MINNESOTA SLIP
FOCUSED FEASIBILITY STUDY

Duluth, Minnesota
MPCA Work Order # SFBW-0605
MPCA Technical Document: tdr-fg05-05

Prepared for:

Minnesota Pollution Control Agency
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Duluth, Minnesota, 55802

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November 2005

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SIGNATURE PAGE

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EXECUTIVE SUMMARY

This Focused Feasibility Study (FFS) for the Minnesota Slip presents a summary of current site conditions, a discussion of preliminary remediation goals, the identification, screening, evaluation and comparison of potential alternatives, and provides a recommended alternative.

The Minnesota Slip, an active manmade slip surrounded by land on three sides, is located at the mouth of the St. Louis River in the Duluth Harbor. The total area of the Slip is slightly larger than three acres. Due to the considerable contamination in the St. Louis River estuary, the International Joint Commission (IJC) designated the lower St. Louis River as one of 43 Areas of Concern (AOCs) in the Great Lakes basin in the late 1980's. Many sites within the St. Louis River AOC have elevated concentrations of metals, Polynuclear Aromatic Hydrocarbons (PAHs), Polychlorinated Biphenyls (PCBs), dioxins, and furans (Schubauer-Berigan and Crane 1997; Crane et al. 1997; Breneman et al. 2000). In addition, the St. Louis River, including the Duluth/Superior Harbor, is listed as impaired water on the Clean Water Act 303(d) list for bioaccumlative toxins. Toxins include mercury, PCBs and pesticides (DDT, dioxin, etc.). It is widely recommended by many programs that biotoxins be reduced with in the St. Louis River estuary and harbor.

Minnesota Slip has been studied in the past as a part of the St. Louis River AOC, (see Section 1.4.4 Nature and Extent of Contamination). In 2003, the Minnesota Pollution Control Agency (MPCA) applied for and received a grant in 2003 from the US Environmental Protection Agencies (EPA), Great Lakes National Program Office (GLNPO) to perform additional studies to determine the nature and extent of contaminated sediments and the preparation of this FFS. These investigations showed that the sediments in the Slip are contaminated with PAHs, PCBs, mercury, cadmium, chromium, copper, lead, nickel, and zinc. Contaminated sediment is generally present through out the entire Slip. Contamination was detected to a depth of up to 12 feet below the surface of the sediment in one location with an average depth of 6.5 feet below the sediment surface. Contaminated sediment volumes have been estimated at approximately 33,000 cubic yards.

The MPCA studies also included a limited screening assessment which indicated that the direct risk to human health from contaminated sediments in the Slip is low. However, fish consumption advisories are in effect for selected fish species in the St. Louis River AOC because of elevated concentrations of PCBs and mercury found in the fish tissue (MDH, 2000). It is probable that contaminants from Minnesota Slip are contributing to bioaccumulation in the aquatic food chain up to fish consumed by humans and contributing to the overall impaired use in the St. Louis River AOC. The limited screening assessment indicated that there is an unacceptable risk of significant effects from exposure to surficial sediments throughout the Slip to aquatic receptors.

As identified in the St. Louis River Remedial Action Plan (RAP-1992) and later proven with testing, Minnesota Slip is contributing to two impairments to the St. Louis River AOC: 1) fish consumption advisory; and 2) degradation of the benthos environment. As recommended by the RAP, areas that are contributing to river sediment impairments should be addressed through remedial activities. In addition, removing the contaminated sediments from MN Slip would also help in the reduction of the impaired water resulting from bioaccumlative toxins in the St. Louis River.

In September 2005, a draft FFS was submitted for MPCA and EPA GLNPO review. Comments received on the draft FFS recommended removal of the Alternative 2, Scenario 2A and 2B (6 Foot Cap), since they were similar to Alternative 3, Total Dredge with Two Foot Cover. Therefore, this Final FFS was further focused and does not include the 6 foot dredge options. The following alternatives are presented and evaluated in this Final FFS:

Alternative 1. No Action. The No Action Alternative does not include any treatment or engineering controls. The No Action Alternative does include long-term monitoring and institutional controls. The estimated total present value cost for Alternative 1 is approximately $524,525.

Alternative 2. Partial Dredging with In-Situ Capping.

> Alternative 2A, Partial Dredging with 3-Foot Cap, Erie Pier Disposal. This alternative includes dredging approximately 16,000 cubic yards of contaminated sediment transporting, and placing the sediments in the containment cell constructed at Erie Pier. This alternative also includes removal of sediment at Erie Pier and construction of a containment cell at Erie Pier. The remainder of the contaminated sediment would be capped in place under a 3-foot cap. Approximately 14,600 cubic yards of capping material would be needed under Alternative 2A. The estimated total present value cost for this Alternative is approximately $5,182,200

> Alternative 2B, Partial Dredging with 3-Foot Cap, Off-Site Disposal. This alternative includes dredging approximately 16,000 cubic yards of contaminated sediment, transporting, staging sediments at Erie Pier, and disposing the sediments at an off-site landfill. The remainder of the contaminated sediment would be capped in place under a 3-foot cap. Approximately 14,600 cubic yards of capping material would be needed under Alternative 2B. The estimated total present value cost for this Alternative is approximately $4,902,500.

Alternative 3. Total Dredging with Two Foot Cover.

> Alternative 3A. Total Dredging with Two Foot Cover, Erie Pier Disposal. This alternative includes dredging all of the contaminated sediments exceeding the criteria or depth specified by the MPCA (estimated at approximately 33,000 cubic yards) transporting, and placing the sediments in a containment cell constructed at Erie Pier. This alternative also includes removal of sediment at Erie Pier and construction of a containment cell at Erie Pier. Two feet of restoration material/environmental medium would be placed in the excavated areas to provide a protective aquatic substrate and isolate dredge residual. Approximately 9,782 cubic yards of cover material would be needed under Alternative 3A. The estimated total present worth cost for Alternative 3A with Erie Pier Disposal is approximately $7,016,500.

> Alternative 3B. Total Dredging with Two Foot Cover, Off-Site Disposal. This alternative includes dredging all of the contaminated sediments exceeding the criteria or depth specified by the MPCA (estimated at approximately 33,000 cubic yards) transporting, staging sediments at Erie Pier, and disposing the sediments at an off-site landfill. Two feet of restoration material/environmental medium would be placed in the excavated areas to provide a protective aquatic substrate and isolate dredge residual. Approximately 9,782 cubic yards of cover material would be needed under Alternative 3B. The estimated total present worth cost for Alternative 3B with Off-Site Disposal is approximately $7,132,500.

The comparative analysis of Alternatives presented in Section 5, identified Alternative 2B as receiving the highest overall scoring (See Table 7). Based on this scoring, the recommended alternative is Alternative 2B, Partial Dredging with In-Situ Capping (3-foot cap with off-site disposal).

If short-term effectiveness, costs, and implementability were less of a concern, total removal with disposal in a containment cell constructed at Erie Pier (Alternative 3A) would be more desirable since all of the contaminated sediments would be removed from the aquatic environment. However, there were significant concerns under each of these criteria that made total removal a less desirable option.

The modifying criteria, State/support agency acceptance and community acceptance are assessed formally after the public comment period. Stakeholder and community input may also provide valuable insight in the implementation of the selected response action.

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ACRONYMS

ARARs .... Applicable or Relevant and Appropriate Requirements
Bay West .... Bay West, Incorporated
BAZ .... Bioactive Zone
BMP .... Best Management Practice
BT/PT .... Best Technology in Process and Treatment
COCs .... Contaminants of Concern
DRO .... Diesel Range Organics
DECC .... Duluth Entertainment and Convention Center
EPA .... United States Environmental Protection Agency
FFS .... Focused Feasibility Study
GLNPO .... Great Lakes National Program Office IZ Isolation Zone
LIF .... Laser Induced Fluorescence
MERLA .... Minnesota Environmental Response and Liability Act
mg/kg .... milligrams per kilogram
mg/L .... milligrams per Liter
MPCA .... Minnesota Pollution Control Agency
MSL .... Mean Sea Level
NCP .... National Contingency Plan
NPL .... National Priority List
OSWER .... Office of Solid Waste and Emergency Response
PAHs .... Polynuclear Aromatic Hydrocarbons
PCB .... Polychlorinated Biphenyl
PEC-Q .... Probable Effect Concentration Quotient
pg/L .... picograms per Liter
PLP .... Permanent List of Priorities
PRG .... Preliminary Remediation Goal
RAOs .... Response Action Objectives
RBSE .... Risk Based Site Evaluation
R-EMAP .... Regional Environmental Monitoring and Assessment Program
RI .... Remedial Investigation
Site .... Minnesota Slip
SLRIDT .... St. Louis River/Interlake/Duluth Tar
SOW .... Statement of Work/Cost Estimate
SQT .... Sediment Quality Target
TBD .... To Be Determined
TC .... Toxicity Characteristic
TCLP .... Toxicity Characteristic Leaching Potential
μg/kg .... micrograms per kilogram
USACE .... United States Army Corps of Engineers

1.0 INTRODUCTION AND BACKGROUND

This Focused Feasibility Study (FFS) has been prepared for evaluation of remedial alternatives for the contaminated sediment in the Minnesota Slip (also referred to as Slip and/or Site) located in Duluth, Minnesota (Figure 1). This FFS has been developed pursuant to the Minnesota Pollution Control Agency (MPCA) July 13, 2005 Contract Work Order No.: SFBW-0605 and accompanying Scope of Work/Cost Estimate (SOW) for the Site.

Figure 1: Site Location Map, Duluth Harbor
(From Streitz et al., 2005)

This FFS has also been developed in accordance with MPCA Site Response Section Guidance Document Draft Guidelines on Remedy Selection (MPCA 1998), the Minnesota Environmental Response and Liability Act (MERLA), the National Contingency Plan (NCP), 40 C.F.R. Part 300, along with other Minnesota and federal rules, statues, and guidance. Although this Site is not listed in the Minnesota National Priorities List (NPL) or the United States Environmental Protection Agency (EPA) Permanent List of Priorities (PLP), the MPCA may be transferring this Site to EPA for implementation of the remedy. Therefore, the MPCA has requested the FFS be developed in general accordance with the NCP remedy selection criteria.

1.1 REPORT ORGANIZATION

Section 1 presents general background information including the Site history and a summary of current Site conditions based largely on information presented in The Detailed Investigation of the Minnesota Slip (RI) (MPCA, 2005). Section 2 discusses Applicable or Relevant and Appropriate Requirements (ARARs) and summarizes Preliminary Remediation Goals (PRGs) to provide the framework for alternative evaluations for the Site. Alternatives descriptions are presented in Section 3. Section 4 presents the NCP remedy selection criteria used in this FFS. Section 5 presents an evaluation of alternatives against standards and criteria. Section 6 presents the recommended alternative for the Minnesota Slip. References are presented in Section 7.

1.2 SITE LOCATION AND CURRENT USE

Minnesota Slip, an active manmade slip surrounded by land on three sides, is located at the mouth of the St. Louis River in the Duluth Harbor (Figure 1). The river, which discharges into Lake Superior, has a long history of serving the manufacturing and shipping needs of the very active Duluth-Superior shipping port, and has been home to significant historical heavy industry including paper mills, coal gasification plants and steel processing. The port remains active in the transport of iron ore, coal, limestone and grain, and is the largest on the Great Lakes in terms of shipping volume.

