Final

## MINNESOTA SLIP REVISED FOCUSED FEASIBILITY STUDY

SR\#1010
Duluth, Minnesota
MPCA Work Order \# 3000008714


Prepared for:
Minnesota Pollution Control Agency
525 South Lake Avenue Suite 400 Duluth, Minnesota, 55802


Prepared by:
Bay West LLC
5 Empire Drive
St. Paul, Minnesota 55103-1867

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## Executive Summary

This Revised Focused Feasibility Study (FFS) for the Minnesota Slip (Slip) is an update to the FFS completed in November 2005 by Bay West LLC (Bay West) and presents: a summary of current site conditions; a discussion of remedial action objectives (RAOs); and the identification, screening, evaluation, and comparison of potential alternatives. This report has been prepared by Bay West in accordance with the Minnesota Pollution Control Agency (MPCA) Contract Work Order No. 3000008714 and includes the following revisions to the 2005 FFS:

1. Updated bathymetric data was collected and used to evaluate the change in the top of sediment elevation from the 2004 data.
2. An additional two storm sewer outfalls into the slip were identified, for a total of five.
3. Sediment samples were collected and analyzed for toxicity characteristic leaching procedure (TCLP), semi-volatile organic compounds (SVOCs), and metals to evaluate disposal options.
4. The estimated volume of contaminated sediments was updated based on the collected bathymetry data and revised Sediment Quality Target criteria.
5. Disposal options for dredged materials were re-evaluated, as the option to dispose of sediment at the Erie Pier is no longer feasible.
6. Cost estimates for all alternatives were revised based on current pricing.
7. A fourth alternative to install a 0.8 -meter cap without dredging was added.
8. The volume of material required to fill in the Slip post-capping material was calculated. However, the costs for filling in the slip were not included.
The Slip has been studied as a part of the St. Louis River AOC (see Section 1.4.4). In 2003, the MPCA received a grant from the United States Environmental Protection Agencies (USEPA), Great Lakes National Program Office (GLNPO) to perform additional studies to determine the nature and extent of contaminated sediments and prepare a detailed investigation and a Focused Feasibility Study (FFS). A detailed investigation was prepared in 2005, resulting in the identification of sediments in the Slip contaminated with PAHs, PCBs, mercury, cadmium, chromium, copper, lead, nickel, and zinc. Contaminated sediment was generally identified throughout the entire Slip and considered to present a high likelihood of significant effects to benthic invertebrates from exposure to surficial sediments throughout the Slip.
As identified in the St. Louis River Remedial Action Plan (RAP; MPCA and Wisconsin Department of Natural Resources [WDNR], 1992) and later proven with testing, the Slip is potentially contributing to two impairments to the St. Louis River AOC:

- Fish consumption advisory; and
- 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, addressing the contaminated sediments from Slip would also help in the reduction of the impaired water resulting from bioaccumulative toxins in the St. Louis River.
Based on the results of the 2005 Detailed Investigation, the updated depth-to-sediment measurements completed with this Revised FFS, the average thickness of contaminated sediment is approximately 7 feet, with a maximum contaminated sediment thickness of approximately 12 feet. Contaminated sediment volume within the Slip is approximately 36,750 cubic yards, which includes a 5 percent (\%) increase in volume to account for the updated sediment clean up goals since the original FFS was prepared.

## Remedial Action Objectives (RAOs) developed by the MPCA for the Slip are:

1. Minimize or remove exposure to sediment contaminants that bioaccumulate in the food chain and contribute to fish consumption advisories;
2. Minimize or remove exposure of the benthic organisms to contaminated sediments above the preliminary sediment cleanup goals;
3. Preserve water depth to enable the current use of the slip; and
4. Enhance deep water aquatic habitat if conditions allow.

Alternatives were identified and screened to determine if they could meet these RAOs. The following alternatives were evaluated in this Revised FFS:
Alternative 1: No Action. This 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 $\$ 240,900$.
Alternative 2: Partial Dredging with 0.8-Meter Cap. This alternative includes dredging approximately 18,000 cubic yards of contaminated sediment from shallower areas, transporting, staging sediments at an off-site facility, and disposing the sediments at an off-site landfill. The remainder of the contaminated sediment would be capped across this slip in-place under a 0.8 meter thick cap. Approximately 12,800 cubic yards of capping material would be needed under Alternative 2. The estimated total present value cost for Alternative 2 is approximately\$4,664,3000.
Alternative 3: Total Dredging with 0.3-Meter Cover. This alternative includes dredging all of the contaminated sediments exceeding the goals or to a depth specified by the MPCA (estimated at approximately 36,750 cubic yards) transporting, staging sediments, and disposing the sediments at an off-site landfill. 0.3 meter of restoration material/environmental medium would be placed in the excavated areas to provide a protective aquatic substrate and isolate dredge residual. Approximately 4,800 cubic yards of cover material would be needed under Alternative 3. The estimated total present value cost for Alternative 3 is approximately $\$ 6,446,700$.

Alternative 4: Slip Leveling with 0.8 -Meter Cap. This alternative includes moving sediment from the two shallow areas within the slip to deeper areas within the slip in order to maintain the water depth required to continue the slip's current use. The contaminated sediment would be isolated in-place under a 0.8 meter thick cap. Approximately 12,800 cubic yards of capping material would be needed under Alternative 4. The estimated total present value cost for Alternative 4 is approximately $\$ 1,566,400$.
The comparative analysis of alternatives presented in Section 5.0. Alternatives 2, 3 and 4 were all protective of human health and the environment. No significant difference in the balancing criteria score was found between these alternatives other than cost. More information is needed prior to selecting a preferred alternative. The MPCA will conduct further outreach activities with the public, resource managers and local units of government. The modifying criteria, State/support agency acceptance and community acceptance are assessed formally after the public comment period. Alternative 1 was not protective and will not be considered.
Further studies are recommended during the design phase of the preferred alternative. These recommended studies, depending on the chosen alternative, include:

- Hydrodynamic study to understand the depositional and scouring forces in the slip to inform design and placement of armoring if needed.
- Storm water sewer evaluation, including an evaluation of need to sediment maintenance.
- Additional surface sampling to understand if incoming storm water deposition is contaminated, thus a continuing source of contamination
- Pore-water transport and attenuation modeling for engineered cap design.
- Cap/sediment consolidation calculations and modeling for engineered cap design.
- Bench scale study to determine the amount of stabilizing agent required to desiccate sediments after dredging, possible leading to consideration of other dewatering techniques.
- Future use of the slip and required water depth study.


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## Acronyms and Abbreviations




### 1.0 INTRODUCTION AND BACKGROUND

This Revised Focused Feasibility Study (FFS) has been prepared to evaluate remedial alternatives for the identified contaminated sediment in the Minnesota Slip (Slip) located in Duluth, Minnesota (Figure 1-1). The scope of this Revised FFS does not consider alternatives for any other matrix such as soil, surface water, or groundwater that may be impacted at the Slip. This report has been developed pursuant to the Bay West Master Contract 63186 and Minnesota Pollution Control Agency (MPCA) Contract Work Order No. 3000008714, dated September 13, 2013, and accompanying the Scope of Work/Cost Estimate (SOW) for the Site.
This Revised FFS has been written in general accordance with the MPCA Site Response Section Guidance Document Draft Guidelines on Remedy Selection (MPCA, 1998), the Minnesota Environmental Response and Liability Act (MERLA), the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 C.F.R. Part 300, along with other Minnesota and Federal rules, statutes, and guidance. The Slip FFS was originally prepared in 2005 by Bay West LLC (Bay West) and included the analysis of five options to remediate the Slip. The options evaluated in 2005 are summarized below:

1. Alternative 1: No Action
2. Alternative 2A: Partial Dredging with 1-Meter Capping and Disposal at Erie Pier
3. Alternative 2B: Partial Dredging with 1-Meter Capping and Off-Site Disposal
4. Alternative 3A: Total Dredging with 2-Foot Cover and Disposal at Erie Pier
5. Alternative 3B: Total Dredging with 2-Foot Cover and Off-Site Disposal

Subsequent to transmittal of the 2005 FFS, the MPCA contracted with Bay West to revise the document to include the following:
6. Updated bathymetric data to evaluate the change in the top of sediment elevation from the 2004 data.
7. Toxicity characteristic leaching procedure (TCLP) semi-volatile organic compounds (SVOCs) and metals data for sediments to evaluate disposal options.
8. An updated estimate of the volume of contaminated sediments based on the collected bathymetry data and revised Sediment Quality Target criteria.
9. Re-evaluated disposal options for dredged materials as the option to dispose of sediment at the Erie Pier is no longer feasible; Options 2A and 3A were eliminated.
10. Updated cost estimates based on current pricing.
11. A fourth alternative to install a 0.8 meter cap after leveling the slip to maintain current use.
12. A volume of capping material in-place for filling in the Slip. However, costs for filling in the slip were not estimated.

### 1.1 Report Organization

Section 1.0 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 (Streitz and Johnson, 2005). Section 2.0 discusses Applicable or Relevant and Appropriate Requirements (ARARs) and summarizes Remedial Action Objectives (RAOs) to provide the framework for alternative evaluations for the Site. Section 3.0 and Section 4.0 present alternatives descriptions and the NCP remedy selection criteria used in this Revised FFS. Section 5.0 presents an evaluation of alternatives against standards and criteria. References are presented in Section 6.0.

### 1.2 Site Location and Current Use

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

The Slip is located in the northern section of the Duluth Harbor basin between Canal Park and the Duluth Entertainment and Convention Center (DECC; Figure 1-1). Although the length of the Slip is oriented approximately 30 degrees west of north, for the purposes of this Revised 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. The west side of the Slip is bounded by Harbor Avenue, 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 (the south side of the Slip) is spanned by a pedestrian drawbridge allowing access between the DECC and Canal Park. Both the sidewalk and the drawbridge 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 1-2 identifies the current property owners.

The total area of the Slip is approximately 3.25 acres. Charter fishing boats are docked in the Slip on a routine basis and there are currently two vessels permanently docked in the Slip, including:

- The SS. William A. Irvin, a former United States Steel flag ship; and
- The Vista Fleet, a seasonal tourist harbor cruise vessel.

The Slip has been home to at least one of these vessels since 1986, providing daily tours in the summer months. Remaining space in the Slip is occupied in the summer by charter fishing boats, leased docks, and a harbor tour boat. The Irvin and the Vista Fleet are docked on the west side of the Slip, while the charter fishing boats are docked on the east side (see picture shown on the cover sheet of this Revised FFS). The docks on the east side of the slip are removed seasonally. 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 1-3 shows the network of storm sewers in the vicinity of the Slip. The largest storm sewers that empty into the Slip are located along the north and west sides of the Slip. There are five storm sewers that outlet to the Slip as designated Outlet-1 through Outlet-5 on Figure 1-3 and two that outlet just south of the mouth of the Slip. Outlet-1 (Figure 1-3) outlets to the slip on the west side wall approximately 125 feet south of the north side wall and was identified as a major contributor of sediment to the Slip during the 2005 FFS. 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).
The MPCA and the City of Duluth worked together to submit complimentary grants to the Great Lakes National Program Office (GLNPO) to ensure that if the Slip was remediated that it would not further degrade 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 was completed in the Fall of 2005. Continued identification
and implementation of effective Best Management Practices (BMPs) for dealing with storm water runoff will reduce the quantity of pollutants discharging to the Slip and the St. Louis River.

### 1.3 Site History (from Streitz and Johnson, 2005)

Historically, the 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 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 the Slip that was eventually replaced by a scrap yard. A double train freight shed used to be located just west of the Slip. A photo of the Slip dated May 1, 1929, 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 the Slip; this area is now filled in and is the current location of the DECC. Over time, parts of the Slip have been dredged out and filled in including the north end of 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 Slip. According to the MPCA Record of Decision for the SLRIDT 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 embayment 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 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 ordnances. Ecological risk is limited to the slip where the contamination is located.

## 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 2004 (Streitz and Johnson, 2005) and 2014 in association with this Revised FFS details the Slip is shallowest to the north and deeper to the south. Erosional forces that may be responsible for the difference in bathymetry 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.

Section 7.1 of the Detailed Investigation of the Minnesota Slip (Streitz and Johnson, 2005; Appendix A2) provides a discussion of each of these forces and their effect on the Slip in detail. The MPCA also reported during the development of this Revised FFS that the western dock wall previously collapsed and was repaired. Sediment accumulated in the Slip as a result of the dock wall collapse.

### 1.4.3 Nature and Extent of Contamination

The nature and extent of contamination has been delineated by several studies in the Duluth/Superior Harbor that included the collection and analysis of sediments, biota samples, and measurements of the depths of sediment in the Slip. These studies are identified in Section 1.4.4.1, and selected historical summary tables are included in Appendix A1. This section also presents a discussion on the Contaminants of Potential Concern (COPCs) and the 2004 and 2014 thickness, depth, and volume of contaminated sediments.

### 1.4.3.1 Previous Studies

The following is a list of previous studies conducted in the Duluth and Superior Harbor that included the collection and analysis of sediments and biota samples in the 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 ( $0-5$ centimeters [cm]) site sampled in 1995 and resampled in 1996.
- The 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 (PCBs) bioaccumulation by Lumbriculus variegates exposed to St. Louis Bay sediment samples (AScl 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 Minnesota Slip (Streitz and Johnson, 2005). Twenty-nine Laser Induced Fluorescence (LIF) probes and 18 core samples (See Figure 7 in Appendix A). 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 included a limited screening ecological risk assessment. The LIF response percentage correlated to 0.9 with total PAHs for samples in the back half of the Slip where the erosional effects of seiche, wave action, and propeller disturbance was at a minimum. This statistical treatment of the data produced a 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.
- Focused Feasibility Study (Bay West, Inc., 2005). An FFS was completed in 2005 to evaluate alternatives to remediate the depth of contaminated sediment that was identified in the 2005 Detailed Investigation. Since 2005, a remedial alternative was not implemented, and the depth of sediment may have changed in the Slip. Therefore, the MPCA contracted with Bay West to revise the 2005 FFS with updated depth-to-sediment measurements, revised updated Sediment Quality Target criteria, and an added alternative to install a cap without dredging.
- TCLP analysis of sediment samples taken in 2013 for SVOCs and metals to evaluate disposal options (Appendix E).

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.

### 1.4.3.2 Contaminants of Potential Concern

The COPCs associated with the Slip include PAHs, PCBs, mercury, cadmium, chromium, copper, lead, and zinc as identified in the Detailed Investigation (Streitz and Johnson, 2004). Table 1-1 presents a list of the COPCs along with the maximum concentration detected. Tables 1-2 and 1-3 provide statistics of two separate data sets for comparison. Section 1.4.5 compares each COPC to sediment quality targets (SQTs), and the following presents a general discussion of risks associated with the COPCs at the Site:

- Total PAHS: PAHs are a group of over 100 different chemicals, although only 13 priority PAHs are included in the calculation for comparison to the SQTs for total PAHs. The 13 priority PAH's include phenanthrene, pyrene, acenaphthene, acenaphthylene, anthracene, b fluoranthene, fluorene, naphthalene, 2-methyInaphthalene benz[a]anthracene, benzo[a]pyrene, chrysene and dibenz[a,h]anthracene. PAHs are ubiquitous environmental contaminates which form as a result of incomplete combustion of organic materials such as wood or fossil fuels. Natural sources of PAHs include
volcanoes, forest fires, crude oil, and shale oil. PAHs are also found in asphalt used in road construction, roofing tar, and creosote. Individual PAHs generally do not occur alone in the environment; they are found as part of complex mixtures of chemicals that may be found in soot or crude oil. PAHs are generally attached to sediments. The movement of PAHs in the environment depends on their chemical properties, such as water solubility and vapor pressure. Some PAHs dissolve more readily in water and evaporate more readily into air (e.g., anthracene, naphthalene). Increased incidences of tumors in fish are often associated with PAH-contaminated sediments.
- PCBs: According to the February 2001 Agency for Toxic Substances and Disease Registry (ATSDR) ToxFaQs, PCBs are taken up by small organisms and fish in water. They are also taken up by other animals that eat these aquatic animals as food. PCBs accumulate in fish and marine mammals, reaching levels that may be many thousands of times higher than in water. Animals that ate food containing large amounts of PCBs for short periods of time had mild liver damage and some died. Animals that ate smaller amounts of PCBs in food over several weeks or months developed various kinds of health effects, including anemia; acne-like skin conditions; and liver, stomach, and thyroid gland injuries. Other effects of PCBs in animals include changes in the immune system, behavioral alterations, and impaired reproduction. PCBs are not known to cause birth defects. Many waters in Minnesota, including the St. Louis River estuary where the Slip is located, have fish consumption advisories due to PCB contamination of fish.
- Heavy Metals:
o Cadmium: Cadmium is bioconcentrated and bioaccumulated by organisms and may biomagnify in lower trophic levels of food chains.
o Chromium: Discharge of chromium wastes into streams and lakes has caused damage to aquatic ecosystems. No biomagnification of chromium has been observed in food chains.
o Copper: Copper is among the most toxic of the heavy metals in aquatic biota and often accumulates and causes irreversible harm to some species at concentrations just above levels required for growth and reproduction. Copper does not tend to biomagnify in the food chain.
o Lead: Lead is toxic to aquatic organisms, plants, and wildlife; however, food chain biomagnification of lead is negligible.
o Zinc: Zinc is toxic to some aquatic organisms at relatively low concentrations. Zinc is of particular importance in aquatic environments because the gills of fish are physically damaged by elevated concentrations. Biomagnification of zinc through food chains is negligible.
o Mercury: Organic mercury compounds are more toxic than inorganic compounds. The most common organic mercury compound, methyl mercury, is produced mainly by small organisms in the water, sediment, and soil. Once methyl mercury is formed, it can bioaccumulate and biomagnify through the food chain, causing adverse effects in upper trophic level species. Ingestion of contaminated fish can be a significant source of exposure for humans and wildlife. Many waters in Minnesota, including the St. Louis River estuary where the Slip is located, have fish consumption advisories due to mercury contamination of fish. Additional methyl mercury data does not exist in the SLR sediment database for this location.

PAHs are the primary COPC at the Slip; 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 parts per million (ppm; Streitz and Johnson, 2005). During the 2005 Detailed Investigation, however, detection limits for PCBs were higher than the regulatory criteria (see Section 1.4.5.2); therefore, PCBs may be present at low concentrations at depth. Because PCBs were found in surface sediments (Crane, 2002) they are considered a COPC.

The following comparison of the descriptive statistics of two datasets, one representing sediment samples taken in 1998 and 1999 and the other for sediments sampled in 2004, was also conducted. The earlier investigation focused on the surface sediments in the Slip, while the 2004 samples were taken primarily from depths exceeding 4 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 Tables 1-2 and 1-3). 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 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.

### 1.4.3.3 Depth, Thickness, and Volume of Contaminated Sediment

The depth, thickness, and volume calculations were originally included in the 2005 FFS prepared by Bay West. The calculations and associated correspondence are included in Appendix B of this Revised FFS. In accordance with the SOW for this Revised FFS, the depth, thickness, and volume calculations have been updated based on January 2014 measurements from depth to top of the sediment. The following discussion provides the 2004 calculations, the 2014 calculations, and a comparison of the change in sediment elevations.
The total area of the Slip is approximately 3.25 acres. Using a surface water elevation of 601 above mean sea level (amsl), the depth to sediment in 2004 ranged from approximately 5 feet at the north end of the Slip to 21 feet at the south end of the Slip. Currently, the depth to sediment ranges from approximately 4 feet at the north end of the Slip to 22 feet at the south end of the Slip. The average water depth within the Slip in 2004 was approximately 15 feet, and is currently approximately 14.5 feet. Therefore, an average of approximately 0.5 feet of additional sediment has accumulated within the Slip. Figure 1-4 presents a bathymetric map based on data collected for the Detailed Investigation (Streitz and Johnson, 2005). Figure 1-5 presents a bathymetric map based on data collected January 2014 for this Revised FFS. Figure 1-6 presents a comparison of the change in the depth to sediment from 2004 to 2014. As detailed in Figure 1-6, there has been an increase in sediment in the northwest corner of the Slip and along the west side of the Slip, along the south side of the Irvin dock location.

