be considered.

Alternative 6 would be moderately easy to moderately difficult to implement technically; although dredging methods are generally well-established, ex-situ treatment for sediment is not as widely used. In addition to the considerations for dredging, technical feasibility would also depend on the ability to identify a process that can treat the sediment adequately enough for reuse. The alternative would be moderately difficult to difficult to implement administratively; in addition to dredging concerns, specialized vendors and contractors are often required to perform ex-situ treatment.

Alternative 7 would be moderately easy to implement technically. Administrative concerns would be similar to dredging, except that the smaller extent of dredging would be less disruptive to local residents and businesses than dredging of all areas having contaminants exceeding RAOs. Staging areas and disposal siting would be easier to find for a smaller volume of sediment. Adding a sand cover would decrease depth of the harbor and may limit future use; the difficulty this presents would depend on the areas where the cover is added and the depth of water in those areas.

4.4 COST

There are no costs associated with Alternative 1. Costs associated with Alternative 2 are very low as there are no capital costs and the O&M cost is low. The cost associated with Alternative 3 is also low due to low capital costs and low O&M costs. In comparison with the other alternatives, the cost for Alternative 4 and Alternative 7 are moderately low, the costs for Alternative 5a and Alternative 5b are moderately high, and the cost for Alternative 6 is high.

4.5 SHORT-TERM IMPACTS

There are no short-term impacts associated with Alternative 1 or Alternative 2 because no remedial action is taking place. All other alternatives have short-term impacts of temporary access during installation or when conducting the remedial alternative. During Alternatives 3, 4, 5, 6, and 7 there is a short-term impact of sediment suspension during removal or covering/capping activities.

4.6 LONG-TERM IMPACTS

The long-term impacts for Alternative 1 are continued risk and the implementation of ICs which could restrict access to the Site, continued risk would not be associated with the other alternatives. Alternatives 2, 3, 4, and 7 could have water way restrictions implemented to protect the caps and the alternatives could potentially impose continued fish advisories. Long-term risk associated with Alternatives 5a, 5b, 6, and 7 would be sedimentation of any materials suspended during dredging.

4.7 COMMUNITY ACCEPTANCE

The community would most likely accept Alternatives 5a, 5b, and 6; these alternatives remove the contamination exceeding RAOs and do not restrict access to the area in the long term. Alternative 7 would likely be acceptable to the community; this alternative partially removes the contamination with a partial sand cover. A reduction in some access could be required to protect the sand cover. Although there would be short-term disturbance in access to the area, dredging would also increase the depth near the marina and that would facilitate boat clearance. Alternative 1 would not likely be accepted because nothing would be done to remedy the situation. Alternative 2 would not likely be accepted due to ICs implemented such as water use restrictions. Alternatives 3 and 4 would not likely be accepted because the level of the lake bed would rise and ICs would likely be implemented restricting access to covered/capped areas.

4.8 RESULTS OF COMPARATIVE ANALYSIS AND RECOMMENDED ALTERNATIVE

Results of the comparative analysis outlined in Table 4-2 show Alternatives 5a/b, and 7 tied with the highest point total of 25. A closer look at the individual scores indicates that Alternatives 5a/b, and 7 scored the same in the categories of short term effectiveness, long term effectiveness, implementability, short term impacts, and community acceptance. Alternative 5a/b scored better in long term impacts while Alternative 7 scored better in cost. Additionally, both of these alternatives consistently recorded medium to high scores for each of the evaluation criteria, and therefore, either would be a reasonable and effective approach to sediment remediation at the Division Street Outfall site.

The stakeholders anticipate that budget constraints, especially among the non-federal stakeholders, will play an major role in determining what, if any, remedial alternative is implemented at this site. Discussions with the state and local stakeholders have indicated that Alternative 7, is the only high scoring alternative that will fall within the anticipated available budget of all potential funding partners. Therefore, using cost as a tie-breaking criteria, Alternative 7, “Dredging, Disposal, and ENR”, is recommended as the most feasible option to protect human health and the environment by meeting the RAOs for the Muskegon Lake AOC.

This recommendation is given with the following caveat. If the project stakeholders are able to quickly identify additional sources of funding for project implementation, the stakeholders should reconvene to discuss any impacts the additional funding might have on the recommended alternative. However, any additional sources of funding will need to be identified quickly, in order for any changes to be incorporated into the engineering design plans.

5. REFERENCES

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TABLES

Table 1-2

Summary of Recent Sediment Investigation
Division Street Outfall
Muskegon, Michigan

			Chemical Name	**HEM**	**MERCURY**	**OIL RANGE ORGANICS**	**TOTAL PAH**
			Unit	**MG/KG**	**MG/KG**	**UG/KG**	**UG/KG**
			RAO	**1,500**	**1**		**48,000**
Location ID	**Field Sample ID**	**Depth Interval**	**Sample Date**				
DSO SEWER 01	DSO SEWER 01	0- 6	5/4/2007	NA	0.05 U	NA	394
DSO SEWER 02	DSO SEWER 02	0- 6	5/4/2007	NA	0.05 U	NA	35,061
DSO SEWER 03	DSO SEWER 03	0- 6	5/4/2007	NA	0.05 U	NA	5,770
DSO SEWER 04	DSO SEWER 04	0- 6	5/4/2007	NA	0.05 U	NA	27,115
DSO04	DSO04	0- 6	5/6/2008	**14,000**	**1.6**	2,500,000	**51,087**
DSO04	DSO04 0-1	0- 1	5/6/2008	NA	0.66	1,900,000	**53,244**
DSO04	DSO04 1-2	1- 2	5/6/2008	NA	**1.1**	1,300,000	36,261
DSO04	DSO04 2-3	2- 3	5/6/2008	NA	0.77	1,600,000	39,967
DSO04	DSO04 3-4	3- 4	5/6/2008	NA	0.8	2,000,000	**49,909**
DSO04	DSO04 4-5	4- 5	5/6/2008	NA	0.93	940,000	15,385
DSO04	DSO04 5-6	5- 6	5/6/2008	NA	**1.3**	2,300,000	**52,569**
DSO07	DSO07	0- 6	5/6/2008	**2,000**	**1.4**	2,500,000	**989,502**
DSO07	DSO07 DUP	0- 6	5/6/2008	**2,200**	**2.1**	1,600,000	**984,198**
DSO21	DSO21	0- 6	5/6/2008	**7,000**	**1.1**	1,600,000	14,280
DSO21	DSO21 0-1	0- 1	5/6/2008	NA	0.58	540,000	9,622
DSO21	DSO21 1-2	1- 2	5/6/2008	NA	0.94	590,000	17,932
DSO21	DSO21 2-3	2- 3	5/6/2008	NA	0.85	780,000	10,086
DSO21	DSO21 3-4	3- 4	5/6/2008	NA	**1.6**	970,000	14,455
DSO21	DSO21 4-5	4- 5	5/6/2008	NA	1	2,000,000	46,369
DSO21	DSO21 5-6	5- 6	5/6/2008	NA	**1.7**	1,600,000	18,615
DSO21	DSO21 DUP	0- 6	5/6/2008	**8,000**	**1.4**	1,400,000	13,745
DSO53	DSO53	0- 6	5/6/2008	**2,800**	0.83	610,000	9,282
DSO53	DSO53 0-1	0- 1	5/6/2008	NA	0.73	390,000	8,772

Table 1-2

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Muskegon, Michigan

			Chemical Name	**HEM**	**MERCURY**	**OIL RANGE ORGANICS**	**TOTAL PAH**
			Unit	**MG/KG**	**MG/KG**	**UG/KG**	**UG/KG**
			RAO	**1,500**	**1**		**48,000**
Location ID	**Field Sample ID**	**Depth Interval**	**Sample Date**				
DSO53	DSO53 1-2	1- 2	5/6/2008	NA	0.7	370,000	8,891
DSO53	DSO53 2-3	2- 3	5/6/2008	NA	1	430,000	8,755
DSO53	DSO53 3-4	3- 4	5/6/2008	NA	0.86	800,000	14,909
DSO53	DSO53 4-5	4- 5	5/6/2008	NA	0.94	880,000	13,940
DSO53	DSO53 5-6	5- 6	5/6/2008	NA	**1.2**	870,000	12,674
DSO62	DSO62 0-1'	0- 1	5/5/2008	NA	0.9	770,000	11,501
DSO62	DSO62 1-2'	1- 2	5/5/2008	NA	0.49	400,000	8,369
DSO62	DSO62 2-3'	2- 3	5/5/2008	NA	0.05 U	51,000 U	0 U
DSO62	DSO62 3-4'	3- 4	5/5/2008	NA	0.05 U	67,000 U	0 U
DSO63	DSO63 0-1'	0- 1	5/5/2008	NA	1	1,100,000	10,931
DSO63	DSO63 1-2'	1- 2	5/5/2008	NA	**3.8** J	920,000	26,432
DSO63	DSO63 2-3'	2- 3	5/5/2008	NA	0.2 U	160,000 U	0 U
DSO63	DSO63 3-4'	3- 4	5/5/2008	NA	0.2 U	150,000 U	0 U
DSO64	DSO64 0-1'	0- 1	5/5/2008	NA	0.15 U	160,000	996
DSO64	DSO64 1-2'	1- 2	5/5/2008	NA	0.17 U	140,000	0 U
DSO64	DSO64 24-40	24- 40	5/5/2008	NA	0.05 U	98,000	0 U
DSO65	DSO65 0-1'	0- 1	5/5/2008	NA	0.82	2,500,000	9,447
DSO65	DSO65 1-2'	1- 2	5/5/2008	NA	0.05 U	52,000	58
DSO66	DSO66 0-1'	0- 1	5/5/2008	NA	**4.5**	2,200,000	16,555
DSO66	DSO66 1-2'	1- 2	5/5/2008	NA	0.09	150,000	899
DSO66	DSO66 2-3'	2- 3	5/5/2008	NA	0.05 U	64,000	0 U
DSO66	DSO66 2-3D'	2- 3	5/5/2008	NA	0.05 U	55,000	219
DSO66	DSO66 3-4'	3- 4	5/5/2008	NA	0.05 U	120,000	0 U
DSO67	DSO67 0-1'	0- 1	5/5/2008	NA	0.39	280,000	4,335

Table 1-2

Summary of Recent Sediment Investigation
Division Street Outfall
Muskegon, Michigan

			Chemical Name	**HEM**	**MERCURY**	**OIL RANGE ORGANICS**	**TOTAL PAH**
			Unit	**MG/KG**	**MG/KG**	**UG/KG**	**UG/KG**
			RAO	**1,500**	**1**		**48,000**
Location ID	**Field Sample ID**	**Depth Interval**	**Sample Date**				
DSO67	DSO67 1-2'	1- 2	5/5/2008	NA	0.36	300,000	2,990
DSO67	DSO67 2-3'	2- 3	5/5/2008	NA	0.2 U	160,000 U	0 U
DSO67	DSO67 3-4'	3- 4	5/5/2008	NA	0.2 U	170,000	0 U
DSO68	DSO68 0-1'	0- 1	5/5/2008	NA	0.34	540,000	9,860
DSO68	DSO68 1-2'	1- 2	5/5/2008	NA	0.45	890,000	14,831
DSO68	DSO68 2-3'	2- 3	5/5/2008	NA	**2.1**	1,100,000	20,206
DSO68	DSO68 3-4'	3- 4	5/5/2008	NA	1	390,000	12,735
DSO69	DSO69 0-1'	0- 1	5/5/2008	NA	**1.2**	1,100,000	10,064
DSO69	DSO69 1-2'	1- 2	5/5/2008	NA	**1.8** J	430,000	7,429
DSO69	DSO69 1-2D'	1- 2	5/5/2008	NA	**2.2**	380,000	10,285
DSO69	DSO69 2-3'	2- 3	5/5/2008	NA	0.2 U	190,000	0 U
DSO69	DSO69 3-4'	3- 4	5/5/2008	NA	0.2 U	190,000	0 U
DSO-SD01	DSO-SD01	0- 6	10/24/2005	**9,180**	0.25	NA	**90,070**
DSO-SD01	DSO-SD01-01	0- 12	10/24/2005	NA	**1.1**	NA	**109,820**
DSO-SD01	DSO-SD01-02	12- 24	10/24/2005	NA	0.05 U	NA	425
DSO-SD01	DSO-SD01-03	24- 41	10/24/2005	NA	0.05 U	NA	0 U
DSO-SD02	DSO-SD02	0- 6	10/4/2005	**2,431**	0.05 U	NA	**59,070**
DSO-SD02	DSO-SD02-01	0- 23	10/4/2005	NA	0.49	NA	**243,695**
DSO-SD02	DSO-SD02-02	23- 44	10/4/2005	NA	**1.2**	NA	**57,477**
DSO-SD02	DSO-SD02-03	44- 72	10/4/2005	NA	0.94	NA	30,940
DSO-SD02	DSO-SD02-04	72- 86	10/4/2005	NA	0.05 U	NA	0 U
DSO-SD02(07)	DSO-SD02(07)-01	0- 1	9/25/2007	**10,000**	0.35	NA	**95,215**
DSO-SD02(07)	DSO-SD02(07)-02	1- 2	9/25/2007	**13,000**	0.99	NA	**146,115**

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Division Street Outfall
Muskegon, Michigan

			Chemical Name	HEM	MERCURY	OIL RANGE ORGANICS	TOTAL PAH
			Unit	MG/KG	MG/KG	UG/KG	UG/KG
			RAO	1,500	1		48,000
Location ID	**Field Sample ID**	**Depth Interval**	**Sample Date**				
DSO-SD02(07)	DSO-SD02(07)-03	2- 3	9/25/2007	**11,000**	**2.1**	NA	42,923
DSO-SD02(07)	DSO-SD02(07)-04	3- 4	9/25/2007	**3,600**	0.39	NA	28,179
DSO-SD02(07)	DSO-SD02(07)-05	4- 5	9/25/2007	56	0.05 U	NA	239
DSO-SD03	DSO-SD03	0- 6	10/4/2005	**11,542**	0.41	NA	14,248
DSO-SD03	DSO-SD03-01	0- 23	10/4/2005	NA	**4**	NA	44,999
DSO-SD03	DSO-SD03-02	23- 32	10/4/2005	NA	0.05 U	NA	0 U
DSO-SD04	DSO-SD04	0- 6	10/4/2005	900	**1.3**	NA	45,928
DSO-SD04	DSO-SD04-01	0- 12	10/4/2005	NA	**1.5**	NA	37,910
DSO-SD04	DSO-SD04-01 DP	0- 12	10/4/2005	NA	**1.4**	NA	**60,350**
DSO-SD04	DSO-SD04-02	13- 52	10/4/2005	NA	**2.1**	NA	**61,999**
DSO-SD04	DSO-SD04-03	52- 68	10/4/2005	NA	0.16	NA	2,448
DSO-SD04(07)	DSO-SD04(07)-01	0- 1	9/25/2007	**6,400**	**1.7**	NA	45,076
DSO-SD04(07)	DSO-SD04(07)-02	1- 2	9/25/2007	**46,000**	**8.2**	NA	**66,492**
DSO-SD04(07)	DSO-SD04(07)-03	2- 3	9/25/2007	**56,000**	**3.7**	NA	**147,135**
DSO-SD04(07)	DSO-SD04(07)-04	3- 4	9/25/2007	**35,000**	**3**	NA	42,194
DSO-SD04(07)	DSO-SD04(07)-05	4- 5	9/25/2007	**21,000**	**11.3**	NA	**77,401**
DSO-SD04(07)	DSO-SD04(07)-06	5- 6	9/25/2007	430	0.25	NA	1,983
DSO-SD05	DSO-SD05	0- 6	10/3/2005	**1,550**	0.22	NA	11,997
DSO-SD05	DSO-SD05 DP	0- 6	10/3/2005	NA	0.08	NA	10,907
DSO-SD05	DSO-SD05-01	0- 19	10/3/2005	NA	0.81	NA	2,958
DSO-SD05	DSO-SD05-02	19- 35	10/3/2005	NA	0.05 U	NA	0 U
DSO-SD05	DSO-SD05-03	35- 48	10/3/2005	NA	0.05 U	NA	0 U
DSO-SD06	DSO-SD06	0- 6	10/3/2005	**2,273**	0.09	NA	10,224

Table 1-2

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Division Street Outfall
Muskegon, Michigan