Minnesota Slip is located in the northern section of the Duluth Harbor basin between Canal Park and the Duluth Entertainment and Convention Center (DECC) (Figure 1). Though the Slip is oriented approximately 30 degrees west of north in its long dimension, for the purposes of this FFS when referring to compass directions the Slip will be assumed to be oriented due north. The east side of the Slip is bounded by a parking lot, hotel, restaurant and shops, while the west side is bounded by harbor Avenue and a parking lot, the DECC, and a movie theater. The north end of the Slip is bounded by a sidewalk and the south is open to the harbor. The Slip mouth is spanned by a drawbridge allowing access between the DECC and Canal Park. Both the sidewalk and the foot bridge have considerable pedestrian traffic. The land that borders the Slip to the west is owned by the DECC. The property and the buildings on the eastern half are privately owned. The City of Duluth owns and maintains both the sidewalk on the north side and the draw bridge. Figure 2 identifies the current property owners.

Buildings N and D are owned by Palucci, Marine Iron and Waterfront Plaza are owned by Meirhoff

Figure 2: Minnesota Slip Property Owners

The total area of the Slip is slightly larger than three acres. There are currently three vessels permanently docked in the Slip. They are the former United States Steel flag ship the SS. William A. Irvin, the decommissioned US Coast Guard Cutter, Sundew, and the US Army Corps of Engineers (USACE) Tug Boat, Lake Superior. The Slip has been home to at least one of these floating museums since 1986, providing daily tours in the summer months. Remaining space in the Slip is occupied in the summer by charter fishing boats and docks and a harbor tour boat. The Irvin and the tour boat are docked on the west side of the Slip while the charter fishing boats and the Sundew are docked on the east side (see Figure shown on the cover sheet of this FFS). The drawbridge controls entry into and out of the Slip while also acting as a wave retention wall that decreases washout of the Slip.

Figure 3 shows the network of storm sewers in the neighborhood of the Slip, which is outlined in red. The largest of the storm sewers which empty into the Slip are circled in green. There are three storm sewers that empty into the Slip and two that empty just outside the mouth of the Slip (Figure 3). Two of the three storm sewers that empty into the Slip are located at both of the east and west corners of the north end of the Slip. The third storm sewer is located approximately 125 feet south of the northern end of the Slip, on the west wall. This outfall was identified as a major contributor of sediment to the Slip in this investigation. Most of the Slip drainage area borders the downtown business area of Duluth and adjacent residential neighborhoods; extending from 2nd Avenue West to 1st Avenue East and up to 14th Street. Storm sewers that drain Canal Park and Commerce Street also discharge into the Slip (Crane et al., 2002).

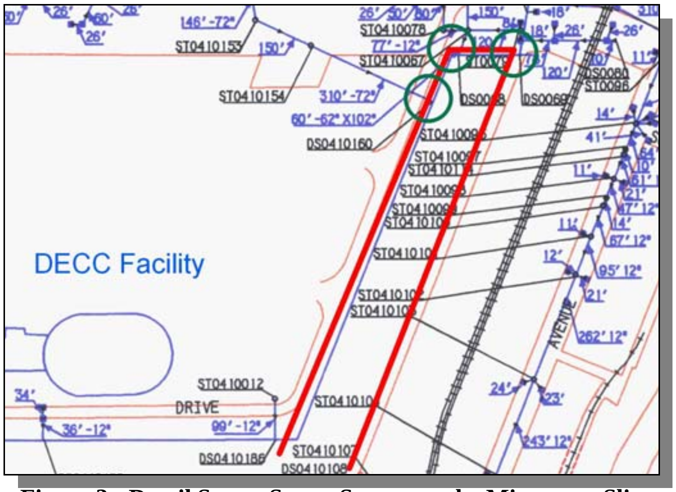

Figure 3: Detail Storm Sewer System at the Minnesota Slip
(from the City of Duluth presented in Streitz et al., 2005)

The MPCA and the City of Duluth worked together to submit complimentary grants to Great Lakes National Program Office (GLNPO) to ensure that if Minnesota Slip was remediated that it wouldn't suffer degradation from contaminated storm water and sediments emptying into the Slip at several outfall points. The City received funding to implement the installation of sediment traps to reduce sediment loading, which is scheduled to be completed in fall 2005. Identification and implementation of an effective Best Management Practice (BMP) for dealing with storm water runoff will reduce the quantity of pollutants discharging to the Slip, and therefore to the St. Louis River. An effective project will serve as a model for other similar urbanized areas of Duluth and Superior along the St. Louis River as well as an example to other cold climate lake communities.

1.3 SITE HISTORY (FROM STREITZ ET AL., 2005)

Historically, Minnesota Slip has undergone several physical modifications since European settlement of the area. The area encompassing the northern section of the Duluth Harbor was initially swampland. Modern development of the harbor began after 1861. Construction of the Duluth Ship Canal was started in 1870, thereby providing a Duluth entry into the harbor from Lake Superior. As of 1887 a portion of the current Minnesota Slip had already been formed through dredging operations. The Slip formerly was called the Marshall Wells Slip, and a Marshall Wells building was adjacent to it; part of this building is now called the Meierhoff building.

Several historical photos of the Slip are retained at the USACE Maritime Museum in Duluth. A photo taken in 1904 shows a coal yard west of Minnesota Slip that was eventually replaced by a scrap yard. A double train freight shed used to be located just west of the Slip. A May 1, 1929, photo of the Slip shows a pile of material to the north of the Slip that appears to be coal. Another historical photo shows workers dumping wheelbarrows full of material into the Slip, approximately half-way down the east side of the Slip. As of 1931, there was another Slip just west of Minnesota Slip; this area is now filled in and is the current location of the DECC. Over time, parts of Minnesota Slip have been dredged out and filled in. However, none of these historical businesses have been determined to be directly responsible for sediment contamination of Minnesota Slip.

The contamination constituents and proportions found in the Slip sediments are similar to the coal tar wastes found off the US Steel and Interlake/Duluth Tar sites further up the river, particularly the Polynuclear Aromatic Hydrocarbons (PAH) compounds. At the US Steel Site the steel process waste stream was contaminated chiefly with metals and PAHs that originated with the large amounts of coal used in the coking process. It may be that coal gasification, which occurred in many places along the harbor including the Canal Park area, was the cause of the similar waste products identified in the Slip.

1.4 SITE CHARACTERIZATION

1.4.1 Site Geology

Regional geology in the Duluth area consists primarily of materials deposited during the last glaciation, and more recently as river sediment, overlying Precambrian igneous and sedimentary bedrock. These materials consist of silts, sands, and gravels which were deposited as the glaciers retreated northward. Fine grained sediment, primarily red silt and clay, was deposited in the ancestral glacial Lake Duluth. This red silt and clay occurs over much of the lower elevations in the Duluth area.

Bedrock units underlying the area consist of olivine gabbro and anorthositic gabbro members of the Duluth Complex, and the sedimentary units of the Fond du Lac Formation. The Duluth Complex is lower Precambrian, and the Fond du Lac Formation is upper Precambrian in age. The gabbroic members of the Duluth Complex form the hills to the west of the St. Louis River and Lake Superior shore (MPCA, 1995).

1.4.2 Site Hydrology

The regional groundwater flow system in the area generally flows from the Minnesota and Wisconsin uplands and discharges to Lake Superior and the St. Louis River estuary. Groundwater studies conducted at other sediment sites within the St. Louis River estuary were evaluated for their similarities to the Minnesota Slip. According to the MPCA Record of Decision for the St. Louis River/Interlake/Duluth Tar (SLRDIT) site the deep regional aquifer at the SLRIDT site is under artesian conditions (MPCA, 2004). Similar artesian conditions have been observed at the U.S. Steel Site. The local groundwater flow system at the SLRIDT site is a water table aquifer that is supplied by local recharge and generally flows south from the adjacent uplands and radially from the on-site peninsulas to the on-site embayments and slips. Lateral groundwater flow was also observed in the local groundwater flow system at the U.S. Steel Site.

Although a Site-specific groundwater study has not been performed, local Site groundwater flow is generally assumed to be similar to other sites within the estuary. Subsurface studies and excavations on adjacent properties have shown extremely heterogeneous materials buried in the subsurface, including a landfill with unexploded ordinances. Site specific groundwater studies would likely provide erroneous information. Therefore, the MPCA is not recommending groundwater studies be performed at the Minnesota Slip.

1.4.3 Physical Influences

There are many physical influences operating throughout the Slip. Slip sediments have been moved, mixed and removed by a variety of forces at work on the waters in the bay. Bathymetry obtained from previous studies shows that the Slip is shallowest in the back, and deeper in the front. Erosional forces that may be responsible include wave action in the bay, river flow, seiche-induced flow, storm water flow, and propeller turbulence from boats moving in and out of the Slip. The Detailed Investigation Report (CD in Appendix A2) provides a discussion of each of these forces and their effect on the Slip in detail.

1.4.4 Nature and Extent of Contamination

The nature and extent of contamination has been delineated through the conduct of several studies in the Duluth/Superior Harbor that included the collection and analysis of sediments and biota samples in Minnesota Slip. These studies are identified below and selected historical summary tables are included in

Appendix A1. This section also presents a discussion on the Contaminants of Concern (COCs) and the thickness, depth and volume of contaminated sediments.

1.4.4.1 Previous Studies

The following is a list of previous studies conducted in the Duluth/Superior Harbor that included the collection and analysis of sediments and biota samples in Minnesota Slip:

- Survey of Sediment Quality in the Duluth/Superior Harbor: 1993 Sampling Results (Schubaur-Berigan et al., 1997). One sediment core.
- Sediment Assessment of Hotspot Areas in the Duluth/Superior Harbor (Crane et al., 1997). Five sediment cores.
- Regional Environmental Monitoring and Assessment Program (R-EMAP) surveying, sampling and testing: 1995 and 1996 sampling results (Breneman et al., 2000 and unpublished data). One surficial (0-5 cm) site sampled in 1995 and resampled in 1996.
- Minnesota Slip sampling to assess PAH analytical techniques (MPCA, 1998, unpublished data). Two core sites and three surficial sites.
- Summary of test results determining potential mercury, PAH and polychlorinated biphenyls (PCB) bioaccumulation by *Lumbriculus variegates* exposed to St. Louis Bay sediment samples (AScI Corporation 1999). Four surficial sites.
- Sediment Remediation Scoping Project in Minnesota Slip, Duluth Harbor (Crane et al., 2002). Eighteen sediment cores. Primarily shallow cores with one extending approximately 6.9 feet into the sediment.
- Evaluation of Electrochemical Geo-Oxidation as a means to treat sediments contaminated with PAHs (USACE, 2002). In the spring of 2002, a USACE project dredged approximately 750 cubic yards of sediment from the back half of the Slip to be used in an innovative treatment test performed at Erie Pier. This treatability study proved ineffective in treating contaminated sediment.
- Detailed Investigation of the Minnesota Slip (Streitz et al., 2005). Twenty-nine Laser Induced Fluorescence (LIF) probes and 18 core samples (See Appendix A Figure 7). This investigation focused on delineating the extent and magnitude of contamination, particularly at depth. The investigation also used LIF as a screening tool to provide qualitative detail as to the presence of PAHs in the sediments at depth in real time. This investigation also included a limited screening ecological risk assessment. The LIF was able to provide detailed coverage of the Slip through probe pushes that were collected quickly, and provide qualitative information on the presence of PAHs in real time. The LIF fluorescence response % correlated to 0.9 with total PAHs for samples in the back half of the Slip where the erosional affects of seiche, wave action, and propeller disturbance was at a minimum. This statistical treatment of the data produced a statistical measure of equivalence, allowing the more numerous and better spatially distributed LIF results to be used in the determination of the degree of sediment contamination by PAHs.

As described in the following subsections, results of these investigations indicated the presence of contaminated sediments throughout the slip. In addition, analytical studies indicated there is a high likelihood of significant effects from exposure to surficial sediments to benthic invertebrates throughout the Slip.

1.4.4.2 Contaminants of Concern

The COCs associated with the Minnesota Slip include PAHs, PCBs, mercury, cadmium, chromium, copper, lead, nickel, and zinc. Table 1 presents a list of the COCs along with the maximum concentration detected. Tables 2 and 3 provide statistics of two separate data sets for comparison. Section 1.4.5 compares each COC to sediment quality criteria and Appendix B presents a discussion of risks associated with the COCs at the Site.