As previously stated, Appendix B provides the rationale for calculating the volume of contaminated sediment, as well as the contaminated sediment volume and thickness calculated for the 2005 FFS based on data collected for the Detailed Investigation (Streitz and Johnson, 2005). Table 1-4 provides the updated sediment thickness and volume calculations, as well as a comparison summary between the 2004 and 2014 calculations. In summary, contaminated sediment is generally present throughout the entire Slip. In 2004, the maximum contamination thickness was approximately 12 feet with an average thickness of 6.5 feet. In January 2014, the maximum contamination thickness was approximately 12 feet with an average thickness of approximately 7 feet. A cross-section location map (Figure 1-7) and a series of cross sections (Cross Sections A-A' [Figure 1-8] through H-H' [Figure 1-14]) were developed to present the approximate depth of contaminated sediment and clean sediment interface within the Slip. The cross-sections detail the previously reported top of sediment in 2004 and the top of sediment
based on measurements collected in January 2014. For purposes of the FS, the newly accumulated sediment since 2004 will be considered impacted by contaminants although it is unknown if there are elevated concentrations. It is possible that the newly accumulated sediment is clean but will still require removal in dredging scenarios.
In 2004, the vertical limits of contamination were estimated based on 2 percent (\%) of the LIF response, which was shown to correlate to a total PAH concentration of 13.7 milligrams per kilogram ( $\mathrm{mg} / \mathrm{kg}$; see detailed discussion in Section 2.2.1). Sediments at elevations above this total PAH level within the Slip were assumed contaminated, as previous studies indicated the presence of contaminants in the surficial sediments throughout the Slip. For the purposes of the 2014 volume calculations, the bottom of sediment elevation identified in 2004 that was based on the $2 \%$ of the LIF response was also used (see detailed discussion in Section 2.2.1).
In 2004, volumes were calculated using two methods: Golden Software's Surfer, Version 8; and a prismoidal formula within a spreadsheet. The sediment contamination depths in 2004 were interpolated from the 29 LIF probe analysis figures presented in Appendix C of the Detailed Investigation of the Minnesota Slip (Appendix A2). In 2014, volumes were calculated utilizing the prismoidal formula spreadsheet that was used in 2004 and a 3-dimensional software program, ArcScene, Version 10.2 with the 3D Analyst and Spatial Analyst extensions. The sediment contamination depths for the 2014 calculations were adjusted for the top of sediment measurements collected in January 2014. The bottom of contamination elevations for both calculations corresponded to the $2 \%$ LIF response cut-off depths as reported in the Detailed Investigation (Streitz and Johnson, 2005).

In 2004, contaminated sediment volumes were estimated to be 33,000 cubic yards with an accuracy between the computer-generated volume and the calculated volume of approximately $3 \%$ (Table 1-4). In 2014, contaminated sediment volumes were estimated to be 35,000 cubic yards with an accuracy between the computer-generated volume and the calculated volume of approximately $0.3 \%$ (Table 1-4). The percent increase in contaminated sediment volume from 2004 to 2014 is approximately $6 \%$.

Historical information on navigational dredging conducted in the 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 in Appendix A is a display of 10 LIF readouts that extend 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 amsl, which corresponds to the 27 -foot dredging depth (Streitz and Johnson, 2005).

### 1.4.4 Exposure Pathways

As identified in the St. Louis River Remedial Action Plan (RAP, 1992) and later proven with testing, the Slip is contributing to two impairments to the St. Louis River Area of Concern (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
bioaccumulative toxins. Toxins include mercury, PCBs, and pesticides (DDT, dioxin, etc.). According to the MPCA, it is recommended by many programs that biotoxins be reduced with in the St. Louis River estuary and harbor. Removing or isolating the contaminated sediments from the surface water/sediment interface will help in the reduction of the impaired water resulting from bioaccumulative toxins in the St. Louis River AOC.
The following information provides greater detail on the human health and ecological limited screening assessment and standards from the Detailed Investigation (Streitz and Johnson, 2005) and other studies.

### 1.4.4.1 Risk to Human Health

The Slip is within an active harbor surrounded by retail and commercial businesses. More than half the Slip is open to the public year round, as described in Section 1.2. Exposure from contaminated sediments to the public is limited given the depth to sediments within the Slip. No public swimming or wading is permitted or practical, and the Slip does not serve as a public water supply. All information to date indicates that the proposed future use of the Slip is consistent with the current use. The major contaminants, PAHs, are generally non-volatile and not emitted from the waters of the Slip; therefore, the only remaining pathway for human exposure to contamination from the Slip is fish consumption. 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 due to elevated concentrations of PCBs and mercury found in fish tissue (Minnesota Department of Health [MDH], 2000). There is a potential that contaminated sediments in the Slip are contributing bioaccumulative 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.

### 1.4.4.2 Ecological Risks

The depth to which benthic organisms can penetrate sediment varies, but for water depths of less than 2.5 meters at the nearby SLRIDT Superfund Site, the potential penetration depth was estimated to be 0.15 meters. Accounting for the root penetration of aquatic plants increases the depth of penetration of all flora and fauna to a depth of 1.0 meter. 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 greater than 2.5 meters, except for the immediate vicinity of a stormwater outfall in the northwest corner of the Slip (Figure 1-3), the sediment interval of greatest relevance for ecological exposure is the top 0.5 meters. 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 Slip. 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 of invertebrates by fish, 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 SQTs 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 1-5 presents the COPCs, the Level 1 and 2 SQTs, and the maximum concentration detected for that contaminant. Appendix A includes a summary of historical analytical data for each sample point and in some cases compares the results to the SQTs. Exceedances are detailed with bold text, shading, and color coding (Crane et al., 2002; Streitz and Johnson, 2005). Selected statistical data sets are presented and discussed in Section 1.4.4.2. Based on a comparison of the available analytical data and SQT values, the contaminants detected in the Slip sediments exceeding the SQT values are considered a risk to the benthic community and the larger ecological environment, where they are found in the top meter of sediment.
Contamination within the Slip was found to be heterogeneous, with several locations exceeding the corresponding Level 1 or Level 2 SQTs. The greatest exceedence of the Level 2 SQTs occurred with PAHs (Streitz and Johnson, 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 north side of the Slip. Therefore, areas identified by total PAH concentrations above the Level 2 SQT should also correspond with increased 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 no samples exceed the Level 2 value (Streitz and Johnson, 2005).


### 1.4.4.3 Site Specific Numerical Evaluations and Ecological Study

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.
Mean Probable Effect Concentration Quotient (PEC-Q Values, 2004). To evaluate the combined effects of multiple contaminants, the 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 Slip, 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 during the sampling conducted for the Detailed Investigation. Mercury has a known toxic effect but, because a reliable consensus-based PEC is not available, it was not included in the quotient. For more information regarding the calculation of the mean PEC-Q, see Appendix D of the Detailed Investigation of the Minnesota Slip (Streitz and Johnson, 2005; Appendix A2).
Only two of the 2004 sediment samples included sediment from the top 0.5 meter. The surficial samples both exceed 0.1 mean PEC-Q (Level 1 SQT) but are less than 0.6 mean PEC-Q (Level 2 SQT), indicating the potential for moderate toxic effects to the benthic community. A total of 5 sediment samples from the remaining samples, all deeper than 0.5 meters, were above the 0.6 mean PEC-Q.

Top Two Feet of Sediment Results (1998, 1999, and 2004). 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 cm intervals were calculated from the data. Most of the mean PEC-Q 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 the Detailed Investigation of the Minnesota Slip (Streitz and Johnson, 2005; Appendix A2).
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 \#2 [see Figure A1 in Appendix A]) there was no 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.
SQTs and Sediment Contamination (2002). Sublethal 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 in Appendix A). Mercury exceeded the Level 1 SQT in a large portion of the surfical sediments of the Slip. The ecological and toxicological effects of mercury are strongly dependent on the chemical species present. No bioaccumulation of mercury was found in the 28-day bioaccumulation test with Lumbriculus variegates that used surfical sediments from the Slip (AScl 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 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 the 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 Revised FFS include the SQTs and PEC-Q.

### 2.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND REMEDIAL ACTION OBJECTIVES

Remedial actions for releases and threatened releases of hazardous substances, pollutants, or contaminants must be selected and carried out in accordance with State and Federal requirements. These requirements are referred to as ARARs. RAOs specify contaminants of concern (COCs), media of concern, potential exposure pathways, and remediation goals. Initially, Site remediation goals for the COCs are developed based on readily available information such as chemical-specific ARARs or other reliable information. The Slip RAOs are modified, as necessary, as more information becomes available during the FFS process.

This section presents the preliminary ARARs, RAOs, and COCs to be used in the development of this Revised FFS. The final ARARs, RAOs, and COCs will be developed in the Record of Decision (ROD) for the Slip.

### 2.1 Applicable or Relevant and Appropriate Requirements

This preliminary ARAR section summarizes the MPCA, Minnesota Department of Natural Resources (MDNR), and MDH ARARs and to be considered (TBC) criteria for aquatic sediment associated with the Slip. Local and Federal ARARs have also been included; however, the list may not include all applicable local and federal ARARs.
The NCP (40 CFR 300.5) defines "applicable" requirements as: "those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility citing laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site." Only those promulgated state standards identified by a state in a timely manner that are substantive and equally or more stringent than federal requirements may be applicable.

The NCP (40 CFR 300.5) further defines "relevant and appropriate" requirements as: "those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility citing laws that, while not 'applicable' to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstances at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site." Like "applicable" requirements, the NCP also provides that only those promulgated state requirements that are identified in a timely manner and are more stringent than corresponding federal requirements may be relevant and appropriate.

ARARs generally fall into one of the following three classifications:

- Chemical-specific: These ARARs are usually health- or risk-based numerical values or methodologies which, when applied to site-specific conditions, result in numerical values. These values establish an acceptable amount or concentration of a chemical that may be found in, or discharged to, the ambient environment. These requirements provide the basis for protective Site remediation levels for the COCs in the designated media.
- Location-specific: These ARARs generally restrict certain activities or limit concentrations of hazardous substances solely because of geographical or land use concerns. Requirements addressing wetlands, historic places, floodplains, or sensitive ecosystems and habitats are potential location-specific ARARs.
- Action-specific: These ARARs are restrictions on the conduct of certain activities or the operation of certain technologies at a particular site. Examples of action-specific ARARs would be regulations dictating the design, construction, and/or operating procedures for dredging, on-site landfilling, or capping. Action-specific requirements do not themselves determine the cleanup alternative, but define how the chosen cleanup alternative should be achieved.
In addition, criteria, advisories, guidance, and proposed standards developed by Federal and State environmental and public health agencies that are not legally enforceable, but contain helpful information, are collectively referred to as TBCs. TBCs can be helpful in carrying out selected remedies or in determining the level of protectiveness of selected remedies. TBCs are meant to complement the use of ARARs, not compete with or replace them. TBCs are included, where appropriate, in the Chemical-, Location-, and Action-specific discussions.
Several Federal and State laws govern or provide the framework for remedial actions. Remedial actions must comply with substantive portions of these laws or acts, which were also reviewed during the ARAR development process. The following provides a summary of laws and acts that do not readily fall into one of the Chemical-, Location-, or Action-specific classifications, but are applicable to the Slip:

| ARAR/TBC | Citation | Description/Potential Application |
| :--- | :--- | :--- |
| CERCLA | 42 United States Code (USC) <br> $\S \S 9601$ et seq. | Federal Superfund Law |
| NCP | 40 Code of Federal Regulations <br> (CFR) part (pt.) 300 | Provides organizational structure and <br> procedures for preparing for and <br> responding to discharges of oil and <br> releases of hazardous substances, <br> pollutants, and contaminants. |
| MERLA | Minn. Stat. §§ 115B.01 to <br> 115B.20 | State Superfund Law. |
| Water Pollution Control <br> Act | Minn. Stat. chapter (ch.) 115 | Administration and enforcement of all laws <br> relating to the pollution of any waters of <br> the state. |
| Duty to Notify and <br> Avoid Water Pollution | Minn. Stat. § 115.061 | Requires notification and recovery of <br> discharge pollutants to minimize or abate <br> pollution of the waters of the state. |
| Pollution Control <br> Agency | Minn. Stat. ch. 116 | Provides organizational structure and <br> procedures for responding to problems <br> relating to water, air, and land pollution. |
| Water Law | Minn. Stat. chs. 103A, 103B, <br> $103 C, 103 D, 103 E ; ~ 103 F, ~ a n d ~$ <br> $103 G$ | Provides regulations pertaining to any <br> waters of the state, including surface <br> water, wetlands and groundwater. |
| Safe Drinking Water <br> Act | 42 USC §§ 300f et seq. | Established to protect the quality of <br> drinking water (above or underground). |
| Clean Water Act | 33 USC §§ 1251 et seq. | Establishes structure for regulating <br> discharges of pollutants and regulating <br> quality standards for surface waters. |
| Resource <br> Conservation and <br> Recovery Act (RCRA) | 42 USC §§ 6901 et seq. | Establishes RCRA Program and <br> Regulations. |
| Clean Air Act | 42 USC §§ 7401 et seq. | Regulates air remissions from stationary <br> and mobile sources. |

### 2.1.1 Chemical-Specific ARARs and TBCs

The COCs associated with the sediments include PAHs, PCBs, and metals. The following are the Chemical-specific ARARs and TBCs associated with the sediments and shall be used to develop site-specific cleanup levels:

| ARAR/TBC | Citation/Source | Description/Application |
| :--- | :--- | :--- |
| Sediment | Guidance for the Use and <br> Application of SQTs for the <br> Protection of Sediment-dwelling <br> Organisms in Minnesota | To be used as benchmark values for <br> making comparisons to surficial <br> sediment chemistry measurements |
| SQTs |  |  |
| All Media | Guidance for estimating <br> health risks from <br> carcinogenic PAHs | MDHidance Document updated <br> in March 2012 |
| Analysis of carcinogenic <br> PAHs | For estimating health risks from <br> (carcinogenic PAHs. <br> (06/11) Remediation Division Policy | Background and situations where <br> extended list of carcinogenic PAH <br> methodology applies |
| Site screening <br> guidelines | Working Draft Site Screening <br> Evaluation Guidelines. MPCA Risk- <br> Based Site Evaluation (RBSE) <br> Manual (09/98) | Guidelines and criteria for screening <br> human health and ecological risks. |

## Sediment:

To achieve protection and restoration of habitat, minimize exposure of the benthic organisms to contaminated sediments and movement of contaminants up the food chain, Preliminary Sediment Remediation Goals were developed for use in this Revised FFS. The MPCA does not have sediment quality standards. SQTs, adopted for use in the St. Louis River Area of Concern, can be used throughout the state as benchmark values for making comparisons to surficial sediment chemistry measurements. For more information about the SQTs, refer to the report Guidance for the Use and Application of Sediment Quality Targets for the Protection of Sediment-dwelling Organisms in Minnesota, MPCA Document Number: tdr-gl-04, which can be found at:

## http://www.pca.state.mn.us/water/sediments/index.html.

## All Media:

The MPCA Site Screening and Evaluation Document presents an overall process for conducting a Tier 1 evaluation of the various exposure pathways at a site. The screening criteria worksheet can be found at MPCA website (http://www.pca.state.mn.us/cleanup/riskbasedoc.html).
The MDH guidance for estimating health risks from carcinogenic PAHs for all media, including benzo(a)pyrene (BaP) equivalency calculation worksheets, can be found at the MDH website (http://www.health.state.mn.us/divs/eh/risk/guidance/pahmemo.html).

### 2.1.2 Location-Specific ARARs and TBCs

The Location-Specific ARARs and TBCs for the Slip are as follows:

| ARAR/TBC | Citation/Source | Description/Application |
| :---: | :---: | :---: |
| Waters of the State and Groundwater Protection | Minn. Stat. 103G and 103H | Groundwater protection, nondegredation, and best management practices. |
| Floodplain Management and Wetlands Protection | 40 CFR Part 6, Appendix A, <br> Section 6.a.(1) | Requires agencies to evaluate potential effects of actions in a floodplain to avoid adverse impacts |
| Shoreland and Floodplain Management | Minn. Rules ch. 6120 | Conserves economic and natural environmental values (MDNR) |
| St. Louis County Land Use Ordinances | St. Louis County Zoning Ordinances, ch. 1003 | Floodplain management, Manages on-site waste disposal and other site activities |
| Shoreland Management | Duluth City Code §51-26 et seq. | The City of Duluth requires a permit for any excavation or grading above the Ordinary High Water Mark within 300 feet of a river. |
| Endangered Species Act | 16 USC §1531 et seq. <br> 50 CFR §17.11-12 | Conservation of threatened and endangered plants and animals and their habitats. |
| Endangered, Threatened, Special Concern Species | Minn. Rules ch. 6134 <br> Minn. Statute, Section $84.0895$ | Protection of endangered, threatened, special concern species (MDNR). |
| Migratory Bird Treaty Act | 16 USC Chapter 7, <br> Subchapter II §§ 703 \& 712.2 | Protects migratory birds and their ecosystems |
| MDH Advisory for St. Louis River | MDH | Provides fish consumption advisories. |

The Slip is located within the Lake Superior Drainage Basin. Surface water quality standards and provisions for Class 2B and 3B waters apply. In addition, USEPA and the Great Lakes states agreed in 1995 to a comprehensive plan to restore the health of the Great Lakes. The Final Water Quality Guidance for the Great Lakes System, also known as the Great Lakes Initiative (GLI), includes criteria for states to use when setting water quality standards for 29 pollutants, including bioaccumulative chemicals of concern, and prohibits the use of mixing zones for these toxic chemicals. Because the surface water at the Slip is within the drainage basin of Lake Superior, the ARARs specified in the GLI, Minn. Rules ch. 7052 are applicable to the Slip. Requirements of the Great Lakes Water Quality Agreement of 2012 apply to the Slip. In addition, the surface waters adjacent to the Site are identified as an Outstanding International Resource Water (OIRW). The objective for OIRW is to maintain water quality at existing conditions when the quality is better than the water quality standards. Generally, OIRWs are considered surface water quality standards applicable to the St. Louis River for Class 2B and OIRWs, as set forth in Minn. Rules, chs. 7050 and 7052, and to the additional surface water quality standards for the St. Louis River, as set forth in Minn. Rules ch. 7065. The OIRW was established after the ROD was issued.

As stated in Minn. Rules ch. 7050.0210 Subp. 2:
Nuisance conditions prohibited. No sewage, industrial waste, or other wastes shall be discharged from either point or nonpoint sources into any waters of the state so as to cause any nuisance conditions, such as the presence of significant amounts of floating solids, scum, visible oil film, excessive suspended solids, material discoloration,
obnoxious odors, gas ebullition, deleterious sludge deposits, undesirable slimes or fungus growths, aquatic habitat degradation, excessive growths of aquatic plants, or other offensive or harmful effects.

Title 40 CFR Part 6, Appendix A, Section 6 Requirements, requires federal agencies to evaluate the potential effects of actions taken within a floodplain to avoid adversely impacting floodplains wherever possible.
Title 40 CFR Part 6, Appendix A, Section 6.a.(1) Floodplain/Wetlands Determination -- Before undertaking an Agency action, each program office must determine whether or not the action will be located in or affect a floodplain or wetlands. The Agency shall utilize maps prepared by the Federal Insurance Administration of the Federal Emergency Management Agency (Flood Insurance Rate Maps or Flood Hazard Boundary Maps), Fish and Wildlife Service (National Wetlands Inventory Maps), and other appropriate agencies to determine whether a proposed action is located in or will likely affect a floodplain or wetlands. If there is no floodplain/wetlands impact identified, the action may proceed without further consideration of the remaining procedures set in this section. If floodplain/wetlands impact is identified, this section presents procedures that must be taken.
Shoreland and Floodplain Management (Minn. Rules Ch. 6120) provides standards and criteria intended to preserve and enhance the quality of surface waters, conserve the economic and natural environmental values of shorelands, and provide for the wise use of water and related land resources of the state. St. Louis County Zoning Ordinances, ch. 1003, establish additional floodplain management and manage site activities such as on-site waste disposal.

Shoreland Management Permit (Duluth City Code §51-26 et seq.), as defined by the City of Duluth, requires a permit for any excavation or grading above the Ordinary High Water Mark within 300 feet of a river. Each alternative will involve some of these activities. The substantive requirements of this permit are found in the ordinance and may govern removal of natural vegetation, grading and filling, placement of roads, sewage and waste disposal, and setbacks.

The Endangered Species Act (16 U.S.C.A. §1531 et seq.) and the Minnesota Endangered, Threatened, Special Concern Species Act (Minn. Rules ch. 6134) protect threatened and endangered plants and animals and their habitats.

Title 16 United States Code (USC) Chapter 7, Subchapter II §§ 703 \& 712.2. (The Migratory Bird Treaty Act) protects migratory birds and their ecosystems by specifying the taking, killing, or possessing migratory birds unlawful. Public Law 95-616, an amendment to this act, provides measures to protect identified ecosystems of special importance to migratory birds such as bald eagles against pollution, detrimental alterations, and other environmental degradations.

The MDH has established various fish consumption advisories for the St. Louis River due to the presence of PAHs, PCBs, and RCRA metals in water and sediments.