			Chemical Name	HEM	MERCURY	OIL RANGE ORGANICS	TOTAL PAH
			Unit	MG/KG	MG/KG	UG/KG	UG/KG
			RAO	1,500	1		48,000
Location ID	**Field Sample ID**	**Depth Interval**	**Sample Date**				
DSO-SD06	DSO-SD06-01	0- 20	10/3/2005	NA	0.14	NA	1,258
DSO-SD06	DSO-SD06-01 DP	0- 20	10/3/2005	NA	0.1	NA	1,360
DSO-SD06	DSO-SD06-02	20- 40	10/3/2005	NA	0.05 U	NA	0 U
DSO-SD06	DSO-SD06-02 DP	20- 40	10/3/2005	NA	0.05 U	NA	0 U
DSO-SD07	DSO-SD07	0- 6	10/3/2005	1,439	**9.4**	NA	**463,940**
DSO-SD07	DSO-SD07-01	0- 12	10/3/2005	NA	**2.8**	NA	**91,664**
DSO-SD07	DSO-SD07-02	12- 24	10/3/2005	NA	0.05 U	NA	0 U
DSO-SD07	DSO-SD07-02 DP	12- 24	10/3/2005	NA	0.05 U	NA	2,788
DSO-SD08	DSO-SD08	0- 6	10/3/2005	**2,990**	0.3	NA	20,723
DSO-SD08	DSO-SD08-01	0- 10	10/3/2005	NA	**1.4**	NA	8,449
DSO-SD08	DSO-SD08-02	10- 25	10/3/2005	NA	0.05 U	NA	0 U
DSO-SD08	DSO-SD08-03	25- 40	10/3/2005	NA	0.05 U	NA	0 U
DSO-SD09	DSO-SD09	0- 6	10/4/2005	**1,892**	0.05 U	NA	3,381 / 5,161
DSO-SD09	DSO-SD09-01	0- 12	10/4/2005	NA	0.05 U	NA	0 U
DSO-SD09	DSO-SD09-02	12- 39	10/4/2005	NA	0.05 U	NA	0 U
DSO-SD10	DSO-SD10	0- 6	10/4/2005	763	0.39	NA	9,486
DSO-SD10	DSO-SD10-01	0- 18	10/4/2005	NA	0.99	NA	6,936
DSO-SD10	DSO-SD10-02	18- 45	10/4/2005	NA	0.05 U	NA	0 U
DSO-SD11	DSO-SD11	0- 6	10/4/2005	**5,940**	0.05 U	NA	1,536
DSO-SD11	DSO-SD11-01	0- 13	10/4/2005	NA	0.05 U	NA	0 U
DSO-SD12	DSO-SD12	0- 6	10/4/2005	**8,743**	**1.4**	NA	9,851
DSO-SD12	DSO-SD12-01	0- 14	10/4/2005	NA	**6.3**	NA	11,866
DSO-SD12	DSO-SD12-02	14- 72	10/4/2005	NA	1	NA	646
DSO-SD12	DSO-SD12-03	72- 93	10/4/2005	NA	0.05 U	NA	0 U

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			Chemical Name	**HEM**	**MERCURY**	**OIL RANGE ORGANICS**	**TOTAL PAH**
			Unit	**MG/KG**	**MG/KG**	**UG/KG**	**UG/KG**
			RAO	**1,500**	**1**		**48,000**
Location ID	**Field Sample ID**	**Depth Interval**	**Sample Date**				
DSO-SD12(07)	DSO-SD12(07)-01	0- 1	9/26/2007	**13,000**	**6.3**	NA	18,425
DSO-SD12(07)	DSO-SD12(07)-02	1- 2	9/26/2007	**11,000**	**18**	NA	31,331
DSO-SD12(07)	DSO-SD12(07)-03	2- 3	9/26/2007	420	**2.3**	NA	7,138
DSO-SD12(07)	DSO-SD12(07)-04	3- 4	9/26/2007	170	0.78	NA	727
DSO-SD12(07)	DSO-SD12(07)-05	4- 5	9/26/2007	38	0.07	NA	272
DSO-SD12(07)	DSO-SD12(07)-06	5- 6	9/26/2007	9	0.05 U	NA	0 U
DSO-SD12(07)	DSO-SD12(07)-07	6- 7	9/26/2007	50	0.05 U	NA	0 U
DSO-SD13	DSO-SD13	0- 6	10/4/2005	**2,852**	**1.9**	NA	5,865
DSO-SD13	DSO-SD13-01	0- 16	10/4/2005	NA	**10**	NA	39,100
DSO-SD13	DSO-SD13-02	16- 48	10/4/2005	NA	0.05 U	NA	0 U
DSO-SD13	DSO-SD13-03	48- 66	10/4/2005	NA	0.05 U	NA	0 U
DSO-SD14	DSO-SD14	0- 6	10/5/2005	**3,075**	**1.4**	NA	34,355
DSO-SD14	DSO-SD14-01	0- 15	10/5/2005	NA	**6.5**	NA	8,517
DSO-SD14	DSO-SD14-01 DP	0- 15	10/5/2005	NA	**7.9**	NA	13,260
DSO-SD14	DSO-SD14-02	15- 40	10/5/2005	NA	0.2	NA	1,054
DSO-SD14	DSO-SD14-02 DP	15- 40	10/5/2005	NA	0.21	NA	561
DSO-SD14	DSO-SD14-03	40- 51	10/5/2005	NA	0.05 U	NA	0 U
DSO-SD14	DSO-SD14-03 DP	40- 51	10/5/2005	NA	0.05 U	NA	0 U
DSO-SD15	DSO-SD15	0- 6	10/4/2005	577	**2.4**	NA	9,775
DSO-SD15	DSO-SD15-01	0- 12	10/4/2005	NA	**2.3**	NA	9,775
DSO-SD15	DSO-SD15-02	12- 36	10/4/2005	NA	0.34	NA	2,567
DSO-SD15	DSO-SD15-03	36- 52	10/4/2005	NA	0.05 U	NA	0 U
DSO-SD16	DSO-SD16	0- 6	10/4/2005	**2,317**	0.09	NA	22,903

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			Chemical Name	**HEM**	**MERCURY**	**OIL RANGE ORGANICS**	**TOTAL PAH**
			Unit	**MG/KG**	**MG/KG**	**UG/KG**	**UG/KG**
			RAO	**1,500**	**1**		**48,000**
Location ID	**Field Sample ID**	**Depth Interval**	**Sample Date**				
DSO-SD16	DSO-SD16 DP	0- 6	10/4/2005	NA	0.05 U	NA	7,083
DSO-SD16	DSO-SD16-01	0- 22	10/4/2005	NA	0.11	NA	493
DSO-SD16	DSO-SD16-01 DP	0- 22	10/4/2005	NA	0.14	NA	612
DSO-SD16	DSO-SD16-02	22- 45	10/4/2005	NA	0.05 U	NA	0 U
DSO-SD17	DSO-SD17	0- 6	10/4/2005	**3,512**	0.4	NA	3,281
DSO-SD17	DSO-SD17-01	0- 12	10/4/2005	NA	0.05 U	NA	1,190
DSO-SD17	DSO-SD17-02	12- 41	10/4/2005	NA	0.05 U	NA	0 U
DSO-SD18	DSO-SD18	0- 6	10/5/2005	**3,520**	**1.6**	NA	17,793
DSO-SD18	DSO-SD18-01	0- 12	10/5/2005	NA	**1.7**	NA	4,250
DSO-SD18	DSO-SD18-02	12- 57	10/5/2005	NA	0.54	NA	1,632
DSO-SD18	DSO-SD18-03	57- 77	10/5/2005	NA	0.05 U	NA	0 U
DSO-SD18	DSO-SD18-04	77- 89	10/5/2005	NA	0.05 U	NA	0 U
DSO-SD19	DSO-SD19	0- 6	10/5/2005	**3,760**	0.98	NA	15,788 / 20,783
DSO-SD19	DSO-SD19-01	0- 12	10/5/2005	NA	**1.5**	NA	4,250
DSO-SD19	DSO-SD19-02	12- 50	10/5/2005	NA	**1.5**	NA	3,060
DSO-SD19	DSO-SD19-03	50- 68	10/5/2005	NA	0.05 U	NA	0 U
DSO-SD19	DSO-SD19-04	68- 90	10/5/2005	NA	0.05 U	NA	0 U
DSO-SD19(07)	DSO-SD19(07)-01	0- 1	9/27/2007	**12,000**	**1.7**	NA	9,200 J
DSO-SD19(07)	DSO-SD19(07)-01 DP	0- 1	9/27/2007	NA	**1.3**	NA	19,276
DSO-SD19(07)	DSO-SD19(07)-02	1- 2	9/27/2007	**17,000**	**7.6**	NA	22,253
DSO-SD19(07)	DSO-SD19(07)-03	2- 3	9/27/2007	**3,400**	**4**	NA	11,397
DSO-SD19(07)	DSO-SD19(07)-04	3- 4	9/27/2007	280	0.05 U	NA	349
DSO-SD19(07)	DSO-SD19(07)-05	4- 5	9/27/2007	220	0.05 U	NA	187
DSO-SD19(07)	DSO-SD19(07)-06	5- 6	9/27/2007	67	0.05 U	NA	0 U

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			Chemical Name	**HEM**	**MERCURY**	**OIL RANGE ORGANICS**	**TOTAL PAH**
			Unit	**MG/KG**	**MG/KG**	**UG/KG**	**UG/KG**
			RAO	**1,500**	**1**		**48,000**
Location ID	**Field Sample ID**	**Depth Interval**	**Sample Date**				
DSO-SD19(07)	DSO-SD19(07)-07	6- 7	9/27/2007	91	0.05 U	NA	0 U
DSO-SD20	DSO-SD20	0- 6	10/4/2005	**1,867**	1	NA	4,590
DSO-SD20	DSO-SD20-01	0- 12	10/4/2005	NA	**3.3**	NA	1,411
DSO-SD20	DSO-SD20-02	12- 45	10/4/2005	NA	0.29	NA	816
DSO-SD20	DSO-SD20-03	45- 63	10/4/2005	NA	0.05 U	NA	0 U
DSO-SD21	DSO-SD21	0- 6	10/5/2005	**2,893**	**1.2**	NA	20,624
DSO-SD21	DSO-SD21-01	0- 12	10/5/2005	NA	**1.8**	NA	13,192
DSO-SD21	DSO-SD21-02	12- 47	10/5/2005	NA	0.11	NA	0 U
DSO-SD21	DSO-SD21-03	47- 62	10/5/2005	NA	0.05 U	NA	0 U
DSO-SD22	DSO-SD22	0- 6	10/5/2005	**1,962**	0.72	NA	3,757
DSO-SD22	DSO-SD22-01	0- 12	10/5/2005	NA	0.44	NA	3,383
DSO-SD22	DSO-SD22-02	12- 39	10/5/2005	NA	0.05 U	NA	0 U
DSO-SD22	DSO-SD22-03	39- 66	10/5/2005	NA	0.05 U	NA	0 U
DSO-SD23	DSO-SD23	0- 6	10/5/2005	904	0.49	NA	11,634
DSO-SD23	DSO-SD23-01	0- 15	10/5/2005	NA	0.11	NA	629
DSO-SD23	DSO-SD23-02	15- 32	10/5/2005	NA	0.05 U	NA	0 U
DSO-SD24	DSO-SD24-01	1- 28	7/25/2006	NA	**1.9**	NA	2,397
DSO-SD24	DSO-SD24-02	28- 56	7/25/2006	NA	0.11	NA	0 U
DSO-SD24	DSO-SD24-03	56- 80	7/25/2006	NA	0.05 U	NA	0 U
DSO-SD25	DSO-SD25-01	1- 28	7/25/2006	NA	**1.4**	NA	1,309
DSO-SD25	DSO-SD25-02	28- 62	7/25/2006	NA	0.15 U	NA	0 U
DSO-SD25	DSO-SD25-03	62- 82	7/25/2006	NA	0.05 U	NA	0 U
DSO-SD26	DSO-SD26-01	1- 24	7/25/2006	NA	1	NA	0 U
DSO-SD26	DSO-SD26-02	24- 45	7/25/2006	NA	0.2 U	NA	0 U

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			Chemical Name	**HEM**	**MERCURY**	**OIL RANGE ORGANICS**	**TOTAL PAH**
			Unit	**MG/KG**	**MG/KG**	**UG/KG**	**UG/KG**
			RAO	**1,500**	**1**		**48,000**
Location ID	**Field Sample ID**	**Depth Interval**	**Sample Date**				
DSO-SD26	DSO-SD26-03	45- 66	7/25/2006	NA	0.05 U	NA	0 U
DSO-SD27	DSO-SD27-01	1- 20	7/25/2006	NA	**1.4**	NA	1,411
DSO-SD27	DSO-SD27-02	20- 51	7/25/2006	NA	0.1 U	NA	0 U
DSO-SD27	DSO-SD27-03	51- 58	7/25/2006	NA	0.05 U	NA	0 U
DSO-SD28	DSO-SD28-01	1- 18	7/26/2006	NA	0.76	NA	612
DSO-SD28	DSO-SD28-01 DP	1- 18	7/26/2006	NA	0.86	NA	714
DSO-SD28	DSO-SD28-02	18- 41	7/26/2006	NA	0.2 U	NA	0 U
DSO-SD28	DSO-SD28-02 DP	18- 41	7/26/2006	NA	0.2 U	NA	0 U
DSO-SD28	DSO-SD28-03	41- 61	7/26/2006	NA	0.05 U	NA	0 U
DSO-SD28	DSO-SD28-03 DP	41- 61	7/26/2006	NA	0.05 U	NA	0 U
DSO-SD29	DSO-SD29-01	1- 18	7/26/2006	NA	0.66	NA	0 U
DSO-SD29	DSO-SD29-02	18- 48	7/26/2006	NA	0.25 U	NA	0 U
DSO-SD29	DSO-SD29-03	48- 80	7/26/2006	NA	0.25 U	NA	0 U
DSO-SD29	DSO-SD29-04	80- 94	7/26/2006	NA	0.2 U	NA	0 U
DSO-SD30	DSO-SD30-01	1- 24	7/26/2006	NA	0.71	NA	5,100
DSO-SD30	DSO-SD30-02	24- 48	7/26/2006	NA	0.25 U	NA	0 U
DSO-SD30	DSO-SD30-03	48- 72	7/26/2006	NA	0.25 U	NA	0 U
DSO-SD30	DSO-SD30-04	72- 92	7/26/2006	NA	0.25 U	NA	0 U
DSO-SD31	DSO-SD31-01	1- 24	7/26/2006	NA	0.65	NA	0 U
DSO-SD31	DSO-SD31-02	24- 48	7/26/2006	NA	0.25 U	NA	0 U
DSO-SD31	DSO-SD31-03	48- 72	7/26/2006	NA	0.25 U	NA	0 U
DSO-SD31	DSO-SD31-04	72- 85	7/26/2006	NA	0.25 U	NA	0 U
DSO-SD32	DSO-SD32-01	1- 24	7/27/2006	NA	0.62	NA	7,939
DSO-SD32	DSO-SD32-02	24- 60	7/27/2006	NA	0.25 U	NA	0 U

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			Chemical Name	HEM	MERCURY	OIL RANGE ORGANICS	TOTAL PAH
			Unit	MG/KG	MG/KG	UG/KG	UG/KG
			RAO	1,500	1		48,000
Location ID	**Field Sample ID**	**Depth Interval**	**Sample Date**				
DSO-SD32	DSO-SD32-03	60- 77	7/27/2006	NA	0.25 U	NA	0 U
DSO-SD33	DSO-SD33-01	1- 24	7/27/2006	NA	0.25 U	NA	0 U
DSO-SD33	DSO-SD33-02	24- 48	7/27/2006	NA	0.25 U	NA	0 U
DSO-SD33	DSO-SD33-03	48- 72	7/27/2006	NA	0.25 U	NA	0 U
DSO-SD33	DSO-SD33-04	72- 90	7/27/2006	NA	0.2 U	NA	0 U
DSO-SD34	DSO-SD34-01	1- 18	7/26/2006	NA	0.46	NA	0 U
DSO-SD34	DSO-SD34-02	18- 37	7/26/2006	NA	0.64	NA	0 U
DSO-SD34	DSO-SD34-03	37- 50	7/26/2006	NA	0.05 U	NA	0 U
DSO-SD35	DSO-SD35-01	1- 26	7/26/2006	NA	0.74	NA	7,718
DSO-SD35	DSO-SD35-02	26- 48	7/26/2006	NA	0.05 U	NA	0 U
DSO-SD35	DSO-SD35-03	48- 72	7/26/2006	NA	0.15 U	NA	0 U
DSO-SD36	DSO-SD36-01	1- 24	7/26/2006	NA	0.94	NA	0 U
DSO-SD36	DSO-SD36-01 DP	1- 24	7/26/2006	NA	0.96	NA	0 U
DSO-SD36	DSO-SD36-02	24- 70	7/26/2006	NA	0.15 U	NA	0 U
DSO-SD36	DSO-SD36-02 DP	24- 70	7/26/2006	NA	0.15 U	NA	0 U
DSO-SD36	DSO-SD36-03	70- 76	7/26/2006	NA	0.05 U	NA	0 U
DSO-SD36	DSO-SD36-03 DP	70- 76	7/26/2006	NA	0.05 U	NA	0 U
DSO-SD37	DSO-SD37-01	1- 14	7/26/2006	NA	0.35	NA	2,346
DSO-SD37	DSO-SD37-02	14- 29	7/26/2006	NA	0.2 U	NA	0 U
DSO-SD37	DSO-SD37-03	29- 42	7/26/2006	NA	0.05 U	NA	0 U
DSO-SD38	DSO-SD38-01	1- 15	7/26/2006	NA	0.33	NA	6,035
DSO-SD38	DSO-SD38-02	15- 31	7/26/2006	NA	0.05 U	NA	0 U
DSO-SD39	DSO-SD39-01	1- 24	7/25/2006	NA	**1.1**	NA	4,879
DSO-SD39	DSO-SD39-02	24- 60	7/25/2006	NA	0.05 U	NA	0 U