TABLE 1. Contaminants of Concern

Contaminant	Units	Maximum Concentration Detected
Total PAHs	mg/kg	1188 (2)
PCBs	μg/kg	612 (1)
Mercury	mg/kg	3.3 (3)
Cadmium	mg/kg	3.6 (3)
Chromium	mg/kg	51 (2)
Copper	mg/kg	99 (2)
Lead	mg/kg	544 (3)
Zinc	mg/kg	559 (3)
DRO	mg/kg	230 (3)

(1) Summary of previous sampling presented in Table 2, Crane et al., 2002
(2) Crane et al., 2002
(3) Streitz et al., 2005
μg/kg = micrograms per kilogram
mg/kg = milligrams per kilogram

PAHs are the primary COC at the Site. However, elevated concentrations of metals are often found in the same sediments as high levels of PAHs. PCBs were mainly detected in the surficial sediments. In the most recent sampling event, that focused primarily on sediments at depth, PCBs, were not detected in any samples at a reporting limit of 0.04 ppm (Streitz et al., 2005) [note: Detection limits for PCBs were higher in this data set than regulatory criteria (See Section 1.4.5.2). Therefore, low levels of PCBs may be present at depth). However, PCBs were found in surface sediments (Crane, 2002) and will be considered as a COC.

The following comparison of the descriptive statistics of two datasets, one representing sediment samples taken in 1998 & 1999, and the other for sediments sampled in 2004, was also conducted. The earlier investigation focused on the top couple feet of the sediments in the Slip, while the 2004 samples were taken primarily from depths greater than four feet. A comparison of the statistics for these two datasets shows that the levels encountered in the surface sediment are much higher than those found in the deep sediments (see Table 2 and Table 3). The mean and median concentrations for Total PAHs, lead and zinc are 2 to 3 times higher in the surficial sediments. PCBs also follow this pattern, where they are detected in the surface sediments, but were non-detect above 0.04 parts per million (ppm) at depth. The median mercury concentration drops dramatically with depth, though the presence of two samples with high concentrations at depth raises the mean value to a level nearly as high as the surficial sediment. Diesel Range Organics (DRO) and arsenic were not sampled in 1998 and 1999.

Table 2. Statistics for Selected Parameters of 1998 & 1999 Samples							
	All results ppm, dry weight concentrations						
	Total PAH	**PCB**	**Arsenic**	**Lead**	**Mercury**	**Zinc**	
Mean	113.4	0.21	NA	234.4	0.46	309.7	
Median	47.6	0.18	NA	220.0	0.31	300	
Standard Dev.	202.0	0.13	NA	149.7	0.42	167.1	
Range	1,181.1	0.61	NA	870.0	2.2	1,059.0	
Minimum	7.1	0.0	NA	10	0.0	41	
Maximum	1,188.1	0.61	NA	880	2.2	1,100	
Count: >54							

From the report, "Sediment Remediation Scoping Project in MN Slip, Duluth Harbor, (February 2002") and Report Tables (website- http://www.pca.state.mn.us/water/sediments/studies-stlouis.html)

Table 3. Statistics for Selected Parameters of 2004 Samples							
	All results ppm, dry weight concentrations						
	Total PAH	**DRO**	**Arsenic**	**Lead**	**Mercury**	**Zinc**	**TOC (%)**
Mean	32.1	58.8	1.8	117.5	0.4	118.6	1.4
Median	14.5	28.5	1.3	59.4	0.1	66.4	0.0
Standard Dev.	62.7	73.0	1.4	162.9	0.8	167.9	1.6
Range	270.0	225.0	4.4	541.0	3.2	558.6	4.9
Minimum	0.0	5.0	0.6	3.0	0.1	0.4	0.1
Maximum	270.0	230.0	5.0	544.0	3.3	559.0	5.0
Count: 18							

Companion to Table 3 from the 2005 Report, "Detailed Investigation of the Minnesota Slip", page 28, Table 1: Descriptive Statistics for all Samples, Selected Laboratory Parameters.

1.4.4.3 Depth, Thickness and Volume of Contaminated Sediment

The total area of the Slip is slightly larger than three acres. Using a surface water elevation of 601 above Mean Sea Level (MSL), the depth to the surface of the sediments ranges from approximately 5 feet (at the north end of the slip) up to 21 feet, with an average depth of approximately 15 feet below MSL. Figure 4 presents a bathymetric map based on data collected for the Detailed Investigation (Streitz et al., 2005).

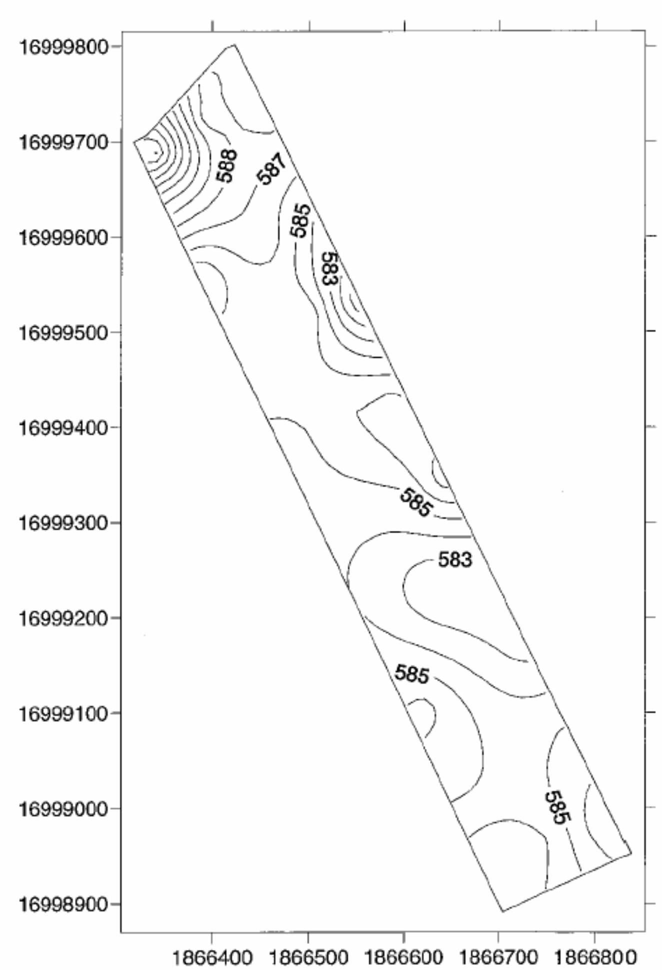

Figure 4. Bathymetric Contours Map of the top Surface of Minnesota Slip
(Top of Map oriented north)

Appendix C provides a contaminated sediment volume calculation and contamination thicknesses based on data collected for the Detailed Investigation (Streitz et al., 2005). The rational for identifying sediment as contaminated is discussed in Appendix C and in Section 2.2.1 of this FFS. In summary, contaminated sediment is generally present through out the entire Slip. Contamination was detected to a depth of up to 12 feet below the surface of the sediment in one location with an average depth of 6.5 feet below the sediment surface. A series of cross sections (Cross Sections A-A' through G-G') were developed to show the depth of sediment and the contaminated sediment/clean sediment interface within Minnesota Slip. A Cross Section Location Map is included to show locations of each cross section.

The vertical limits of contamination were estimated based on 2% of the LIF response that correlates to a Total PAH level of 13.7 mg/Kg (see detail discussion in Section 2.2.1). Sediments located above this Total PAH level within the Slip, were assumed contaminated since previous studies indicated the presence of contaminants in the surficial sediments throughout the Slip. Volumes were calculated using two methods: Golden Software's Surfer, Version 8; and a prismoidal formula within a spreadsheet. The sediment contamination depths were interpolated from the 29 LIF probe analysis figures presented in Appendix C of the Detailed Investigation report (a CD of this report is included as Appendix A2 of this FFS). The calculated volumes represent the volume of sediment between the top surface of the sediment and the 2% LIF response cut-off depths. Contaminated sediment volumes are estimated at approximately 33,000 cubic yards.

Historical information on navigational dredging conducted in the Minnesota Slip along with physical and chemical data collected for the Detailed Investigation was used to establish an estimated boundary between disturbed and undisturbed sediment providing a lower boundary of possible contamination. The depth of the main shipping channel has steadily increased since the construction of the Slip on or before 1887, giving a maximum probable depth to the Slip of 27 feet. It is likely that historical dredging produced a ragged sediment surface interface. Also, depending on how the Slip was used, the official channel depth may not have always been matched in the Slip. Figure A2 of Appendix A is a display of ten LIF readouts that run in a line down the center of the Slip, roughly north-south (see plan view inset). Based on the LIF data, the maximum depth of impacted sediments is at approximately 574 feet above MSL datum which corresponds to the 27-foot dredging depth (Streitz et al., 2005).

1.4.5 Summary of Site Risks

A limited screening assessment was completed in the Detailed Investigation (Streitz et al., 2005). In summary, the limited screening assessment indicated that the direct risk to human health from contaminated sediments in the Slip is low. Therefore, no risk based standards for human health exposure routes will be used to evaluate alternatives in this FFS. However, it is probable that contaminants from Minnesota Slip are contributing to bioaccumulation in the aquatic food chain up to fish consumed by humans and contributing to the overall impaired use in the St. Louis River AOC. The limited screening assessment indicated that there is an unacceptable risk of significant effects from exposure to surficial sediments throughout the Slip to aquatic receptors. The risk based standards for aquatic exposure routes that will be used to evaluate alternatives in this FFS include the Sediment Quality Targets (SQTs) and Probable Effect Concentration Quotient (PEC-Q).

As identified in the St. Louis River Remedial Action Plan (RAP-1992) and later proven with testing, Minnesota Slip is contributing to two impairments to the St. Louis River AOC: 1) fish consumption advisory; and 2) degradation of the benthos environment. As recommended by the RAP, areas that are contributing to river sediment impairments should be addressed through remedial activities. In addition, the St. Louis River, including the Duluth/Superior Harbor, is listed as impaired water on the Clean Water Act 303(d) list for bioaccumlative toxins. Toxins include mercury, PCBs and pesticides (DDT, dioxin, etc.). According to the MPCA, it is widely recommended by many programs that biotoxins be reduced with in the St. Louis River estuary and harbor. Removing the contaminated sediments from MN Slip would help in the reduction of the impaired water resulting from bioaccumlative toxins in the St. Louis River.

The following information provides greater detail on the human health and ecological limited screening assessment and standards from the Detailed Investigation and other studies.

1.4.5.1 Risk to Human Health

Minnesota Slip is within an active harbor surrounded by retail and commercial businesses. More than half the Slip is open to the public year round. The Slip is used for docking of tour boats, museum boats and charter fishing boats. Exposure from contaminated sediments to the public is very limited given the depth of the Slip. No public swimming or wading is permitted or practical. No public water supplies are taken from the Slip. All information to date indicates that the proposed future use of Minnesota Slip is similar to the current use. The major contaminants, PAHs, are generally non-volatile and not emitted from the waters of the Slip. Therefore, the remaining pathway for human exposure is fish consumption. This too is thought to be limited since the Slip is relatively small and too deep for spawning and foraging for feeder fish. However, fish consumption advisories are in effect for selected fish species in the St. Louis River AOC because of elevated concentrations of PCBs and mercury found in the fish tissue (MDH, 2000). It is probable that contaminated sediments in Minnesota Slip are contributing bioaccumaltive contaminants into the fish food chain and contributing to the overall impaired use in the St. Louis River AOC. In summary, risk to human health from contaminated sediments in the Slip is low.