### 2.1.3 Action-Specific ARARs and TBCs

The following summarizes the Action-Specific ARARs for the Slip. In addition, Occupational Safety and Health Standards (Minn. Rules ch. 5205) for worker health, safety, and training are applicable to remedial actions performed at the Slip.

| ARAR/TBC | Citation/Source | Description/Application |
| :--- | :--- | :--- |
| Waters of the State (both surface | Minn. Rules ch. 7050 and | Surface water quality during remedy |
| and underground) | 7052 | construction. |
| Wetlands Conservation Act | Minn. Stat. §§ 103G.221- | Protection of wetlands. |
| (WCA) | .2373 |  |


| ARAR/TBC | Citation/Source | Description/Application |
| :--- | :--- | :--- |
| Wetlands Conservation | Minn. Rules 8420 | Protection of wetlands, wetland <br> functions for determining public <br> values. |
| Floodplain Management Order | Executive Order 11988 and 40 <br> CFR Part 6, Appendix A, | Regulates remedial action <br> implementation in floodplains. |
| Section 404 Permit and Section <br> 401 Certification (Clean Water <br> Act) | 33 CFR pts 320 and 323; 33 <br> USC §1341 | Applies t to discharge of dredged or fill <br> material into waters of the United <br> States. |
| National Pollutant Discharge <br> Elimination System/ State <br> Disposal System (NPDES/SDS) <br> permits | Clean Water Act 33 USC <br> §1342 | Surface water quality requirements for <br> discharges of pollutants to waters of <br> the state. |
| Section 10 (Rivers and Harbors <br> Act of 1899) | 33 USC 403 | Applies to activities that will obstruct <br> or alter any navigable water of the <br> United States. |
| Work in Public Waters | Minn. Stat. §103G.245 | Permit requirements applicable to <br> work in public waters that will change <br> or diminish its course, current, or <br> cross-section. |
| Public Water Resources | Minn. Rules ch. 6115 | Water appropriation permitting, <br> standards and criteria for alterations <br> to structure of public water (MDNR). |
| Minnesota Sediment Quality <br> Targets | Guidance for the Use and <br> Application of Sediment <br> Quality Targets for the <br> Protection of Sediment- <br> dwelling Organisms in <br> Minnesota, MPCA Document <br> Number: tdr-gl-04 | Establishes procedures for bioactive <br> zone caps and covers. |
| Noise Pollution Control | Minn. Rules ch. 7030 | Noise standards applicable to remedy <br> construction. |
| Hazardous Waste | WLSSD Industrial Pre- | Requirements for any dredge water <br> discharged into public sanitary <br> sewers. |
| Treatment Ordinance |  |  |

## Water Quality:

If any activity associated with the remedial actions results in an unregulated release, in accordance with the Water Pollution Control Act and Minn. Stat. 115.061, Duty to Notify, a notification and recovery of any pollutants discharged to minimize or abate pollution of the waters of the state is required.
In accordance with Minn. Rules ch. 7050, surface water quality standards for the maintenance and preservation of surface water quality during remedy construction, including discharges from treatment/work and storm water runoff zones, shall be based on surface water quality standards that currently apply to Class 2B and OIRWs, as set forth in Minn. Rules, chs. 7050 and 7052, and to the additional surface water quality standards for the St. Louis River set forth in Minn. Rules ch. 7065. Therefore, if water is discharged directly to the waters on or adjacent to the Slip, it shall be treated to a level that meets applicable surface water discharge standards. Groundwater non-degradation and standards for the protection of groundwater during remedy construction are presented in Minn. Rules 7060.

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. Other discharges occurring during remedy construction that are 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, it would be treated to a level that meets applicable surface water discharge standards. The MPCA water quality standards may apply to these discharges. Final standards would be determined by the MPCA prior to implementation of the remedial actions. 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.

## Wetlands and Shoreland and Floodplain Management:

In accordance with Minn. Rules ch. 7050, wetlands at the Slip are classified as unlisted wetlands, Class 2B and 3B waters. In accordance with Minn. Rules ch 8420, compliance with wetland ARARs will involve consultation with the MDNR to determine the category of wetlands present at the Slip and any avoidance, mitigation, and replacement that may be necessary. Water quality standards for the maintenance and preservation of surface water quality during remedy construction including discharges from treatment/work and storm water runoff zones shall be based on surface water quality standards that currently apply to Class 2 B and 3 B waters and shall comply with Minn. Stat. §§ 103G.221-.2373. Standards and specifications applicable to shoreland and floodplain management can be found in Executive Order 11988 and 40 CFR Part 6, Appendix A, Minn. Rules ch. 6120.
Minn. Stat. §103G. 222 provides that a wetland replacement plan must be approved by the Local Governmental Unit before any Wetlands Conservation Act (WCA) wetlands may be drained or
filled, unless draining or filling falls within the "De Minimis" exemption or another exemption of Minn. Stat. §103G.2241. WCA wetlands are those wetlands that are not public water wetlands regulated by the MDNR and USACE. WCA wetlands would be located above the Ordinary High Water Mark. The South St. Louis Soil and Water Conservation District provides additional guidance regarding WCA requirements for the Slip at the following website:
http:// www.southstlouisswcd.org/wcact.html

## Permits and Certifications:

Possible permits for cleanup activities include the following:
Section 404 Permit (Clean Water Act): Required for discharge of dredged or fill material into waters of the United States. The substantive requirements of this permit shall be met for alternatives that dredge or fill waters of the state. USACE evaluates applications for Section 404 permits. Substantive requirements that may be incorporated within a Section 404 permit for off-site activities can be found in 33 CFR Parts 320 and 323.
Section 401 Certification: The Clean Water Act, 33 USC $\S 1341$, requires that any application for a Federal permit that may result in a discharge to a navigable water must be accompanied by a certification from the affected state indicating that the discharge will comply with all applicable water quality standards and effluent limitations of the Act. Thus, a Section 401 certification or a 401 certification waiver for remedial action at the Slip would be necessary before the USACE may issue a Section 404 permit, and a certification may be necessary before the USACE may issue a Section 10 permit if that permit authorizes a "discharge."
National Pollutant Discharge Elimination System (Clean Water Act 33 USC §1342): Discharges of pollutants to waters of the state associated with construction of the selected remedy would be subject to the requirements applicable to a NPDES permit. Discharges could include the discharge of capping material, the discharge of contaminants released and suspended by dredging operations, the discharge of treated dredge water during dredging operations, and the discharge of storm water runoff from shoreland modifications. These types of discharges would be subject to the same regulatory standards and controls that would apply under an MPCA permit. In addition, NPDES General Permit number MNG990000 has been required for managing dredged materials; however, this permit has expired and has not been renewed. According to Managing Dredged Materials in the State of Minnesota (MPCA, 2009), an individual National Pollutant Discharge Elimination System/State Disposal System (NPDES/SDS) Dredge Materials Management permit may be required. A NPDES Construction Permit and a Stormwater Pollution Prevention Plan are required by the MPCA if more than one acre of land is disturbed by excavation activities.

Section 10 of the Rivers and Harbors Act of 1899 (33 USC 403): A Section 10 permit is required from the USACE for any construction in or over any navigable water, or the excavation or discharge of material into such water, or the accomplishment of any other work affecting the course, location, condition, or capacity of such waters. The substantive requirements that may be incorporated within a Section 10 permit can be found in 33 CFR Parts 320 and 322.

Work in Public Waters (Minn. Stat. §103G.245): A permit from the Department of Natural Resources (DNR) is necessary for any work in public waters that will change or diminish its course, current, or cross-section. If an alternative under consideration involves dredging or capping, a public waters permit from the DNR may be required. The substantive requirements that the DNR may incorporate within its public waters permit are codified in statute and at Minn. Rules, ch. 6115. These requirements include compensation or mitigation for the detrimental aspects of any major change in the resource. The DNR permits may require restoration of
bathymetry (water depth) and habitat substrate (bottom) as part of the public waters permit. The DNR would set the specific cover depth and composition requirements.
Additionally, if capping of contaminated sediments is conducted, requirements would include specifications for cap construction. In-situ caps constructed for the containment of contaminated sediment must contain an isolation zone (IZ) and a bioactive zone (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 Slip contaminants that could potentially be transported upward into the BAZ at concentrations above the cleanup levels by diffusion or advection transport mechanisms. The $B A Z$ 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 and BAZ should be determined based on pore water transport and attenuation modeling.
Air Emissions and Waste Management Permits: In accordance with Minn. Stat. § 116.081, a permit is required for the construction, installation or operation of an emission facility, air contaminant treatment facility, treatment facility, potential air contaminant storage facility, storage facility, or system or facility related to the collection, transportation, storage, processing, or disposal of waste, or any part thereof, unless otherwise exempted by any agency rule now in force or hereinafter adopted, until plans have been submitted to the agency, and a written permit granted by the agency.

On-Site Disposal: The placement of dredged sediment into an on-site confined aquatic disposal (CAD) area and any subsequent seepage from the CAD, if implemented, would be regulated by the MPCA under the requirements applicable to an SDS permit. The legal requirements for an SDS are found in Minn. Stat. § 115.07, Minn. Rules, Parts 7065.0100 to 7065.0160 and in other MPCA water quality rules including Minn. Rules chs. 7050 and 7052.

Discharge into Sewers: A permit from the Western Lake Superior Sanitary District (WLSSD) will be necessary if any dredge water is discharged into the public sewers. Pretreatment standards that would likely apply can be found at:

## http://www.wlssd.duluth.mn.us/pdf/WLSSDPretreatmentOrdinance.pdf.

The permit will also include requirements to assure there will be no detrimental effects to their bio-solids program. A WLSSD permit would also represent compliance with Minn. Rule, Part 4715.1600 and the MPCA water rules governing indirect discharges.

Invasive Species: A prohibited/regulated invasive species permit will be required to transport sediment to a landfill, if invasive species are present near the proposed work area.
CERCLA provides for waiving of necessary permits for on-site work, provided the work is conducted in compliance with the substantial conditions of such permits. Although the permits themselves may not be required on CERLCA Sites, compliance with the substantial conditions of these identified permits shall be met.

## Construction and Use of Public Sewers:

Minn. Rules ch. 4715 governing the use of sewers and public water systems would apply if any water associated with remedial activities is disposed of in public sewers.

## Waste Management:

Solid and hazardous waste management requirements and standards can be found in Minn. Rules chs. 7035 and 7045, respectively. USEPA guidance has consistently stated that Superfund remedies involving movement of contaminated material within the area of a Site where such material is already located (sometimes referred to as an AOC) do not create a "waste" that is subject to RCRA (42 USC §§ 6901 et seq.) or other waste management
requirements. Remedy alternatives that require contaminated materials to be moved to an off-site land disposal site are considered to generate waste which must be managed under applicable waste management requirements.
St. Louis County Zoning Ordinances, ch. 1003, establish additional floodplain management and manage site activities such as on-site waste disposal.

## Ambient Air Quality Standards:

Air quality standards applicable to releases into the air from cleanup activities include Min. Stat. 116.061, Air Pollution Emissions and Abatement. During remedy construction, activities such as transportation, storage and placement of capping material may result in particulate matter becoming airborne. Minn. Rules ch. 7009 establishes ambient air quality standards for criteria pollutants regulated under the Clean Air Act. Compliance points shall be selected in accordance with Minn. Rules ch. 7009. The ambient air quality standards for particulate matter that apply to remedial actions are found at:

## https://www.revisor.mn.gov/rules/?id=7009.0080

Control of the generation of airborne particulate matter during remedy construction is regulated in Minn. Rule pt. 7011.0150, Preventing Particulate Matter from Becoming Airborne, which includes measures to control dust which may be generated during remedy construction activities such as transportation, storage, and placement of capping material, which shall be addressed in the remedial design plan. Minn. Rules pt. 7011.8010, Site Remediation, incorporates the National Emission Standards for Hazardous Air Pollutants applicable during Site remediation activities.

## Noise Pollution Control:

Minn. Rules ch. 7030 establishes noise standards for various land uses. Compliance points will be selected in accordance with Minn. Rules ch. 7030. The noise standards that will apply to the selected remedial action can be found at:
https://www.revisor.leg.state.mn.us/rules/?id=7030.0040

### 2.1.4 Other Considerations

Other considerations under MERLA set forth the regulatory requirements, RAOs and Cleanup Levels that must be met by a remedy to meet the legal standard for a remedy under MERLA and the threshold criterion for protection of public health and welfare and the environment. A remedy, as defined under MERLA, must also include any monitoring, maintenance and institutional controls and other measures that MPCA determines are reasonably necessary to assure the protectiveness of the selected remedy over the long term.
It is particularly important to consider the requirements for long-term assurance of protectiveness where the remedy alternatives involve the use of capping or containment to manage contaminated media within the Slip. Some requirements may also be necessary to assure long-term protectiveness of alternatives that involve excavation or dredging and off-site disposal of contaminated soil or sediment.
In addition, MERLA requires the MPCA to consider the planned use of the property where the release of contaminants is located when determining the appropriate standards to be achieved by a remedy.

## Long-term Assurance of Protectiveness:

MERLA requires that a remedy include measures that are reasonably required to assure the ongoing protectiveness of a remedy once the components of the remedy have been constructed
and entered their operational phase. Such measures may include, but are not limited to, institutional controls and monitoring and maintenance requirements. This section discusses the measures that MPCA determines are reasonably necessary to assure long-term protectiveness.

## Institutional Controls

Institutional controls are legally enforceable restrictions, conditions or controls on the use of property, groundwater or surface water at a property that are reasonably required to assure the protectiveness of a remedy or other response actions taken at the Slip. Areas of the Slip where contaminated media remains in place after remedial construction will 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. Restrictions on use may also be required for areas of the Slip where contaminated media are treated and/or removed and where some residual contamination may remain.
Minn. Stat. §115B.16, subd. 2, requires an Affidavit Concerning Real Property Contaminated with Hazardous Substances to be recorded with the St. Louis County recorder by the owner of the property. The Uniform Environmental Covenants Act (UECA) and the authority for requiring environmental covenants can be found in Minn. Stat. ch. 114E. This statute requires MPCA approval of environmental covenants (which include restrictive covenants and access) when there is an environmental response project (which includes superfund cleanups) is overseen by the MPCA. Because the Site is not platted, the UECA may not apply and other institutional controls such as a City Ordinance may be required to prevent anchoring, fishing, dredging, and other activities that may disturb a cap or contaminated sediments left in place.

## Long-term Operation and Maintenance, Monitoring, and Contingency Action:

On-site containment facilities and capping of impacted media (sediment) or any other alternative that may leave impacted media on-site will require post-construction monitoring, operation and maintenance, and contingency action plan to assure that ARARs, RAOs and Cleanup Levels that apply to the alternative are fully achieved and maintained over time.

General details of the post-construction monitoring, operation and maintenance, and contingency action plan requirements would be set forth in the FFS, along with an estimate of the cost to carry out each activity.

Sediment traps or other means of limiting incoming sediment to maintain appropriate water depth may be required; this need will be further evaluated in the design phase of this project. If sediment traps are implemented, long-term maintenance of these traps such as sediment removal will be required.

## Planned Use of Property

In a provision entitled "Cleanup Standards" (Minn. Stat. § 115B.17, subd. 2a), MERLA provides that when MPCA determines the standards to be achieved by response actions to protect public health and welfare and the environment from a release of hazardous substances, the agency must consider the planned use of the property where the release is located. The purpose of this provision of MERLA is to allow the MPCA to select cleanup standards that provide a level of protection that is compatible with the uses of the Slip property that can be reasonably foreseen.

The specific properties directly affected by the remedies are currently part of treatment or containment facilities considered to be commercial/industrial land use. In addition, impacted areas include wetlands/semi-aquatic and aquatic areas and associated habitat. The cleanup standards must provide protection of public health and welfare and the environment that is consistent with any planned or potential future uses of the Slip, including natural resource and
habitat restoration, navigation and recreational uses. These cleanup standards are also compatible with the use of the adjacent land for residential, recreational, habitat restoration, or commercial and industrial use.
The Irvin requires a depth 10 feet while a depth of 6 feet will accommodate the Vista Fleet and the vast majority of charter fishing vessels. A water depth of 10 feet, which equals a sediment surface at 591 feet amsl, would need to be maintained to continue current use of the slip in the future. These depths must be considered in all dredging and capping scenarios. As previously discussed, sediment traps or other means of limiting incoming sediment to maintain appropriate water depth may be required.

### 2.2 Remedial Action Objectives

The RAOs developed by the MPCA for the Slip are:

1) Minimize or remove exposure to sediment contaminants that bioaccumulate in the food chain and contribute to fish consumption advisories.
2) Minimize or remove exposure of the benthic organisms to contaminated sediments above the preliminary sediment cleanup levels discussed in Section 2.2.1.
3) Preserve water depth to enable the current use of the slip; and
4) Enhance deep water aquatic habitat if conditions allow.

The following subsection present preliminary sediment cleanup levels developed to achieve these RAOs.

### 2.2.1 Preliminary Sediment Cleanup Levels

To achieve protection and restoration of habitat and 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 2-1 presents the Preliminary Sediment Cleanup Levels for the COPCs identified in the Detailed Investigation 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), determining COCs and developing and evaluating remedial alternatives for this FFS.
Metals (cadmium, chromium, copper, lead, and zinc) are 0.6 times the mean PEC-Q based on Level 2 SQTs, and mercury is $0.3 \mathrm{mg} / \mathrm{kg}$ the MPCA calculated upper limit ambient concentration in the St. Louis River estuary. PCBs are 0.6 times the mean PEC-Q based on Level 2 SQTs.
MacDonald and others have found that 0.6 of the mean PEC-Q approximates a $20 \%$ probability of observing sediment toxicity, and it is proposed as a potentially acceptable (as a "Level 2 Sediment Quality Target") SQT (Macfarlane and MacDonald, 2002; MacDonald and Ingersoll, 2002; Crane et al., 2000). The mean PEC-Q is calculated by averaging the ratios of the individual COPCs to their Probable Effects Concentration (PEC) values. The PEC is a concentration at which significant toxic effects are predicted to occur. Table 2-1 presents Preliminary Sediment Cleanup Levels for each COC based on 0.6 of the Level 2 SQT.
The vertical limits of contamination were estimated based on LIF data (Streitz and Johnson, 2005) that will achieve the total PAH Cleanup Level of $13.7 \mathrm{mg} / \mathrm{kg}$. Sediments above these criteria within the Slip not exceeding this $13.7 \mathrm{mg} / \mathrm{kg}$ 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. Cross Sections A-A' through H-H' show sediment areas exceeding these criteria (Figures 1-8 through 1-15).

During the development of this Revised FFS, the correlation of the percentage of LIF response to total PAH concentration was evaluated, as the MPCA is currently utilizing the mid-point between the Level 1 and Level 2 SQTs as the selected cleanup criteria. The mid-point SQTs are presented in Table 2-1. The mid-point SQT for total PAHs ( $12.3 \mathrm{mg} / \mathrm{kg}$ ) is lower than the 0.6 of the Level 2 SQT ( $13.7 \mathrm{mg} / \mathrm{kg}$ ) that was previously used in the development of the FFS. The Detailed Investigation provided a correlation between the percentage of LIF response and the total PAH concentration; however, the correlation was not precise enough to adjust the rationale for determining the bottom of the contaminated sediments, as discussed in Section 1.4.4.3. It is recommended the calculated total volume of contaminated sediment, as identified in Section 1.4.4.3 ( 35,000 cubic yards), is increased by $5 \%$ to account for the decrease in Preliminary Sediment Cleanup Level (mid-point SQT). Therefore, the recommended total volume of contaminated sediment to be addressed with the selected remedy is 36,750 cubic yards.

### 3.0 DEVELOPMENT AND SCREENING ALTERNATIVES

This section describes the Alternatives evaluated for the Slip. The alternatives were originally developed and screened in the Technologies and Response Action Components prepared by Bay West, as provided in Appendix B. The alternatives were further refined in the September 2005 Draft FFS. Alternatives 2A and 3A of the original FFS were deleted as staging and disposal options at the Erie Pier are no longer available. Alternative 4 was modified to accommodate continued current use of the Slip. Additional supporting documentation on alternative components can be found in the Technical Analysis Memorandums presented in Appendix C .

### 3.1 Alternative 1: No Action

The No Action Alternative is retained for a baseline comparison. The No Action Alternative does not include any treatment or engineering controls. The No Action Alternative does include longterm monitoring and institutional controls.
Current USEPA guidance (USEPA, 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 every year for first 5 , then every 5 years thereafter. Chemical monitoring and reporting would be conducted annually for 5 , then every 5 years thereafter. Details of what is assumed to be included in the long term operations and maintenance estimated costs are found in Appendix F7. Details of present value calculations for all alternatives are included as Appendix D.
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 Slip. If contaminated sediments remain in place after remedial actions are taken, the Slip 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 $\$ 240,900$. Table 3-1 presents a detailed breakdown of the estimated costs associated with Alternative 1.

### 3.2 Alternative 2: Partial Dredging with 0.8 meter Cap

This alternative includes partial dredging and removal of approximately half of the contaminated sediments prior to cap placement. Major components of this remedy are described below.