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			Chemical Name	HEM	MERCURY	OIL RANGE ORGANICS	TOTAL PAH
			Unit	MG/KG	MG/KG	UG/KG	UG/KG
			RAO	1,500	1		48,000
Location ID	Field Sample ID	Depth Interval	Sample Date				
DSO-SD39	DSO-SD39-03	60- 99	7/25/2006	NA	0.05 U	NA	0 U
DSO-SD39	DSO-SD39-04	99- 105	7/25/2006	NA	0.05 U	NA	0 U
DSO-SD40	DSO-SD40-01	1- 22	7/25/2006	NA	0.69	NA	2,805
DSO-SD40	DSO-SD40-02	22- 31	7/25/2006	NA	0.62	NA	1,513
DSO-SD41	DSO-SD41-01	1- 24	7/25/2006	NA	**2**	NA	2,329
DSO-SD41	DSO-SD41-02	24- 43	7/25/2006	NA	0.77	NA	1,292
DSO-SD41	DSO-SD41-03	43- 59	7/25/2006	NA	0.15 U	NA	0 U
DSO-SD42	DSO-SD42-01	1- 24	7/25/2006	NA	0.33	NA	0 U
DSO-SD42	DSO-SD42-02	24- 72	7/25/2006	NA	0.05 U	NA	0 U
DSO-SD42	DSO-SD42-03	72- 84	7/25/2006	NA	0.05 U	NA	0 U
DSO-SD42	DSO-SD42-04	84- 94	7/25/2006	NA	0.05 U	NA	0 U
DSO-SD43	DSO-SD43-01	1- 24	7/27/2006	NA	0.41	NA	0 U
DSO-SD43	DSO-SD43-01 DP	1- 24	7/27/2006	NA	0.43	NA	0 U
DSO-SD43	DSO-SD43-02	24- 60	7/27/2006	NA	0.32	NA	0 U
DSO-SD43	DSO-SD43-03	60- 89	7/27/2006	NA	0.2 U	NA	0 U
DSO-SD44	DSO-SD44-01	1- 24	7/27/2006	NA	0.2 U	NA	0 U
DSO-SD44	DSO-SD44-02	24- 56	7/27/2006	NA	0.15 U	NA	0 U
DSO-SD44	DSO-SD44-03	56- 62	7/27/2006	NA	0.05 U	NA	0 U
DSO-SD45	DSO-SD45-01	0- 1	9/27/2007	**9,000**	0.75	NA	7,878
DSO-SD45	DSO-SD45-01 DP	0- 1	9/27/2007	**10,000**	0.75	NA	10,149
DSO-SD45	DSO-SD45-02	1- 2	9/27/2007	**5,400**	**1.1**	NA	7,147
DSO-SD45	DSO-SD45-02 DP	1- 2	9/27/2007	**5,500**	1	NA	6,836
DSO-SD45	DSO-SD45-03	2- 3	9/27/2007	1,200	0.71	NA	3,908
DSO-SD45	DSO-SD45-03 DP	2- 3	9/27/2007	1,400	0.7	NA	4,692

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			Chemical Name	**HEM**	**MERCURY**	**OIL RANGE ORGANICS**	**TOTAL PAH**
			Unit	**MG/KG**	**MG/KG**	**UG/KG**	**UG/KG**
			RAO	**1,500**	**1**		**48,000**
Location ID	**Field Sample ID**	**Depth Interval**	**Sample Date**				
DSO-SD45	DSO-SD45-04	3- 4	9/27/2007	600	0.15 U	NA	226
DSO-SD45	DSO-SD45-04 DP	3- 4	9/27/2007	1,000	0.15	NA	508
DSO-SD46	DSO-SD46-01	0- 1	9/27/2007	**6,100**	0.89	NA	5,212
DSO-SD46	DSO-SD46-02	1- 2	9/27/2007	**1,700**	0.87	NA	6,295
DSO-SD46	DSO-SD46-03	2- 3	9/27/2007	820	0.17 U	NA	464
DSO-SD46	DSO-SD46-04	3- 4	9/27/2007	370	0.15 U	NA	97
DSO-SD47	DSO-SD47-01	0- 1	9/26/2007	**2,700**	0.37	NA	3,606
DSO-SD47	DSO-SD47-02	1- 2	9/26/2007	700	0.2 U	NA	156
DSO-SD47	DSO-SD47-03	2- 3	9/26/2007	180	0.05 U	NA	0 U
DSO-SD47	DSO-SD47-04	3- 4	9/26/2007	71	0.05 U	NA	0 U
DSO-SD48	DSO-SD48-01	0- 1	9/27/2007	**6,300**	**1.1**	NA	6,751
DSO-SD48	DSO-SD48-02	1- 2	9/27/2007	620	0.39	NA	2,035
DSO-SD48	DSO-SD48-03	2- 3	9/27/2007	440	0.16	NA	765
DSO-SD48	DSO-SD48-04	3- 4	9/27/2007	510	0.15 U	NA	90
DSO-SD49	DSO-SD49-01	0- 1	9/28/2007	**11,000**	0.67	NA	12,048
DSO-SD49	DSO-SD49-01 DP	0- 1	9/28/2007	**9,300**	0.91	NA	14,127
DSO-SD49	DSO-SD49-02	1- 2	9/28/2007	**7,500**	**2.1**	NA	23,554
DSO-SD49	DSO-SD49-03	2- 3	9/28/2007	**2,100**	0.25	NA	2,533
DSO-SD49	DSO-SD49-04	3- 4	9/28/2007	1,100	0.2 U	NA	741
DSO-SD50	DSO-SD50-01	0- 1	9/28/2007	**9,500**	0.49	NA	15,001
DSO-SD50	DSO-SD50-02	1- 2	9/28/2007	**7,600**	**1.3**	NA	18,583
DSO-SD50	DSO-SD50-03	2- 3	9/28/2007	**1,600**	0.21	NA	2,844
DSO-SD50	DSO-SD50-04	3- 4	9/28/2007	960	0.2 U	NA	969

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			Chemical Name	HEM	MERCURY	OIL RANGE ORGANICS	TOTAL PAH
			Unit	MG/KG	MG/KG	UG/KG	UG/KG
			RAO	1,500	1		48,000
Location ID	Field Sample ID	Depth Interval	Sample Date				
DSO-SD51	DSO-SD51-01	0- 1	9/25/2007	320	**1.2**	NA	17,952
DSO-SD51	DSO-SD51-01 DP	0- 1	9/25/2007	**6,800**	0.95	NA	13,906
DSO-SD51	DSO-SD51-02	1- 2	9/25/2007	170	**1.4**	NA	14,314
DSO-SD51	DSO-SD51-02 DP	1- 2	9/25/2007	**4,500**	**1.5**	NA	15,030
DSO-SD51	DSO-SD51-03	2- 3	9/25/2007	860	0.46	NA	2,773
DSO-SD51	DSO-SD51-03 DP	2- 3	9/25/2007	840	0.49	NA	2,543
DSO-SD51	DSO-SD51-04	3- 4	9/25/2007	870	0.2 U	NA	1,217
DSO-SD51	DSO-SD51-04 DP	3- 4	9/25/2007	720	0.2 U	NA	860
DSO-SD52	DSO-SD52-01	0- 1	9/26/2007	**8,400**	**2.8**	NA	11,574
DSO-SD52	DSO-SD52-02	1- 2	9/26/2007	1,200	0.98	NA	2,620
DSO-SD52	DSO-SD52-03	2- 3	9/26/2007	880	0.2 U	NA	114
DSO-SD52	DSO-SD52-04	3- 4	9/26/2007	140	0.22	NA	411
DSO-SD53	DSO-SD53-01	0- 1	9/27/2007	**11,000**	**6.8**	NA	26,243
DSO-SD53	DSO-SD53-02	1- 2	9/27/2007	1,100	0.61	NA	2,489
DSO-SD53	DSO-SD53-03	2- 3	9/27/2007	800	0.2 U	NA	0 U
DSO-SD53	DSO-SD53-04	3- 4	9/27/2007	710	0.15 U	NA	0 U
DSO-SD54	DSO-SD54-01	0- 1	9/26/2007	710	0.25	NA	7,234
DSO-SD54	DSO-SD54-02	1- 2	9/26/2007	1,500	0.22	NA	8,109
DSO-SD55	DSO-SD55-01	0- 1	9/26/2007	**19,000**	**6.7**	NA	26,061
DSO-SD55	DSO-SD55-02	1- 2	9/26/2007	**2,700**	**2.7**	NA	**58,395**
DSO-SD55	DSO-SD55-03	2- 3	9/26/2007	230	0.08	NA	1,907
DSO-SD55	DSO-SD55-04	3- 4	9/26/2007	660	0.05 U	NA	80
DSO-SD56	DSO-SD56-01	0- 1	9/25/2007	920	0.15 U	NA	859
DSO-SD56	DSO-SD56-02	1- 2	9/25/2007	110	0.05 U	NA	0 U

Table 1-2

Summary of Recent Sediment Investigation
Division Street Outfall
Muskegon, Michigan

			Chemical Name	**HEM**	**MERCURY**	**OIL RANGE ORGANICS**	**TOTAL PAH**
			Unit	**MG/KG**	**MG/KG**	**UG/KG**	**UG/KG**
			RAO	**1,500**	**1**		**48,000**
Location ID	**Field Sample ID**	**Depth Interval**	**Sample Date**				
DSO-SD56	DSO-SD56-03	2- 3	9/25/2007	71	0.05 U	NA	17
DSO-SD56	DSO-SD56-04	3- 4	9/25/2007	37	0.05 U	NA	0 U
DSO-SD57	DSO-SD57-01	0- 1	9/25/2007	330	0.29	NA	1,979
DSO-SD57	DSO-SD57-02	1- 2	9/25/2007	37	0.05 U	NA	133
DSO-SD58	DSO-SD58-01	0- 1	9/27/2007	**14,000**	**1.3**	NA	8,628
DSO-SD58	DSO-SD58-02	1- 2	9/27/2007	**2,900**	0.72	NA	4,559
DSO-SD58	DSO-SD58-03	2- 3	9/27/2007	300	0.05 U	NA	127
DSO-SD58	DSO-SD58-04	3- 4	9/27/2007	88	0.05 U	NA	0 U
DSO-SD59	DSO-SD59-01	0- 1	9/27/2007	**8,100**	**1.2**	NA	8,162
DSO-SD59	DSO-SD59-02	1- 2	9/27/2007	640	0.95	NA	4,432
DSO-SD59	DSO-SD59-03	2- 3	9/27/2007	**2,300**	0.2 U	NA	706
DSO-SD59	DSO-SD59-04	3- 4	9/27/2007	750	0.2 U	NA	202
DSO-SD60	DSO-SD60-01	0- 1	9/26/2007	**2,300**	0.63	NA	5,245
DSO-SD60	DSO-SD60-02	1- 2	9/26/2007	330	0.05 U	NA	0 U
DSO-SD60	DSO-SD60-03	2- 3	9/26/2007	190	0.05 U	NA	0 U
DSO-SD60	DSO-SD60-04	3- 4	9/26/2007	67	0.05 U	NA	0 U
DSO-SD61	DSO-SD61-01	0- 1	9/26/2007	**5,700**	**1.1**	NA	5,811
DSO-SD61	DSO-SD61-02	1- 2	9/26/2007	490	0.09	NA	1,124
DSO-SD61	DSO-SD61-03	2- 3	9/26/2007	47	0.05 U	NA	0 U
GLM1	GLM 1	0- 6	5/6/2008	360	0.13 U	100,000	1,658
GLM2	GLM 2	0- 6	5/6/2008	400	0.05 U	28,000 U	134
GLM2	GLM 2 DUP	0- 6	5/6/2008	NA	0.05 U	28,000 U	242
GLM3	GLM 3	0- 6	5/6/2008	320	0.05 U	25,000 U	36
GLM4	GLM 4	0- 6	5/6/2008	75	0.05 U	110,000	683

Table 1-2

Summary of Recent Sediment Investigation
Division Street Outfall
Muskegon, Michigan

			Chemical Name	**HEM**	**MERCURY**	**OIL RANGE ORGANICS**	**TOTAL PAH**
			Unit	**MG/KG**	**MG/KG**	**UG/KG**	**UG/KG**
			RAO	**1,500**	**1**		**48,000**
Location ID	**Field Sample ID**	**Depth Interval**	**Sample Date**				
HSM 1	HSM 1	0- 6	4/30/2007	NA	0.39	NA	NA
HSM 2	HSM 2	0- 6	4/30/2007	NA	0.16	NA	NA
HSM 3	HSM 3	0- 6	4/30/2007	NA	0.05 U	NA	NA
HSM 4	HSM 4	0- 6	4/30/2007	NA	0.59	NA	NA
HSM 5	HSM 5	0- 6	4/30/2007	NA	0.37	NA	NA
HSM 5	HSM 5 DUP	0- 6	4/30/2007	NA	0.35	NA	NA
HSM6	HSM 6	0- 6	5/6/2008	460	0.08	150,000	6,504
HSM7	HSM 7	0- 6	5/6/2008	**3,300**	0.43	760,000	**117,161**
PMA1	PMA 1	0- 6	5/6/2008	1,000	0.05 U	70,000	10,290
PMA1	PMA 1 DUP	0- 6	5/6/2008	NA	0.05 U	53,000 J	5,500
PMA2	PMA 2	0- 6	5/6/2008	1,100	0.05 U	25,000 U	524
PMA3	PMA 3	0- 6	5/6/2008	170	0.05 U	31,000	0 U
PMA4	PMA 4	0- 6	5/6/2008	**1,600**	0.22	240,000	1,635
SCRAP 1	SCRAP 1	0- 6	8/27/2007	NA	0.35 U	NA	2,142
SCRAP 2	SCRAP 2	0- 6	8/27/2007	NA	0.25 U	NA	6,664
SCRAP 3	SCRAP 3	0- 6	8/27/2007	NA	0.05 U	NA	0 U
SCRAP 4	SCRAP 4	0- 6	8/27/2007	NA	0.05 U	NA	0 U
SCRAP 5	SCRAP 5	0- 6	8/27/2007	NA	0.05 U	NA	0 U
SCRAP 6	SCRAP 6	0- 6	8/27/2007	NA	0.05 U	NA	4,641
TPM2	TPM 2	0- 6	5/6/2008	**1,800**	0.16	540,000	34,187
TPM3	TRM 3	0- 6	5/6/2008	NA	0.15 U	340,000	28,174
TPM3	TRM 3 DUP	0- 6	5/6/2008	NA	0.15 U	320,000	24,235
TPM4	TRM 4	0- 6	5/6/2008	NA	0.05 U	140,000	35,190

Table 1-2

Summary of Recent Sediment Investigation
Division Street Outfall
Muskegon, Michigan

			Chemical Name	HEM	MERCURY	OIL RANGE ORGANICS	TOTAL PAH
			Unit	MG/KG	MG/KG	UG/KG	UG/KG
			RAO	1,500	1		48,000
Location ID	Field Sample ID	Depth Interval	Sample Date				

Notes:

mg/kg - Milligrams per kilogram
ug/kg - Micrograms per kilogram
RAO - Remedial Action Objective
J - Estimated result
U - the analyte was not detected above the reported sample quantitation limit
HEM - Hexane extractable material
NA - Not analyzed

Table 3-1
Alternative 2 Monitored Natural Recovery Cost Estimate
Division Street Outfall
Muskegon, Muskegon County, Michigan

COMPONENT	ENGINEER'S ESTIMATE					COMMENTS
	Quantity	Unit	Unit Price	Cost	Subtotal	
MONITORED NATURAL RECOVERY						
No capital costs are incurred for MNR.		EA		$0		
Subtotal					$0	
DIRECT COST SUBTOTAL					$0	
Institutional Controls						
Institutional Controls Plan	1	EA	$ 5,000.00	$ 5,000.00		
Water Usage Restrictions	1	LS	$ 6,500.00	$ 6,500.00		
Site Information Database	1	LS	$ 4,800.00	$ 4,800.00		
Subtotal					$16,300	
INDIRECT COST SUBTOTAL					$16,300	
CAPITAL COST SUBTOTAL (DIRECT AND INDIRECT COSTS)					$16,300	
Bid Contingency (15%)					$2,400	
Scope Contingency (15%)					$2,400	
CAPITAL COST TOTAL					$21,100	
Permitting and Legal (5%)					$1,100	
Construction Services (10%)					$2,100	
CONSTRUCTION COSTS TOTAL					$24,300	
TOTAL PRESENT WORTH					$24,300	

Notes:
* Accuracy of +50%/-30%
EA - Each
LS - Lump sum

Table 3-2
Alternative 3 Enhanced Natural Recovery Cost Estimate
Division Street Outfall
Muskegon, Muskegon County, Michigan

COMPONENT	ENGINEER'S ESTIMATE					COMMENTS
	Quantity	Unit	Unit Price	Cost	Subtotal	
ENHANCED NATURAL RECOVERY						
Pre-Survey	1	LS	$ 10,000.00	$ 10,000.00		Pre survey assumes bathymetric survey of remedial area and calculations
Post-Survey	1	LS	$ 10,000.00	$ 10,000.00		Post survey assume bathymetric survey of remedial area after sand cap placement
Mobilization/Demobilization	1	LS	$ 450,000.00	$ 450,000.00		
Cover Sand	91,375	TON	$ 30.00	$ 2,741,245.11		Price delivered, sand density assumed to be 1.22 tons/cy
Sand Placement	74,897	CY	$ 25.00	$ 1,872,435.19		Assumes 12 inch sand cover in two inch lifts
Subtotal					$5,083,680	
DIRECT COST SUBTOTAL					$5,083,680	
CONTRACTOR PROCUREMENT	1	LS	$3,500	$3,500		
Subtotal					$3,500	
CONSTRUCTION MANAGEMENT						
Installation Management	7,200	Hour	$75	$540,000		Two people overseeing work 12 hours per day for 300 days
Health and Safety Monitoring	24	Week	$500	$12,000		
Post Construction Documentation	1	LS	$12,000	$12,000		
Subtotal					$564,000	
INSTITUTIONAL CONTROLS						
Institutional Controls Plan	1	EA	$ 6,500.00	$ 6,500.00		
Site Information Database	1	LS	$ 4,800.00	$ 4,800.00		
					$ 11,300.00	
INDIRECT COST SUBTOTAL					$578,800	
CAPITAL COST SUBTOTAL (DIRECT AND INDIRECT COSTS)					$5,662,480	
Bid Contingency (15%)					$849,400	
Scope Contingency (15%)					$849,400	
CAPITAL COST TOTAL					$7,361,280	
Permitting and Legal (5%)					$368,100	
Construction Services (10%)					$736,100	
CONSTRUCTION COSTS TOTAL					$8,465,480	
TOTAL PRESENT WORTH					$8,465,500	