1.4.5.2 Ecological Risks

The depth to which benthic organisms can penetrate sediment varies, but at the nearby SLRIDT Superfund site, for water depths of less than 2.5 meters, the potential penetration depth was estimated to be 0.15 meters. Taking into account the root penetration of aquatic plants increases the depth of penetration of all flora and fauna to a depth of 1.0 meter. However, where water depths are greater than 2.5 meters, limiting the effect of sunlight, the depth of penetration for plants and benthic organisms into the sediment was estimated to be no greater than 0.5 meters. Since water depths in the Slip were found to be everywhere greater than 2.5 meters except for the immediate vicinity of a stormwater outfall in the northwest corner of the Slip (Figure 3), the sediment interval of greatest relevance for ecological exposure is the top 0.5 meter. It should be noted that no recent investigation of the Slip has found the presence of aquatic plants growing in the sediment.

There are limited pathways by which ecological receptors might be exposed to contaminants in the sediments at the Site. Direct environmental exposure pathways include direct contact with contaminated sediments or water by benthic invertebrates and fish; and ingestion of sediments by sediment dwelling organisms and fish which feed on invertebrates living in sediment. Indirect exposure pathways include ingestion by fish of invertebrates, or fish which have bioaccumulated sediment contaminants in their tissues.

The limited screening ecological risk assessment prepared for the Detailed Investigation was conducted by comparing the sediment chemistry results with the Level 1 and Level 2 SQTs (Crane, et al, 2000). SQTs are contaminant values that represent a level of protection of sediment-dwelling organisms. Level 1 SQTs identify chemical concentrations which will provide a high level of protection for designated water uses, specifically for aquatic life. By comparison, a lower level of protection for designated water uses will be provided by the Level 2 SQTs. Therefore, goals of the SQT developed for the protection of sediment dwelling organisms are:

> Level 1 SQTs are intended to identify contaminant concentrations below which harmful effects on sediment dwelling organisms are unlikely to be observed.
>
> Level 2 SQTs are intended to identify contaminant concentrations above which harmful effects on sediment-dwelling organisms are likely to be frequently or always observed.

Table 4 presents the COCs, the Level 1 and 2 SQTs and the maximum concentration detected for that contaminant. Historical data presented in Appendix A provide analytical data for each sample point and in some cases compare the results to the SQTs. Exceedances are shown in the form of bolding, shading and/or color coding (Crane et al., 2002 and Streitz et al., 2005). Selected statistical data sets are presented and discussed in Section 1.4.4.2. Based on a comparison of analytical data and SQT values the contaminants found in Minnesota Slip sediments exceeding the SQT values of the contaminated sediment are considered a risk to the benthic community and the larger ecological environment, where they are found in the top meter of sediment.

TABLE 4. COCs and Sediment Quality Targets				
Contaminant	**Units**	**Level 1 SQT**	**Level 2 SQT**	**Maximum Concentration Detected**
Total PAHs	mg/kg	1.6	23	1188 (2)
PCBs	μg/kg	60	680	612 (1)
Mercury	mg/kg	0.18	1.1	3.3 (3)
Cadmium	mg/kg	0.99	5	3.6 (3)
Chromium	mg/kg	43	110	51 (2)
Copper	mg/kg	32	150	99 (2)
Lead	mg/kg	36	130	544 (3)
Zinc	mg/kg	120	460	559 (3)
DRO	mg/kg	NA	NA	230 (3)

(1) Summary of previous sampling presented in Table 2, Crane et al., 2002
(2) Crane et al., 2002
(3) Streitz et al., 2005
μg/kg = micrograms per kilogram
mg/kg = milligrams per kilogram
SQT = Sediment Quality Target
NA = Not Applicable

Contamination within the Slip was found to be heterogeneous, with several sites exceeding the corresponding Level I or Level 2 SQTs. The greatest exceedence of the Level 2 Sediment Quality Targets occurred with PAHs (Streitz et al., 2005).

There is no SQT value available for DRO, however in the Detailed Investigation DRO correlates above 0.96 with the total PAH concentrations in the back of the Slip, so areas identified by total PAH concentrations above Level 2 SQT should also cover corresponding DRO concentrations. The Wisconsin Department of Natural Resources calculated DRO effect concentrations based on Hog Island/Newton Creek data. Based on this work three samples exceed the Level 1 screening value, and none exceed the Level 2 value (Streitz et al., 2005).

1.4.5.3 Site Specific Numerical Evaluations and Ecological Studie.

Several of the previous studies provided an analysis of chemistry and/or benthic data and their potential ecological effects. Summaries of these studies are provided below.

<u>2004 Minnesota Slip Mean PEC-Q Values</u>. To evaluate the combined effects of multiple contaminants, the mean Probable Effect Concentration Quotient (mean PEC-Q) is calculated by dividing the individual contaminants by their respective Level 2 SQTs and taking the mean of the summed quotients. For the MN Slip site, the PEC-Q contaminant inputs are metals and total PAHs. The mean PEC-Q calculation also includes PCBs, a contaminant not detected in the Slip in this round of sampling (Note: the detection limits for PCBs were above Level 1 and 2 SQTs). Mercury has a known toxic effect but because a reliable consensus-based PEC is not available, it is not included in the quotient. For more information regarding the calculation of the mean PEC-Q, see Appendix D of Streitz et al., 2005 (CD in Appendix A to this FFS).

Only two of the 2004 sediment samples included sediment from the top 0.5 meter. The surficial samples both exceed 0.1 (Level 1 SQT) but are less than 0.6 (Level 2 SQT), indicating the potential for moderate toxic effects to the benthic community. A total of five sediment samples from the remaining samples, all deeper than 0.5 meters, were above the 0.6 Mean PEC-Q.

The 2004 investigation did not result in an adequate number of surface samples to fully evaluate the top 0.5 meters. There is more information on sediment toxicity in the form of PEC-Q values in the data collected for the Slip in 1998 and 1999. Mean PEC-Qs for surficial samples taken in the top 0 to 5 or 0 to 15 centimeters (cm) interval were calculated from these data. Most of the sample values exceed the Level 2 SQT of 0.6, indicating a high likelihood of significant effects from exposure to surficial sediments throughout the Slip. The complete list of calculated 1998-1999 mean PEC-Q values is presented in Appendix A, Table A5 of Streitz et al., 2005 (see CD in Appendix A2).

Top Two Feet of Sediment; 1998, 1999 & 2004. The R-EMAP data, unpublished data collected in 1995 and 1996, revealed that for the testing performed on the one sample taken from the Slip (in the vicinity of LIF point #20, see Figure A1 of Appendix A) there was not significant toxicity. But because the bioaccumulation testing showed significant accumulation of PAHs in the oligochaete worm, *Lumbriculus*, it is another indicator of potential impacts to the benthic community.

Crane, 2002. Subleathal effects to growth and/or reproduction were not found in the sediment toxicity tests conducted. However, in terms of survival, the 28- to 42-day sediment toxicity tests with *H. azteca* provided a more sensitive test than the 10-day *C. Tentans* toxicity test. Significant toxicity was observed at two sites for the amphipod test (Table A2 of Appendix A). Mercury exceeded the Level 1 SQT in a large portion of the surfical sediments of Minnesota Slip. The ecological and toxicological effects of mercury are strongly dependent on the chemical species present. No bioaccumulation of mercury was found in 28-day bioaccumulation test with *Lumbriculus* variegates that used surfical sediments from Minnesota Slip (AScI Corporation 1999). However, fish consumption advisories are in effect for selected fish species in the St. Louis River AOC because of elevated concentrations of mercury found in the fish tissue (MDH, 2000).

In conclusion, toxicity and chemical tests support the conclusion that there is an unacceptable risk from exposure to surficial sediments throughout the Slip to aquatic receptors.

2.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND PRELIMINARY REMEDIATION GOALS

Remedial actions for releases and threatened releases of hazardous substances, and pollutants or contaminants, must be selected and carried out in compliance with State and Federal legal requirements. These requirements are called ARARs.

This section presents the preliminary ARARs and Preliminary Remediation Goals (PRGs) to be used in the development of this FFS. The final ARARs and Site-Specific Response Action Objectives (RAOs) and Cleanup Levels will be developed in the remedy decision document for the Site.

2.1 ARARS

ARARs are classified into three types: chemical-specific, action-specific, and location-specific requirements. The following paragraphs describe the three types of ARARs.

Chemical-specific ARARs are usually health or risk -based numerical values or methodologies which, when applied to site-specific conditions, result in the establishment of an acceptable amount or concentration of a chemical that may be found in, or discharged to, the ambient environment. These requirements provide protective Site remediation levels for the COCs in the designated media.

Location-specific ARARs are “restrictions placed on the concentration of hazardous substances or the conduct of activities solely because they are in specific locations.”

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 that are selected to accomplish the remedy. Action-specific requirements do not themselves determine the cleanup alternative, but define how the chosen cleanup alternative should be achieved.”

The preliminary ARARs for this Site are outlined in Appendix D

2.2 PRELIMINARY REMEDIATION GOALS

This PRGs developed by the MPCA for the Minnesota Slip are:

- Minimize or remove exposure to sediment contaminants that bioaccumulate in the food chain and contribute to fish consumption advisories.
- Minimize or remove exposure of the benthic organisms to contaminated sediments.
- Preserve surface water quality during remedy construction.
- Protect and restore aquatic habitat.

The following subsections present preliminary cleanup levels developed to achieve these PRGs.

2.2.1 Preliminary Sediment Cleanup Levels

To achieve protection and restoration of habitat, minimize exposure of the benthic organisms to contaminated sediments and movement of contaminants up the food chain the remedy should meet the Preliminary Sediment Cleanup Levels. Table 5 presents the Preliminary Sediment Cleanup Levels that were calculated to assist in evaluating potential impacts to the environment, calculating the volume and depth of contamination (see Section 1.4.4.3), and developing and evaluating remedial alternatives for this FFS.

TABLE 5. Preliminary Sediment Cleanup Levels

Contaminant	Units	Level 1 SQT	Level 2 SQT	0.6 of Level 2 SQT	Maximum Concentration Detected
Total PAHs	mg/kg	1.6	23	13.7	1188 (2)
PCBs	μg/kg	60	680	408	612 (1)
Mercury	mg/kg	0.18	1.1	0.3	3.3 (3)
Cadmium	mg/kg	0.99	5	3	3.6 (3)
Chromium	mg/kg	43	110	66	51 (2)
Copper	mg/kg	32	150	90	99 (2)
Lead	mg/kg	36	130	78	544 (3)
Zinc	mg/kg	120	460	276	559 (3)
DRO	mg/kg				230 (3)

(1) Summary of previous sampling presented in Table 2, Crane et al., 2002
(2) Crane et al., 2002
(3) Streitz et al., 2005
μg/kg = micrograms per kilogram
mg/kg = milligrams per kilogram
SQT = Sediment Quality Target
DRO = No SQTs are available for DRO. SQT for PAH will apply.

Metals (cadmium, chromium, copper, lead, and zinc) are 0.6 times the mPEC-Q based on Level 2 SQTs; and mercury is 0.3 mg/kg, the MPCA calculated upper limit ambient concentration in the St. Louis River estuary. PCBs are 0.6 times the mPEC-Q based on Level 2 SQTs.

MacDonald and others have found that 0.6 of the mean Probable Effects Concentration Quotient (mPEC-Q) approximates a 20% probability of observing sediment toxicity and it is proposed as a potentially acceptable (as a “Level 2 Sediment Quality Target”) sediment quality target (SQT) (Macfarlane and MacDonald, 2002; MacDonald and Ingersoll, 2002; Crane et al., 2000). The mPEC-Q is calculated by averaging the ratios of the individual COCs to their Probable Effects Concentration (PEC) values. The PEC is a concentration at which significant toxic effects are predicted to occur. Table 5 presents Preliminary Sediment Cleanup Levels for each COCs based on 0.6 of the Level 2 SQT.