### 3.2.1 Dredging

Mechanical dredging with debris removal would be conducted to remove a portion of the contaminated sediment prior to cap placement. The target dredging elevation would be 582 feet amsl. This would remove approximately half of the contaminated sediments in the slip. The addition of a 0.8 meter cap would bring the final sediment elevation of 585 feet amsl, which was
was the approximate sediment elevation at the mouth of the Slip in 2004 and the approximate center channel elevation of the Slip in 2014 (Figure 1-6). A final sediment elevation of 585 feet amsl would provide sufficient depth to allow current activities in the slip to continue, as described in Section 2.1.4.
The target depth for removal of contaminated sediments of 582 feet amsl, would require approximately 18,000 cubic yards of contaminated sediment to be removed. This includes the additional sediment that has accumulated on the surface since 2004, based on depth-to-sediment measurements in January 2014. The cap thickness of 0.8 meters across the entire slip would require approximately 12,800 cubic yards of capping material. The capping material would be imported to cap the remaining contaminated sediments in-place. Additional characterization of the added sediments could be conducted to identify if they could be considered part of the cap.
There are three general types of dredges that could be used to mechanically excavate contaminated sediments: conventional clamshell, enclosed bucket, or articulated mechanical. According to the MPCA, there is a significant amount of debris present in the Slip; therefore, a conventional clamshell bucket is recommended. Debris removal would be performed on the barge prior to transportation for disposal. Debris removal would be conducted through mechanical screening of the sediment as it is loaded onto the barge. Debris would be stockpiled on City or DECC property, then transported and disposed of at a landfill. Appendix C1 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 regarding the stability of the dock walls during dredging activities (see Appendix C1 and Other Logistical Issues at the end of this section).

### 3.2.2 Sediment Transportation and Staging

For purposes of this FFS, Former Hallet Dock \#7, referred to herein as offsite facility, is assumed to be used as the off-site facility for a processing and temporary staging, since there is no available land area to stage contaminated sediments at the Slip or within the harbor (Sharrow, 2014). Other options for sediment staging, nearer to the Slip, should be investigated during final remedy design.
Sediments would initially be transported by barge to the off-site facility for processing and staging until disposal. Stabilizing agents would be added to the dredged sediments in the barge at the off-site facility. These stabilizing agents are used to desiccate the dredged sediments and render them stackable. Per the EPA's/MPCA's direction, it is assumed that physical removal and treatment of the interstitial and entrained water will not be required. Stabilized sediments would then be directly moved from the barge to a lined and bermed gravel pad. The lined pad would capture any water to be treated or captured through further addition of stabilizing agents. Temporary sediment staging is needed to allow time for analytical testing and to ensure that sediment has been sufficiently dewatered and stabilized for transport to a disposal facility. Sediment will be stage for no longer than 90 days. Direct loading into trucks would add significant time and equipment to the unloading process and is therefore considered not feasible. Prior approval by the landfill, based on worst-case or composite sampling and analytical, could possibly be negotiated. This could reduce the amount of time that sediments remain staged. Appendix C2 presents a Technical Analysis that provides additional detail and assumptions used to evaluate sediment transportation and staging.

### 3.2.3 Sediment disposal at an off-site landfill

The disposal option evaluated in this Revised FFS includes disposal at an off-site landfill. The off-site facility used in this cost estimate was Vonco V Waste Management Facility located in

Duluth, MN. During the development of this Revised FFS, two samples were collected for TCLP analysis to determine if the sediment would be hazardous or non-hazardous for disposal purposes. The samples analyzed were determined to be non-hazardous. The TCLP results are included in Appendix E. As such, the cost estimate assumes the sediment would be disposed as non-hazardous waste and could be used for daily cover material at the land fill. As previously discussed, a stabilization agent will be added to the sediments in order to bind excess water and allow it to pass a paint filter test.
Several factors were incorporated in the sediment removal/volume calculations for the cost estimate. These factors are presented in Table D-5 (Appendix D) and described briefly below:

```
In-place sediment volume (neat excavation line)
Six inch over-dredge
Removal of oversize debris (5%)
Bulking Factor (10%)
Stabilization Agents (15%)
```

Unless otherwise noted, in-place sediment volumes are discussed in the text. Approximately 23,700 cubic yards of stabilized and bulked sediment would need to be disposed under Alternative 2. Estimated costs for off-site landfill disposal include TCLP testing for metals, volatile organic compounds (VOCs), gasoline-range organics (GRO) and diesel-range organics (DRO) in accordance with Vonco V requirements. Appendix C2 presents a Technical Analysis that provides additional detail on the disposal options and the assumptions used to evaluate sediment disposal.

### 3.2.4 0.8 meter Cap

This alternative includes capping to minimize any potential that the contaminated sediment that may be exposed to aquatic organisms. Capping material must provide adequate protection against the physical forces occurring within slip and potential habitat for deep water aquatic biota. For this Revised FFS, the total cap thickness will be 0.8 meter, indicating that approximately 12,800 cubic yards of capping material will be required. Appendix C3 presents a Technical Analysis that provides additional detail and assumptions used to evaluate capping productivity and equipment requirements.

For protection of the benthic community, the 0.8 meter cap would consist of an isolation zone $(I Z)$ of 0.5 meters and a bioaccumulation zone (BAZ) of 0.3 meters. The $I Z$ is the portion of the cap that is applied directly over the contaminated sediments and is designed to isolate and attenuate the Slip contaminants that could potentially be transported upward into the BAZ at concentrations above the preliminary remediation goals (PRGs) by diffusion or advection transport mechanisms. The BAZ is the area within the cap above the IZ where biological activity may potentially be present. The thickness and material specifications for the IZ are usually based on pore water transport and attenuation modeling and would be approved in the remedial design document. The IZ would be constructed of a sandy material

The BAZ portion of the cap would become the new benthic substrate for the enhanced deep water aquatic ecosystem. Therefore, contaminant levels should not exceed the sediment cleanup values 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. The BAZ would consist of sandy material, with the uppermost portion containing more fine grained material. Additional armoring material may be considered in order protect the cap from physical forces in the slip and potentially provide cobble habitat. Final specifications would be approved in the remedial design document. Armoring material costs are not included in this FFS cost estimate.

Cap breakthrough modeling, completed as a part of the remedy design for the SLRIDT, finding a cap thickness of 0.8 meters sufficient. The thickness of the cap would need to be considered in the design phase. 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. Other stability enhancements may include armoring with cobble or other materials

### 3.2.5 Surface water control during remedy implementation

Surface water control structures (i.e., silt curtains, water filled dam, sheet piling) would be necessary during dredging and capping. Appendix C4 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 5 feet to accommodate the flow of water across the curtain, while isolating suspended sediment. 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.

### 3.2.6 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.

### 3.2.7 Long-term Operation, Maintenance, and Monitoring

Contaminated sediments would remain in-place, and therefore long-term operation, maintenance, and monitoring of the cap 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 cap materials. Therefore, cap repair is estimated every 10 years.

A 100-year monitoring period was used to evaluate long-term monitoring costs, as contaminated sediments would remain indefinitely. Physical monitoring would be performed indirectly from the surface through overlapping echo sounding or with a high resolution multi-beam system, producing a detailed bathymetric surface of the Slip water/sediment interface.

For cost estimating purposes, monitoring and reporting includes the following:

- Physical (bathymetry) monitoring would be required annually for the first 10 years, then every 5 years thereafter; and
- Chemical monitoring (bulk sediment chemistry) is estimated for years 2, 5, and 10, and then again only if the physical structure is compromised (one event 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 and every 10 years until year 100.
The MPCA has stated that biota and fish tissue sampling will not be conducted as part of this remedy since the Slip is small and not a primary fish habitat. In addition, there is limited biota due to depth of water within the Slip.
As previously discussed, sediment traps or other means of limiting incoming sediment to maintain appropriate water depth may be required; this need will be further evaluated in the design phase of this project. If sediment traps are implemented, long-term maintenance of these traps such as sediment removal will be required.


### 3.2.8 Institutional Controls

Institutional controls would be necessary to maintain the cap integrity because contaminated sediments would remain in-place with this alternative. Institutional controls may include restrictions on dredging, boat depths, boat use that may erode cap materials, and anchoring.

### 3.2.9 Habitat Restoration

Although there is limited habitat due to the depth of the Slip, it is desirable to design the cap to enhance habitat for the deep water aquatic community. The habitat enhancements may be built into the design if conditions allow. No additional costs have been included in the FS for habitat enhancement.

### 3.2.10 Estimated Cost

The estimated total present value cost for Alternative 2 is $\$ 4,664,300$. Table 3-2 presents a breakdown of the estimated costs associated with the disposal option under Alternative 2. Repairs to the dock walls, if necessary, could add a significant increase to the overall project costs. Dock wall repair costs of $\$ 20,000$ were included in the cost estimate (see Appendix C1); however, these costs could exceed $\$ 2,000,000$, depending on additional dock wall inspection results and dredging conditions. Given the unknowns about the actual location of the staging area for dredged sediments, additional costs not accounted for in the estimate could be incurred, including more than $\$ 250,000$ for construction of berthing, mooring and associated facilities (see Appendix C2).

### 3.2.11 Other Logistical Issues

Additional logistical issues that may affect dredging and off-loading operations include:

- Construction Window: Because the Slip is actively used (Section 1.2) in the spring, summer, and fall, there is a limited timeframe for remedial actions to take place without having an effect 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 to occur that does not impact the tourist and commerce seasons significantly. 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 midMarch. The cost estimate includes relocating the dock tenants within the Slip for an entire season.
- 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 operations. However, if it
cannot be removed, it will need to be moved within the Slip during dredging and capping operations.
- Pedestrian Drawbridge: Bay West has been informed that the small pedestrian drawbridge at the mouth of the Slip does not operate when the air temperature is below 45 degrees; it may need to be left open throughout the duration of the project.
- Contaminated Sediment Staging Area: No fully functional facility currently handling contaminated sediments exists in or near the Harbor (Sharrow, 2014). While this FFS assumes that Former Hallet Dock \#7 will be used as a staging area, costs associated with preparing Former Hallet Dock \#7 for staging use and renting it are not included in this estimate and could significantly impact the final cost.
- Slip Staging Areas: There is limited room for staging areas adjacent to the slip, but some nearby equipment and debris storage will be necessary. Potential staging areas are a City parking lot at the head of the Slip and DECC parking areas (Figures 1-1 and 1-2).
- Stability of Seawalls: Stability of the dock walls during dredging activities is a concern (Appendix F1). Therefore, this Alternative includes a cost for inspecting the dock walls prior to implementing remedial actions and a best-case estimate for minimal repairs (Table 3-2). The costs for repair of damaged dock walls or repairing of sink holes around the perimeter of the Slip could be over $\$ 2,000,000$, if significant damage occurs during dredging. Measures that may minimize potential stress on the dock walls during the remedial action should be investigated during the design phase. The measures may include staging the dredging and capping so that the stress on dock walls is kept to a minimum, which could lengthen the time required for remedial activities significantly.
- Erosion and Deposition: As illustrated in Figure 1-6, some areas of the slip have experienced erosion or deposition. The forces responsible will need to be further studied and considered in the design phase, possibly leading to different target dredging depths and armoring materials as a part of cap placement, which could add to total cost.


### 3.3 Alternative 3: Total Dredging with 0.3-Meter Cover

This alternative includes dredging all of the contaminated sediments exceeding the preliminary sediment cleanup levels, as described in Section 2.2.1. This alternative will consist of transporting, dewatering, and disposing of the sediments at an off-site facility. To isolate any potential dredge residual and provide a protective aquatic substrate, 0.3 meter of environmental medium will be placed over the dredged areas. Dredging and off-site disposal 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.

### 3.3.1 Dredging

Mechanical dredging with debris removal would be conducted to remove all of the contaminated sediment prior to cap placement. The depth and thickness of contaminated sediment to be removed is presented in Section 1.4.4.3. The volume of contaminated sediment to be removed is presented in Section 2.2.1. In summary, contaminated sediment volumes have been estimated at approximately 36,750 cubic yards. Dredging and debris removal would be conducted as described in Alternative 2. Appendix C1 presents a Technical Analysis that provides additional detail and assumptions used to evaluate mechanical dredging options and dredging productivity and equipment.

There are concerns with the stability of the dock walls during dredging activities (see Appendix F1 and Other Logistical Issues at the end of this section). The risk of added cost increases as dredging volume increases, exposing more dock wall in both vertical and horizontal dimensions. A previous project incurred a cost of $\$ 2,500$ per lineal foot of dock wall repair. Since the Slip has over 2,000 lineal feet of dock wall, widespread damage or undermining could cost over \$4,500,000.

### 3.3.2 Sediment transportation and staging

Sediments would initially be transported by barge to an off-site facility for staging prior to transporting to an off-site landfill, as described in Alternative 2 and Appendix C2.

### 3.3.3 Sediment disposal at an off-site landfill

The disposal option for dredged sediment that will be evaluated in this Revised FFS is disposal at an off-site landfill (Vonco $\vee$ Waste Management Facility in Duluth, MN). Sediment transportation and staging would be conducted as described in Alternative 2. Approximately 46,200 cubic yards of stabilized and bulked sediment would need to be disposed under Alternative 3. Appendix C2 presents a Technical Analysis that provides additional detail on the disposal options and the assumptions used to evaluate sediment disposal.

### 3.3.4 Surface water control during remedy implementation

Surface water control structures would be necessary during dredging and capping. Surface water control structures would be conducted as described in Alternative 2. Appendix C4 presents a Technical Analysis that provides additional detail and assumptions used to evaluate water quality control during remedy implementation.

### 3.3.5 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.

### 3.3.6 Dredging Residuals and 0.3-Meter Cover

Dredging is expected to leave some residual contaminated sediment. The residue is the result of re-suspension 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 SQTs 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 0.3 meter of cover with an environmental medium that would provide protection to the aquatic environment from dredge residuals. Over time, the Slip is expected to fill in through natural processes. Cover material must provide a suitable substrate for the benthic community and natural biodegradation. Approximately 4,800 cubic yards of cover material would be needed under Alternative 3. Appendix C3 presents a Technical Analysis that provides additional detail and assumptions used to evaluate cover productivity and equipment requirements. Consideration of physical forces would need to be considered as in Alternative 2.

### 3.3.7 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 environmental monitoring event 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 as a result of dredging activities. Therefore, costs for maintenance will be included annually for the first three years after remedy completion.
As previously discussed, sediment traps or other means of limiting incoming sediment to maintain appropriate water depth may be required; this need will be further evaluated in the design phase of this project. If sediment traps are implemented, long-term maintenance of these traps such as sediment removal will be required.

### 3.3.8 Institutional controls

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

### 3.3.9 Habitat Restoration

Although there is limited habitat due to the depth of the Slip, it desired to design the cover to enhance habitat for deep water aquatic community.

### 3.3.10 Cost

The estimated total present value cost for Alternative 3 is approximately $\$ 6,446,700$. Table 3-3 presents a breakdown of the estimated costs associated with Alternative 3. Repairs to the dock walls could add a significant increase to the overall project costs. Dock wall repair costs of $\$ 40,000$ were included in the cost estimate (see Appendix C1); however, these costs could exceed $\$ 4,500,000$, depending on additional dock wall inspection results and dredging conditions. Given the unknowns about the actual location of the staging area for dredged sediments, additional costs not accounted for in the estimate could be incurred, including more than $\$ 250,000$ for construction of berthing, mooring and associated facilities (see Appendix C2).

### 3.3.11 Other Logistical Issues

Logistical issues that may affect dredging and off-loading operations are similar to those described in Alternative 2 (Section 3.2.11) with additional considerations including:

- Construction Window: The possible timeframes for construction and impacts on local commerce are the same as describe for Alternative 2 (Section 3.2.11). However, an additional four weeks is estimated to be required for Alternative 3.
- Stability of Seawalls: The risks of damage to dock walls and sinkholes described for Alternative 2 (Section 3.2.11) are greater for Alternative 3. The vertical area of dock wall to be exposed during dredging for Alternative 3 is approximately double compared to Alternative 2. The costs for repair of significant damage to larger areas of dock wall and sink holes around the perimeter of the Slip could exceed $\$ 4,500,000$. Additional measures to ensure dock wall stability during construction should be considered during
the design phase. These measures, however, could add both time and cost to the remedial actions.


### 3.4 Alternative 4: Slip Leveling with 0.8-meter Cap

This alternative includes moving sediment from the two shallow areas (Figure 1-17) to deeper areas within the slip, followed by placement a 0.8 meter cap. The selection of the two shallow areas was based upon maintaining a water depth required to continue the Slip's current use. A 0.8 -meter cap, without sediment removal, would provide protection of human health and the environment. Major components of Alternative 4 are as follows:

### 3.4.1 Dredging

The Irvin requires a depth 10 feet while a depth of 6 feet would accommodate the Vista Fleet and the majority of charter fishing vessels. The current and assumed future use of the slip by the Irvin, Vista Fleet and charter fishing vessels therefore requires a sediment elevation of 591 feet amsl. A target dredging elevation of 588 feet amsl would therefore leave room for the addition of a 0.8 meter cap and bring the final elevation to no greater than 591 feet amsl. The entire slip, with the exception of the two areas shown in Figure 1-17, is sufficiently deep (588 feet amsl or less) to accommodate continued current use of the slip even with the addition of a 0.8 meter cap.

Approximately 2,500 cubic yards of sediment in the two proposed areas (Figure 1-17) would be dredged in the method describe in Alternatives 2 and 3 (Sections 3.2.1, 3.3.1 and Appendix C1). This sediment would then be placed, in a method similar to cap placement described in Appendix C3, into deeper areas of the slip. Several areas of the slip along the eastern edge (Figure 1-5) have depths of 16 feet or more. These areas can accommodate placement the dredged sediment with a 0.8 meter cap and still remain under the 591 feet amsl target elevation.

### 3.4.2 Surface water control during remedy implementation

Surface water control structures would be necessary during dredging and capping. Surface water control structures would be conducted as described in Alternative 2. Appendix C4 presents a Technical Analysis that provides additional detail and assumptions used to evaluate water quality control during remedy implementation. Unlike Alternatives 2 and 3, the turbidity controls can be secured and remain in place during dredging since no barge traffic in and out of the slip is required under Alternative 4.

### 3.4.3 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.

### 3.4.4 0.8-meter Cap

This alternative includes capping to minimize any potential that the contaminated sediment may be exposed to aquatic organisms. Capping material must provide a suitable substrate for the benthic community and enhance natural biodegradation. For this Revised FFS, the total cap thickness will be 0.8 meter. The cap will be similar to the cap described in Alternative 2. Appendix C3 presents a Technical Analysis that provides additional detail and assumptions used to evaluate capping productivity and equipment requirements.

Because this alternative would decrease the water depth in the Slip, the available storm sewer outlet elevations were evaluated. The invert elevations of Outlet-1 and Outlet-5 (Figure 1-3) were available during the development of this Revised FFS and the addition of a 0.8-meter cap would not impact those storm sewer outlets. Invert elevations for Outlet-2, 3, and 4 were not available and should be evaluated further during final design to determine whether reconstruction of the storm sewer is necessary during the cap construction.
The effects of physical forces within the slip would need to be similar to Alternative 2, but with further evaluation of sedimentation and its effect on water depth. Additional materials for armoring, along with construction of sediment traps, may need to be considered, but have not been included in the cost estimate.

### 3.4.5 Long-term Operation, Maintenance, and Monitoring

Contaminated sediments would remain in-place; therefore, 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 operations, maintenance, and monitoring will be necessary due to potential erosion of cap materials, as described in Alternative 2.

As previously discussed, sediment traps or other means of limiting incoming sediment to maintain appropriate water depth may be required; this need will be further evaluated in the design phase of this project. If sediment traps are implemented, long-term maintenance of these traps such as sediment removal will be required.

### 3.4.6 Institutional Controls

Institutional controls would be necessary to maintain the cap integrity because contaminated sediments would remain in-place with this alternative. Institutional controls may include restrictions on dredging, boat depths, boat use that may erode cap materials, and anchoring.

### 3.4.7 Habitat Restoration

Habitat enhancement options would be limited with this alternative but could be considered during the design phase.

### 3.4.8 Estimated Cost

The estimated total present value cost for Alternative 4 is $\$ 1,566,400$. Table $\mathbf{3 - 4}$ presents a breakdown of the estimated costs associated with the disposal option under Alternative 4. Repairs to the dock walls, if necessary, could add a significant increase to the overall project costs.

### 3.4.9 Other Logistical Issues

Additional logistical issues that may affect dredging and off-loading operations are similar to those described in Alternative 2; however, the costs to relocate the dock tenants on the east side of the slip have been reduced because the construction duration is approximately 22 days. Erosional and depositional forces would need to be studied and considered during remedy design similar to Alternative 2; however, these forces in this alternative may be more impactful on final design due to the decreased water depths.

As previously discussed, sediment traps or other means of limiting incoming sediment to maintain appropriate water depth may be required; this need will be further evaluated in the design phase of this project. If sediment traps are implemented, long-term maintenance of these traps such as sediment removal will be required.