Notes:

* Accuracy of +50%/-30%
CY - Cubic yard
EA - Each
LS - Lump sum

Table 3-3
Alternative 4 In-Situ Capping Cost Estimate
Division Street Outfall
Muskegon, Muskegon County, Michigan

COMPONENT	ENGINEER'S ESTIMATE					COMMENTS
	Quantity	Unit	Unit Price	Cost	Subtotal	
IN-SITU CAPPING						
Pre Survey	1	LS	$ 10,000.00	$ 10,000.00		Assumes bathymetric survey only to determine elevations of placement locations
Post Survey	1	LS	$ 10,000.00	$ 10,000.00		Assumes bathymetric survey only to determine final depths for advisories and bans
Mobilization/Demobilization	1	LS	$ 450,000.00	$ 450,000.00		
Cap Material	47	Acre	$ 200,000.00	$ 9,300,000.00		Aqua-Blok was used for costing purposes for this method
Subtotal					$9,770,000	
DIRECT COST SUBTOTAL					$9,770,000	
CONTRACTOR PROCUREMENT	1	LS	$3,500	$3,500		
Subtotal					$3,500	
CONSTRUCTION MANAGEMENT						
Installation Management	2,880	Hour	$75	$216,000		Assumes 120 days for installation and 2 personnel on-site at all times
Health and Safety Monitoring	16	Week	$500	$8,000		Assumes 4 months for installation over 47 acres
Post Construction Documentation	1	LS	$12,000	$12,000		
Subtotal					$236,000	
INSTITUTIONAL CONTROLS						
Institutional Controls Plan	1	EA	$ 6,500.00	$ 6,500.00		
Warning Signs	1	LS	$ 2,000.00	$ 2,000.00		
Site Information Database	1	LS	$ 4,800.00	$ 4,800.00		
Subtotal					$ 13,300.00	
INDIRECT COST SUBTOTAL					$252,800	
CAPITAL COST SUBTOTAL (DIRECT AND INDIRECT COSTS)					$10,022,800	
Bid Contingency (15%)					$1,503,400	
Scope Contingency (15%)					$1,503,400	
CAPITAL COST TOTAL					$13,029,600	
Permitting and Legal (5%)					$651,500	
Construction Services (10%)					$1,303,000	
CONSTRUCTION COSTS TOTAL					$14,984,100	
TOTAL PRESENT WORTH					$14,984,100	

Notes:
* Accuracy of +50%/-30%
EA - Each
LS - Lump sum

Table 3-4
Alternative 5a Mechanical Dredging Cost Estimate
Division Street Outfall
Muskegon, Muskegon County, Michigan

COMPONENT	ENGINEER'S ESTIMATE Quantity	Unit	Unit Price	Cost	Subtotal	COMMENTS
DEWATERING TEST	1	LS	$30,000	$30,000		
					$30,000	
DREDGING						
Pre-Survey	1	LS	$ 50,000.00	$ 50,000.00		Assumes a bathymetric survey, thickness confirmation, and figure generation
Mobilization/Demobilization	1	LS	$ 450,000.00	$ 450,000.00		
Pad Construction	1	LS	$ 50,000.00	$ 50,000.00		Assumes the construction of a dewatering pad will be necessary for staging material prior to shipment
Water Disposal	1	LS	$ 29,000.00	$ 29,000.00		For connection to sanitary sewer if allowed or use of NPDES permit including sampling costs
Post-Survey	1	LS	$ 25,000.00	$ 25,000.00		Assumes bathymetric survey only and mapping
Mechanical Dredging	161,760	CY	$ 25.00	$ 4,044,000.00		Includes labor, materials, equipment, and incidentals; assumes an even cut; and includes 25% contingency.
Water Treatment	161,760	CY	$ 20.00	$ 3,235,200.00		Assumes the use of filters and carbon treatment with frac tank storage prior to discharge, and includes 25% contingency.
Disposal Sampling	24	Per Event	$ 3,500.00	$ 84,000.00		Assumes initial sampling for TCLP and weekly samples for paint filter and moisture content
Transportation	177,936	TON	$ 8.00	$ 1,423,488.00		Assumes regulated waste disposal at Type II landfill, tonnage calucated using an average sediment density of 1.10 tons/cy
Disposal	177,936	TON	$ 20.00	$ 3,558,720.00		Assumes regulated waste disposal at Type II landfill, tonnage calucated using an average sediment density of 1.10 tons/cy
Subtotal					$12,949,408	
DIRECT COST SUBTOTAL					$12,979,408	
CONTRACTOR PROCUREMENT	1	LS	$3,500	$3,500		
Subtotal					$3,500	
PERMITS						
Joint Permit	1	LS	$3,000	$3,000		
Water Discharge Permit	1	LS	$5,000	$5,000		
Subtotal					$8,000	
CONSTRUCTION MANAGEMENT						
Dredge Management	7,200	Hour	$ 75.00	$ 540,000.00		Assumes 12 hours per day working for 300 days for two people
Confirmation Sampling	1	LS	$ 25,000.00	$ 25,000.00		Assumes 35 confirmation samples collected over one week with 2 people working 10 hour days
Health and Safety Monitoring	24	Week	$ 500.00	$ 12,000.00		
Post Construction Documentation	1	LS	$ 12,000.00	$ 12,000.00		
Institutional Controls Plan	1	EA	$ 5,000.00	$ 5,000.00		
Site Information Database	1	LS	$ 4,800.00	$ 4,800.00		
Subtotal					$598,800	
INDIRECT COST SUBTOTAL					$610,300	
CAPITAL COST SUBTOTAL (DIRECT AND INDIRECT COSTS)					$13,589,708	
Bid Contingency (15%)					$2,038,500	
Scope Contingency (15%)					$2,038,500	
CAPITAL COST TOTAL					$17,666,708	
Permitting and Legal (5%)					$883,300	
Construction Services (10%)					$1,766,700	
CONSTRUCTION COSTS TOTAL					$20,316,708	
TOTAL PRESENT WORTH					$20,316,700	

Notes:
* Accuracy of +50%/-30%
CY - Cubic yard
EA - Each
LS - Lump sum

Table 3-5
Alternative 5b Hydraulic Dredging Cost Estimate
Division Street Outfall
Muskegon, Muskegon County, Michigan

COMPONENT	ENGINEER'S ESTIMATE Quantity	Unit	Unit Price	Cost	Subtotal	COMMENTS
DEWATERING TEST	1	LS	$30,000	$30,000		
					$30,000	
DREDGING						
Pre-Survey	1	LS	$ 50,000.00	$ 50,000.00		Assumes a bathymetric survey, thickness confirmation, and figure generation
Mobilization/Demobilization	1	LS	$ 450,000.00	$ 450,000.00		
Pad Construction	1	LS	$ 50,000.00	$ 50,000.00		Assumes the construction of a dewatering pad will be necessary for staging material prior to shipment
Water Discharge	1	LS	$ 29,000.00	$ 29,000.00		For connection to sanitary sewer if allowed or use of NPDES permit including sampling costs
Post-Survey	1	LS	$ 25,000.00	$ 25,000.00		Assumes bathymetric survey only and mapping
Hydraulic Dredging	161,760	CY	$ 25.00	$ 4,044,000.00		Includes labor, materials, equipment, incidentals, ash 25% contingency
Soil Drying	161,760	CY	$ 27.00	$ 4,367,520.00		Assumes soil drying using geotubes and includes 25% contingency
Water Treatment	161,760	CY	$ 20.00	$ 3,235,200.00		Assumes the use of filters and carbon treatment with frac tank storage prior to discharge; includes 25% contingency
Disposal Sampling	24	Per Event	$ 3,500.00	$ 84,000.00		Assumes initial sampling for TCLP and weekly samples for paint filter and moisture content
Transportation	177,936	TON	$ 8.00	$ 1,423,488.00		Assumes regulated waste disposal at Type II landfill, tonnage calucated using an average sediment density of 1.10 tons/cy
Disposal	177,936	TON	$ 20.00	$ 3,558,720.00		Assumes regulated waste disposal at Type II landfill, tonnage calucated using an average sediment density of 1.10 tons/cy
Subtotal					$17,316,928	
DIRECT COST SUBTOTAL					$17,346,928	
CONTRACTOR PROCUREMENT	1	LS	$3,500	$3,500		
Subtotal					$3,500	
PERMITS						
Joint Permit	1	LS	$3,000	$3,000		
Water Discharge Permit	1	LS	$2,000	$2,000		
Subtotal					$5,000	
CONSTRUCTION MANAGEMENT						
Dredge Management	7200	Hour	$ 75.00	$ 540,000.00		Assumes 12 hours per day working for 300 days for two people
Confirmation Sampling	1	LS	$ 25,000.00	$ 25,000.00		Assumes 35 confirmation samples collected over one week with 2 people working 10 hour days
Health and Safety Monitoring	24	Week	$ 500.00	$ 12,000.00		
Post Construction Documentation	1	LS	$ 12,000.00	$ 12,000.00		
Institutional Controls Plan	1	EA	$ 5,000.00	$ 5,000.00		
Site Information Database	1	LS	$ 4,800.00	$ 4,800.00		
Subtotal					$598,800	
INDIRECT COST SUBTOTAL					$607,300	
CAPITAL COST SUBTOTAL (DIRECT AND INDIRECT COSTS)					$17,954,228	
Bid Contingency (15%)					$2,693,100	
Scope Contingency (15%)					$2,693,100	
CAPITAL COST TOTAL					$23,340,428	
Permitting and Legal (5%)					$1,167,000	
Construction Services (10%)					$2,334,000	
CONSTRUCTION COSTS TOTAL					$26,841,428	
TOTAL PRESENT WORTH					$26,841,400	

Notes:
* Accuracy of +50%/-30%
CY - Cubic yard
EA - Each
LS - Lump sum

Table 3-6
Alternative 6 Dredging, Soil Washing, Beneficial Reuse Cost Estimate
Division Street Outfall
Muskegon, Muskegon County, Michigan

COMPONENT	ENGINEER'S ESTIMATE					COMMENTS
	Quantity	Unit	Unit Price	Cost	Subtotal	
DEWATERING TEST	1	LS	$30,000	$30,000		
					$30,000	
DREDGING						
Pre-Survey	1	LS	$ 50,000.00	$ 50,000.00		Assumes a bathymetric survey, thickness confirmation, and figure generation
Mobilization/Demobilization	1	LS	$ 450,000.00	$ 450,000.00		
Pad Construction	1	LS	$ 50,000.00	$ 50,000.00		Assumes the construction of a dewatering pad will be necessary for staging material prior to shipment
Water Disposal	1	LS	$ 29,000.00	$ 29,000.00		For connection to sanitary sewer if allowed or use of NPDES permit including sampling costs
Post-Survey	1	LS	$ 25,000.00	$ 25,000.00		Assumes bathymetric survey only and mapping
Mechanical Dredging	161,760	CY	$ 25.00	$ 4,044,000.00		Includes labor, materials, equipment, and incidentals, assumed mechanical dredging and 25% contingency
Soil Washing	177,936	TON	$ 100.00	$ 17,793,600.00		Tonnage calucated using an average sediment density of 1.10 tons/cy
Water Treatment	161,760	CY	$ 20.00	$ 3,235,200.00		Includes 25% contingency
Confirmation Reuse Sampling	24	Per Event	$ 3,500.00	$ 84,000.00		Sampling to confirm safe for beneficial reuse
Beneficial Reuse	-		-	-		Beneficial reuse is assumed to not incur any additional cost for transportation or disposal
Subtotal					$25,760,800	
DIRECT COST SUBTOTAL					$25,790,800	
CONTRACTOR PROCUREMENT	1	LS	$3,500	$3,500		
Subtotal					$3,500	
CONSTRUCTION MANAGEMENT						
Dredge Management	7,200	Hour	$75	$540,000		Assumes 12 hours per day working for 300 days for two people
Confirmation Sampling	1	LS	$ 25,000.00	$ 25,000.00		Assumes 35 confirmation samples collected over one week with 2 people working 10 hour days
Health and Safety Monitoring	24	Week	$500	$12,000		
Post Construction Documentation	1	LS	$12,000	$12,000		
Institutional Controls Plan	1	EA	$ 5,000.00	$ 5,000.00		
Site Information Database	1	LS	$ 4,800.00	$ 4,800.00		
Subtotal					$598,800	
INDIRECT COST SUBTOTAL					$602,300	
CAPITAL COST SUBTOTAL (DIRECT AND INDIRECT COSTS)					$26,393,100	
Bid Contingency (15%)					$3,959,000	
Scope Contingency (15%)					$3,959,000	
CAPITAL COST TOTAL					$34,311,100	
Permitting and Legal (5%)					$1,715,600	
Construction Services (10%)					$3,431,100	
CONSTRUCTION COSTS TOTAL					$39,457,800	
TOTAL PRESENT WORTH					$39,457,800	

Notes:
* Accuracy of +50%/-30%
CY - Cubic yard
EA - Each
LS - Lump sum

Table 3-7
Alternative 7 Dredging and ENR Cost Estimate
Division Street Outfall
Muskegon, Muskegon County, Michigan

COMPONENT	ENGINEER'S ESTIMATE					COMMENTS
	Quantity	Unit	Unit Price	Cost	Subtotal	
DEWATERING TEST	1	LS	$30,000	$30,000		
					$30,000	
DREDGING						
Pre-Survey	1	LS	$ 50,000.00	$ 50,000.00		Assumes a bathymetric survey, thickness confirmation, and figure generation
Mobilization/Demobilization	1	LS	$ 450,000.00	$ 450,000.00		
Pad Construction	1	LS	$ 50,000.00	$ 50,000.00		Assumes the construction of a dewatering pad will be necessary for staging material prior to shipment
Water Disposal	1	LS	$ 29,000.00	$ 29,000.00		For connection to sanitary sewer if allowed or use of NPDES permit including sampling costs
Post-Survey	1	LS	$ 25,000.00	$ 25,000.00		Assumes bathymetric survey only and mapping
Mechanical Dredging	52,046	CY	$ 25.00	$ 1,301,137.50		Includes labor, materials, equipment, and incidentals, assumed mechanical dredging and even cut; includes 50% contingency
Water Treatment	52,046	CY	$ 20.00	$ 1,040,910.00		Includes 50% contingency
Disposal Sampling	24	Per Event	$ 3,500.00	$ 84,000.00		
Sand Cover	73,060	Ton	$ 30.00	$ 2,191,799.81		Price delivered, sand density assumed to be 1.22 tons/cy
Sand Placement	59,885	CY	$ 25.00	$ 1,497,131.02		Assumes 12 inches sand cover on undredged >1 ppm Hg and 6 inches sand cover after dredging of >2 ppm Hg
Transportation	57,250	TON	$ 8.00	$ 458,000.40		Assumes regulated waste disposal at Type II landfill, tonnage calucated using an average sediment density of 1.10 tons/cy
Disposal	57,250	TON	$ 20.00	$ 1,145,001.00		Assumes regulated waste disposal at Type II landfill, tonnage calucated using an average sediment density of 1.10 tons/cy
Subtotal					$8,321,980	
DIRECT COST SUBTOTAL					$8,351,980	
CONTRACTOR PROCUREMENT	1	LS	$3,500	$3,500		
Subtotal					$3,500	
CONSTRUCTION MANAGEMENT						
Dredge Management	7,200	Hour	$75	$540,000		Assumes 12 hours per day working for 300 days for two people
Confirmation Sampling	1	LS	$ 25,000.00	$ 25,000.00		Assumes 35 confirmation samples collected over one week with 2 people working 10 hour days
Health and Safety Monitoring	24	Week	$500	$12,000		
Post Construction Documentation	1	LS	$12,000	$12,000		
Institutional Controls Plan	1	EA	$ 5,000.00	$ 5,000.00		
Site Information Database	1	LS	$ 4,800.00	$ 4,800.00		
Subtotal					$598,800	
INDIRECT COST SUBTOTAL					$602,300	
CAPITAL COST SUBTOTAL (DIRECT AND INDIRECT COSTS)					$8,954,280	
Bid Contingency (15%)					$1,343,100	
Scope Contingency (15%)					$1,343,100	
CAPITAL COST TOTAL					$11,640,480	
Permitting and Legal (5%)					$582,000	
Construction Services (10%)					$1,164,000	
CONSTRUCTION COSTS TOTAL					$13,386,480	
TOTAL PRESENT WORTH					$13,386,500	

Notes:
* Accuracy of +50%/-30%
CY - Cubic yard
EA - Each
LS - Lump sum

Table 4-1
Comparative Analysis of Remedial Alternatives
Division Street Outfall, Muskegon, Muskegon County, Michigan