As stated previously, there is no SQT value available for DRO. However in the Detailed Investigation, DRO correlates above 0.96 with the total PAH concentrations in the back of the Slip, so areas identified by total PAH concentrations above Level 2 SQT should also cover corresponding DRO concentrations.

The vertical limits of contamination were estimated based on LIF data (Streitz et al., 2005) that will achieve the Total PAH Cleanup Level of 13.7 mg/Kg. Sediments above these criteria within the Site, not exceeding this 13.7 mg/kg Total PAH level, are also included in the contaminant volumes since other studies indicated the presence of contaminants in the surficial sediments throughout the Slip (see Section 1.4.4.3). For evaluating alternatives in this FFS, these sediments would need to be addressed by the selected remedy. Section 2.2.1 presents a discussion of sediment areas exceeding theses criteria. Cross Sections A-A’ through G-G’ show sediment areas exceeding these criteria.

2.2.2 Preliminary Surface Water Quality Standards

Preliminary surface water quality standards for the maintenance and preservation of surface water quality during remedy construction are based on surface water quality standards that currently apply to the St. Louis River.

During remediation, the MPCA would consider the areas in which work is performed as “treatment/work zones” to which the surface water quality standards normally applicable to the St. Louis River would temporarily not apply. These treatment/work zones would be physically separated from adjacent waters through the use of engineering controls such as single or multiple silt curtains, inflatable dams, sheet piling, or other measures. During construction of the remedy, any discharges occurring within those controlled treatment/work zones, such as the discharge of capping material during capping operations, the release of contaminants during dredging operations, or runoff from activities on shore would not be subject to water quality standards. Rather, water quality standards would apply outside of the treatment/work zone, beyond the outermost engineering control structure where the water from the treatment/work zone is discharged to the river. Other discharges occurring during remedy construction to parts of the river not included in a treatment/work zone - including discharges of treated dredge water, and discharges of stormwater runoff from shoreland modifications outside of the treatment/work zones, would also be subject to regulation.

If water is discharged directly to the river, it would be treated to a level that meets applicable surface water discharge standards. The MPCA water quality standards that may apply to these discharges are set forth in Appendix D. Final standards would be determined by the MPCA prior to implementation of the remedial actions.

In general the MPCA water quality standards that would likely apply during remedy construction are as follows:

> Discharges From Treatment/Work And Stormwater Runoff Zones. The MPCA would apply Final Acute Values (FAV) for aquatic life established by Minn. Rules, chs. 7050 and 7052, adjusted, as appropriate, to account for significant differences between FAVs and chronic standards (see Minn. Rules, Part 7050.0222, subp. 7(E)) and to account for the hardness of the water. To account for the dissolved fraction see Minn. Rules, Part 7052.0360.

> Treated Water Discharge Directly To Surface Water. The MPCA would require the use of Best Technology in Process and Treatment (BT/PT) for discharge of treated dredge water where treatment technology can reduce the concentration of most compounds below their FAVs. In addition to the Appendix D requirements, discharges of mercury and PCBs at the Site would also be subject ordinarily to Minn. Rules, Part 7052.0310, subp.2, which regulates new or expanded discharges of bioaccumulative substances of immediate concern (BSICs) and bioaccumulative chemicals of concern (BCC) such as mercury and PCBs. (Under this rule, discharges of mercury would be required to meet the chronic standard of 0.0013 μg/L, and discharges of PCBs would be required to meet the chronic standard of 122 picograms per Liter (pg/L). The chronic standard, rather than the maximum standard or FAV, would apply, because Minn. Rule, Part 7052.0210, subp. 3 prohibits mixing zones for BCCs. However, Minn. Rules, Part 7052.0310, subp. 7, provides an exemption from the requirements of Part 7052.0310 for remedial actions taken pursuant to MERLA.

In the event that a standard is exceeded, further management practices would likely be required during remedy construction to reduce the amount of suspended contaminants escaping the treatment/work zone.

3.0 POTENTIAL REMEDIAL ALTERNATIVES

This section describes the Alternatives evaluated for the Site. The alternatives were originally developed and screened in the Technologies and Response Action Components prepared by Bay West under Task 2 of the SOW/CE (Appendix C). The Alternatives were further refined in the September 2005, draft FFS. Additional supporting documentation on alternative components can be found in the Technical Analysis Memorandums presented in Appendix E.

3.1 ALTERNATIVE 1: NO ACTION

Based on current analytical data, the No Action Alternative is not protective of aquatic receptors and would not meet applicable or relevant and appropriate requirements. However, the No Action Alternative will be retained for a baseline comparison. The No Action Alternative does not include any treatment or engineering controls. The No Action Alternative does include long-term monitoring and institutional controls.

Current EPA guidance (EPA, 2000) does not recommend the "blanket use of a 30-year period of analysis" for long term operation and maintenance costs. For long-term projects (e.g., project duration exceeding 30 years), it is recommended that a present value analysis include a "no discounting" scenario. Because contaminated sediments would remain indefinitely, a 100-year monitoring period was used to evaluate long-term monitoring costs. For cost estimating purposes under the No Action Alternative, physical monitoring and reporting would be conducted annually for the first 30 years then every 5 years thereafter.

Institutional controls are legally enforceable restrictions, conditions or controls on the use of property, ground water or surface water at a contaminated site that are reasonably required to assure the protectiveness of a remedy or other response actions taken at the Site. If contaminated sediments remain in place after remedial actions are taken the Site would be subject to institutional controls (such as easements and restrictive covenants) which are legally binding on current and future owners of the property to assure ongoing protection from disturbance of or exposure to the contamination. Because no actions would be taken institutional controls would be necessary to minimize exposure to contaminants. Institutional controls may include restrictions on boat depths, parameters restricting boat use that may erode sediments and anchoring.

The estimated total present value cost for Alternative 1 is approximately $524,525. Table F1 of Appendix F presents a detailed breakdown of the estimated costs associated with Alternative 1.

3.2 ALTERNATIVE 2: PARTIAL DREDGING WITH IN-SITU CAPPING

In-Situ Capping alone could provide protection of human health and the environment if completed properly. However, capping would not allow the current and proposed use of Minnesota Slip to be maintained because it would not preserve the water depth necessary for navigation. Therefore, this alternative includes partial dredging prior to cap placement. Major components of this remedy are described below.

<u>Dredging</u>. Mechanical dredging with debris removal would be conducted to remove contaminated sediment prior to cap placement. Elevation 585 above MSL is the approximate current sediment elevation at the mouth of Minnesota Slip (see Figure 4). This elevation would allow for current and future navigation uses to remain the same. Therefore, this elevation was used to establish the dredging depth.

For protection of the benthic community, an isolation zone (IZ) of 1 foot would be necessary on top of the contaminated sediments and below a 0.5 meter cap for the Bioactive Zone (BAZ). The IZ and BAZ are further described in the In-situ Cap subheading below. A six inch over dredge will also be included.

Therefore, the total cap thickness is estimated to be 3 feet thick. Based on this thickness, the target depth for removal of contaminated sediments would be 582 above MSL. Approximately 16,000 cubic yards of contaminated sediment would be removed and approximately 14,600 cubic yards of capping material would be brought in to cap the remaining sediments in place.

There are three general types of dredges that could be used to mechanically excavate contaminated sediments: conventional clamshell, enclosed bucket, articulated mechanical. According to the MPCA, there is a significant amount of debris present in Minnesota Slip. Therefore, a conventional clamshell bucket would perform the best in this environment. Debris removal would be performed in the barge, prior to transportation to Erie Pier. Debris removal would be conducted through mechanical screening of the sediment as it is loaded into the barge. Debris would be stockpiled on City or DECC property then transported and disposed of at a landfill. Appendix E1 presents a Technical Analysis that provides additional detail and assumptions used to evaluate mechanical dredging options and dredging productivity and equipment. There are some concerns with the stability of the dock walls during dredging activities (see Appendix G1 and Other Logistical Issues at the end of this section).

<u>Sediment transportation and staging.</u> Sediments would initially be transported by barge to Erie Pier for either disposal or staging prior to transporting to an off-site landfill. Because there is no available land area to stage sediments at the Site, if sediment is disposed at an off-site landfill, it would be staged at Erie Pier prior to transportation. Stabilizing agents would be added to the barge at Erie Pier. Stabilized sediments would be directly moved from the barge to the containment cell or offloaded to a gravel pad prior to transportation to an off-site landfill. Appendix E2 presents a Technical Analysis that provides additional detail and assumptions used to evaluate sediment transportation and staging.

<u>Sediment disposal at Erie Pier or an off-site landfill.</u> There are two disposal options for dredged sediment that were evaluated in this FFS, Erie Pier and an off-site landfill. The off-site facility used in this cost estimate was Allied Waste in Sarona, Wisconsin. The cost estimate assumed the sediment would be used for daily cover material.

Several factors were incorporated in the sediment removal/volume calculations for the cost estimate. These factors are presented in Table F6 of Appendix F and described briefly below:

In place sediment volume (neet excavation line)
Six inch overdredge
Removal of oversize debris (5%)
Bulking Factor (10%)
Stabilization Agents (15%)

Unless otherwise noted, in place sediment volumes are discussed in the text. Approximately 21,300 cubic yards of stabilized and bulked sediment would need to be disposed of under Alternative 2. Estimated cost for off-site landfill disposal also includes TCLP testing for metals and PAHs (1 test for every 2500 cubic yards). Appendix E2 presents a Technical Analysis that provides additional detail on the disposal options and the assumptions used to evaluate sediment disposal.

Disposal of sediments at Erie Pier would require:

- Removal and off-site transportation of in place navigational dredge material to create space for the containment cell. Dewatering and compaction of the subsurface sediment at Erie Pier may also be necessary prior to construction of the containment cell. However, costs for subsurface preparation were not included in the cost estimate.
- Construction of a gravel covered area for stockpiling stabilizing agents and other equipment.
- Construction of a containment cell. For cost estimating purposes, the MPCA has directed Bay West to include the following cell construction costs:

40 ml liner below and above the sediment
12 inch <3/8 inch drainage layer
12 inch top soil
1% slope with a small sump for backup (no water collection costs)

- Off-loading of stabilized/solidified sediments from the barge to the containment cell by truck.

<u>In-Situ Cap</u>. Because this alternative includes capping any potential dredge residue that may create an exposure to aquatic organisms would be minimized. Capping material must provide a suitable substrate for the benthic community and enhance natural biodegradation. For this FFS, the cover thickness will be roughly equal to the thickness that is removed by dredging and the upper-most layer will be composed of loosely consolidated organic-rich material to enhance aquatic habitat. Approximately 14,600 cubic yards of capping material will be needed. Appendix E3 presents a Technical Analysis that provides additional detail and assumptions used to evaluate capping productivity and equipment requirements.

The in-situ cap would consist of an IZ and a BAZ. The IZ is the portion of the cap that is applied directly over the contaminated sediments and is designed to isolate and attenuate the Site contaminants that could potentially be transported upward into the BAZ at concentrations above the PRGs by diffusion or advection transport mechanisms. The BAZ is the area within the cap above the IZ where significant biological activity may potentially be present. The thickness and material specifications for the IZ are usually determined based on pore water transport and attenuation modeling and would be approved in the remedial design document. In general, the IZ would be constructed with a sandy material and is expected to be approximately one-foot thick.

The BAZ portion of the cap would become the new benthic substrate for the restored aquatic ecosystem. Therefore, contaminant levels should not exceed the PRGs for the COCs throughout the entire thickness of the BAZ. The BAZ material specifications should be based on hydrogeologic properties to allow appropriate advective pore water flow, settling characteristics, and substrate requirements. In general, the BAZ would consist of sandy material with the uppermost portion containing more fine grained material and organic matter for substrate enhancement. Final specifications would be approved in the remedial design document. The preliminary BAZ thickness established by the MPCA for this Site is 0.5 meters below the sediment surface. The BAZ thickness is based on the depth at which light penetration would likely limit plant growth (approximately 8 feet). The rational for establishing the BAZ thicknesses is detailed in the August 2004, MPCA St. Louis River/Interlake/Duluth Tar Record of Decision (MPCA, 2004).