### 4.0 REMEDY SELECTION CRITERIA

The alternatives were evaluated and compared using the NCP remedy selection criteria outlined below and in general accordance with USEPA guidelines for feasibility studies (USEPA, 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. Green Sustainable Remediation (GSR) criteria were also evaluated during this FFS and are included as a fourth group of criteria. Additional detail may be added from MPCA and/or USEPA 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:

### 4.1.1 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 Slip 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.

### 4.1.2 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 the following.

### 4.2.1 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.

### 4.2.2 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 Slip. 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 Slip.

### 4.2.3 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 mitigating measures during implementation; and
4. Time until protection is achieved.

### 4.2.4 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); and
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.

### 4.2.5 Costs

The 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 operation and maintenance (O\&M) costs.

The USEPA guidance document "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study" (USEPA, 2000) was used to develop cost estimates presented in this Revised FFS. The cost estimates developed for this Revised 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 will be factored into the identification of the preferred alternative.

### 4.3.1 State/Support Agency Acceptance

Assessment of state/agency concerns may not be completed until comments on this Revised FFS are received, but may be discussed, to the extent possible, in the proposed plan issued for public comment. The state/agency concerns that 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.

### 4.3.2 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.

### 4.4 Green Sustainable Remediation

The last group is made up of the GSR criteria specified below. There are six criteria included with this analysis which are then summarized to provide each alternative with an overall GSR rating. The six GSR criteria evaluated with this Revised FFS include the following:

- Green House Gas (GHG) Emissions;
- Toxic Chemical Usage and Disposal;
- Energy Consumption;
- Use of Alternative Fuels;
- Water Consumption; and
- Waste Generation.


### 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 5-1. Table 5-2 presents a numerical comparison of the evaluated alternatives.

### 5.1 Threshold Criteria

Only those alternatives that would meet the threshold criteria of providing overall protection of human health and the environment and whether they would attain compliance with ARARs were carried forward with the comparative analysis. Alternative 1 does not meet the threshold criteria, but was carried forward as it is required for analysis under the NCP. Alternative 2, Alternative 3, and Alternative 4 will achieve protection of human health and the environment and comply with the identified ARARs.
Alternatives 2, 3, and 4 would achieve the threshold criterion because all three alternatives would adequately protect human health and the environment from unacceptable risks posed by hazardous substances, pollutants, or contaminants present at the Slip. Alternatives 2, 3, and 4 would eliminate, reduce, or control exposure to contaminated sediment; however, contaminated sediment would remain in-place under Alternatives 2 and 4 requiring monitoring to assure longterm effectiveness. Alternative 3 would provide the highest level of protection, since contaminated sediments would be removed from the aquatic environment.

### 5.2 Balancing Criteria

### 5.2.1 Long-Term Effectiveness and Permanence

Alternative 1 is not effective in the long-term or permanent. Alternatives 2, 3, and 4 are effective in the long-term. However, contaminated sediment would remain in place under Alternatives 2 and 4, requiring long-term O\&M and institutional controls to assure long-term effectiveness therefore they are not as permanent. Disposal of sediment at an off-site landfill would be equally effective in the long-term. Since all contaminated sediments would be removed, Alternative 3 would provide the most permanence, even though contaminants would not be permanently destroyed.

In summary, Alternative 3 will provide a moderate to high achievement of this criterion by removing all of the contaminated sediment in the aquatic environment above the SCVs. Alternatives 2 and 4 will 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 0.8-meter cap with Alternative 2, and all contaminated sediment would remain in the aquatic environment with Alternative 4. Physical forces will be further evaluated in the design phase; however, these forces may be more impactful on final design of Alternative 4 due to the decreased water depths.

### 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, with Alternatives 2 and 3, the 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 at an off-site landfill. The amount of dredged sediment to be removed from the
environment and stabilized is included in Table 5-3. 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.
Alternatives 1 and 4 would not provide a reduction in the toxicity, mobility, or volume through treatment. However, for Alternative 4 the contaminated sediment would be capped in-place, reducing the mobility of the sediment.
In summary, Alternative 3 will provide the highest achievement of this criterion by removing all of the contaminated sediment in the aquatic environment above the SCVs. Alternative 2 will provide a moderate achievement of this criterion, since approximately one half of the contaminated sediment would remain in the aquatic environment underneath a 0.8-meter cap. Alternative 4 will provide a low achievement of this criterion, as all the contaminated sediment would remain in-place. Alternative 1 provides the lowest achievement of this criterion as no reduction in mobility is provided.Short-Term Effectiveness
There are no short-term risks associated with Alternative 1 as no actions would be implemented at the Slip. The rest of the alternatives would have some short-term risks during implementation of the remedy. Both Alternatives 2, 3 and 4 require varying amounts of dredging/capping that may impact short-term effectiveness.. The potential short-term risks increase as the volume of contaminated sediment to be dredged increases due to additional coordination and due to the uncertainty of the Slip wall stability. The potential short-term risks to the community and workers with Alternatives 2, 3 and 4 are associated with increase boat/barge traffic, safety, noise, and related impacts due to working in the Duluth Harbor and other publicly accessible locations. There are also potential short term risks to workers from dust created from stabilization agents that are stockpiled and mixed. Truck transportation of dredged sediments to an off-site landfill would also 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 Alternatives 2, 3 , and 4, and would include displacement of fish and smothering of benthic organisms; however, Alternative 4 would likely present less adverse effects since less contaminated sediment would be disturbed during dredging, however this is the only alternative that moves sediments within the slip.. 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 for Alternatives 2 and 3 are also a concern and increase significantly with the total dredging option.

Table 5-4 presents the estimated time for construction completion at the Slip. The time frame estimates do not include additional construction time that would be required at the staging area including: construction of a gravel staging pad, stabilization, and off-site transportation to a landfill (Alternatives 2 and 3 ).

Overall, Alternative 1 will have the highest achievement of the short-term effectiveness criterion followed by Alternative 4. Alternative 2 will have a moderate achievement of this short-term effectiveness criterion due to an increase in short-term risks from construction truck traffic to an off-site landfill. Alternative 3 will have the lowest achievement of the short-term effectiveness criterion.

### 5.2.3 Implementability

There are fewimplementability concerns associated with Alternative 1, limiting ICs are required and maybe difficult to implement.. Dredging, capping, restoration, surface water control structures, as well as monitoring and O\&M that would be required under Alternatives 2,3 , and 4 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 Slip. 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 (Alternatives 2, 3 and 4). In addition, there are concerns with the stability of the dock walls during dredging activities (Alternatives 2 and 3; Appendix F1). Dock wall inspection is included in the cost estimates for Alternatives 2 and 3. However, minimal structural repairs are included in the cost estimate, but much higher costs 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 (Alternative 3). Therefore, the total removal scenarios would likely provide the lowest 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 large waves that could impact productivity. Barge traffic would be postponed in the spring until ice breaking in the harbor is completed. Winter or freezing conditions in the fall could also impact productivity. Alternative 3 has the longest estimated time to complete and therefore would stand to be the most impacted by weather.

Monitoring can be completed to evaluate the effectiveness of the remedy. Monitoring the effectiveness of the remedy could be more challenging, as dredging will be conducted under water; however, specialized equipment is available. Dock wall inspection, equipment staging and surface water controls would also be necessary to accommodate Alternatives 2, 3 and 4.

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. Additional time will be required to obtain any necessary approvals and permits from other agencies. Both Alternatives 2 and 3 will require more coordination with other regulatory agencies than Alternative 4, as no off site disposal will be required. Permits for capping, however, would be required for Alternatives 2 and 4.

In summary, Alternative 1 has no actions to be implemented, so will provide the greatest achievement of the implementability criterion. Alternative 4 is then the next easiest to implement since it requires the smallest dredging effort, least concern of dock wall stability, no disposal, no contaminated sediment staging and less overall coordination. Alternative 2 will provide a moderate achievement of the implementability criterion, as less dredging and shorter schedule. In contrast, Alternative 3 will provide the lowest achievement of the implementability criterion because of the longer schedule and higher potential for dock wall issues. Table 5-2 presents a numerical score that provides a scale to compare all Alternatives.

### 5.2.4 Cost

Cost estimates developed for each alternative are included in Section 3.0 and summarized in Table 5-5. The cost estimates include: capital costs, including both direct and indirect costs; annual O\&M costs; and net present value of capital and O\&M costs.

Several factors that could greatly affect cost could not be reasonably estimated during this FFS and are not included in the estimated costs. These factors, which should be evaluated during final design, include:

- Dock Wall and Sink Hole Repair: The risks of damage to and stability of dock walls described within this report increases as dredging volume increases. The vertical area of dock wall to be exposed during dredging for Alternative 3 is approximately double compared to Alternative 2. The costs for repair of significant damage to larger areas of dock wall and sink holes around the perimeter of the Slip, which were not included in this estimate, could be over $\$ 4,500,000$. Additional measures to ensure dock wall stability during construction should be considered during the design phase. These measures, however, could add both time and cost to the remedial actions.
- Sediment traps or other means of limiting incoming sediment to maintain appropriate water depth may be required; this need will be further evaluated in the design phase of this project. If sediment traps are implemented, long-term maintenance of these traps such as sediment removal will be required. Costs for installation and/or maintaining these sediment traps are not included.
- While this FFS assumes that Former Hallet Dock \#7 will be used as a staging area for Alternatives 2 and 3, costs associated with preparing Former Hallet Dock \#7 for staging use and renting it are not included in this estimate and could significantly impact the final cost.
- Additional costs for habitat enhancement materials are dependent on final design and are not included.

In summary, Alternative 1 provides the most cost effective option, followed by Alternative 4 as removal of sediment is required, and Alternative 2 provides the most cost effective option that includes dredging and disposal of sediments. Alternative 3 will provide the lowest achievement of the cost criterion. Table 5-2 presents a numerical score that compares the cost for all alternatives.

### 5.3 Modifying Criteria

The modifying criteria, State/support agency acceptance, and community acceptance are assessed formally after the public comment period, and to the extent that they are known will be factored into the identification of the preferred alternative.
In past correspondence between the MPCA and the City of Duluth on August 8, 2005, the City stated: "At this point in time I think you should assume that the Slip will continue to operate as it has in the last 14 years since the Pedestrian Bridge began operations" (Appendix F2).
The City of Duluth has proposed filling in the Slip to accommodate future development. As such, a calculated volume of material necessary to completely fill in the Slip after placement of a 0.8 meter cap was included at the request of the MPCA. The estimated volume of material required to completely fill the Slip to street level over a 0.8-meter cap is 63,000 cubic yards. A cost estimate for this option was not included in this study.
Because the Slip is home to a floating museum that provides 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 Slip would need to be coordinated with the tourism season. The tourism season lasts from May through September. As shown in Table 5-4, the total estimated time needed for on-site construction is 2.4 weeks for Alternative 4, 6.9 weeks for Alternative 2, and 11.2 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. As previously discussed, the footbridge may need to be closed to foot traffic during remediation.
With regards to Community acceptance, the formal opinion of the Community will be evaluated following the public comment period.

### 5.4 Green Sustainable Remediation Criteria

### 5.4.1 Green House Gas Emissions

Alternative 1 would not produce GHG emissions. Alternatives 2, 3, and 4 would result in GHG emissions from the mobilization, operation, and demobilization of all fuel-powered construction equipment required to dredge and install the cap/cover. Alternatives 2 and 3 would also produce emissions during transport by water to the handling area and during transport by land to the disposal facility; however, Alternative 2 would produce less GHG emissions than Alternative 3 because the amount of dredging is considerably less with Alternative 2. Reduction of emissions can be accomplished by using equipment that is compliant with the latest USEPA non-road engine standards and retrofitting older equipment with appropriate filters.

### 5.4.2 Toxic Chemical Usage and Disposal

Portland cement is the stabilization agent used for Alternatives 2 and 3. There are no other toxic chemical usage and disposal considerations associated with these alternatives.

### 5.4.3 Energy Consumption

Alternative 1 would not consume fossil fuels. Alternatives 2, 3 and 4 would result in the consumption of fossil fuels for the mobilization, operation, and demobilization of all diesel-powered construction equipment associated with the dredging, hauling, and disposal of the contaminated sediment and the installation of the cap/cover material. Because the amount of sediment removed in Alternative 2 is considerably less than in Alternative 3, the energy consumption for sediment dredging and hauling would be less than Alternative 2. Alternative 4 would result in the lowest consumption of fossil fuels since the amount dredged is much smaller that both Alternatives 2 and 3.

### 5.4.4 Use of Alternative Fuels

Alternative 1 would not require the use of alternative fuels. Biodiesel blended fuels (B10 or B20) could be used as a supplemental fuel source for all diesel powered construction equipment associated with Alternatives 2, 3, and 4.

### 5.4.5 Water Consumption

Alternative 1 would not require the consumption of water. There are few water consumption considerations associated with Alternatives 2, 3, and 4. A minimal quantity of water would be required to decontaminate personnel and equipment during sediment dredging activities with Alternatives 2 and 3.

### 5.4.6 Waste Generation

Alternatives 1 and 4 would not generate waste. Alternatives 2 and 3 would generate waste that includes the dredged contaminated sediments. Alternative 3 would generate approximately
waste than Alternative 2 because all the contaminated sediment would be removed from the slip and disposed.

### 5.5 Comparative Analysis Summary

The comparative analysis of alternatives narrative discussion and quantitation table did not clearly identify a superior alternative to address the contamination in the slip. Alternatives 2, 3 and 4 were all protective of human health and the environment. No significant difference in the balancing criteria score was found between these alternatives other than cost. Alternative 1 was not protective and will not be selected nor considered further.
The modifying criteria, State/support agency acceptance, and community acceptance are assessed formally after the public comment period. Stakeholder and community input will provide valuable insight as the MPCA considers information for the selection of a preferred alternative. The MPCA will conduct outreach activities to resource managers, current slip users, the public and local units of government prior to the public comment period.
Further studies are recommended during the design phase of the preferred alternative. These recommended studies, depending on the alternative selected include:

- Hydrodynamic study to understand the depositional and scouring forces in the slip to inform design and placement of armoring, if needed.
- Storm water sewer evaluation, including an evaluation of need to sediment maintenance, to evaluate the need to limit sediments entering the Slip.
- Additional surface sampling to understand if incoming storm water deposition is contaminated, thus a continuing source of contamination
- Pore-water transport and attenuation modeling for engineered cap design.
- Cap/sediment consolidation calculations and modeling for engineered cap design.
- Future use of the slip study and required water depths.


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Figures


Figure 1-1

## Site Location Map

Minnesota Slip - Revised Focused Feasibility Study

Duluth, MN


Map Projection: NAD 1983 UTM Zone 15 N
Site Location
(4) Bay West

Drawn By: SG Date Drawn/Revised:2/6/2014 Project No.J130485


Figure 1-2
Property Owners Adjacent To Project Site
Minnesota Slip - Revised Focused Feasibility Study

Duluth, MN


Map Projection: NAD 1983 UTM Zone 15 N


Building D INC
Building E INC
DA
Building N INC
Z City of Duluth
B
ETOR Properties LLC
VA
Grandma's Sport Bar \& Grill INC
Marine Iron \& Ship Building Co
Michael J. Paulucci
St. Paul \& Duluth RY. CO
(6) Bay West

Drawn By: SG Date Drawn/Revised:2/27/2014 Project No.J130485


Figure 1-3
Detailed Storm Sewer System Outletting to the Minnesota Slip (Source: City of Duluth)
Minnesota Slip - Revised Focused Feasibility Study

Duluth, MN


Map Projection: NAD 1983 UTM Zone 15 N

(ID)
Manhole
[B]
Catch Basin
$\square$
Storm Sewer Outlet

- ST - Storm Sewer
(6)Bay West

Drawn By: SG Date Drawn/Revised:2119/2014 Project No.J130485


Figure 1-4
Bathymetric Contours of Minnesota Slip - March 2004
(Source: Streitz and Johnson, 2005)
Minnesota Slip - Revised Focused
Feasibility Study
Duluth, MN


Map Projection: NAD 1983 UTM Zone 15 N


Catch Basin
(ID)
Manhole
Storm Sewer Outlet
Bathymetric Contour Line

- ST - Storm Sewer


Figure 1-5
Bathymetric Contours of Minnesota Slip - January 2014
Minnesota Slip - Revised Focused
Feasibility Study
Duluth, MN


Map Projection: NAD 1983 UTM Zone 15 N

(CB Catch Basin
(A) Manhole
$\square$
Storm Sewer Outlet
Bathymetric Contour Line

- ST - Storm Sewer
(6) Bay West

Drawn By: SG Date Drawn/Revised:2/7/2014 Project No.J130485


2014 Bathymetric Contours



Figure 1-6

## 2004 to 2014 Bathymetric

 Contour ComparisonMinnesota Slip - Revised Focused Feasibility Study

Duluth, MN
 "会

Map Projection: NAD 1983 UTM Zone 15 N

(CB Catch Basin
(ID) Manhole
$\square$ Storm Sewer Outlet
Bathymetric Contour Line

- ST - Storm Sewer

Sediment Comparison

- Decrease in Sediment
- Increase in Sediment

Sample ID $\stackrel{66 \stackrel{(-0.2)}{4} \stackrel{4}{\longleftrightarrow}}{\square}$
+/- Change (Meters)
(6)Bay West

Drawn By: SG Date Drawn/Revised:27/12014 Project No.J130485


Figure 1-7
Cross Section Location Map
Minnesota Slip - Revised Focused
Feasibility Study
Duluth, MN


Map Projection: NAD 1983 UTM Zone 15 N


82004 Sediment Measurement Location

- 632014 Sediment Measurement Location

Cross Section Locations
— A-A' (See Figure 1-8)
B-B' (See Figure 1-9)
C-C' (See Figure 1-10)
D D-D' (See Figure 1-11)
——E-E' (See Figure 1-12)
_ F-F' (See Figure 1-13)
_ G-G' (See Figure 1-14)
—— H-H' (See Figure 1-15)
(6) Bay West




——— 2004 SEDIMENT BATHYMETRY
— 2014 SEDIMENT BATHYMETRY
NOTE:

1) SEDIMENT MEASUREMENT LOCATIONS INDICATED WITH BLUE TEXT REPRESENT DATA TAKEN FROM 2004, WHILE BLACK TEXT REPRESENTS DATA FROM 2014.


LIF RESPONSE GREATER THAN 2\% NO CHANGE IN SEDIMENT

INCREASE IN SEDIMENT

DECREASE IN SEDIMENT

HORIZONTAL SCALE


| ENGR'G B.W. | DATE |  |  |  |
| :--- | :--- | :--- | :--- | :--- |
| DRAWN K.M. | $08 / 30 / 05$ |  |  |  |
| REV. | S.G. | $01 / 17 / 14$ |  | Customer-Focused Environmental \& Industrial Solutions |
| PROJECT NAME | MINNESOTA SLIP |  |  |  |
| TITLE | CROSS-SECTION D TO D' |  |  |  |
| JOB NO. | J130485 |  | FIGURE \# | $1-11$ |


$\qquad$ 2004 SEDIMENT BATHYMETRY


LIF RESPONSE GREATER THAN 2\% NO CHANGE IN SEDIMENT

INCREASE IN SEDIMENT
NOTE:

1) SEDIMENT MEASUREMENT LOCATIONS INDICATED WITH BLUE TEXT REPRESENT DATA TAKEN FROM 2004, WHILE BLACK TEXT REPRESENTS DATA FROM 2014.

HORIZONTAL SCALE


——— 2004 SEDIMENT BATHYMETRY
2014 SEDIMENT BATHYMETRY

NOTE:

1) SEDIMENT MEASUREMENT LOCATIONS INDICATED WITH BLUE TEXT REPRESENT DATA TAKEN FROM 2004, WHILE BLACK TEXT REPRESENTS DATA FROM 2014.