	Alternative[1]	Description[2]	Short Term Effectiveness[3]	Long Term Effectiveness[3]	Implementability[4]	Cost Evaluation	Short Term Impacts	Long Term Impacts	Community Acceptance
1	No Action	Required by NCP for baseline comparison; no remedial action is conducted, no monitoring is performed, and no institutional controls are implemented.	Not effective at protecting human health and the environment.	Not effective at protecting human health and the environment.	Not Applicable - no actions to implement.	--	None	Continued exposure and risk	Most likely not accepted
2	Institutional Controls (ICs) and Monitored Natural Recovery (MNR)	Natural sedimentation will occur to isolate the contaminated sediments, and sampling will be periodically performed to monitor contaminant concentrations and sediment depths. Institutional controls will be implemented as necessary to prevent or reduce human exposure to contaminants.	Minimally effective at reducing short-term risk; natural sedimentation will occur over long time periods. Time period to achieve RAOs is uncertain.	May provide acceptable reduction of long-term risk, depending on contaminant/sediment transport mechanisms. Resuspension of sediment due to heavy use of the harbor may reduce effectiveness.	Easy to implement technically; alternative is non-invasive and primarily involves monitoring. Difficult to implement administratively; would require use restrictions on public access. May not be accepted by the public.	$ 24K	None	Use restrictions	Most likely not accepted
3	Enhanced Natural Recovery (ENR)	A 6-inch sand cover, or other comparable barrier, will be added to the existing sediment layer to physically isolate the contaminated sediments. No sediment removal will be performed. The sand cover will be added over the entire area that has sediment concentrations exceeding the RAOs.	Moderately effective at reducing short-term risk due to added barrier.	More likely to provide acceptable reduction of long-term risk than MNR alone due to added cover.	Easy to implement technically; materials for cover are readily available and easily placed. Difficult to implement administratively; would decrease depth of the harbor and may limit future use. May not be accepted by the public.	$8.5	Access and dispersion of sediment into the water column	Water use restrictions and potential for sand erosion	Most likely not accepted
4	In-Situ Capping	A low-permeability, sub-aqueous cap will be installed to stabilize and physically isolate the contaminated sediments. Contaminant flux to the water column will be reduced. The cap will be placed over all areas of sediment having concentrations exceeding RAOs.	Likely to provide high level of short-term risk reduction after cap is installed, assuming that the cap adequately covers the extent of contaminated sediments.	May provide moderate to high level of long-term risk reduction, depending upon extent of cap placement, design, construction, and adequacy of long-term maintenance.	Moderately easy to implement technically; cap installation methods are well-established and reliability is generally high. Difficult to implement administratively; adding a cap would decrease the available depth of water column for navigation when lake levels are already low and problematic. Installing a cap may limit future use of the site, and may limit navigational dredging.	$14.9	Restricted use of marina and heavy machinery	Water use restrictions	Most likely not accepted
5a	Mechanical Dredging and Disposal	All contaminated sediments having concentrations exceeding RAOs will be mechanically dredged and disposed at an off-site location.	Likely will be low to moderate potential for health impacts to community and workers from contaminant release during dredging, staging, transport, and disposal.	Likely to provide moderate to high level of protection and risk reduction, depending on adequacy of removal and low residual contamination.	Moderately easy to implement technically; dredging methods are generally well-established. Technical feasibility depends on accessibility, depth of water column, extent of debris in sediment, and ability to over-dredge. Moderately difficult to implement administratively; dredging would require coordination with the City and other authorities. Temporary reduction of recreational and navigational waterway access during dredging would need to be considered. Dredging would cause some disruption to local residents and businesses. Staging areas and disposal sitting for a large volume of sediments may be difficult.	$20.3	Suspension of sediment into the water column and restricted use of the marina during dredging	Sedimentation of suspended sediments	Most likely accepted
5b	Hydraulic Dredging and Disposal	All contaminated sediments having concentrations exceeding RAOs will be hydraulically dredged and disposed at an off-site location.				$26.8			Most likely accepted
6	Dredging, Soil Washing, and Beneficial Reuse	All contaminated sediments having concentrations exceeding RAOs will be mechanically dredged and treated ex-situ by soil washing. Treated sediments will then be considered for beneficial reuse.	Similar to other dredging alternatives, except that removed sediment is treated and beneficially reused.	Provides greater long-term reduction of risk because contaminated sediments are treated instead of being placed in disposal sites that must be controlled.	Moderately easy to moderately difficult to implement technically; although dredging methods are generally well-established, ex-situ treatment for sediment is not as widely used. In addition to the considerations for dredging, technical feasibility would also depend on the ability to identify a process that can treat the sediment adequately enough for reuse. Moderately difficult to difficult to implement administratively; in addition to dredging concerns, specialized vendors and contractors are often required to perform ex-situ treatment. Ex-situ sediment treatment by soil washing is limited in use in the United States.	$39.5	Suspension of sediment into the water column and restricted use of the marina during dredging	Sedimentation of suspended sediments	Most likely accepted
7	Dredging, Disposal, and ENR	The most contaminated sediments will be mechanically dredged and disposed off-site. Ex-situ treatment for beneficial reuse could also be considered. A 6-inch sand cover will be added to the remainder of areas with sediment concentrations exceeding RAOs.	Likely to have lower potential for health impacts to community and workers from contaminant release during dredging, staging, transport, and disposal than complete dredging.	Will provide greater long-term risk reduction than ENR alone, but not as much as complete dredging of all areas having sediment concentrations that exceed RAOs.	Moderately easy to implement technically. Moderately easy to moderately difficult to implement administratively. Concerns would be similar to dredging, except that the smaller scope of dredging would be less disruptive to local residents and businesses than dredging of all areas having contaminants exceeding RAOs. Staging areas and disposal sitting would be easier to find for a smaller volume of sediments. Adding a sand cover would decrease depth of the harbor and may limit future use; difficulty this presents would depend on the areas where the cover is added and the depths of water in those areas.	$13.4	Suspension of sediment into the water column and restricted use of the marina during dredging	Sedimentation of suspended sediments and possible water use restrictions	Could be accepted

Notes:

1. Alternatives 5a and 5b compare hydraulic and mechanical dredging methods.
2. All remedial options will include any source control activities necessary to meet the requirements of the GLLA.

Table 4-2
Alternative Ranking
Division Street Outfall, Muskegon, Muskegon County, Michigan

Alternative[1]		Short Term Effectiveness[3]	Long Term Effectiveness[3]	Implementability[4]	Cost	Short Term Impacts	Long Term Impacts	Community Acceptance	Total
1	No Action	0	0	0	5	5	0	0	10
2	Institutional Controls (ICs) and Monitored Natural Recovery (MNR)	1	2	5	5	5	1	0	19
3	Enhanced Natural Recovery (ENR)	4	3	3	4	3	2	2	21
4	In-Situ Capping	4	4	1	3	3	3	1	19
5a/b	Dredging	4	4	4	2	3	4	4	25
6	Dredging, Soil Washing, and Beneficial Reuse	4	5	3	1	3	4	4	24
7	Dredging, Disposal, and ENR	4	4	4	3	3	3	4	25

Notes:

Alternatives are ranked on a scale of 0 to 5 (0 - not favorable, 5 - favorable)

1. Alternatives 5a and 5b compare hydraulic and mechanical dredging methods.
2. All remedial options will include any source control activities necessary to meet the requirements of the GLLA.
3. Effectiveness is evaluated based on the alternative's ability for protecting human health and the environment.
4. Implementability is based on the technical and administrative feasibility of each alternative.

FIGURES

File: D:\Ryerson_Creek_GIS\mxd\FFS\F1-1_SiteLocation.mxd, 11-Mar-09 14:46, wojdakon

Legend

0 2,000 Feet

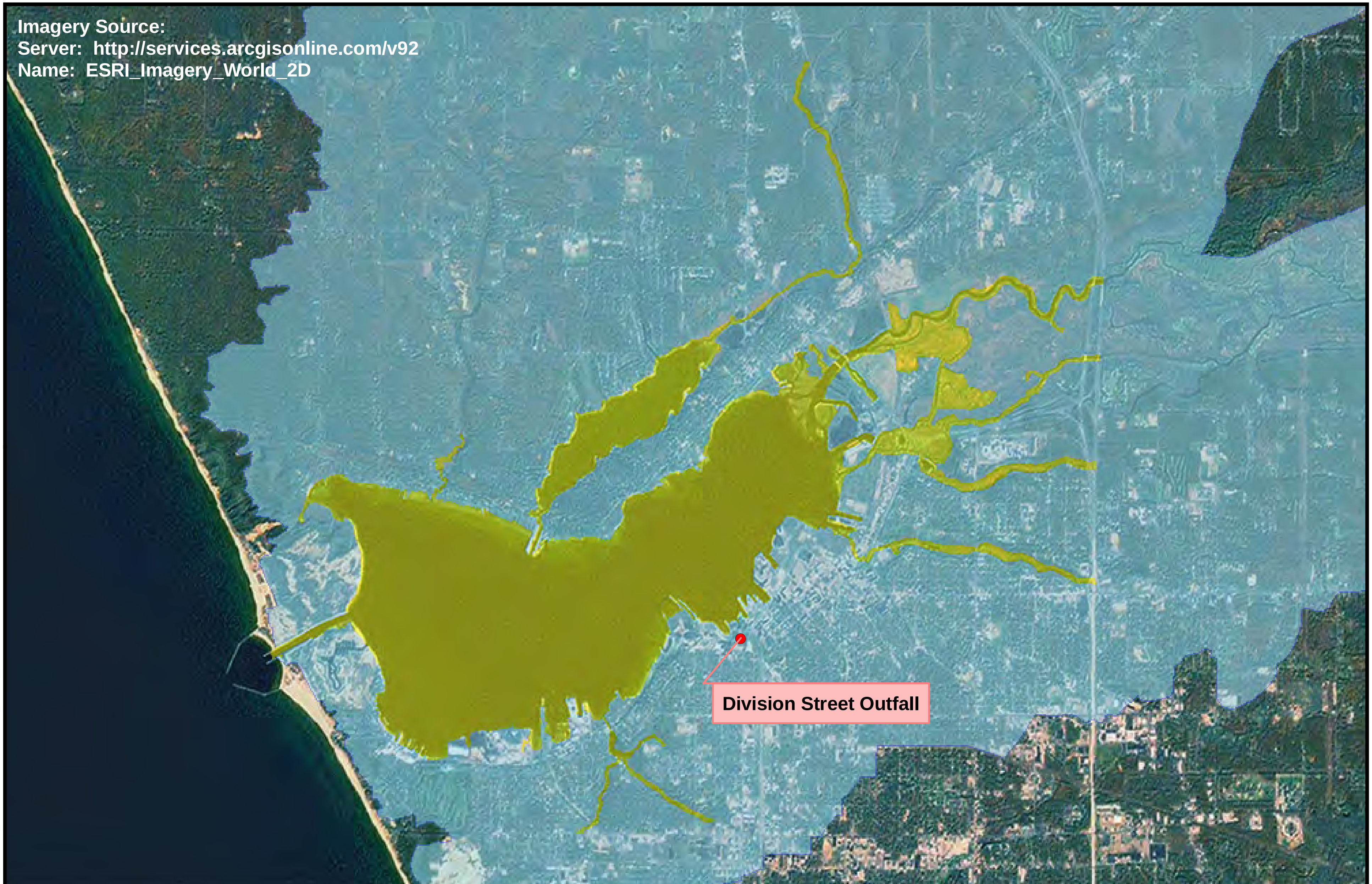
N

Prepared for:
U.S. EPA Region V

Contract No: EP-S5-06-04
TDD: S05-0008-0711-007
DCN: 330-2A-ADPP

Prepared By:
WESTON SOLUTIONS
Weston Solutions, Inc.
750 E. Bunker Ct. Suite 500
Vernon Hills, Illinois 60061

Figure 1-1
Site Location Map
Division Street Outfall
Muskegon, Muskegon County, Michigan



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Legend

0 6,000 Feet

N

Muskegon Lake Area of Concern

Muskegon Lake Watershed

Prepared For:
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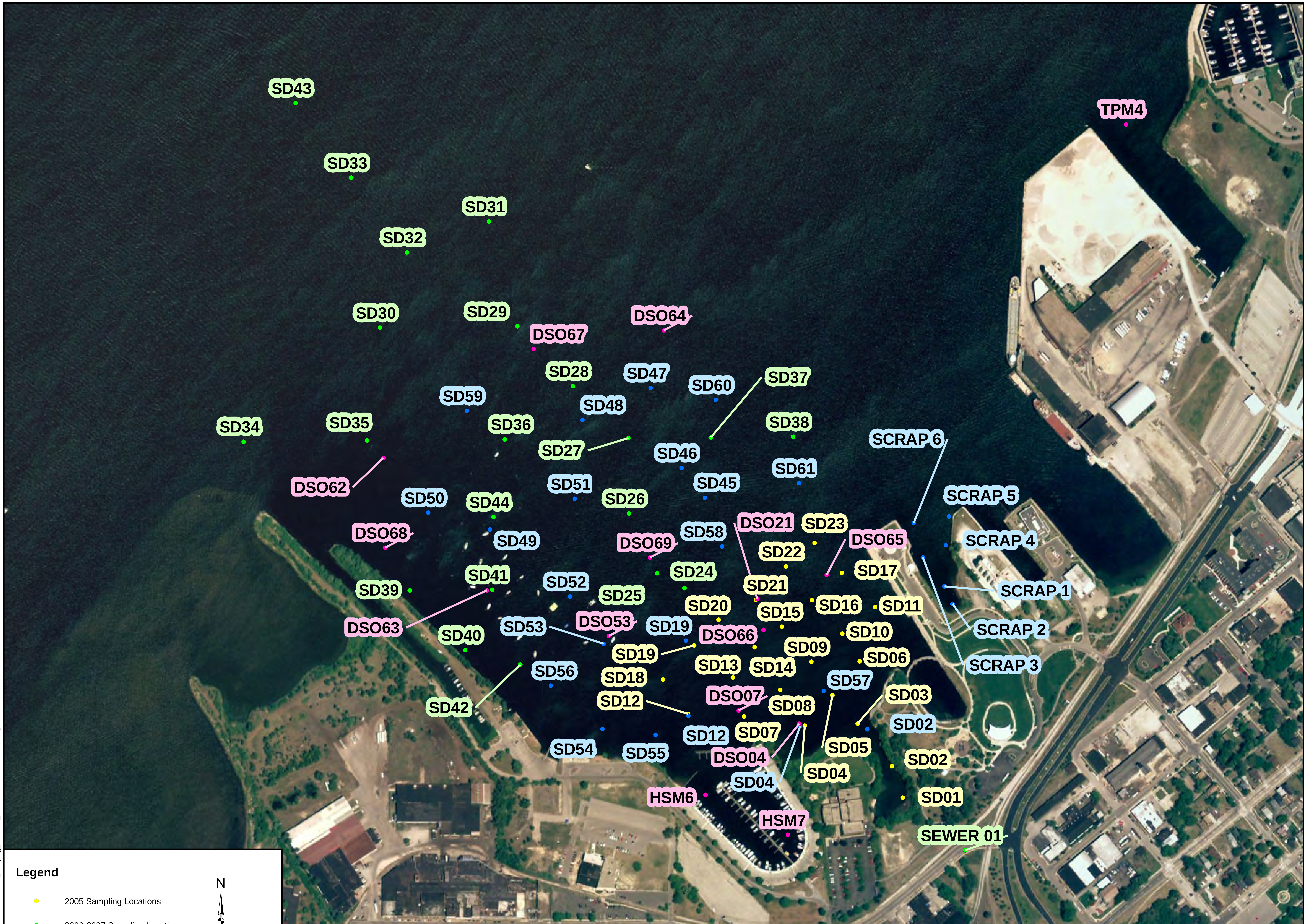
Contract No: EP-S5-06-04
TDD: S05-0008-0711-007
DCN: 330-2A-ADPP

Prepared By:
WESTON SOLUTIONS, INC.
750 East Bunker Ct, Suite 500
Vernon Hills, Illinois 60061

Figure 1-2
DSO Location Map
Division Street Outfall
Muskegon, Muskegon County, Michigan

File: D:\Ryerson_Creek_GIS\mxd\FFS\F1-3_Sampling_Locations.mxd, 11-Mar-09 14:55, wojdakon

Notes:	Prepared For: US EPA Region V	Contract No: EP-S5-06-04 TDD: S05-0008-0711-007 DCN: 330-2A-ADPP	WESTON SOLUTIONS	Prepared By: WESTON SOLUTIONS, INC. 750 E Bunker Ct. Suite 500 Vernon Hills, Illinois 60061	**Figure 1-3** Sampling Location Map Division Street Outfall Muskegon, Muskegon County, Michigan



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Notes:

Prepared For:
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TDD: S05-0008-0711-007
DCN: 330-2A-ADPP