For cost estimating purposes, this alternative includes a 3-foot cap (1-foot IZ and 2-foot BAZ). The IZ would be constructed with sandy material and would be approximately one-foot thick. The cap material would be obtained from an off-site source and transported by barge from Erie Pier.

Other factors, such as propeller wash and navigational dredging in and adjacent to the slip, would also need to be included in the evaluation of the cap to ensure the cap integrity is maintained.

<u>Surface water control during remedy implementation</u>. Surface water control structures (i.e., silt curtains, water filled dam, sheet piling) would be necessary during dredging and capping. Appendix E4 presents a Technical Analysis that provides additional detail and assumptions used to evaluate water quality control during remedy implementation. In summary, surface water control structures evaluated for this FFS include the use of two sets of non-structural barriers with each set consisting of an oil absorbent boom and a “full height” turbidity/silt curtain anchored to the bed with a permeable fabric at the top five feet to accommodate flow across the curtain. The first turbidity barrier would be placed within approximately 15 feet of the dredge on the entrance side of the slip and would be periodically moved as the dredge works from the northern end of the slip to the south towards the slip entrance. The second turbidity barrier would be placed near the “mouth” of the slip and would require a modified installation to allow rapid deployment for the hopper barges and other required on-water access. If water quality standards are exceeded outside of the work area, additional BMPs, including increased turbidity controls (i.e., turbidity curtains) would likely be necessary.

Environmental and physical monitoring during remedy implementation. Environmental and physical monitoring would be necessary during remedial actions. Types of monitoring may include: bathymetry, borrow material, air quality, dredge water, surface water, and cap thickness. The types of monitoring would be specified in the design documents.

Long-term Operation, Maintenance, and Monitoring. Because contaminated sediments would remain in place long-term operation, maintenance and monitoring of the cap and the BAZ would be necessary.

Potential maintenance costs include cap repair and replacement. For cost estimating purposes it is assumed that repairs will be necessary due to potential erosion of caps material. Therefore, Cap repair would be estimated for every 10 years.

Because contaminated sediments would remain indefinitely, a 100-year monitoring period was used to evaluate long-term monitoring costs. Physical monitoring would be performed indirectly from the surface through overlapping echo sounding or with a high resolution multibeam system, producing a detailed bathymetric surface of the Slip water/sediment interface. Chemical monitoring would be performed by insertion of a LIF probe through the BAZ cap, to the top of the isolation zone.

For cost estimating purposes, monitoring and reporting would be as follows:

- physical (bathymetry) monitoring would be required annually for the first 10 years then every 5 years thereafter; and
- chemical screening monitoring (LIF and x-ray florescence or XRF) are estimated for years 2, 5 and 10, and then again only if the physical structure is compromised (one round is included for cost estimating purposes).

Additional monitoring and maintenance costs may also be necessary in the first few years after remedy completion to repair sink holes that may form on the land surface resulting from dredging activities. Therefore, costs for maintenance will be included annually for the first 3 years after remedy completion.

The MPCA has stated that biota and fish tissue sampling will not be conducted as part of this remedy since the site is very small and not likely a primary habitat of fish. In addition, there is very limited biota due to overall depth of the sediment and if fish tissue samples taken from fish in the Slip detect contaminants, the major source of fish tissue contamination would not be from this Site.

Institutional Controls. Because contaminated sediments would remain in place under both scenarios, institutional controls would be necessary to maintain the cap integrity. Institutional controls may include restrictions on dredging, boat depths, parameters restricting boat use that may erode cap materials and anchoring.

Habitat Restoration. Although there is limited habitat due to the depth of the slip, it would be necessary to design the cap to create/restore habitat for the existing aquatic community.

Cost. The estimated total present value cost for Alternative 2A, Erie Pier Disposal is $5,182,200 and for Alternative 2B, Off-Site Landfill is $4,902,500. Tables F2 and F3 of Appendix F presents a breakdown of the estimated costs associated with the disposal options under Alternative 2. Preparation of the subsurface sediment at Erie Pier and repairs to the dock walls, if necessary, could add a significant increase to the overall project costs.

Other Logistical Issues. Additional logistical issues that may affect dredging and off-loading operations include:

> Construction Window: Because the slip is actively used (see Section 1.2) in the spring, summer and fall, there is a small window of opportunity for remedial actions to take place without having an affect on local commerce. Two opportunities, early spring (mid-March to mid-May) and late fall (October to November) are likely timeframes for a remedial project that doesn’t overly intrude on the tourist and commerce seasons. The harbor ice is usually cleared for shipping

around March 15. The commercial fishing boats docks are in place and are active during the trout fishing season from mid-May until September 30. The harbor is closed for ship movement from January until mid-March.

Irvin Museum Boat: If feasible, it is recommended that the Irvin be temporarily removed from the Slip to the DECC dock during dredging and capping/cover operations. However, if it cannot be removed, it will need to be moved back/forth, side-to-side during dredging and capping/cover operations.

Lift Bridge: Bay West has been informed that the small lift bridge at the mouth of the Minnesota Slip will not operate below 45 degrees but could possibly left open during the project.

Staging Areas: Although it is understood that there is insufficient room for staging of contaminated sediments adjacent to Minnesota Slip, staging of some equipment and debris will likely be necessary. Potential staging areas are a City parking lot at the head of the Slip and DECC parking areas (See Figures 1 and 2).

Stability of Seawalls: There are some concerns with the stability of the dock walls during dredging activities (see Appendix G1). Therefore, this Alternative includes $10,000 for inspection of the dock walls prior to implementing remedial actions. However, there are no costs for repair of damaged dock walls or repairing of sink holes around the perimeter of the Slip, if needed. Measures that may minimize potential stress on the dock walls during remedial actions should be investigated, including staging the dredging and capping so that the stress on dock walls is kept to a minimum.

3.3 ALTERNATIVE 3: TOTAL DREDGING WITH TWO FOOT COVER

This alternative includes dredging all of the contaminated sediments exceeding the criteria or depth specified by the MPCA, transporting, dewatering, and placing the sediments in an off-site containment facility. To isolate any potential dredge residual and provide a protective aquatic substrate two feet of environmental medium will be placed over the dredged areas. Dredging and off-site containment of contaminated sediments would provide protection of human health and the environment in the long term. It would also provide unlimited use of the Slip. Because contaminated sediments would be removed, long-term operation, maintenance and monitoring and institutional controls would not be necessary. Major components of this remedy are described below.

Dredging. Mechanical dredging with debris removal would be conducted to remove all of the contaminated sediment prior to cap placement. The depth, thickness and volume of contaminated sediment to be removed is presented in Section 1.4.4.3. In summary, contaminated sediment volumes have been estimated at approximately 33,000 cubic yards. Dredging and debris removal would be conducted as described in Alternative 2. Appendix E1 presents a Technical Analysis that provides additional detail and assumptions used to evaluate mechanical dredging options and dredging productivity and equipment.

There are some concerns with the stability of the dock walls during dredging activities (see Appendix G1 and Other Logistical Issues at the end of this section).

Sediment transportation and staging. Sediments would initially be transported by barge to Erie Pier for either disposal or staging prior to transporting to an off-site landfill as described in Alternative 2.

Sediment disposal at Erie Pier or an off-site landfill. There are two disposal options for dredged sediment that will be evaluated in this FFS, Erie Pier or an off-site landfill (Allied Waste in Sarona, Wisconsin). Sediment transportation and staging would be conducted as described in Alternative 2. Approximately 41,700 cubic yards of stabilized and bulked sediment would need to be disposed under Alternative 3. Appendix E2 presents a Technical Analysis that provides additional detail on the disposal options and the assumptions used to evaluate sediment disposal.

Surface water control during remedy implementation. Surface water control structures would be necessary during dredging and backfilling. Surface water control structures would be conducted as described in Alternative 2. Appendix E4 presents a Technical Analysis that provides additional detail and assumptions used to evaluate water quality control during remedy implementation.

Environmental and physical monitoring during remedy implementation. Environmental and physical monitoring would be necessary during remedial actions. Types of monitoring may include: bathymetry, borrow material, air quality, dredge water, and surface water. The types of monitoring would be specified in the design documents.

Dredging Residuals and Two Foot Cover. Dredging is expected to leave some residual contaminated sediment. The residue is the result of resuspension and settlement of fine grained contaminated sediment from dredging activities and sloughing of soft high water content sediment along the edges of dredge cuts. In addition, contaminated sediment exceeding Level 1 SQT may remain after dredging is complete. The thickness of residue and the concentration of contaminants in the residue are very difficult to accurately predict. Therefore, this alternative includes two feet of cover with an environmental medium that would provide protection to the aquatic environment from dredge residuals. Over time, the Minnesota Slip is expected to fill in through natural processes. Cover material must provide a suitable substrate for the benthic community and enhance natural biodegradation. Approximately 9,782 cubic yards of cover material would be needed under Alternative 3. Appendix E3 presents a Technical Analysis that provides additional detail and assumptions used to evaluate cover productivity and equipment requirements.

One round of environmental monitoring after remedy implementation and maintenance. Post Dredge verification sampling would be required in areas where contaminated sediment has been dredged to assure removal of contaminated sediment in accordance with the approved design documents. The sampling would identify contaminated sediment, other than normal dredge residual that should have been removed by dredging. Only one round of environmental monitoring would be required to confirm removal activities met the established criteria.

Additional monitoring and maintenance costs may also be necessary in the first few years after remedy completion to repair sink holes that may form on the land surface resulting from dredging activities. Therefore, costs for maintenance will be included annually for the first 3 years after remedy completion.

Institutional controls. Contaminated sediments exceeding the Tier 1 SQTs may remain in place beneath the backfill material. Therefore, institutional controls could be required to maintain the integrity of the cover material. Institutional controls may include restrictions on dredging in Minnesota Slip. Because it is unlikely that future dredging will occur below the proposed dredging depth, institutional controls were not included in Alternative 3.

Habitat Restoration. Although there is limited habitat due to the depth of the slip, it would be necessary to design the cover to create/restore habitat for the existing aquatic community.

Cost. The estimated total present worth cost for Alternative 3A, Erie Pier disposal is approximately $7,016,500 and for Alternative 3B, Off-Site Landfill disposal is $7,132,500. Tables F4 and F5 of Appendix F presents a breakdown of the estimated costs associated with Alternative 3. Preparation of the subsurface sediment at Erie Pier and repairs to the dock walls could add a significant increase to the overall project costs.

Other Logistical Issues. Additional logistical issues that may affect dredging and off-loading operations are similar to those described in Alternative 2. In addition, there would likely be a need to repair sink holes and a higher risk to the stability of the dock walls under a total removal scenario. Therefore, this alternative includes $20,000 for maintenance for three years after remedy completion. However, costs associated with dock wall repair have not been included.

4.0 REMEDY SELECTION CRITERIA

The alternatives were evaluated and compared to one another in Section 5.0 using the NCP remedy selection criteria outlined below and in general accordance with EPA guidelines for feasibility studies (EPA, 1990). The NCP remedy selection criteria are divided into three groups based on the function of the criteria in remedy selection. The NCP definitions of each criterion are included below. Additional detail may be added from MPCA and/or EPA guidance where appropriate.