LIF RESPONSE GREATER THAN
2\% No CHANGE IN SEDIMENT

INCREASE IN SEDIMENT

DECREASE IN SEDIMENT





Figure 1-16
3D Sediment Comparison (2004-2014)
Minnesota Slip - Revised Focused Feasibility Study

Duluth, MN


Map Projection: NAD 1983 UTM Zone 15 N


Bay West
Drawn By: SG Date Drawn/Revised:26/2014 Project No.J130485


South View

Figure 1-17
Alternative 4 Proposed Dredging Locations
Minnesota Slip - Revised Focused Feasibility Study

Duluth, MN


Map Projection: NAD 1983 UTM Zone 15 N

Sediment (2014 Elevation)
Sediment To Be Dredged
Dredging Elevation ( 588 Feet AMSL)
Non-Contaminated Sediment


Water

NOTES:

1) The 3d representation of the Minnesota Silp was prepared using
ESRI's ArcScene coupled with ESRI's Arc ESRI's Arcscene coupled with EERI's Arcimap that utilizes standard Minnesota Slip

Bay West
Drawn By: SG Date Drawn/Revised:6/24/2014 Project No.J130485

## Tables

Table 1-1 Contaminants of Potential Concern

## Revised Focused Feasibility Study <br> Minnesota Slip Minnesota Pollution Control Agency

| Contaminant | Units | Maximum <br> Concentration <br> Detected |
| :--- | :---: | :---: |
| Total PAHs | $\mathrm{mg} / \mathrm{kg}$ | $1188(2)$ |
| PCBs | $\mu \mathrm{g} / \mathrm{kg}$ | $612(1)$ |
| Mercury | $\mathrm{mg} / \mathrm{kg}$ | $3.3(3)$ |
| Cadmium | $\mathrm{mg} / \mathrm{kg}$ | $3.6(3)$ |
| Chromium | $\mathrm{mg} / \mathrm{kg}$ | $51(2)$ |
| Copper | $\mathrm{mg} / \mathrm{kg}$ | $99(2)$ |
| Lead | $\mathrm{mg} / \mathrm{kg}$ | $544(3)$ |
| Zinc | $\mathrm{mg} / \mathrm{kg}$ | $559(3)$ |
| DRO | $\mathrm{mg} / \mathrm{kg}$ | $230(3)$ |
| (1) Summary of previous sampling presented in Table 2, Crane et <br> al., 2002 <br> (2) Crane et al., 2002 <br> (3) Streitz and Johnson, 2005 <br> $\mu \mathrm{g} / \mathrm{kg}=$ micrograms per kilogram <br> DRO $=$ diesel range organics <br> mg/kg $=$ milligrams per kilogram <br> PAHs $=$ polycyclic aromatic hydrocarbons <br> PCBs $=$ polychlorinated biphenyls |  |  |

Table 1-2 Statistics for Selected Parameters of 1998 and 1999 Samples
Revised Focused Feasibility Study
Minnesota Slip
Minnesota Pollution Control Agency

| Statistic | 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 | 0.31 | 300.0 |
| Standard Deviation | 202 | 0.13 | NA | 149.7 | 0.42 | 167.1 |
| Range | $1,181.10$ | 0.61 | NA | 870 | 2.2 | $1,059.0$ |
| Minimum | 7.1 | 0 | NA | 10 | 0 | 41.0 |
| Maximum | $1,188.10$ | 0.61 | NA | 880 | 2.2 | $1,100.0$ |

Source: 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)
(1) All results ppm, dry weight concentrations
(2) Count of samples is greater than 54
$N A=$ not available
PAH = polycyclic aromatic hydrocarbon
$P C B=$ polychlorinated biphenyl
ppm = parts per million

Table 1-3 Statistics for Selected Parameters of 2004 Samples
Revised Focused Feasibility Study
Minnesota Slip
Minnesota Pollution Control Agency

| Statistic | 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 Deviation | 62.7 | 73 | 1.4 | 162.9 | 0.8 | 167.9 | 1.6 |
| Range | 270 | 225 | 4.4 | 541 | 3.2 | 558.6 | 4.9 |
| Minimum | 0 | 5 | 0.6 | 3 | 0.1 | 0.4 | 0.1 |
| Maximum | 270 | 230 | 5 | 544 | 3.3 | 559 | 5.0 |

Source: 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) All results ppm, dry weight concentrations
(2) Count of samples is 18
$D R O=$ diesel range organics
PAH = polycyclic aromatic hydrocarbon
TOC = total organic carbon

Table 1-4 Contaminants of Concern and Sediment Quality Targets
Revised Focused Feasibility Study
Minnesota Slip
Minnesota Pollution Control Agency
Prismodial Calculations
All units in feet except at final voume


## Cross Section A-A'

East Sediment Thickness
Center Line Sediment Thickness
West Sediment Thickness

| Distance East | 42.0 |
| :--- | :--- |
| Distance West | 63.7 |

Cross Section B-B'
East Sediment Thickness
Center Line Sediment Thickness
West Sediment Thickness
$\begin{array}{ll}\text { Distance East } & 57.2 \\ \text { Distance West } & 73.7\end{array}$
Cross Section C-C'
$\begin{array}{lr}\text { East Sediment Thickness } \\ \text { Center Line Sediment Thickness } \\ \text { West Sediment Thickness } \\ \text { Distance East } & 67.6 \\ \text { Distance West } & 76.3\end{array}$
Cross Section D-D'
East Sediment Thickness
Center Line Sediment Thickness
West Sediment Thickness

| Distance East | 39.7 |
| :--- | :--- |
| Distance West | 72.6 |

## Cross Section E-E'

East Sediment Thickness
Center Line Sediment Thickness
West Sediment Thickness
Distance East 59.3
Distance West 75.5
Cross Section F - F'
East Sediment Thickness
Center Line Sediment Thickness
West Sediment Thickness
$\begin{array}{ll}\text { Distance East } & 62.8 \\ \text { Distance West } & 63.3\end{array}$

## Cross Section G-G'

East Sediment Thickness
Center Line Sediment Thickness
West Sediment Thickness
Distance East
Distance West
63.1
57.1

## 2004 Location - 19-18-21

10.0
12.0 0.0
Distance Between Cross Sections
2004 Location-20-17-23
11.0
10.0
7.0
Distance Between Cross Sections

## 2004 Location - 29-16-24

4.0
10.0
8.5

| Distance Between Cross Sections | 201.3 |
| :---: | :---: |
| $\mathbf{2 0 0 4}$ Location $\mathbf{- 2 8 - 1 4 - 2 5}$ | $\mathbf{2 0 1 4}$ Location $\mathbf{- 1 9 - 5 5 - 5 6}$ |
| 10.5 | 11.8 |
| 8.0 | 7.7 |
| 9.0 | 9.6 |

## Distance Between Cross Sections

 2004 Location - 3-6-73.56.0
7.5

Distance Between Cross Sections
2004 Location - 2-4-5
0.0
5.0
6.0

Distance Between Cross Sections
2004 Location - 1-8-9
3.0
4.5
5.5

Distance Between Cross Sections

2014 Location - 2-73-74
9.0
12.1
0.7

## 53.8

2014 Location - 4-50-49
11.5
9.7
9.8
93.1

2014 Location - 9-51-52
2.5
9.8
10.9
201.3

2014 Location - 19-55-56
7.7
9.6
204.0

2014 Location - 29-59-60
2.6
5.2
8.2
100.5

2014 Location - 34-61-62
0.0
4.0
10.2
91.1

2014 Location - 35-63-64
2.3
4.1
8.1
99.3

Table 1-4 Contaminants of Concern and Sediment Quality Targets
Revised Focused Feasibility Study
Minnesota Slip
Minnesota Pollution Control Agency

| Cross Section H-H' | 2004 Location - 12-11-10 | 2014 Location - 65-66-67 |
| :---: | :---: | :---: |
| East Sediment Thickness | 2.0 | 1.2 |
| Center Line Sediment Thickness | 7.0 | 6.8 |
| West Sediment Thickness | 0.0 | 2.0 |
| Distance East 61.7 |  |  |
| Distance West 54.1 |  |  |
|  | Distance Between Cross Sections | 49.2 |
| Cross Section at Bridge |  |  |
| East Sediment Thickness | 2.0 | 1.2 |
| Center Line Sediment Thickness | 7.0 | 6.8 |
| West Sediment Thickness | 0.0 | 2.0 |
| Distance East 61.7 |  |  |
| Distance West 54.1 |  |  |

East Side and West Side Prisms

| Section A East | 2004 | 2014 |  | Section A West | 2004 | 2014 |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Sediment Thickness | 10.0 | 9.0 |  | Sediment Thickness | 0.0 | 0.7 |  |
| Width 16.4 |  |  |  | Width 21.5 |  |  |  |
| Section B East | 2004 | 2014 |  | Section B West | 2004 | 2014 |  |
| Sediment Thickness | 11.0 | 11.5 |  | Sediment Thickness | 7.0 | 9.8 |  |
| Width 0.0 |  |  |  | Width 12.7 |  |  |  |
| Distance Between Se | A - B |  | 53.8 | Distance Between Se | A - B |  | 53.8 |
| Section C East | 2004 | 2014 |  | Section C West | 2004 | 2014 |  |
| Sediment Thickness | 4.0 | 2.5 |  | Sediment Thickness | 8.5 | 10.9 |  |
| Width 8.2 |  |  |  | Width 0.0 |  |  |  |
| Distance Between Se | B-C |  | 93.1 | Distance Between Se | B - C |  | 93.1 |
| Section D East | 2004 | 2014 |  | Section D West | 2004 | 2014 |  |
| Sediment Thickness | 10.5 | 11.8 |  | Sediment Thickness | 9.0 | 9.6 |  |
| Width 20.5 |  |  |  | Width 10.9 |  |  |  |
| Distance Between Se | C-D |  | 201.3 | Distance Between Se | C-D |  | 201.3 |
| Section E East | 2004 | 2014 |  | Section E West | 2004 | 2014 |  |
| Sediment Thickness | 3.5 | 2.6 |  | Sediment Thickness | 7.5 | 8.2 |  |
| Width 0.0 |  |  |  | Width 8.8 |  |  |  |
| Distance Between Se | D-E |  | 204.0 | Distance Between Se | D-E |  | 204.0 |
| Section F East | 2004 | 2014 |  | Section F West | 2004 | 2014 |  |
| Sediment Thickness | 0.0 | 0.0 |  | Sediment Thickness | 6.0 | 10.2 |  |
| Width 0.0 |  |  |  | Width 17.4 |  |  |  |
| Distance Between Se | E-F |  | 100.5 | Distance Between Se | E-F |  | 100.5 |
| Section G East | 2004 | 2014 |  | Section G West | 2004 | 2014 |  |
| Sediment Thickness | 3.0 | 2.3 |  | Sediment Thickness | 5.5 | 8.1 |  |
| Width 4.1 |  |  |  | Width 19.3 |  |  |  |
| Distance Between Se | F-G |  | 91.1 | Distance Between Se | F - G |  | 91.1 |
| Section H East | 2004 | 2014 |  | Section H West | 2004 | 2014 |  |
| Sediment Thickness | 2.0 | 1.2 |  | Sediment Thickness | 0.0 | 2.0 |  |
| Width 12.3 |  |  |  | Width 15.4 |  |  |  |
| Distance Between Se | G - H |  | 99.3 | Distance Between Se | G - H |  | 99.3 |

Table 1-4 Contaminants of Concern and Sediment Quality Targets
Revised Focused Feasibility Study
Minnesota Slip
Minnesota Pollution Control Agency

| Section H to Bridge I | 2004 | 2014 |  | Sectio | Bridge V | 2004 | 2014 |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Sediment Thickness | 2.0 | 1.2 |  | Sedim | kness | 0.0 | 2.0 |  |
| Width 12.3 | 12.3 |  |  | Width | 15.4 |  |  |  |
| Distance Between Section | H-B |  | 49.2 | Distan | veen Section | H-B |  | 49.2 |


| North Triangle |  |
| :--- | ---: |
| Height | 49.2 |
| Base | 131.3 |
| Sediment Thickness | 12.5 |

## Minnesota Slip Contaminated Sediment Calculation Volume Calculations

| Cross Section A - A' | $\mathbf{2 0 0 4}$ | 2014 Cross Section B - B' | $\mathbf{2 0 0 4}$ | $\mathbf{2 0 1 4}$ |
| :--- | ---: | :---: | ---: | ---: | ---: |
| Area of West Center Prism | 382.2 | 407.7 Area of West Center Prism | 626.7 | 718.8 |
| Area of East Center Prism | 462.2 | 443.3 Area of East Center Prism | 600.6 | 606.3 |
| Area of West Side Prism | 0.0 | 15.0 Area of West Side Prism | 88.7 | 124.2 |
| Area of East Side Prism | 164.0 | 164.0 Area of East Side Prism | 0.0 | 0.0 |


| Volumes A - B | $\mathbf{2 0 0 4}$ | $\mathbf{2 0 1 4}$ |
| :--- | ---: | ---: |
| Volume of West Center Prism | 26904.6 | 29991.6 |
| Volume of East Center Prism | 28645.1 | 28215.6 |
| Volume of West Side Prism | 2938.4 | 4462.9 |
| Volume of East Side Prism | 4557.0 | 4483.5 |
| Total Volume of A - B | 63045.0 | 67153.5 |


| Cross Section B - B' | 2004 | 2014 Cross Section C - C' | $\mathbf{2 0 0 4}$ | 2014 |
| :--- | ---: | :---: | ---: | ---: | ---: |
| Area of West Center Prism | 626.7 | 718.8 Area of West Center Prism | 705.9 | 789.8 |
| Area of East Center Prism | 600.6 | 606.3 Area of East Center Prism | 473.0 | 415.6 |
| Area of West Side Prism | 88.7 | 124.2 Area of West Side Prism | 0.0 | 0.0 |
| Area of East Side Prism | 0.0 | 0.0 Area of East Side Prism | 32.8 | 20.5 |


| Volumes B - C | 2004 | 2014 |
| :--- | ---: | ---: |
| Volume of West Center Prism | 62031.5 | 70239.1 |
| Volume of East Center Prism | 50565.7 | 48310.0 |
| Volume of West Side Prism | 4427.4 | 6001.5 |
| Volume of East Side Prism | 2418.7 | 2100.5 |
| Total Volume of B - C | 119443.3 | 126651.1 |


| Cross Section C - C' | 2004 | 2014 Cross Section D - D' | $\mathbf{2 0 0 4}$ | $\mathbf{2 0 1 4}$ |
| :--- | ---: | :---: | ---: | ---: | ---: |
| Area of West Center Prism | 705.9 | 789.8 Area of West Center Prism | 616.7 | 627.6 |
| Area of East Center Prism | 473.0 | 415.6 Area of East Center Prism | 366.9 | 386.8 |
| Area of West Side Prism | 0.0 | 0.0 Area of West Side Prism | 97.9 | 104.4 |
| Area of East Side Prism | 32.8 | 20.5 Area of East Side Prism | 215.3 | 241.9 |


| Volumes C - D | $\mathbf{2 0 0 4}$ | $\mathbf{2 0 1 4}$ |
| :--- | ---: | ---: |
| Volume of West Center Prism | 132994.1 | 142416.5 |
| Volume of East Center Prism | 86633.1 | 84112.7 |
| Volume of West Side Prism | 9668.1 | 10981.5 |
| Volume of East Side Prism | 22279.2 | 22568.0 |
| Total Volume of C - D | 251574.5 | 260078.5 |


| Cross Section D - D' | $\mathbf{2 0 0 4}$ | 2014 Cross Section E - E' | $\mathbf{2 0 0 4}$ | $\mathbf{2 0 1 4}$ |
| :--- | ---: | :--- | ---: | ---: | ---: |
| Area of West Center Prism | 616.7 | 627.6 Area of West Center Prism | 509.8 | 506.1 |
| Area of East Center Prism | 366.9 | 386.8 Area of East Center Prism | 281.7 | 231.3 |
| Area of West Side Prism | 97.9 | 104.4 Area of West Side Prism | 65.8 | 71.9 |
| Area of East Side Prism | 215.3 | 241.9 Area of East Side Prism | 0.0 | 0.0 |

Table 1-4 Contaminants of Concern and Sediment Quality Targets
Revised Focused Feasibility Study
Minnesota Slip
Minnesota Pollution Control Agency

| Volumes D - E | $\mathbf{2 0 0 4}$ | $\mathbf{2 0 1 4}$ |
| :--- | ---: | ---: |
| Volume of West Center Prism | 115061.8 | 115806.8 |
| Volume of East Center Prism | 69148.7 | 66932.1 |
| Volume of West Side Prism | 16584.3 | 17883.1 |
| Volume of East Side Prism | 17073.3 | 18257.9 |
| Total Volume of D - E | 217868.0 | 218879.9 |


| Cross Section E - E' | $\mathbf{2 0 0 4}$ | 2014 Cross Section F - F' | $\mathbf{2 0 0 4}$ | $\mathbf{2 0 1 4}$ |
| :--- | ---: | :---: | ---: | ---: | ---: |
| Area of West Center Prism | 509.8 | 506.1 Area of West Center Prism | 348.2 | 449.5 |
| Area of East Center Prism | 281.7 | 231.3 Area of East Center Prism | 157.1 | 125.7 |
| Area of West Side Prism | 65.8 | 71.9 Area of West Side Prism | 104.7 | 178.0 |
| Area of East Side Prism | 0.0 | 0.0 Area of East Side Prism | 0.0 | 0.0 |

## Minnesota Slip Contaminated Sediment Calculation Volume Calculations

| Volumes E - F | 2004 | 2014 |
| :--- | ---: | ---: |
| Volume of West Center Prism | 42863.5 | 44380.7 |
| Volume of East Center Prism | 22185.4 | 18052.2 |
| Volume of West Side Prism | 8785.1 | 12267.7 |
| Volume of East Side Prism | 0.0 | 0.0 |
| Total Volume of E - F | 73834.0 | 74700.7 |


| Cross Section F - F' | 20042014 | 2014 Cross Section G - G' |  |
| :---: | :---: | :---: | :---: |
| Area of West Center Prism | 348.2449 .5 | 449.5 Area of West Center Prism |  |
| Area of East Center Prism | 157.1125 .7 | 125.7 Area of East Center Prism |  |
| Area of West Side Prism | 104.7178. | Area of West | Side Prism |
| Area of East Side Prism | 0.0 | 0.0 Area of East Side Prism |  |
| Volumes F-G |  | 2004 | 2014 |
| Volume of West Center Prism |  | 28801.8 | 36225.5 |
| Volume of East Center Prism |  | 17932.5 | 14920.2 |
| Volume of West Side Prism |  | 9610.7 | 15275.4 |
| Volume of East Side Prism |  | 373.4 | 286.3 |
| Total Volume of F - G |  | 56718.4 | 66707.3 |


| Cross Section G - G' | 200420 | 2014 Cross Section H - H' |  |
| :---: | :---: | :---: | :---: |
| Area of West Center Prism | 277.9247 | 247.0 Area of West Center Prism |  |
| Area of East Center Prism | 236.8 | 202.1 Area of East Center Prism |  |
| Area of West Side Prism | 106.1 | 156.2 Area of West | Side Prism |
| Area of East Side Prism | 12.3 | 9.4 Area of East Side Prism |  |
| Volu |  | 2004 | 2014 |
| Volum | Center Prism | 23375.5 | 27351.1 |
| Volum | Center Prism | 25570.7 | 22314.6 |
| Volum | Side Prism | 4915.0 | 8898.2 |
| Volum | Side Prism | 1967.8 | 1112.8 |
| Total | G -H | 55829.0 | 59676.7 |


| Cross Section H - H' | 2004 | 2014 Cross Section at Bridge | 2004 | 2014 |
| :--- | ---: | :---: | ---: | ---: | ---: |
| Area of West Center Prism | 189.4 | 238.1 Area of West Center Prism | 189.4 | 238.0 |
| Area of East Center Prism | 277.9 | 247.0 Area of East Center Prism | 277.7 | 246.8 |
| Area of West Side Prism | 0.0 | 30.9 Area of West Side Prism | 0.0 | 30.9 |
| Area of East Side Prism | 24.6 | 14.8 Area of East Side Prism | 24.6 | 14.8 |


| Volumes H - Bridge | $\mathbf{2 0 0 4}$ | $\mathbf{2 0 1 4}$ |
| :--- | ---: | ---: |
| Volume of West Center Prism | 9317.8 | 11713.8 |
| Volume of East Center Prism | 13665.8 | 12147.4 |
| Volume of West Side Prism | 0.0 | 1518.3 |
| Volume of East Side Prism | 1210.3 | 726.2 |
| Total Volume of H - Bridge | 24194.0 | 26105.7 |

Table 1-4 Contaminants of Concern and Sediment Quality Targets
Revised Focused Feasibility Study
Minnesota Slip
Minnesota Pollution Control Agency


Table 1-5 Contaminants of Potential Concern and Sediment Quality Targets
Revised Focused Feasibility Study
Minnesota Slip
Minnesota Pollution Control Agency

| Contaminant | Units | Level 1 SQT | Level 2 SQT | Maximum <br> Concentration <br> Detected |
| :--- | :---: | :---: | :---: | :---: |
| Total PAHs | $\mathrm{mg} / \mathrm{kg}$ | 1.6 | 23 | $1188(2)$ |
| PCBs | $\mu \mathrm{g} / \mathrm{kg}$ | 60 | 680 | $612(1)$ |
| Mercury | $\mathrm{mg} / \mathrm{kg}$ | 0.18 | 1.1 | $3.3(3)$ |
| Cadmium | $\mathrm{mg} / \mathrm{kg}$ | 0.99 | 5 | $3.6(3)$ |
| Chromium | $\mathrm{mg} / \mathrm{kg}$ | 43 | 110 | $51(2)$ |
| Copper | $\mathrm{mg} / \mathrm{kg}$ | 32 | 150 | $99(2)$ |
| Lead | $\mathrm{mg} / \mathrm{kg}$ | 36 | 130 | $544(3)$ |
| Zinc | $\mathrm{mg} / \mathrm{kg}$ | 120 | 460 | $559(3)$ |
| DRO | $\mathrm{mg} / \mathrm{kg}$ | NA | NA | $230(3)$ |