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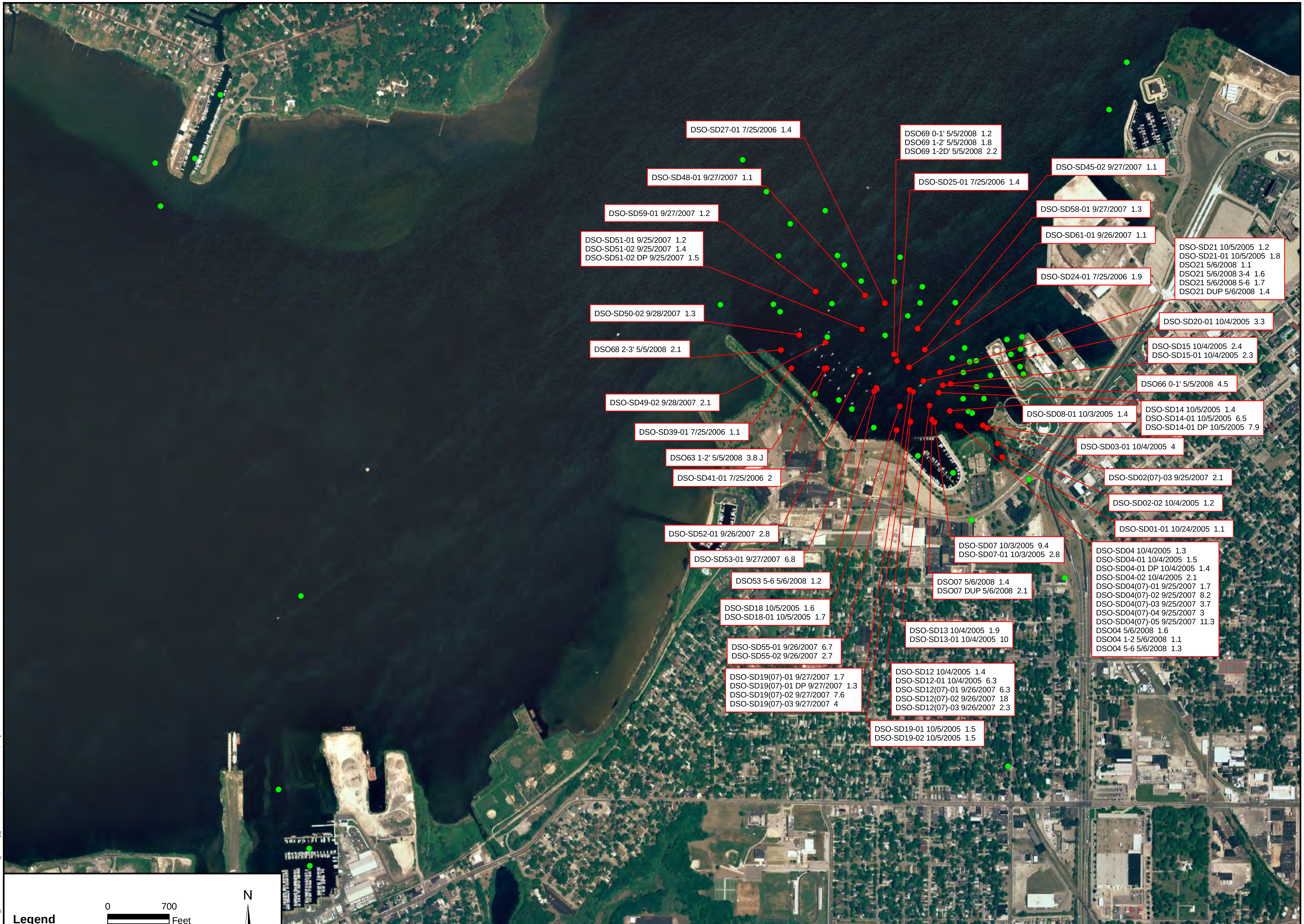
Vernon Hills, Illinois 60061

Figure 1-3
Sampling Location Map
Division Street Outfall
Muskegon, Muskegon County, Michigan



File: D:\Ryerson_Creek_GIS\mxd\FFS\F1-4_Mercury_Exceeds.mxd, 11-Mar-09 15:01, wojdakon

Legend

0 700 Feet

N

- Sampling Locations With No Exceedances
- Sampling Locations With at Least One Exceedance

Notes:
All Result Units = mg/kg
(milligrams per kilogram)
Screening Criteria = 1 mg/kg

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TDD: S05-0008-0711-007
DCN: 330-2A-ADPP

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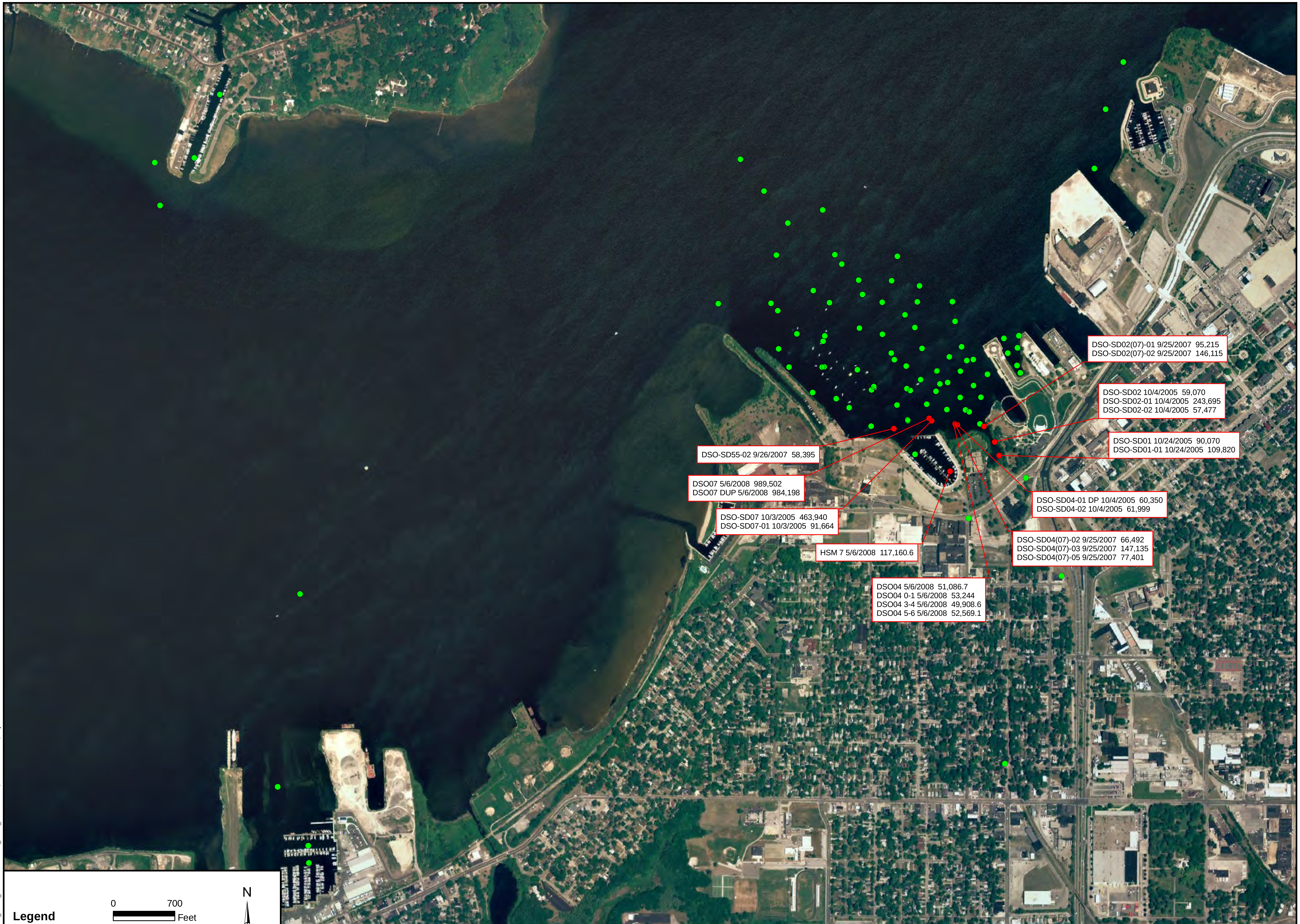
Vernon Hills, Illinois 60061

Figure 1-4
Sampling Results for Hg
Exceeding Screening Criteria
Division Street Outfall
Muskegon, Muskegon County, Michigan



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Legend

0 700 Feet

N

- Sampling Locations with No Exceedances
- Sampling Locations with at Least One Exceedance

Notes:
All Result Units = ug/kg
(micrograms per kilogram)
Screening Criteria 48,000 ug/kg

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DCN: 330-2A-ADPP

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Vernon Hills, Illinois 60061

Figure 1-5
Sampling Results for PAHs
Exceeding Screening Criteria
Division Street Outfall
Muskegon, Muskegon County, Michigan

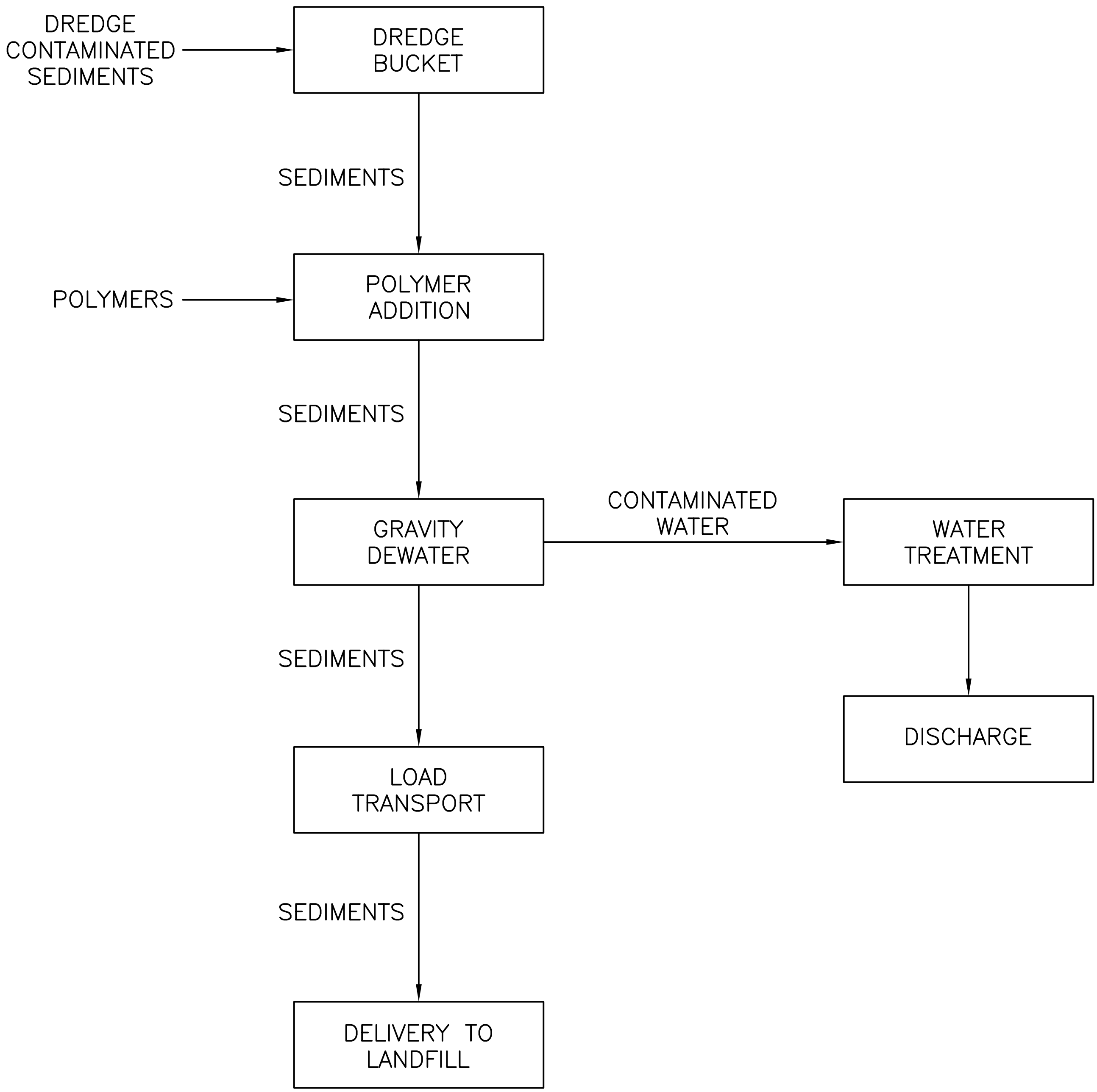

Figure 3-1

Prepared for:
U.S. EPA Region V

Contract No: EP-S5-06-04
TDD NO: S05-0008-0711-007
DCN: 330-2A-ACXU

Prepared by:
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750 East Bunker Ct. Suite 500
Vernon Hills, IL 60061

Conceptual Process Flow Diagram of Mechanical Dredging

Division Street Outfall

Muskegon, Muskegon County, Michigan

Prepared For:
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Contract No: EP-S5-06-04
TDD: S05-0008-0711-007
DCN: 330-2A-ADPP

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Vernon Hills, Illinois 60061

Figure 3-2
Conceptual Plan of Alternative 5
Division Street Outfall
Muskegon, Muskegon County, Michigan

File: D:\Ryerson_Creek_GIS\mxd\FFS\F3-2_CP_Alt5.mxd, 11-Mar-09 15:52, wojdakon

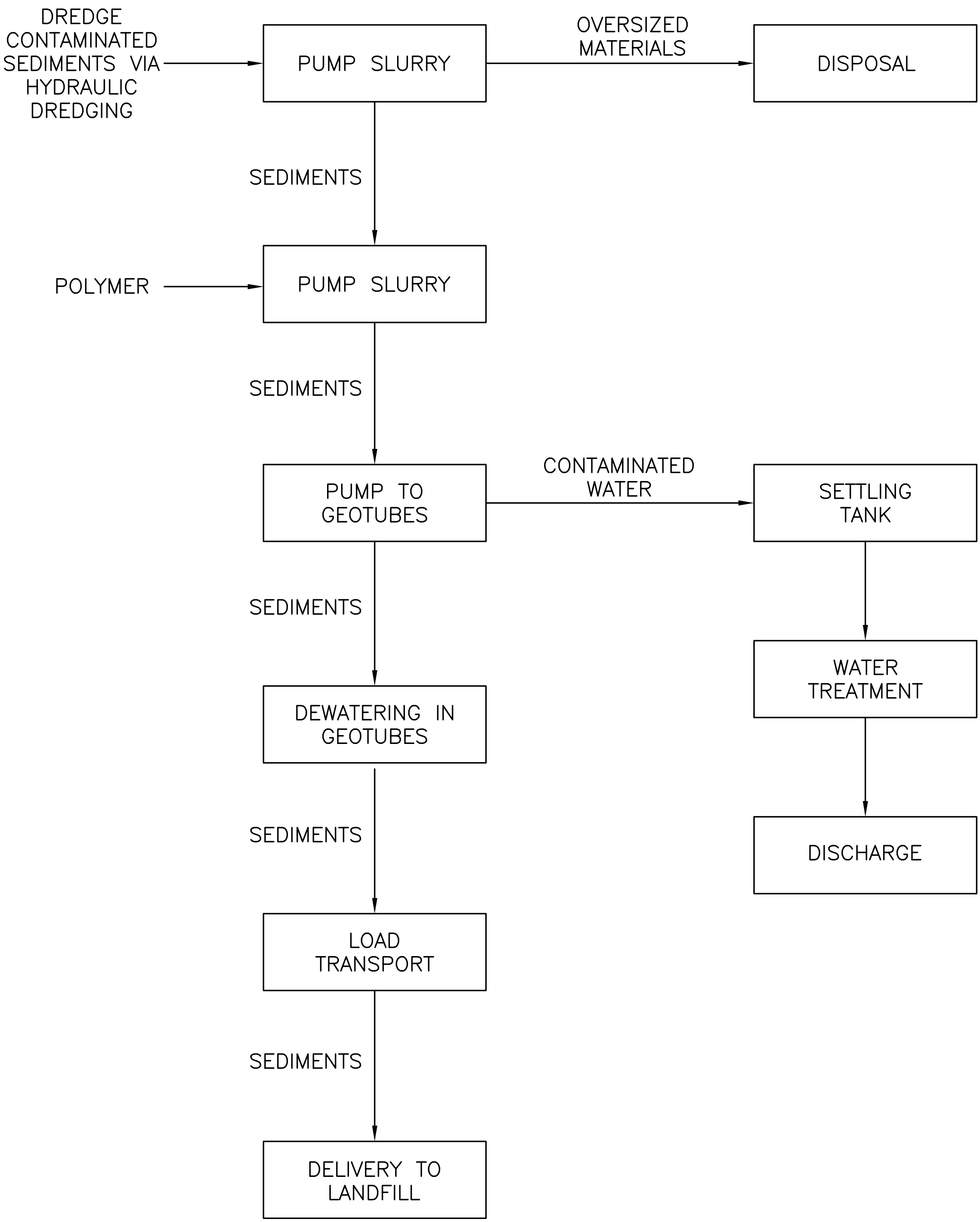

Figure 3-3

Prepared for:
U.S. EPA Region V

Contract No: EP-S5-06-04
TDD NO: S05-0008-0711-007
DCN: 330-2A-ACXU

Prepared by:

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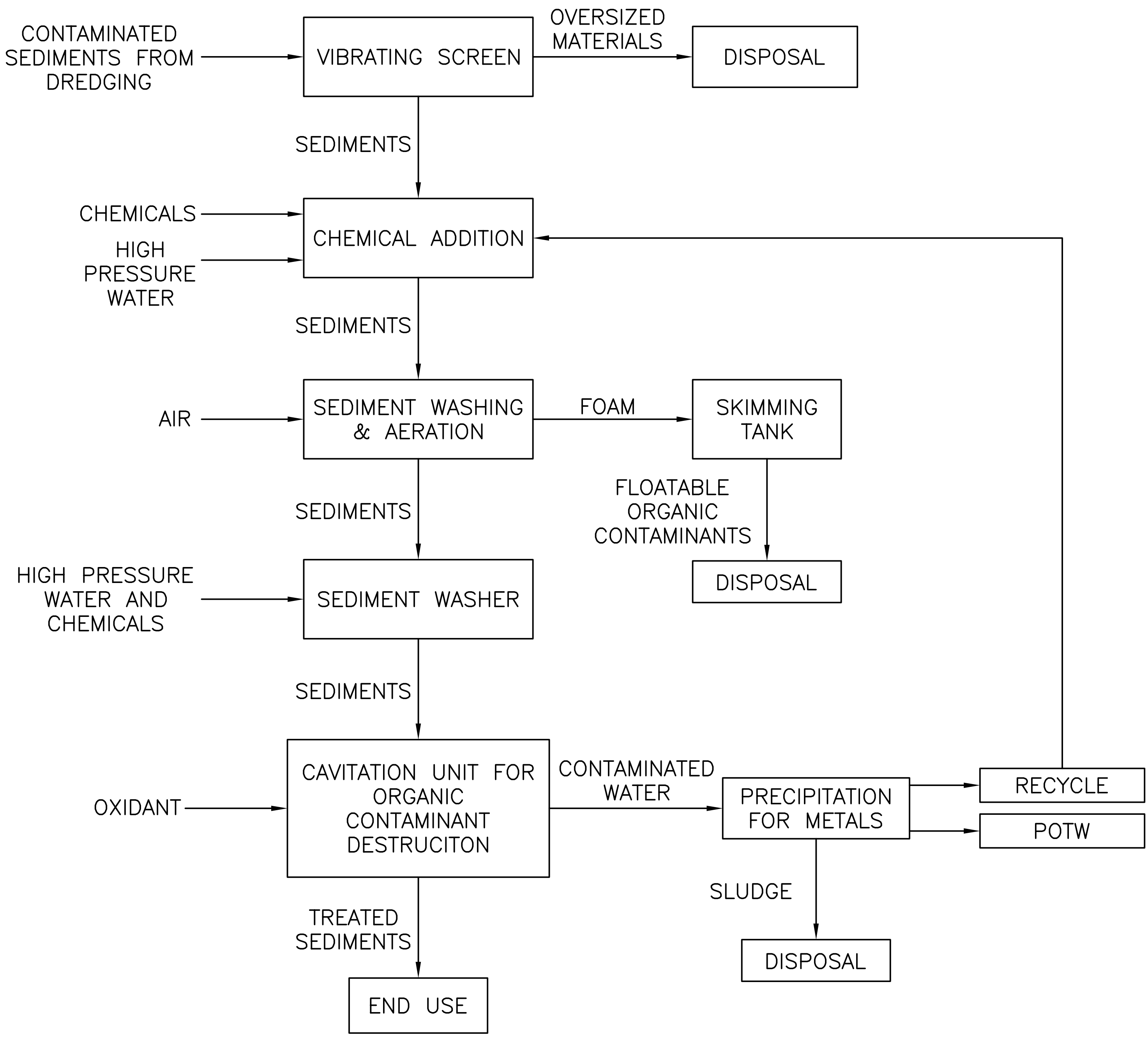
Vernon Hills, IL 60061

Conceptual Process Flow Diagram of Hydraulic Dredging

Division Street Outfall

Muskegon, Muskegon County, Michigan



NOTE:
POTW = PUBLICLY OWNED TREATMENT WORKS

SOURCE: BIOGENESIS ENTERPRISES, INC.

Figure 3-4

Prepared for:
U.S. EPA Region V

Contract No: EP-S5-06-04
TDD NO: S05-0008-0711-007
DCN: 330-2A-ACXU

Prepared by:
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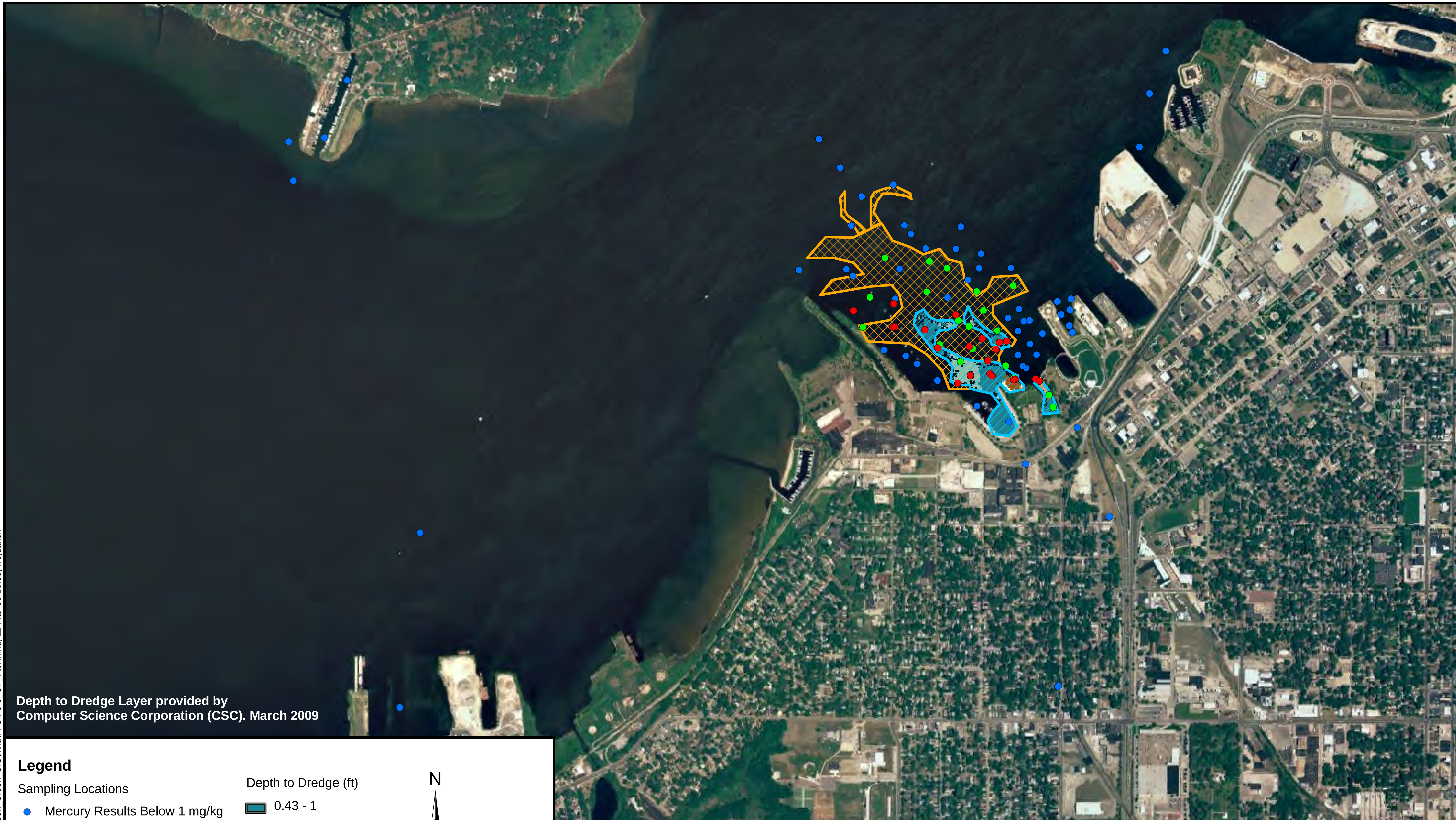
Vernon Hills, IL 60061

Conceptual Process Flow Diagram of Sediment Washing

Division Street Outfall

Muskegon, Muskegon County, Michigan



Legend

Sampling Locations

- Mercury Results Below 1 mg/kg
- Mercury Results Above 1 mg/kg
- Mercury Results Above 2 mg/kg
- Proposed ENR Area
- Proposed Dredging Area

Depth to Dredge (ft)

- 0.43 - 1
- 1.01 - 2
- 2.01 - 3
- 3.01 - 4
- 4.01 - 5.5

N

0 1,150 Feet

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Contract No: EP-S5-06-04
TDD: S05-0008-0711-007
DCN: 330-2A-ADPP

Prepared By:
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Vernon Hills, Illinois 60061

Figure 3-5
Conceptual Plan of Alternative 7
Division Street Outfall
Muskegon, Muskegon County, Michigan

File: D:\Ryerson_Creek_GIS\mxd\FFS\F3-5_CP_Alt7.mxd, 11-Mar-09 16:39, wojdakon

APPENDIX A

FINAL TECHNICAL MEMORANDUM – INTIAL SCREENING OF REMEDIAL ALTERNATIVES FOR DIVISION STREET OUTFALL, MUSKEGON, MICHIGAN

MEMORANDUM

DATE: JANUARY 15, 2008

TO: MICHAEL ALEXANDER, PROJECT MANAGER
MICHIGAN DEQ

FROM: SCOTT CIENIAWSKI, PROJECT MANAGER Scott Cieniawski
U.S. EPA – GLNPO

SUBJECT: PROPOSED REMEDIAL TARGETS FOR MUSKEGON LAKE, DIVISION STREET OUTFALL SITE

As per our earlier discussions, U.S. EPA GLNPO has been evaluating the sediment quality conditions at the Division Street Outfall (DSO), Muskegon Lake, Muskegon, Michigan site based on data collected from 2005 through 2007. Our analysis has focused on the three major contaminants of concern: Oil and Grease, Mercury, and total Polycyclic Aromatic Hydrocarbons (PAHs). Based on our evaluations, we are proposing the following remedial targets for sediment remediation activities at the DSO site:

Contaminant	Proposed Target
Oil and Grease	1,500 mg/kg
Mercury	1 mg/kg
total PAHs	48 mg/kg

In developing these remedial targets, GLNPO relied on the analysis in the attached memorandum, along with the site specific considerations outlined below for each of the contaminant classes.

Mercury

Given the potential for bioaccumulation of mercury in sport and game fish and other wildlife, we propose to adopt the 1.0 mg/kg remedial target for mercury as recommended in the attached memo.

Oil and Grease and total PAHs

The attached memorandum provides a range of potential remedial targets for both oil and grease and total PAHs. With the most stringent recommended remedial target being 5.9 mg/kg for total PAHs and <1,000 mg/kg for oil and grease. However, given the current use characteristics of the DSO site (primarily marina with nearby boat ramp and parking lot) and the proximity of a of potential on-going point (the Division Street outfall) I do not believe that a cleanup levels of 5.9 mg/kg total PAHs and 1,000 mg/kg oil and grease can be maintained at the DSO site. These more stringent remedial targets are more appropriate for un-impacted areas without the presence of even moderate levels of point and/or non-point contamination.

I believe that the parking lot, marina boat traffic, and the Division Street outfall represent low to moderate level sources of PAHs and oil and grease to the sediments at this site, and therefore, the most stringent remedial targets are not appropriate for this site, and could not be maintained over the long term. Therefore, I propose remedial targets of 48 mg/kg for total PAHs (average protective total PAH concentration) and 1,500 mg/kg for oil and grease. Both of these remedial targets are consistent with the moderate levels of contaminant inputs that can be expected at the site given its current use.

Please note that remedial targets do not directly equate to dredging cut lines. The proposed remedial targets potentially could be met utilizing any one of a variety of remedial alternatives (e.g. dredging, insitu capping, enhanced natural recovery, etc.), or a combination of several of these alternatives. The viability of these potential alternatives will be evaluated as part of the site feasibility study that are agencies are currently cooperating on.

Additionally, if the non-federal stakeholders at the site and property owners near the site are able to implement stringent source control measures on the Division Street outfall, the marina traffic, and the adjacent parking lot and boat ramp, we could potentially revisit the proposed remedial targets. However, we would need to be able to demonstrate that only extremely low levels of contaminants were entering the site before we'd be able to adopt the most stringent remedial targets identified in the attached memorandum.

Please feel free to contact me (312.353.9184, cieniawski.scott@epa.gov) if you have any questions regarding this memorandum, or the attachment.

Attachment

Cc: Marc Tuchman (USEPA GLNPO)

ATTACHMENT

MEMORANDUM

DATE: 1-10-08

SUBJECT: Remedial targets for consideration at Division Street Outfall

FROM: D. Scott Ireland, Life Scientist
Technical Assistance & Analysis Branch

TO: Scott Cieniawski, Environmental Engineer
Technical Assistance & Analysis Branch

This memo is intended to summarize my thoughts on appropriate remedial targets for the three parameters you provided (PAHs, Hg, and oil & grease). This analysis did not include the typical risk assessment where you would determine what receptors would be impacted from the contaminants in the sediment then establishing a concentration that would be protective to that receptor for the associated contaminant. Rather this analysis looked at adverse effects on aquatic life (as opposed to human health) from site PAH data and literature values for both Hg and oil & grease.

PAHs

Because PAHs occur in sediments as mixtures and their toxicities in water, tissues, or sediments are additive or nearly additive, their combined toxicities must be considered so that the benchmark is appropriately protective. For this reason, the combined toxicological contributions of the PAH mixture must be used. There is an extremely large number of possible PAH structures (>10,000). Thirty-four PAH structures (specific non-alkylated compounds and generic alkylated forms) have been identified as representing a minimum for 'total PAHs'. It is recognized that this subset of all possible PAHs is not complete; however, the 34 PAHs identified are the ones that are generally most abundant and commonly measured as part of environmental monitoring programs. As analytical techniques improve, the number of PAHs composing 'total PAHs' will most certainly increase (USEPA 2003). Many monitoring and assessment efforts measure a smaller group of PAHs, such as 13 or 23 PAHs. Adjustment factors, or uncertainty factors, have been calculated to relate these smaller subsets to the expected concentration of the 34 PAHs. This, however, may lead to the under- or over-estimation of an equilibrium sediment quality benchmark (ESB) acceptable for the protection of benthic organisms. For Division Street Outfall, the full 34 PAHs were evaluated at 15 locations. These data were used to estimate an ESB by calculating concentration-weighted values at the corresponding 15 locations. This was done by calculating the molar concentration of each PAH in the full 34 PAHs and multiplying those values by the chemical specific guideline value from USEPA 2003. Finally, the sum of these products was then divided by the sum of all the molar concentrations to derive an overall ESB at each location. These values can be found in Table 1. This table shows a range of values that would be protective at that location of roughly 95% of all species from chronic toxicity of PAHs. These values range from 706.5 μg PAH/g OC to 876.7 μg PAH/g OC. When these values are normalized to dry-weight (taking into account the total organic carbon concentration at the specific location) you see a range from 5.9 μg/g dry weight to 88.05 μg/g dry weight. The ESB procedure would suggest that a value of 706.5 μg PAH/g OC or 5.9 μg/g dry weight as protecting roughly 95% of benthic species from chronic toxicity at all 15 locations. This approach allows you a range of options in setting the remedial targets for PAHs based on the level of protection desired. For instance, as stated above, the value of 5.9 μg/g dry weight would be the most protective value based on the available data. From Table 1 you can see that the average dry weight concentration is 47.9 μg/g, using an average TOC value as well. Selecting this value would allow you to be protective at 9 of the 15 locations (60%).

Hg

Like many environmental contaminants, mercury undergoes bioaccumulation. This is the process by which organisms take up contaminants more rapidly than their bodies can eliminate them, thus the amount of mercury in their body accumulates over time. If for a period of time an organism does not ingest mercury, its body burden of mercury will decline. If, however, an organism continually ingests mercury, its body burden can reach toxic levels. This phenomenon occurs because the food source for organisms higher on the food chain is progressively more concentrated in mercury and other contaminants. Consequently bioaccumulation rates at the top of the food chain are magnified. The bioaccumulation effect is generally compounded the longer an organism lives, so that larger predatory game fish will likely have the highest mercury levels. Adding to this problem is the fact that mercury concentrates in the muscle of fish. So, unlike organic contaminants (e.g., PCBs and dioxins) which concentrate in the skin and fat, mercury cannot be filleted or cooked out of consumable game fish.

To evaluate an acceptable remediation target to aquatic life I first looked at the fish tissue toxicity thresholds. These values are defined as the concentrations of bioaccumulative contaminants of concern in fish tissues (whole body) that are sufficient to adversely affect fish, birds or mammals. The toxicity thresholds chosen were those selected by MacDonald *et al.* (2007) that were based on a review of the literature on the toxicity of tissue-associated mercury. Ideally, this would be selected by a site-specific study to determine the appropriate receptor at this site. The receptors outlined below are used as examples based on the literature and may not necessarily reflect receptors at this site (that would be determined from an ecological risk assessment). For fish, the toxicity threshold of 3.7 mg Hg/kg WW in whole-body fish was selected based on the results of a study on rainbow trout (*Oncorhynchus mykiss*: Hawryshyn and Mackay, 1979). The toxicity threshold for kingfishers (piscivorous birds – feeds on fish) of 0.13 mg Hg/kg WW diet represents the lowest observable effect level (LOEL) for reproductive effects in birds (Heinz, 1974; Sample *et al.*, 1996). The toxicity threshold for mink (piscivorous mammals) of 0.18 mg Hg/kg WW diet represents the LOEL for reproductive effects in mink (Sample *et al.*, 1996).