4.1 THRESHOLD CRITERIA

The Threshold Criteria relate to statutory requirements that each alternative must satisfy in order to be eligible for selection and include:

Overall Protection of Human Health and the Environment. Alternatives shall be assessed to determine whether they can adequately protect human health and the environment, in both the short- and long-term, from unacceptable risks posed by hazardous substances, pollutants, or contaminants present at the site by eliminating, reducing, or controlling exposures to levels established during development of remediation goals. Overall protection of human health and the environment draws on the assessment of other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs.

Compliance with Applicable or Relevant and Appropriate Requirements. The alternatives shall be assessed to determine whether they attain applicable or relevant and appropriate requirements under federal environmental laws and state environmental or facility citing laws or provide grounds for invoking a waiver.

4.2 PRIMARY BALANCING CRITERIA

The Primary Balancing Criteria are the technical criteria upon which the detailed analysis is primarily based and include:

Long-term Effectiveness and Permanence. Alternatives shall be assessed for the long-term effectiveness and permanence they afford, along with the degree of certainty that the alternative will prove successful. Factors that shall be considered, as appropriate, include the following:

1. Magnitude of residual risk remaining from untreated waste or treatment residuals remaining at the conclusion of the remedial activities. The characteristics of the residual should be considered to the degree that they remain hazardous, taking into account their volume, toxicity, mobility, and propensity to bioaccumulate.
2. Adequacy and reliability of controls such as containment systems and institutional controls that are necessary to manage treatment residuals and untreated waste. This factor addresses in particular the uncertainties associated with land disposal for providing long-term protection from residuals; the assessment of the potential need to replace technical components of the alternative, such as a cap, a slurry wall, or a treatment system; and the potential exposure pathways and risks posted should the remedial action need replacement.

Reduction of Toxicity, Mobility, or Volume Through Treatment. The degree to which alternatives employ recycling or treatment that reduces toxicity, mobility, or volume shall be assessed, including how treatment is used to address the principal threats posed by the site. Factors that shall be considered, as appropriate, include the following:

1. The treatment or recycling processes the alternatives employ and materials they will treat;

2. The amount of hazardous substances, pollutants, or contaminants that will be destroyed, treated or recycled;
3. The degree of expected reduction in toxicity, mobility, or volume of the waste due to treatment or recycling and the specification of which reductions(s) are occurring;
4. The degree to which the treatment is irreversible;
5. The type and quantity of residuals that will remain following treatment, considering the persistence, toxicity, mobility, and propensity to bioaccumulate of such hazardous substances and their constituents; and
6. The degree to which treatment reduces the inherent hazards posed by principal threats at the site.

Short-term Effectiveness. The short-term impacts of alternatives shall be assessed considering the following:

1. Short-term risks that might be posed to the community during implementation of an alternative;
2. Potential impacts on workers during remedial action and the effectiveness and reliability of protective measures;
3. Potential environmental impacts of the remedial action and the effectiveness and reliability of mitigative measures during implementation; and
4. Time until protection is achieved.

Implementability. The ease or difficulty of implementing the alternatives shall be assessed by considering the following types of factors as appropriate:

1. Technical feasibility, including technical difficulties and unknowns associated with the construction and operation of a technology, the reliability of the technology, ease of undertaking additional remedial actions, and the ability to monitor the effectiveness of the remedy;
2. Administrative feasibility, including activities needed to coordinate with other offices and agencies and the ability and time required to obtain any necessary approvals and permits from other agencies (for off-site actions);
3. Availability of services and materials, including the availability of adequate off-site treatment, storage capacity, and disposal capacity and services; the availability of necessary equipment and specialists, and provisions to ensure any necessary additional resources; the availability of services and materials; and the availability of prospective technologies.

Costs. They types of costs that shall be assessed include the following:

1. Capital costs, including both direct and indirect costs;
2. Annual operation and maintenance costs; and
3. Net present value of capital and O&M costs.

The EPA guidance document "*A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*" (EPA, 2000) was used to develop cost estimates presented in this FFS. The cost estimates developed for this FFS are primarily for the purpose of comparing remedial alternatives during the remedy selection process, not for establishing project budgets.

4.3 MODIFYING CRITERIA

The third group is made up of the Modifying Criteria specified below. These last two criteria are assessed formally after the public comment period, although to the extent that they are known they will be factored into the identification of the preferred alternative.

State/Support Agency Acceptance. Assessment of state/agency concerns may not be completed until comments on the RI/FFS are received but may be discussed, to the extent possible, in the proposed plan issued for public comment. The state/agency concerns shall be assessed include the following:

1. The state's/agency's position and key concerns related to the preferred alternative and other alternatives; and
2. State/agency comments on ARARs or the proposed use of waivers.

Community Acceptance. This assessment includes determining which components of the alternatives interested persons in the community support, have reservations about, or oppose. This assessment may not be completed until comments on the proposed plan are received.

5.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

The purpose of the comparative analysis is to identify and compare advantages and disadvantages of each evaluated alternative relative to one another with respect to remedy selection criteria presented in Section 4.0 in order to determine which of the alternatives best meets those criteria. The comparative analysis is documented in this section and summarized in Table 6. Table 7 presents a numerical comparison of the evaluated alternatives.

TABLE 6. Summary of Comparison of Analysis of Alternatives										
	Threshold Criterion		Balancing Criteria							
Alternative	Overall Protection of Human Health & Environment	ARARs	Long-term Effectiveness and Permanence	Reduction of Toxicity, Mobility or Volume through Treatment	Short-term effectiveness	Implementa				
Alternative 1, No Action	Not protective of the environment(1)									
Alternative 2A, Partial Dredging with In-situ Capping (3-foot cap and Erie Pier Disposal)	Provides a high achievement of protection of Human Health and the Environment. However, approximately one half of the volume of contaminated sediments would remain in place.	Provides a high achievement of ARARs if implemented properly. Contaminants above the PRGs would remain in place.	This Alternative would be protective in the long term but scored lowest in achievement of criteria because a majority of contaminants remain in place under a 3-foot cap and long-term maintenance is required.	This alternative would provide a moderate achievement of this criterion because approximately oe half of the volume of contaminated sediment would be removed from the aquatic environment above the PRGs, and the removed sediments would be treated through stabilization.	This Alternative is predicted to have the highest achievement of this criterion since it would take the shortest amount of time to implement on-site (approximately 6.6 weeks) and thus the least amount of aquatic impact.	This Alternativ would provide to moderate achievement c criterion since requires the le amount of dre but would requ significant age coordination fc disposal.				
Alternative 2B, Partial Dredging with In-situ Capping (3-foot cap and off-site Disposal)	Same as 2A	Same as 2A	Same as 2A	Same as 2A	Although this Alternative is similar to 1A, off-site disposal would have a slightly lower achievement of short-term effectiveness due to a slight increase in short-term risks from truck traffic to an off-site landfill.	This Alternativ would provide highest achiev of this criterior it requires less dredging and l overall agency coordination.				
Alternative 3A, Total Dredging with Two Foot Cover (Erie Pier Disposal)	Provides a high achievement of protection of Human Health and the Environment.	Provides a high achievement of ARARs if implemented properly. All contaminants above the PRGs would be removed.	Provides a moderate to high achievement of long term protectiveness and permanence because it removes contaminated sediments from the aquatic environment.	This alternative would provide high achievement of this criterion by removing all of the contaminated sediment in the aquatic environment above the PRGs, and treating the largest volume of	This Alternative would provide the low to moderate achievement of this criterion since it would take approximately 10.3 weeks to implement on-site and affect the aquatic habitat longer.	This Alternativ would provide lowest achieve of this criterior it requires the dredging and greatest overa agency coordi				

TABLE 6. Summary of Comparison of Analysis of Alternatives

Alternative	Threshold Criterion		Balancing Criteria						
	Overall Protection of Human Health & Environment	ARARs	Long-term Effectiveness and Permanence	Reduction of Toxicity, Mobility or Volume through Treatment	Short-term effectiveness	Implementa			
			Contaminated sediments would be placed in a disposal facility requiring long-term O&M.	sediment.					
Alternative 3B, Total Dredging with Two Foot Cover (Off-Site Disposal)	Same as 3A	Same as 3A	Same as 3A	Same as 3A	Although this Alternative is similar to 3A, off-site disposal would have a lower achievement of short-term effectiveness due to a slight increase in short-term risks from truck traffic to an off-site landfill.	This Alternativ would provide moderate achievement c criterion since requires a larg amount of drec but less overal agency coordi			

(1) Alternative 1 does not meet the Threshold criteria so it is not evaluated.
A = Erie Pier Disposal
B = Off-site Disposal
M = Million
TBD = To Be Determined

TABLE 7. Numerical Comparison of Analysis of Alternatives

	Threshold Criterion		Balancing Criteria					
Alternative	Overall Protection of Human Health & Environment	ARAR	Long-term Effectiveness & Permanence	Reduction of Toxicity, Mobility or Volume through Treatment	Short-term effectiveness	Implementability	Cost	Total Score
Alternative 1, No Action (1)								
Alternative 2A	2.5	3	1.5	2	3	1.5	2	13.5
Alternative 2B	2.5	3	1.5	2	2.5	3	2.5	16.5
Alternative 3A	3	3	2.5	3	1.5	1	1	15
Alternative 3B	3	3	2.5	3	1	2	1	15.5

(1) Alternative 1 does not meet the Threshold criteria so is not scored
Alternative 2 = Partial Dredging
Alternative 3 = Total Dredging
A = Erie Pier Disposal
B = Off-site Disposal
Ratings are based on achievement of criterion: low achievement; moderate achievement; and high achievement
Scores are based on 1 = low achievement; 2 = moderate achievement; and 3 = high achievement
Scoring for cost are based on the following cost breakpoints: > $ 6 million = low achievement; $4 - $6 Million = moderate achievement; and < $4 million = high achievement.
See Table 6 for a discussion of each criterion

5.1 THRESHOLD CRITERIA

Only those Alternatives that would meet the Threshold Criterion of providing overall protection of human health and the environment and whether they would attain compliance with ARARs were evaluated under the Balancing Criteria and carried forward for comparative analysis. Therefore, Alternative 1, No Action, was not carried forward because it is not protective of the environment. Alternative 2 and Alternative 3 are predicted to achieve protection of human health and the environment and attain ARARs.

Both Alternative 2 and Alternative 3 would achieve the Threshold Criterion because they would adequately protect human health and the environment, in both the short- and long-term, from unacceptable risks posed by hazardous substances, pollutants, or contaminants present at the Site. Both Alternative 2 and Alternative 3 would eliminate, reduce, or control exposure to contaminated sediment. However, contaminated sediment would remain in place under Alternative 2, requiring monitoring to assure long-term effectiveness. Alternative 3 would provide the highest achievement of protection since contaminated sediments would be removed from the aquatic environment. Both Alternative 2 and Alternative 3 require varying amounts of dredging that may impacts short-term effectiveness. The potential short-term risks increase as the volume of contaminated sediment to be dredged increases.

5.2 BALANCING CRITERIA

5.2.1 Long-Term Effectiveness and Permanence

Both Alternative 2 and Alternative 3 are predicted to be effective in the long-term. However, contaminated sediment would remain in place under Alternative 2, requiring long-term operation and maintenance and institutional controls to assure long-term effectiveness. Disposal of sediment in a containment cell at Erie Pier or an off-site landfill would be equally effective in the long-term. Since all contaminated sediments would be removed under Alternative 3, Alternative 3 would provide a higher degree of permanence. However, contaminants would not be permanently destroyed requiring some type of long-term monitoring and maintenance at the disposal facility. Over the long term there may be additional concerns with containment of contaminated sediments and long term maintenance of the Erie Pier facility.

In summary, Alternative 3 is predicted to provide a moderate to high achievement of this criterion by removing all of the contaminated sediment in the aquatic environment above the PRGs. Alternative 2 is predicted to provide a low to moderate achievement of this criterion since approximately one half of the contaminated sediment would remain in the aquatic environment underneath a 3-foot cap.