(1) Summary of previous sampling presented in Table 2, Crane et al., 2002
(2) Crane et al., 2002
(3) Streitz and Johnson, 2005
$\mu \mathrm{g} / \mathrm{kg}=$ micrograms per kilogram
DRO = diesel range organics
$\mathrm{mg} / \mathrm{kg}=$ milligrams per kilogram
NA = not applicable
PAHs = polycyclic aromatic hydrocarbons
PCBs = polychlorinated biphenyls
SQT = Sediment Quality Target

Table 2-1 Preliminary Sediment Cleanup Levels
Revised Focused Feasibility Study
Minnesota Slip
Minnesota Pollution Control Agency

| Contaminant <br> of Concern | Units | Level 1 SQT | Level 2 SQT | Midpoint of <br> SQTs | Maximum <br> Concentratio <br> n Detected |
| :--- | :---: | :---: | :---: | :---: | :---: |
| Total PAHs | $\mathrm{mg} / \mathrm{kg}$ | 1.6 | 23 | 12.3 | $1188(2)$ |
| PCBs | $\mathrm{\mu g} / \mathrm{kg}$ | 60 | 680 | 370 | $612(1)$ |
| Mercury | $\mathrm{mg} / \mathrm{kg}$ | 0.18 | 1.1 | 0.64 | $3.3(3)$ |
| Cadmium | $\mathrm{mg} / \mathrm{kg}$ | 0.99 | 5 | 2.995 | $3.6(3)$ |
| Chromium | $\mathrm{mg} / \mathrm{kg}$ | 43 | 110 | 76.5 | $51(2)$ |
| Copper | $\mathrm{mg} / \mathrm{kg}$ | 32 | 150 | 91 | $99(2)$ |
| Lead | $\mathrm{mg} / \mathrm{kg}$ | 36 | 130 | 83 | $544(3)$ |
| Zinc | $\mathrm{mg} / \mathrm{kg}$ | 120 | 460 | 290 | $559(3)$ |
| DRO | $\mathrm{mg} / \mathrm{kg}$ | NA | NA | NA | $230(3)$ |

(1) Summary of previous sampling presented in Table 2, Crane et al., 2002
(2) Crane et al., 2002
(3) Streitz and Johnson, 2005
$\mu \mathrm{g} / \mathrm{kg}=$ micrograms per kilogram
DRO = diesel range organics
$\mathrm{mg} / \mathrm{kg}=$ milligrams per kilogram
NA = not applicable
PAHs = polycyclic aromatic hydrocarbons
PCBs = polychlorinated biphenyls
SQT = Sediment Quality Target

Table 3-1 Cost Estimate
Alternative 1: No Action

## Revised Focused Feasibility Study

Minnesota Slip
Minnesota Pollution Control Agency

| Description | Unit | Estimated Unit Cost* | Estimated Quantity | Extended Value | Present Value** | Comments |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Contractor Costs |  |  |  |  |  |  |
| Chemical Monitoring and Reporting Event |  | \$ 21,492 | 10 | \$ 215,000 | \$ 119,171 | Annually for 5 years then every 5th year for 25 years |
|  |  |  | 25\% Contingency | \$ 53,800 | \$ 29,800 |  |
|  |  |  | SUBTOTAL | \$ 269,000 | \$ 149,000 |  |
| Engineering and Administration |  |  |  |  |  |  |
| O\& M Plan Preparation | Event | \$ 8,850 | 1 | \$ 8,850 | \$ 8,271 | One time Cost for Peparation of O\&M Plan |
| Physical Monitoring/Reporting | Event | \$ 11,350 | 24 | \$ 272,400 | \$ 66,607 | Annually for 5 years then every 5th year for 95 years |
|  |  |  | 25\% Contingency | \$ 68,000 | \$ 17,000 |  |
|  |  |  | SUBTOTAL | \$ 349,300 | \$ 91,900 |  |
|  |  |  | TOTAL | \$ 618,300 | \$ 240,900 |  |

Notes
All values are based on 2014 dollars
*See Appendices for unit rate calculations
**Assumed discount rate of 7\% per year; See Appendix D for present value calculations

## Table 3-2 Cost Estimate

## Alternative 2: Partial Dredging with 0.8-Meter Cap

Revised Focused Feasibility Study

## Minnesota Slip

Minnesota Pollution Control Agency

| Description | Unit | Estimated Unit Cost* |  | Estimated Quantity | Extended Value | Present Value** | Comments |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Construction Costs |  |  |  |  |  |  |  |
| Mobilization/Demobilization | Lump Sum | \$ | 110,760.00 | 1 | \$ 111,000 | \$ 103,741 | Mobilization of dredge, barges, boats, and clamshell |
| Set-Up Offsite Staging Area | Lump Sum | \$ | 125,000.00 | 1 | \$ 125,000 | \$ 116,825 | Lined/bermed containtment area and material handling pads/areas |
| Moving Irvin | Event | \$ | 4,371.00 | 2 | \$ 9,000 | \$ 8,411 | Tug and crew for 2 days of moving the Irvin |
| Relocation of Dock Tentant for One Season | Renter | \$ | 2,400.00 | 48 | \$ 115,000 | \$ 107,479 | Average slip rental price for boats at Lakehead Marina |
| Sediment Controls at MN Slip | Lump Sum | \$ | 30,300.00 | 1 | \$ 30,000 | \$ 28,038 | Two turbidity curtains, boom, anchors, markers |
| Dredge Sediment from MN Slip | Cubic Yard | \$ | 30.00 | 19,700 | \$ 591,000 | \$ 552,349 | Dredging of sediments from the Slip |
| Oversize Debris | Cubic Yard | \$ | 53.61 | 985 | \$ 53,000 | \$ 49,534 | Stockpile, transportation, and disposal of oversize debris |
| Transport Sediment to Offisite Staging Area | Cubic Yard | \$ | 13.40 | 20,587 | \$ 276,000 | \$ 257,950 | Tug, crew, and barges |
| Solidification in Hopper Barge | Cubic Yard | \$ | 27.57 | 20,587 | \$ 567,000 | \$ 529,918 | Addition of solidification agent to bind free water |
| Sediment Unloading at Offsite Staging Area | Cubic Yard | \$ | 10.72 | 23,674 | \$ 254,000 | \$ 237,388 | Crane, trucks, loader |
| MN Slip Cap Materials | Cubic Yard | \$ | 25.41 | 12,800 | \$ 325,000 | \$ 303,745 | Off-Site cap materials delivered to staging area and transported to the Slip |
| Placement of 0.8m Cap | Cubic Yard | \$ | 18.00 | 12,800 | \$ 230,000 | \$ 214,958 | 0.8-m layer of cap material placed in the Slip |
| Off-Site Disposal | Cubic Yard | \$ | 26.44 | 23,674 | \$ 626,000 | \$ 585,060 | Off-Site transportation and disposal |
| Dock Wall Repair/Stabilization | Lump Sum | \$ | 20,000 | 1 | \$ 20,000 | \$ 18,692 | Repair damage to dock walls and/or sink holes; stabilize dock |
| Survey | Lump Sum | \$ | 50,000 | 1 | \$ 50,000 | \$ 46,730 | Survey and drawings of MN Slip and staging are during project |
|  |  |  |  | 25\% Contingency | \$ 846,000 | \$ 790,672 |  |
|  |  |  |  | SUBTOTAL | \$ 4,228,000 | \$ 3,951,500 |  |
| Engineering and Administration |  |  |  |  |  |  |  |
| Design \& Develop Contract Documents | Lump Sum | \$ | 64,500 | 1 | \$ 64,500 | \$ 64,500 | Design sediment removal, \& cap placement |
| Dock Wall Inspection | Lump Sum | \$ | 10,750 | 1 | \$ 10,750 | \$ 10,750 | Underwater inspection of the dock wall |
| Construction QA | Day | \$ | 2,688 | 53 | \$ 142,438 | \$ 142,438 | QA during dredging, capping and mob/demob |
| Construction Report | Lump Sum | \$ | 16,125 | 1 | \$ 16,125 | \$ 16,125 | Documentation of project |
|  |  |  |  | 25\% Contingency | \$ 58,000 | \$ 58,000 |  |
|  |  |  |  | SUBTOTAL | \$ 291,800 | \$ 291,800 |  |
| Operations and Maintenance |  |  |  |  |  |  |  |
| Physical Monitoring/Reporting | Year | \$ | 11,350 | 28 | \$ 318,000 | \$ 94,017 | Annual monitoring for 10 years then every 5th year for 90 years |
| Chemical Monitoring/Reporting | Year | \$ | 21,492 | 4 | \$ 86,000 | \$ 42,805 | Monitoring year 2, 5, and 10 plus 1 additional event in year 50 |
| Maintenance | Year | \$ | 53,750 | 13 | \$ 698,750 | \$ 200,075 | Cap repair for first 3 years and every 10th year for 100 years |
|  |  |  |  |  | \$ 1,102,750 | \$ 336,897 |  |
|  |  |  |  | 25\% Contingency | \$ 254,000 | \$ 84,000 |  |
|  |  |  |  | SUBTOTAL | \$ 1,356,750 | \$ 421,000 |  |
|  |  |  |  | TOTAL | \$ 5,876,550 | \$ 4,664,300 |  |

All values are based on 2014 dollars
Assumptions are based on professional judgment and experience of specialists at Bay West.
*See Appendices for unit rate calculations
**Assumed discount rate of $7 \%$ per year; See Appendices for present value calculations

| Description | Unit | Estimated <br> Unit Cost* | Estimated Quantity | Extended Value | Present Value** | Comments |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Construction Costs |  |  |  |  |  |  |
| Mobilization/Demobilization | Lump Sum | \$ 110,760.00 | 1 | \$ 111,000 | \$ 103,741 | Mobilization of dredge, barges, boats, and clamshell |
| Set-Up Offsite Staging Area | Lump Sum | \$ 125,000.00 | 1 | \$ 125,000 | \$ 116,825 | Gravel pad for handling of sediments |
| Moving Irvin | Event | \$ 4,371.00 | 2 | \$ 9,000 | \$ 8,411 | Tug and crew for two days of moving the Irvin |
| Relocation of Dock Tentant for One Season | Renter | \$ 2,400.00 | 48 | \$ 115,000 | \$ 107,479 | Average slip rental price for boats at Lakehead Marina |
| Sediment Controls at MN Slip | Lump Sum | \$ 30,300.00 | 1 | \$ 30,000 | \$ 28,038 | 2 turbidity curtains, boom, anchors, markers |
| Dredge Sediment from MN Slip | Cubic Yard | \$ 30.00 | 38,450 | \$ 1,154,000 | \$ 1,078,528 | Dredging of sediments from the Slip |
| Oversize Debris | Cubic Yard | \$ 52.75 | 1,923 | \$ 101,000 | \$ 94,395 | Stockpile, transportation, and disposal of oversize debris |
| Transport Sediment to Offsite Staging Area | Cubic Yard | \$ 13.40 | 40,180 | \$ 539,000 | \$ 503,749 | Tug, crew, and barges |
| Solidification in Hopper Barge | Cubic Yard | \$ 27.57 | 40,180 | \$ 1,108,000 | \$ 1,035,537 | Addition of solidification agent to bind free water |
| Sediment Unloading at Offsite Staging Area | Cubic Yard | \$ 10.72 | 46,207 | \$ 495,000 | \$ 462,627 | Crane, trucks, dozer, loader |
| MN Slip Cap Materials | Cubic Yard | \$ 25.41 | 4,800 | \$ 122,000 | \$ 114,021 | Off-Site cap materials delivered to staging area and transported to the Slip |
| Placement of 0.3m Cap | Cubic Yard | \$ 18.00 | 4,800 | \$ 86,000 | \$ 80,376 | 0.5-m layer of sandy material with fine grained organic material |
| Off-Site Disposal | Cubic Yard | \$ 26.43 | 41,701 | \$ 1,102,000 | \$ 1,029,929 | Off-Site transportation and disposal |
| Survey | Lump Sum | \$ 50,000 | 1 | \$ 50,000 | \$ 46,730 | Survey and drawings of the Slip and Former Hallett \#7 during project |
| Dock Wall Repair/Stabilization | Lump Sum | \$ 40,000 | 1 | \$ 40,000 | \$ 37,384 | Repair damage to dock walls and/or sink holes; stabilize dock |
|  |  |  | 25\% Contingency | \$ 1,297,000 | \$ 1,212,176 |  |
|  |  |  | SUBTOTAL | \$ 6,484,000 | \$ 6,059,900 |  |
| Engineering and Administration |  |  |  |  |  |  |
| Design \& Develop Contract Documents | Lump Sum | \$ 64,500 | 1 | \$ 64,500 | \$ 64,500 | Design sediment removal, \& cap placement |
| Dock Wall Inspection | Lump Sum | \$ 10,750 | 1 | \$ 10,750 | \$ 10,750 | Underwater inspection of the dock wall |
| Construction QA | Day | \$ 2,688 | 74 | \$ 198,875 | \$ 198,875 | QA during dredging, capping and mob/demob |
| Construction Report | Lump Sum | \$ 16,125 | 1 | \$ 16,125 | \$ 16,125 | Documentation of project |
|  |  |  | 25\% Contingency | \$ 73,000 | \$ 73,000 |  |
|  |  |  | SUBTOTAL | \$ 363,300 | \$ 363,300 |  |
| Operations and Maintenance |  |  |  |  |  |  |
| Chemical Monitoring/Reporting | Year | \$ 21,492 | 1 | \$ 21,000 | \$ 18,772 | One monitoring event |
|  |  |  |  | \$ 21,000 | \$ 18,772 |  |
|  |  |  | 25\% Contingency | \$ 5,000 | \$ 4,700 |  |
|  |  |  | SUBTOTAL | \$ 26,000 | \$ 23,500 |  |
|  |  |  | TOTAL | \$ 6,873,300 | \$ 6,446,700 |  |
| All values are based on 2014 dollars |  |  |  | Assumptions are based on professional judgment and experience of specialists at Bay West.The actual costs will be highly dependent upon final design, site access configuration, and assumptions related to Former Hallett \#7 |  |  |
|  |  |  |  | The actual costs will be highly dependent upon final design, site access configuration, and assumptions related to Former Hallett \#7 |  |  |
| **Assumed discount rate of 7\% per year; See Appendices for | *See Appendices for unit rate calculations |  |  |  |  |  |

## Table 3-4 Cost Estimate

## Alternative 4: Slip Leveling with 0.8-Meter Cap

Revised Focused Feasibility Study
Minnesota Slip
Minnesota Pollution Control Agency

| Description | Unit |  | imated Unit Cost* | Estimated Quantity | Extended Value | Present Value** | Comments |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Construction Costs |  |  |  |  |  |  |  |
| Mobilization/Demobilization | Lump Sum | \$ | 97,720.00 | 1 | \$ 98,000 | \$ 91,591 | Mobilization of dredge, barges, boats, and clamshell |
| Moving Irvin | Event | \$ | 4,371.00 | 2 | \$ 9,000 | \$ 8,411 | Tug and crew for two days of moving the Irvin |
| Dredge and Replace Sediment in Slip | Cubic Yard | \$ | 35.00 | 2,500 | \$ 88,000 | \$ 82,245 | Dredging and placement of sediments within the Slip |
| Sediment Controls at MN Slip | Lump Sum | \$ | 30,300.00 | 1 | \$ 30,000 | \$ 28,038 | Two turbidity curtains, boom, anchors, markers |
| MN Slip Cap Materials | Cubic Yard | \$ | 25.41 | 12,800 | \$ 325,000 | \$ 303,745 | Off-Site cap materials delivered to staging area and transported to the Slip |
| Placement of 0.8m Cap | Cubic Yard | \$ | 18.00 | 12,800 | \$ 230,000 | \$ 214,958 | 0.8-m layer of cap material placed in the slip |
| Dock Waller Repair/Stabilization | Lump Sum | \$ | 5,000 | 1 | \$ 5,000 | \$ 4,673 | Minimal repair damage to dock walls and/or sink holes |
| Survey | Lump Sum | \$ | 40,000 | 1 | \$ 40,000 | \$ 37,384 | Survey and drawings of the Slip |
|  |  |  |  | 25\% Contingency | \$ 206,000 | \$ 192,528 |  |
|  |  |  |  | SUBTOTAL | \$ 1,031,000 | \$ 963,600 |  |
| Engineering and Administration |  |  |  |  |  |  |  |
| Design \& Develop Contract Documents | Lump Sum | \$ | 48,375 | 1 | \$ 48,375 | \$ 48,375 | Design sediment removal, \& cap placement |
| Dock Wall Inspection | Lump Sum | \$ | 10,750 | 1 | \$ 10,750 | \$ 10,750 | Underwater inspection of the dock wall |
| Construction QA | Day | \$ | 2,688 | 22 | \$ 59,125 | \$ 59,125 | QA during dredging, capping and mob/demob |
| Construction Report | Lump Sum | \$ | 16,125 | 1 | \$ 16,125 | \$ 16,125 | Documentation of project |
|  |  |  |  | 25\% Contingency | \$ 34,000 | \$ 34,000 |  |
|  |  |  |  | SUBTOTAL | \$ 168,400 | \$ 168,400 |  |
| Operations and Maintenance |  |  |  |  |  |  |  |
| Physical Monitoring/Reporting | Year | \$ | 11,350 | 28 | \$ 318,000 | \$ 104,609 | Annual monitoring for 10 years then every 5th year for 90 years |
| Chemical Monitoring/Reporting | Year | \$ | 21,492 | 4 | \$ 86,000 | \$ 42,805 | Monitoring year 2, 5, and 10 plus 1 additional event in year 50 |
| Maintenance | Year | \$ | 53,750 | 13 | \$ 698,750 | \$ 200,075 | Cap repair for first 3 years and every 10th year for 100 years |
|  |  |  |  |  | \$ 1,102,750 | \$ 347,500 |  |
|  |  |  |  | 25\% Contingency | \$ 254,000 | \$ 86,900 |  |
|  |  |  |  | SUBTOTAL | \$ 1,356,750 | \$ 434,400 |  |
|  |  |  |  | TOTAL | \$ 2,556,150 | \$ 1,566,400 |  |
| Notes |  |  |  |  | Assumptions are based on professional judgment and experience of specialists at Bay West |  |  |
| All values are based on 2014 dollars *See Appendix D for unit rate calculations |  |  |  |  | The actual costs will be highly dependent upon final design, site access configuration, and assumptions related to staging area within Duluth Harbor. |  |  |
| **Assumed discount rate of 7\% per year; See Appendix D for present value calculations |  |  |  |  |  |