The next step was to select a bioaccumulation factor (BAF) for estimating the concentrations of contaminants of concern (in this case mercury) in fish tissue. For this calculation, I used a BAF for fish exposed to mercury in the Indiana Harbor Area of Concern (MacDonald *et. al.*, 2007). This study compiled fish tissue chemistry from a total of 184 whole-body or muscle samples from 12 species of fish in the Area of Concern (AOC). The result was an average BAF for mercury of 0.124. This number is comparable to an average BAF for fish exposed to mercury at other sites throughout the United States. In work done on developing remedial alternatives for the West Branch of the Grand Calumet River in NW Indiana 3 separate studies were evaluated (MESL *et al.*, 2006). The result was BAF values ranging from 0.07 to 1.86 (an average of 0.772 ± 0.6445).

These factors (toxicity threshold and BAF) can then be used to "back calculate" a sediment concentration that would be protective for that specific receptor species. This sediment concentration was calculated using the most conservative toxicity threshold (0.13 mg Hg/kg WW - kingfisher) and a BAF of 0.124.

$$BAF_{HG} = \frac{[Hg]_{Tissue}}{[Hg]_{Sediment}}$$

$0.124 = 0.13/[Hg]_{Sediment}$

$[Hg]_{Sediment} = 1.05$ mg/kg.

Therefore, based on this analysis, a cleanup target of 1.0 mg Hg/kg appears appropriate for the protection of aquatic life. If, however, existing fish tissue data exists one could calculate a site specific BAF utilizing a surface weighted mercury concentration to ultimately derive a site-specific sediment cleanup target for mercury. Additionally, as stated above, an ecological risk assessment may identify other receptors at this specific location.

Oil & Grease

There is not a lot of guidance on the effects on aquatic life due to oil & grease even thought it is a common contaminant found in sediments. In 1971 EPA promulgated the "Jensen criteria" for national use in determining the suitability of open water spoils disposal. These "Jensen criteria" were used in the Great Lakes to determine which dredged material required disposal to a confined disposal facility (CDF), constructed under Section 123 of PL 91-611 (Rivers and Harbors and Flood Control Act of 1970). These "criteria" were modified by Region 5, USEPA, in 1974, allowing for a determination based on the collective information and not any single pass-fail number. In 1977, the USEPA, Region 5, published "Interim guidelines for the pollutional classification of Great Lakes harbor sediments" (USEPA 1977). These guidelines expanded the "Jensen criteria" to a system for classifying sediments as non-polluted, moderately polluted, and heavily polluted based on 19 physical and chemical parameters. When one or more parameters exceeded criteria, the sediments were considered unacceptable for open water disposal. The criterion for oil & grease in this document was 1,500 mg/kg (USEPA 1983).

Additionally, the Ontario Ministry of the Environment released "Evaluating Construction Activities Impacting on Water Resources" in 1976. This provided guidelines for the evaluation of the suitability of dredged spoil for open water disposal. These guidelines were based on the Jensen criteria but modified to reflect data from Canadian harbors on the Great Lakes. The guideline for oil & grease was 1,500 mg/kg (USEPA 1983). Finally, in 1977, EPA document entitled "Guidelines for the Pollutional Classification of Great Lakes Harbor Sediments" provides ranges for a variety of pollutants (oil & grease being one of them) used to make decisions on the disposal of dredged material from Great Lakes Harbor sediments. These ranges were based on compilations of data from over 100 different harbors since 1967. Sediments were classified subjectively as heavily polluted, moderately polluted, or non-polluted. Sediments with oil & grease concentrations below 1,000 mg/kg were considered non-polluted, between 1,000 and 2,000 mg/kg were considered moderately polluted, and greater than 2,000 mg/kg were considered heavily polluted (USEPA 1983).

The toxicity of oil & grease is typically associated to component chemicals, particularly PAHs. While PAHs can be toxic to aquatic organisms, it is not entirely clear that they are the *only* source of toxicity from contamination by non-aqueous phases (Mount et al 2007). Recent studies conducted by EPA's Office of Research and Development have concluded that data from controlled experiments indicate that a non-aqueous phase, can cause toxicity to the benthic organisms *Chironomus dilutus* and *Hyalella azteca*, apparently by a mechanism other than toxicity of dissolved components (e.g., physical interactions). In my opinion, this work shows promise in being able to provide guidance on levels of oil & grease that will be protective of the benthic community. In the interim, I recommend you try and set the remediation target for oil & grease as operationally low as you can. If possible, the target should be below 1,000 mg/kg.

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TABLE 1.

	Total PAH concentration (μg/g) - surficial	ESB_{34} (μg PAH/g OC)	TOC (%)	μg/g dry wgt
DSO-SD01	103.6	779.17	11.30	88.05
DSO-SD02	66.7	766.91	3.57	27.38
DSO-SD03	17.3	808.98	1.15	9.30
DSO-SD04	56.1	830.87	9.74	80.93
DSO-SD05	13.9	832.24	1.45	12.07
DSO-SD06	12	821.20	2.36	19.38
DSO-SD07	585.6	706.35	8.91	62.94
DSO-SD09	3.9	817.81	0.75	6.13
DSO-SD11	2.2	807.87	0.73	5.90
DSO-SD12	12.3	812.85	8.70	70.72
DSO-SD14	50.1	793.48	8.75	69.43
DSO-SD18	23.4	804.37	7.88	63.38
DSO-SD19	21.9	794.23	7.13	56.63
DSO-SD21	27.5	802.05	8.52	68.33
DSO-SD23	15.7	801.99	9.67	77.55
MAX		832.24	11.30	88.05
MIN		706.35	0.73	5.90
AVG		798.69	6.04	47.87
ST DEV		30.99	3.86	30.52
MEDIAN		804.37	7.88	62.94

APPENDIX B

SITE RECONNAISSANCE VISIT SUMMARY

Site Reconnaissance Visit – November 14, 2007
Division Street Outfall Feasibility Study
Muskegon, Michigan

Purpose:

On 14 November 2007, Weston Solutions, Inc. (WESTON®) conducted a site walk of the Division Street Outfall area and the shoreline of Muskegon Lake where sediments require remediation (the site). WESTON conducted this site visit as part of **Task 3.4** of the Focused Feasibility Study (FFS) Work Plan, dated November 2007. The work is being conducted at the site as part of a joint assessment project between the Michigan Department of Environmental Quality (MDEQ) and USEPA Great Lakes National Program Office (GLNPO) under the Great Lakes Legacy Act.

The purpose was to familiarize the parties with the site and understand the logistics of conducting remedial activities at the site. The participants met at the Annis Water Resources Institute, then started the walk at the Division Street Boat Launch and continued to the Division Street Outfall. Some of the surrounding properties were also visited. The site walk concluded back at the Annis Water Resources Institute, where a kickoff meeting was conducted and potential alternatives were discussed.

Representatives:

The site walk and meeting was attended by representatives from WESTON, MDEQ, USEPA, the City of Muskegon, the County of Muskegon, and the Watershed Partnership (see attached stakeholder contact list). Robert Fountain was the city representative present during the site walk.

Property Ownership and Staging:

- See attached property ownership map.
- The outfall is located behind the YMCA property. The county is interested in acquiring this property.
- The lawn area on the YMCA property would not be a good area for staging or remedial operations because it is too soft.
- The land on the peninsula located near the Division Street boat launch is owned by the city, and could potentially be used for offloading barges.
- A gate is present on the peninsula that could be locked. A 1-lane gravel access road is also present.
- The nearby factory on the property to the southwest of the peninsula and north of Western Avenue is owned by Michigan Steel.
- A potential area for a staging pad is owned by George Bailey of Great Lakes Dock – GLM, LLC. This area consists of approximately 10 acres. A portion of the property may serve as a parking lot and the remainder is undeveloped land that is currently not in use.

- The Hartshorn Center is the building that is located along Western Avenue.

Public Use:

- The property on the peninsula is used for boat slips. Work on this property would need to be planned in advance and coordinated with the city.
- A public bike path is present around Muskegon Lake, which cuts through the potential staging areas near the boat launch.
- Heritage Park, which is used for summer festivals, is located next to the outfall area.

Utilities:

- Water, sewer, and electricity are available near the site.
- Water from sediment remediation would be able to be sent to the Muskegon treatment plant with pre-treatment.
- The discharge fee is set per gallon by the city. Contact the county WWTP for costs and reporting requirements.
- The sewer system would most likely be adequate to handle the wastewater discharge from the sediment remedial activities. However, the capacity of the sewer system would need to be confirmed by the city.
- A fire hydrant, power, and sewer are located on or near the Great Lakes Dock property.
- The sewer system is believed to be close to Western Avenue – the city will obtain blueprints of the sewer system. The city can also locate the sewer in the field.
- For discharge to the sewer, application for a county wastewater permit would be required.
- Temporary electric hookups have been used at the site before. Consumers Energy supplies electricity to the area.

Muskegon Lake and Sediment:

- The sediment generally has a uniform consistency for treatment (i.e. little wood is present).
- The highest concentrations of mercury are approximately 10 mg/kg, although typically, the concentrations range from approximately 1 to 3 mg/kg.
- Water levels in Muskegon Lake have been low lately. The depth ranges from 18 to 26 feet.

Division Street Outfall:

- The outfall is concrete and several feet in diameter (approximately 4 – 6 feet?)
- The outfall is a storm sewer, and is also connected to the hospital under-drains. As a result, there is always some dry-weather flow.

- The alcove where the outfall is located will also require dredging (or other remediation).
- The outfall area could possibly be dry-dredged and the sediment pulled back out to a barge in the lake.

General Meeting Notes:

- The goal for the project start date is September 2008.
- Legacy program requirements (which are different than Superfund) will need to be considered during development of the FFS (i.e. long term effects on environment).
- The main drivers at the site are mercury, PAHs, and oil & grease.
- Samples collected in 2007 were analyzed for metals, PAHs, TCLP, oil & grease, TOC, grain size, and bulk density. Results of the TCLP testing indicated that the samples did not leach. MDEQ will upload 2006 sampling data to FTP site.
- According to MDEQ, no significant ongoing source of contamination has been identified at the site – MDEQ will document this finding in a report, which will be included as an appendix to the FFS.
- The sampling results from “scrap bay” will be included in the site database and in the FFS – coordinates will be required for these samples.
- The community is most concerned with safety, adequacy of cleanup, and remedial timeframe. Construction safety and safety to the public of each alternative must be considered during the FFS evaluation (short term effectiveness).
- The incremental cost of additional remediation will need to be weighed against the amount of added environmental benefit during the FFS analysis (e.g. graph lbs of mercury removed vs dollars to show during public meeting)
- MDEQ/EPA need to provide some guidance to WESTON on what is considered to be “cost prohibitive” for an alternative.
- Various potential staging and treatment area locations were discussed during the meeting – Kathy Evans of the Watershed Partnership will make the contacts.
- The FFS will state that Muskegon Lake will not necessarily be delisted for mercury advisory after the cleanup activities – other sources of mercury (e.g. depositional) could still be present.
- CSC will complete mass balance calculations based on selected criteria.
- The alternative array screening will be base on technical feasibility.
- Biogenesis will provide information regarding sediment washing and beneficial reuse – contact John Pauling

Potential Remedial Alternatives:

- Alternative 1 – No Action.
- Alternative 2 – Monitored Natural Recovery (MNR)
- Alternative 3 – Subaqueous cap
- Alternative 4 – Subaqueous treatment barrier
- Alternative 5A – Mechanical dredging and disposal
- Alternative 5B – Hydraulic dredging and disposal

- Alternative 5C – Mechanical dredging and sediment washing w/ beneficial reuse
- Alternative 5D – Hydraulic dredging and sediment washing w/ beneficial reuse
- Alternative 6A – Mechanical dredging of hot spots, disposal, and residual cover
- Alternative 6B – Hydraulic dredging of hot spots, disposal, and residual cover
- Other alternatives may include consideration of dredging and other ex-situ treatment technologies (e.g. chemical extraction), if applicable.

Potential Dewatering Technologies:

- Geotubes
- Gravity Pad Dewatering
- Polymer Addition
- Mechanical Dewatering

APPENDIX C

SOURCE CONTROL EVALUATION

(MDEQ WILL PROVIDE AT A LATER DATE)

APPENDIX D

REGULATORY AND PERMITTING REQUIREMENTS

APPENDIX D

REGULATORY AND PERMITTING REQUIREMENTS

SECTION 1 INTRODUCTION

This appendix provides an analysis of the regulatory and permitting requirements, also commonly referred to as the applicable or relevant and appropriate requirements (ARARs), for the FFS prepared for the Division Street Outfall Site in Muskegon, Michigan.

1.1 ARAR DEFINITION

While remedial action at the Division Street Outfall will be conducted under the Great Lakes Legacy Act, this FFS follows the format of the United States Environmental Protection Agency (U.S. EPA) Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Remedial Investigation/Feasibility Study (RI/FS) guidance (U.S. EPA, 1988); and therefore, identification of ARARs is appropriate.

"Applicable requirements," as defined in 40 CFR 300.5, are as follows:

> Those clean-up standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable.

"Relevant and appropriate requirements," also defined in 40 CFR 300.5, are as follows:

> Those clean-up standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws, that, while not 'applicable' to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a site, address problems or situations sufficiently similar to those encountered at the site that their use is well suited to the particular site. Only those state standards that are identified in a timely manner and are more stringent than federal requirements may be relevant and appropriate.

1.2 TO BE CONSIDERED CRITERIA

In addition to ARARs, advisories, criteria, or guidance may be identified as "to be considered" (TBC) for a particular release. As defined in 40 CFR 300.400(g)(3), the TBC category "consists of advisories, criteria, or guidance developed by the U.S. EPA, other federal agencies, or states that may be useful in developing remedies."

Use of TBCs is discretionary rather than mandatory; however, use of ARARs is mandatory.

1.3 ARAR CATEGORIES

In general, there are three categories of ARARs:

- Ambient or chemical-specific requirements
- Location-specific requirements
- Performance, design, or other action-specific requirements

Chemical-specific ARARs are usually health- or risk-based numerical values or methodologies that when applied to site-specific conditions, result in the establishment of numerical values. These values establish the acceptable amount or concentration of a chemical that may be found in or discharged to the ambient environment. If a chemical has more than one such requirement that is an ARAR, the most stringent ARAR generally should be used.

A site's location is a fundamental determinant of its impact on human health and the environment. Location-specific ARARs are restrictions placed on the concentration of hazardous substances or the conduct of activities solely because they are in specific locations. Some examples of special locations include floodplains, wetlands, historic places, and sensitive ecosystems or habitats. An example of a location-specific requirement is the substantive Clean Water Act (CWA) '404 prohibitions of the unrestricted discharge of dredged or fill material into wetlands.

Action-specific ARARs are usually technology- or activity-based requirements or limitations on actions taken with respect to hazardous wastes. These requirements are triggered by the particular remedial activities selected to accomplish a remedy. Since there are usually several alternative actions for any remedial site, very different requirements may be applicable. These action-specific requirements do not in themselves determine the remedial alternative; rather, they indicate how a selected alternative must be achieved.

SECTION 2 IDENTIFICATION AND EVALUATION OF ARARS

At the beginning of the FFS process, a preliminary consideration of location- and action-specific ARARs is commonly conducted. As remedial alternatives are screened during the FFS, action-specific ARARs are identified. When the detailed analysis of the remedial alternatives is conducted, all action-specific ARARs are refined in a more detailed form with respect to each alternative before a comparison of alternatives begins. The ARARs will be finalized based on the review and recommendations of GLNPO and MDEQ. The chemical-specific, location-specific, and action-specific ARARs for the site are discussed in the following subsections.

2.1 CHEMICAL-SPECIFIC ARARS

The health-based, chemical-specific ARARs pertinent to contaminants of concern identified for environmental media at the site are primarily derived from federal and state health and environmental statutes and regulations.

2.2 LOCATION-SPECIFIC ARARS

Location-specific ARARs are statutes or regulations that set restrictions on activities or limits on contaminant levels solely because of location, e.g., within a floodplain, wetland, historic place, or sensitive ecosystem or habitat.

2.3 ACTION-SPECIFIC ARARS

Performance, design, and other action-specific requirements set controls or restrictions on particular kinds of activities related to the management of hazardous substances or pollutants. These requirements are not triggered by the specific chemicals present at a site but rather by site characterization activities and remedial actions. Potential action-specific ARARs are technology-based performance standards, such as the Best Available Technology standard of the Federal Water Pollution Control Act and CWA pretreatment standards for discharges to publicly owned treatment works. The selection of appropriate action-specific ARARs is based on the general response actions (i.e. No Action, Institutional Controls, Containment, Treatment, etc.).

SECTION 3 ORGANIZATION OF ARARS

Tables D-1 through D-4 summarize the ARARs for each alternative. The ARAR summaries include chemical-specific, location-specific, and action-specific ARARs and are separated by Federal, State, and TBC ARARs.

ARARs related to hazardous waste were excluded as it is assumed waste generated for disposal (i.e. dewatered sediment as a result of dredging) is non-hazardous. Several alternatives were combined as the ARARs will be the same due to the level of effort and nature of the remedial alternative construction. Tables D-1 through D-4 summarize ARARs for the alternatives as follows:

- Table D-1: Alternative 1 – No Action
- Table D-2: Alternative 2 – Monitored Natural Recovery
- Table D-3: Alternative 3 – Enhanced Natural Recovery and Alternative 4 – In-Situ Capping
- Table D-4: Alternative 5a/5b – Dredging; Alternative 6 – Dredging/Soil Washing/Beneficial Re-Use; and Alternative 7 – Dredging/Enhanced Natural Recovery.