5.2.2 Reduction of Toxicity, Mobility, or Volume Through Treatment

Treatment of contaminants sediments to reduce toxicity, mobility or volume is not a major component of any of the evaluated alternatives. However, addition of a solidification agent to dredged sediment is proposed as a means to bind excess free water. Addition of the solidification agent would indirectly reduce the toxicity and mobility of sediment disposed of in at an Erie Pier containment cell or off-site landfill.

The amount of dredged sediment to be removed from the environment and stabilized along is included in Table 8.

TABLE 8. Volume Estimates for Treated Sediment

Alternative	Approximate Sediment to be Dredged and Stabilized (cubic yards)
Alternative 2A, Partial Dredging and Capping	16,000
Alternative 2B, Partial Dredging and Capping	16,000
Alternative 3A, Total Dredging and Bathymetry Restoration	33,000
Alternative 3B, Dredging and Bathymetry Restoration	33,000

A = Erie Pier Disposal
B = Off-site Disposal

Therefore, removal of contaminants from the aquatic environment and treatment of the sediments would provide a reduction in toxicity, and mobility of contaminants. Removal and treatment of the contaminants would be considered permanent.

In summary, Alternative 3 is predicted to provide the highest achievement of this criterion by removing all of the contaminated sediment in the aquatic environment above the PRGs. Alternative 2 is predicted to provide a moderate achievement of this criterion since approximately one half of the contaminated sediment would remain in the aquatic environment underneath a 3-foot cap.

5.2.3 Short-Term Effectiveness

All alternatives would have some short-term risks during implementation of the remedy. The potential short-term risks to the community and workers are associated with increase boat/barge traffic, safety, noise and related impacts due to working in the Duluth Harbor. There are also potential short term risks to workers from dust created from stabilization agents stockpiled and mixed at Erie Pier. Truck transportation of dredged sediments from Erie Pier to an off-site landfill would have an increase in the short-term risks to the community and workers.

Short-term adverse effects to aquatic habitat and biota would be similar among the alternatives being compared, and would include displacement of fish, and smothering of benthic organisms. These effects would occur during remedy construction and during the recovery period thereafter. Benthic organisms would be expected to be re-established for all alternatives within several growing seasons.

Short-term adverse effects to surface water may also occur during dredging and capping/habitat restoration activities. Surface water control structures have shown that they are reliable in minimizing these short-term adverse effects.

Short-term risks with dock wall stability during dredging operations are also a concern and increase significantly with the total dredging option.

Table 8 presents the estimated time for construction completion at the Site. The time frame estimates do not include additional construction time that would be required at Erie Pier including: excavation and transportation of sediment for a containment cell under Alternatives 2A and 3A, construction of a containment cell (Alternatives 2A and 3A), construction of a gravel staging pad, stabilization, and/or off-site transportation to a landfill (Alternatives 2B and 3B).

TABLE 9. Estimated Time for Construction Completion on Site

Alternative	Dredging (Weeks)	Restoration/ Capping (Weeks)	Total Time for On-Site Construction Completion (Weeks)
Alternative 2A, Partial Dredging and Capping	5.0	1.6	6.6
Alternative 2B, Partial Dredging and Capping	5.0	1.6	6.6
Alternative 3A, Total Dredging and Bathymetry Restoration	9.2	1.1	10.3
Alternative 3B, Total Dredging and Bathymetry Restoration	9.2	1.1	10.3

A = Erie Pier Disposal
B = Off-site Disposal

Overall, Alternative 2A would be predicted to have the highest achievement of the short-term effectiveness criterion. The off-site disposal options (Alternatives 2B and 3B) would have a slightly lower achievement of short-term effectiveness due to an increase in short-term risks from truck traffic to an off-site landfill. Alternative 3B would be predicted to have the lowest achievement of the short-term effectiveness criterion.

5.2.4 Implementability

Dredging, capping and/or restoration, surface water control structures, as well as monitoring and operation and maintenance that would be required under Alternative 2 and Alternative 3 are all technically feasible and implementable from an engineering perspective. These technologies have been implemented successfully at other sediment sites and could be readily implemented at the Site. Services and materials are available for implementing each component of the remedy.

Dredging contaminated sediment with significant debris may pose additional but not insurmountable difficulties. In addition, there are concerns with the stability of the dock walls during dredging activities (see Appendix G1). Dock wall inspection is included in the cost estimates. However, structural repairs are not included in the cost estimate but may be necessary prior to dredging if significant damage is observed. There would be a higher risk to the stability of the dock walls under a total removal scenario (Alternatives 3A and 3B). Therefore, the total removal scenarios would likely provide a lower achievement of the implementability criterion.

Weather could significantly impact productivity, particularly if done in the early spring or late fall. High winds in the late fall produce rough seas that could hamper productivity. Barge traffic would be postponed in the spring until ice breaking. Winter or freezing conditions in the fall could also impact productivity.

Monitoring can be completed to evaluate the effectiveness of each component of the remedy. Because dredging and capping will be conducted under water, monitoring the effectiveness of the remedy could be more challenging but specialized equipment is available.

Some Erie Pier site work would be necessary to accommodate a selected remedy, including timing with COE disposal operations. Erie Pier does not have adequate disposal capacity so previously placed navigational sediment would need to be excavated to create a containment cell.

Implementability also includes administrative feasibility of the remedy. As with most sediment remediation activities, multiple state and federal agencies and other stakeholders input is required, providing a lower achievement of administrative feasibility of implementing a remedy. Both Alternatives 2 and 3 will require coordination with other offices and agencies. Additional time will be required to obtain any necessary approvals and permits from other agencies. Alternative 2A and 3A include construction of a containment cell and disposal of sediments at Erie Pier requiring significantly more coordination than disposal at an off-site landfill.

In summary, Alternative 2B would be predicted to provide the greatest achievement of the implementability criterion since it requires less dredging and less overall agency coordination. In contrast, Alternative 3A would be predicted to provide the lowest achievement of the implementability criterion. Table 7 presents a numerical score that provides a scale to compare all scenarios under Alternatives 2 and 3.

5.2.5 Cost

Cost estimates developed for each alternative are included in Appendix F and summarized below in Table 10. The cost estimates include: capital costs, including both direct and indirect costs; annual operation and maintenance costs; and net present value of capital and O&M costs.

TABLE 10. Summary of Cost Estimates for Alternatives

Alternative	
Alternative 1, No Action (1)	$524,525
Alternative 2A, Partial Dredging and Capping	$5,182,200
Alternative 2B, Partial Dredging and Capping	$4,902,500
Alternative 3A, Total Dredging and Bathymetry Restoration	$7,016,500
Alternative 3B, Total Dredging and Bathymetry Restoration	$7,132,500
A = Erie Pier Disposal *B = Off-site Disposal*	

(1) The cost for the No Action Alternative was provided for comparison purposes.

Transportation to an off-site landfill under Alternative 2B would be a more cost effective option. However, once the volume of contaminated sediment removal increases (under Alternative 3), disposal at Erie Pier (Alternative 3A) becomes more cost effective for the total removal options. The cost estimate for Erie Pier disposal (Alternatives 2A and 3A) incorporates disposal of Erie Pier sediments at Veit. However, the regulators may choose to beneficially reuse the sediments in mine land reclamation where there is a potential to produce greater beneficial results especially if a larger volume of sediment is removed (See Attachment E2a, Ecosystem Restoration of Mined Lands Using Dredged Material, USACE.).

Other potential factors that could affect cost but are not included in the estimated cost are repair of dock walls, if necessary, prior to implementation of the remedial actions. There would be a higher risk to the stability of the dock walls under a total removal scenario (Alternatives 3A and 3B). In addition, dewatering and compaction of the subsurface sediment may also be necessary prior to construction of the containment cell at Erie Pier. However, costs for subsurface preparation were not included in the cost estimate (Alternatives 2A and 3A).

In summary, Alternatives 3A and 3B are all similar in costs and would provide the lowest achievement of the cost criterion because they are the most costly to implement. Alternatives 2A and 2B would provide the highest achievement of cost criterion because they are the least costly to implement, with Alternative 2B being slightly more cost effective. However, Alternatives 2A and 2B only received a moderate rating because of their high relative cost. Table 7 presents a numerical score that compares the cost for all scenarios and options under Alternative 2 and Alternative 3.

5.3 MODIFYING CRITERIA

The modifying criteria, State/support agency acceptance and community acceptance are assessed formally after the public comment period, although to the extent that they are known they will be factored into the identification of the preferred alternative.

In recent correspondence between the MPCA and the City of Duluth on August 08, 2005, the City stated that “At this point in time I think you should assume that the Minnesota Slip will continue to operate as it has in the last fourteen years since the Pedestrian Bridge began operations.” (See Appendix G2.)

Because the Slip is home to floating museums that provide daily tours in the summer months and it is also occupied by charter fishing boats and docks and a harbor tour boat, the MPCA has indicated that remediation work performed on the Site would need to be coordinated with the tourism season. The tourism season lasts from May through September. As shown in Table 9, the total estimated time needed for on-site construction is 6.6 weeks for Alternative 2 and 10.3 weeks for Alternative 3. Based on the estimated time needed for on-site construction, it would be very difficult to complete Alternative 3 before or after tourism season without running into severe weather, including a frozen navigational channel for transportation of sediment to Erie Pier.

6.0 RECOMMENDED RESPONSE ACTION ALTERNATIVE

The comparative analysis of Alternatives presented in Section 5, identified Alternative 2B as receiving the highest overall scoring (See Table 7). Based on this scoring, the recommended alternative is Alternative 2B, Partial Dredging with In-Situ Capping (3-foot cap with off-site disposal). The major components of Alternative 2B, Partial Dredging with In-Situ Capping (3-foot cap with off-site disposal) are:

Dredging. Mechanical dredging with debris removal using a clamshell bucket would be conducted to remove contaminated sediment prior down to an approximate elevation of 582 above MSL. Approximately 16,000 cubic yards of contaminated sediment would be removed

Debris removal would be performed in the barge, prior to transportation to Erie Pier. Debris removal would be conducted through mechanical screening of the sediment as it is loaded into the barge. Debris would stockpiled on City or DECC property then transported by truck and disposed of at a landfill.

Sediment transportation and staging. Sediments would initially be transported by barge to Erie Pier for staging prior to transporting to an off-site landfill. Stabilizing agents would be added to the barge at Erie Pier. Stabilized sediments would be offloaded to a gravel pad for staging prior to transportation by truck to an off-site landfill.

Sediment disposal at off-site landfill. Stabilized sediments would trucked to an off-site landfill for disposal. The landfill facility used in this cost estimate was Allied Waste in Sarona, Wisconsin. The cost estimate assumed the sediment would be used for daily cover material.

In-Situ Cap. Because this alternative includes capping any potential dredge residue that may create an exposure to aquatic organisms would be minimized. Capping material must provide a suitable substrate for the benthic community and enhance natural biodegradation. For this FFS, the cover thickness will be roughly equal to the thickness that is removed by dredging and the upper-most layer will be composed of loosely consolidated organic-rich material to enhance aquatic habitat. Approximately 14,600 cubic yards of capping material will be needed.

Cost. The estimated total present value cost for Alternative 2B, Off-Site Landfill is $4,902,500. Table F3 of Appendix F presents a breakdown of the estimated costs.

Section 3.2 presents additional details on Alternative 2B, including the following:

- Surface water control during remedy implementation.
- Environmental and physical monitoring during remedy implementation. Long-term Operation, Maintenance, and Monitoring.
- Institutional Controls. Restricting boat use that may erode cap materials and anchoring.
- Habitat Restoration.
- Other Logistical Issues.

The modifying criteria, State/support agency acceptance and community acceptance are assessed formally after the public comment period. Stakeholder and community input may also provide valuable insight in the implementation of the selected response action.

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