| Evaluation Criteria | Alternative 1: No Action | Alternative 2: Partial Dredging with 0.8-Meter Cap | Alternative 3: Total Dredging with 0.3-Meter Cover | Alternative 4:Slip Leveling with 0.8-Meter Cap |
| :---: | :---: | :---: | :---: | :---: |
| Threshold Criteria |  |  |  |  |
| Overall Protection of Human Health \& Environment | Provides a low achievement of protection of Human Health and the Environment as contaminant concentrations remain with no controls to prevent exposure. | Provides a high achievement of protection of Human Health and the Environment; however, approximately one half of the contaminated sediments would remain in place. | Provides a high achievement of protection of Human Health and the Environment. Only residual contaminated sediment would remain in place; however, it is anticipated that the residua contamination will not exceed the RAOs. | Provides a moderate achievement of protection of Human Health and the Environment; however, all contaminated sediments would remain in place. |
| ARARs | Provides a low achievement of ARARs since chemical-specific TBCs are not met for sediment. Location and action-specific ARAR s do not apply to this alternative. | Provides a high achievement of ARARs if implemented properly. Contaminants above the RAOs would remain in place. | Provides a high achievement of ARARs if implemented properly. All contaminants above the RAOs would be removed | Provides a moderate achievement of ARARs if implemented properly. Contaminants above the RAOs would remain in place. |
| Primary Balancing Criteria |  |  |  |  |
| Long-term Effectiveness and Permanence | Provides a low achievement of long-term effectiveness and remedy is not long-term effective or permanent. | Provides a low to moderate achievement of long-term effectiveness. Maintenance, monitoring, and possible replacement of the cap would be necessary as a majority of contaminants would remain in place under a 0.8 -meter cap. | Provides a moderate to high achievement of long-term effectiveness and permanence because it removes contaminated sediments from the aquatic environment. Contaminated sediments would be placed in a disposal facility requiring long-term O\&M. | Provides a low to moderate achievement of long-term effectiveness. Maintenance, monitoring, and possible replacement of the cap would be necessary as all contaminants would remain in place under a 0.8 -meter cap. |
| Reduction of Toxicity, Mobility or Volume through Treatment | Provides a low achievement of this criterion as no reduction in toxicity, mobility, or volume is provided. | Provides a moderate achievement of this criterion as approximately half of the contaminated sediments that exceed the RAOs would be removed from the aquatic environment and treated through stabilization. The remaining sediments would be immobilized under a 0.8-meter cap. | Provides a high achievement of this criterion by removing all contaminated sediments that exceed the RAOs in the aquatic environment. The removed sediments would be treated through stabilization. | Provides a low achievement of this criterion as all contaminated sediment that exceed the RAOs would be left in pace. The contaminated sediments would be immobilized under a 0.8-meter cap. |
| Short-term effectiveness | Provides a high achievement of this criterion as no actions are implemented, so no risks to the community or environment would result from remedy implementation. | Provides a moderate achievement of this criterion since it would take a shorter time than complete dredging, but much longer than only in-situ capping. | Provides a low achievement of this criterion since it would take longer to implement on-site dredging and would affect the aquatic habitat longer. Off-site disposal lowers the ectiveness due to a slight increase in short-term risks from truck traffic to an off-site landfill | Provides a high achievement of this criterion since it would take a shorter time to complete. |
| Implementability | Provides a high achievement of this criterion as no actions would be implemented. | Provides a moderate achievement of this criterion since it requires less dredging and less overall agency coordination; however, would required a moderate amount of staging coordination as it relies on the availability of the Former Hallett Dock \#7 and would be affected by the stability of the Slip walls. In addition, it is anticipated that oversized debris will be encountered. | Provides a low achievement of implementability since it requires a large amount of dredging and staging coordination as it relies on the availability of the Former Hallett Dock \#7. It also may be affected greated by the stability of the Slip walls. In addition, it is anticipated that oversized debris will be encountered. | Provides a high achievement of implementability since it requires minimal dredging and less overall agency coordination |
| Cost (1) | \$ 240,900 | 4,664,300 | 6,446,700 | 1,566,400 |
| Modify ${ }^{\text {a }}$ Criteria |  |  |  |  |
| State Support / Agency | ${ }^{\text {TBD }}$ | ${ }^{\text {TBD }}$ | TBD | TBD |
| Community Acceptance | BD | TBD | BD | TBD |
| Green Sustainable Remediation (GSR) Criteria* |  |  |  |  |
| Green House Gas (GHG) Emissions | No additional GHG emissions would be produced. | Total GHG emissions are limited to dredging activities, hauling by water to Former Hallet Dock \#7, and hauling wastes by land to landfill. | Total GHG emissions are limited to dredging activities, hauling by water to Former Hallet Dock \#7, and hauling wastes by land to landfill. More dredging and hauling generates more GHG emissions. | Least GHG emissions produced during capping (no dredging). |
| Toxic Chemical Usage and <br> Disposal | No toxic chemicals are used or disposed. | No toxic chemicals are used or disposed. | No toxic chemicals are used or disposed. | No toxic chemicals are used or disposed. |
| Energy Consumption | No energy consumption requirements. | Fossil fuels are required for dredging activities, hauling by water to Former Hallet Dock \#7, and hauling wastes by land to landfill. | Fossil fuels are required for dredging activities, hauling by water to Former Hallet Dock \#7, and hauling wastes by land to landfill. More dredging and hauling requires more fossil fuels. | Fossil fuels are limited to the minimal dredging and capping operations only. |
| Use of Alternative Fuels | Does not warrant the use of alternative fuels. | Alternative fuels could be used to run heavy construction equipment. | Alternative fuels could be used to run heavy construction equipment. | Alternative fuels could be used to run heavy construction equipment. |
| Water Consumption | No water consumption is necessary. | Little water consumption is necessary. | Little water consumption is necessary. | Little water consumption is necessary. |
| Waste Generation | No waste generation. | $18,000 \mathrm{yd}^{3}$ of sediment for disposal will be generated. | $36,750 \mathrm{yd}^{3}$ of sediment for disposal will be generated. | No waste generation. |
| GSR Criteria Summary | Provides a high achievement of the GSR criterion. | Provides a moderate achievement of the GSR criterion. | Provides a low achievement of the GSR criterion. | Provides a moderate to high achievement of the GSR criterion. |


| $\begin{array}{l}\text { (1) Cost are presented as Present Value. } \\ M=\text { Milion }\end{array}$ |
| :--- |

*Ne induded in numerical comarison on (Table 5-2)
$*$ Not included in numerical
$T B D=$ To Be Determined

Table 5-2 Numerical Comparison of Analysis of Alternatives
Revised Focused Feasibility Study
Minnesota Slip
Minnesota Pollution Control Agency

| Evaluation Criteria | Alternative 1: No Action | Alternative 2: Partial Dredging with 0.8-Meter Cap | Alternative 3: Total Dredging with 0.3-Meter Cover | Alternative 4:Slip Leveling with 0.8-Meter Cap |
| :---: | :---: | :---: | :---: | :---: |
| Overall Protection of Human Health \& Environment | 0.5 | 2.5 | 3 | 2 |
| ARARs | 0.5 | 3 | 3 | 2.5 |
| Long-term Effectiveness and Permanence | 1 | 2.5 | 3 | 2 |
| Reduction of Toxicity, Mobility or Volume through Treatment | 1 | 2.5 | 3 | 2 |
| Short-term effectiveness | 2 | 2 | 1.5 | 2.5 |
| Implementability | 3 | 2 | 1 | 3 |
| Cost (1) | 3 | 2 | 1 | 3 |
| State Support / Agency Acceptance | TBD | TBD | TBD | TBD |
| Community Acceptance | TBD | TBD | TBD | TBD |
| Total Numerical Value | 11 | 16.5 | 15.5 | 17 |

Notes
(1) Cost are presented as Present Value.

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.
GSR criteria not included in this numerical comparison.
See Table 6 for a discussion of each criterion.

Table 5-3 Volume Estimates for Treated Sediment
Revised Focused Feasibility Study
Minnesota Slip
Minnesota Pollution Control Agency

| Alternative | Dredged Volume | Disposal Volume* | Capping Volume |
| :---: | :---: | :---: | :---: |
| Alternative 1: No Action | 0 | 0 | 0 |
| Alternative 2: Partial Dredging with 0.8-Meter Cap | 18,000 | 23,674 | 12,800 |
| Alternative 3: Total Dredging with 0.3-Meter Cover | 36,750 | 46,207 | 4,800 |
| Alternative 4:Slip Leveling with 0.8-Meter Cap | 2,500 | 0 | 12,800 |

Notes.
All values in Cubic Yards
*Includes over excavation, fluffing factor and solidification agent. (See Appendix C and Table D-5 for details.)

Table 5-4 Estimated Time for Construction Completion
Revised Focused Feasibility Study
Minnesota Slip
Minnesota Pollution Control Agency

| Alternative | Dredging | Restoration/ <br> Capping | Total Time for On- <br> Site Construction <br> Completion |
| :--- | :---: | :---: | :---: |
|  | (Weeks) | (Weeks) | (Weeks) |
| Alternative 1: No Action | 0 | 0 | 0 |
| Alternative 2: Partial Dredging with 0.8 Meter Cap | 5.5 | 1.4 | 6.9 |
| Alternative 3: Total Dredging with 0.3 Meter Cover | 10.2 | 1 | 11.2 |
| Alternative 4: Slip Leveling with 0.8 Meter Cap | 1.0 | 1.4 | 2.4 |

Table 5-5 Summary of Cost Estimates for Alternatives
Revised Focused Feasibility Study
Minnesota Slip
Minnesota Pollution Control Agency

| Alternative | Present Value |
| :--- | :---: |
| Alternative 1: No Action | $\$ 240,900$ |
| Alternative 2: Partial Dredging with 0.8 Meter Cap | $\$ 4,664,300$ |
| Alternative 3: Total Dredging with 0.3 Meter Cover | $\$ 6,446,700$ |
| Alternative 4: Slip Leveling with 0.8 Meter Cap | $\$ 1,566,400$ |

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

## Appendix A

## Historical Documentation

A1: Various analytical result tables and figures
A2: Detailed Investigation of the Minnesota Slip, MPCA Duluth, MN. Streitz, A., Johnson, S., 2005. (on attached DVD)

Table A1: Copy of Table 2 from "Sediment Remediation Scoping Project in Minnesota Slip, Duluth Harbor" Crane et al., 2002.

Table 2. Ranges of Contaminant Concentrations in Minnesota Slip (Schubauer-Berigan and Crane 1997; Crane et al. 1997; unpublished R-EMAP and MPCA data)

| Contaminant | Concentration* |
| :--- | :--- |
|  |  |
| Total PAHs | $5.7-320 \mathrm{mg} / \mathrm{kg}$ |
| PCBs | $7.8-612 \mu \mathrm{~kg}$ |
| Mercury | $0.075-1.6 \mathrm{mg} / \mathrm{kg}$ |
| Lead | $31-280 \mathrm{mg} / \mathrm{kg}$ |
| Cadmium | $2.6 \mathrm{mg} / \mathrm{kg}$ |
| Chromium | $49.8 \mathrm{mg} / \mathrm{kg}$ |
| Copper | $83.2 \mathrm{mg} / \mathrm{kg}$ |
| Nickel | $30.7 \mathrm{mg} / \mathrm{kg}$ |
| Zinc | $214 \mathrm{mg} / \mathrm{kg}$ |
| AVS | $1.43-1.54 \mu \mathrm{~mol} / \mathrm{g}$ |
| SEM** | $5.36-7.59 \mu \mathrm{~mol} / \mathrm{g}$ |
| Toxaphene | $147-204 \mu \mathrm{~g} / \mathrm{kg}$ |
| p,p'-DDD \& o,p'-DDT | $10 \mu \mathrm{gg} / \mathrm{kg}$ |
| KCI-extractable ammonia | $10.2-138 \mathrm{mg} / \mathrm{kg}$ |
|  |  |
| Other Parameters |  |
| TOC | $0.67-8.3 \%$ |
| Particle Size |  |
| Sand | $48.2-96.9 \%$ |
| Silt | $2.0-40 \%$ |

* Single values represent one measurement.
** Includes cadmium, copper, lead, nickel, and zinc.

Table A2: Copy of Table 6 from "Sediment Remediation Scoping Project in Minnesota Slip, Duluth Harbor" Crane et al., 2002.

| Table 6. Results of the 10-d C. tentans Sediment Toxicity Tests on Surficial Sediments $(0-5 \mathrm{~cm})$ from Minnesota Slip |  |  |  |
| :---: | :---: | :---: | :---: |
| Treatment | Mean Survival $\%( \pm \text { SD })^{\mathrm{a}}$ | Mean Dry Weight Surviving Organism (mg; $\pm$ SD $)^{b, c}$ | Mean AFDW Per Surviving Organism (mg; $\pm$ SD $)^{\text {sd }}$ |
| Control | $71.4 \pm 23.4$ | $2.844( \pm 0.503)$ | $1.908( \pm 0.402)$ |
| MNS-99-01 | $95.0 \pm 5.3$ | $2.525( \pm 0.523)$ | $1.925( \pm 0.460)$ |
| MNS-99-02 | $89.4 \pm 8.6$ | $2.448( \pm 0.457)$ | $1.765( \pm 0.348)$ |
| MNS-99-03 | $82.5 \pm 14.9$ | $2.424( \pm 0.240)$ | $1.711( \pm 0.161)$ |
| MNS-99-04 | $82.9 \pm 13.8$ | $2.970( \pm 0.421)$ | $2.208( \pm 0.319)$ |
| MNS-99-05 | $81.4 \pm 9.0$ | $2.559( \pm 0.542)$ | $1.819( \pm 0.411)$ |
| MNS-99-06 | $81.4 \pm 13.5$ | $2.769( \pm 0.423)$ | $2.180( \pm 0.360)$ |
| ${ }^{2}$ Comparison of treatment survival to the control was completed by observation since control survival was less than in any of the treatments. <br> ${ }^{b}$ dried at $81^{\circ} \mathrm{C}$ for $>24$ hours <br> ${ }^{\circ}$ Dry weight and mean AFDW in the test treatments were not significantly reduced relative to the control. <br> ${ }^{d}$ ashed at $550 \pm 50^{\circ} \mathrm{C}$ for 2 hours |  |  |  |
| $\mathrm{SD}=$ standard deviation AFDW $=$ ash free dry weight |  |  |  |

Table A3: Copy of Table 7 from "Sediment Remediation Scoping Project in Minnesota Slip, Duluth Harbor" Crane et al., 2002.

Table 7. Mean Percentage Survival Results of the 28- to 42-d H. azteca Sediment Toxicity Tests on Surficial Sediments $(0-5 \mathrm{~cm})$ from Minnesota Slip

| Treatment | $\begin{aligned} & \text { 28-d Mean \% Survival } \\ & ( \pm \mathrm{SD})^{\mathrm{a}} \\ & \hline \end{aligned}$ | $\begin{aligned} & \text { 35-d Mean \% Survival } \\ & ( \pm \mathrm{SD})^{\mathrm{a}} \end{aligned}$ | $\begin{aligned} & \text { 42-d Mean \% Survival } \\ & ( \pm \mathrm{SD})^{\mathrm{a}} \\ & \hline \end{aligned}$ |
| :---: | :---: | :---: | :---: |
| Control 1 | $84.2( \pm 15.6)$ | $80.0( \pm 20.0)$ | $77.5( \pm 18.3)$ |
| Control 2 | $85.0( \pm 12.4)$ | $83.7( \pm 14.1)$ | $83.7( \pm 14.1)$ |
| Control 3 | $88.3( \pm 20.4)$ | $93.8( \pm 7.4)$ | $91.3 \pm$ (8.3) |
| Combined Controls 1-3 ${ }^{\text {b }}$ | $85.8( \pm 16.1)$ | $85.8( \pm 15.3)$ | $84.2( \pm 14.7)$ |
| MNS-99-01 | $93.3( \pm 8.9)$ | $92.5( \pm 8.9)$ | $90.0( \pm 7.6)$ |
| MNS-99-02 | $85.8( \pm 10.0)$ | $80.0( \pm 12.0)$ | $80.0( \pm 12.0)$ |
| MNS-99-03 ${ }^{\text {c }}$ | $19.2( \pm 18.3)$ | $13.8( \pm 13.0)$ | $13.8( \pm 13.0)$ |
| Control $4^{\text {d }}$ | $77.5( \pm 16.6)$ | $65.0( \pm 30.7)$ | $63.8( \pm 29.2)$ |
| Control $5^{\text {d }}$ | $70.0( \pm 16.5)$ | $66.2( \pm 22.6)$ | $65.0( \pm 21.4)$ |
| Control 6 | $80.8( \pm 17.8)$ | $78.7( \pm 18.1)$ | $75.0( \pm 17.7)$ |
| MNS-99-04 | $69.2( \pm 16.8)$ | $72.5( \pm 18.3)$ | $71.3( \pm 17.3)$ |
| MNS-99-05 ${ }^{\text {c }}$ | $24.2( \pm 21.5)$ | $25.0( \pm 22.7)$ | $25.0( \pm 22.7)$ |
| MNS-99-06 | $75.0( \pm 15.7)$ | $77.5( \pm 7.1)$ | $77.5( \pm 7.1)$ |

${ }^{2}$ Day 28 mean survival is based on all 12 replicates; Days 35 and 42 survival are based on the remaining eight replicates.
${ }^{\text {b }}$ The Combined Controls 1-3 was used for statistical comparison to MNS-99-01, MNS-99-02, and MNS-99-03.
ع Survival in MNS-99-03 and MNS-99-05 was significantly lower than in the respective controls at $\alpha=0.05$.
${ }^{d}$ Controls 4 and 5 had less than $80 \%$ survival on day 28 , and were therefore unacceptable. Only Control 6 was used for statistical comparison to MNS-99-04, MNS-99-05, and MNS-99-06.
$\mathrm{SD}=$ standard deviation

Table A4: Copy of Table 8 from "Sediment Remediation Scoping Project in Minnesota Slip, Duluth Harbor" Crane et al., 2002.

Table 8. Mean Dry Weight Results of the 28- to 42-d H. azteca Sediment Toxicity Tests on Surficial Sediments ( $0-5 \mathrm{~cm}$ ) from Minnesota Slip

| Treatment | $\begin{gathered} \text { 28-d Mean Dry Weight (mg) } \\ ( \pm \mathrm{SD}) \end{gathered}$ | $\begin{aligned} & \text { 42-d Mean Dry Weight (mg) } \\ & ( \pm \mathrm{SD}) \end{aligned}$ |
| :---: | :---: | :---: |
| Control 1 | $0.285( \pm 0.062)$ | $0.300( \pm 0.048)$ |
| Control 2 | $0.332( \pm 0.080)$ | $0.296( \pm 0.026)$ |
| Control 3 | $0.318( \pm 0.034)$ | $0.312( \pm 0.40)$ |
| $\begin{aligned} & \text { Combined } \\ & \text { Controls } 1-3^{z} \end{aligned}$ | $0.312( \pm 0.060)$ | $0.303( \pm 0.038)$ |
| MNS-99-01 | $0.298( \pm 0.053)$ | $0.322( \pm 0.087)$ |
| MNS-99-02 | $0.456( \pm 0.226)$ | $0.365( \pm 0.034)$ |
| MNS-99-03 | $0.443( \pm 0.097)$ | $0.392( \pm 0.131)$ |
| Control 4 | $0.364( \pm 0.087)$ | $0.374( \pm 0.077)$ |
| Control 5 | $0.440( \pm 0.262)$ | $0.320( \pm 0.044)$ |
| Control $6^{\text {b }}$ | $0.364( \pm 0.071)$ | $0.316( \pm 0.087)$ |
| MNS-99-04 | $0.527( \pm 0.192)$ | $0.516( \pm 0.079)$ |
| MNS-99-05 | $0.572( \pm 0.332)$ | $0.537( \pm 0.086)$ |
| MNS-99-06 | $0.419( \pm 0.187)$ | $0.536( \pm 0.030)$ |

${ }^{2}$ The Combined Controls $1-3$ were used for statistical comparison to MNS-99-01, MNS-99-02, and MNS-99-03.
${ }^{\mathrm{b}}$ Controls 4 and 5 had less than $80 \%$ survival on day 28 , and were therefore unacceptable. Only Control 6 was used for statistical comparison to MNS-99-04, MNS-99-05, and MNS-99-06.
$\mathrm{SD}=$ standard deviation

Table A5: Copy of Table 9 from "Sediment Remediation Scoping Project in Minnesota Slip, Duluth Harbor" Crane et al., 2002.

Table 9. Mean Reproduction Results of the 42-d H. azteca Sediment Toxicity Tests on Surficial Sediments ( $0-5 \mathrm{~cm}$ ) from Minnesota Slip

| Treatment | Total Number of Females Alive at Test Termination | Mean Reproduction (young/surviving female) ( $\pm$ SD) |
| :---: | :---: | :---: |
| Control 1 | 31 | 1.16 ( $\pm 0.70)$ |
| Control 2 | 40 | $1.50( \pm 1.66)$ |
| Control 3 | 42 | $2.11( \pm 1.43)$ |
| $\begin{gathered} \text { Combined } \\ \text { Controls } 1-3^{a} \end{gathered}$ | 113 | $1.59( \pm 1.33)$ |
| MNS-99-01 | 41 | $2.32( \pm 1.30)$ |
| MNS-99-02 | 36 | 2.55 ( $\pm 1.11$ ) |
| MNS-99-03 | 7 | $0.42( \pm 0.80)$ |
| Control 4 | 19 | 2.77 ( $\pm 2.61$ ) |
| Control 5 | 31 | 1.65 ( $\pm 1.65$ ) |
| Control $6^{\text {b }}$ | 38 | $0.80( \pm 1.02)$ |
| MNS-99-04 | 28 | $2.27( \pm 1.86)$ |
| MNS-99-05 | 13 | $1.30( \pm 1.99)$ |
| MNS-99-06 | 34 | $3.73( \pm 2.76)$ |

${ }^{2}$ The Combined Controls $1-3$ were used for statistical comparison to MNS-99-01, MNS-99-02, and MNS-99-03.
${ }^{b}$ Controls 4 and 5 had less than $80 \%$ survival on day 28 , and were therefore unacceptable. Only Control 6 was used for statistical comparison to MNS-99-04, MNS-99-05, and MNS-99-06.
$\mathrm{SD}=$ standard deviation

Table A6: Copy of Table 11 from "Sediment Remediation Scoping Project in Minnesota Slip, Duluth Harbor" Crane et al., 2002.

| Table 11. Sediment Quality Data for Surficial ( $0-5 \mathrm{~cm}$ ) Sediments Collected from MNS-99-01 through MNS-99-06. Values in Bold Itallic Exceed the Corresponding Level I SQT Value |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Core |  | Ammonia <br> Nitrogen (mg/kg dry wt.) | Total Metals (mg/kg dry wt.) |  |  |  |  |  |  |  |
| Location | (cm) | (\%) |  | Cadmium* | Chromium | Copper | Lead | Mercury | Nickel | Selenium | Zinc |
| MNS-99-01 | 0-5 | 4.8 | 68 | 2.5 | 43 | 72 | 110 | 0.25 | 32 | 0.15 | 270 |
| MNS-99-02 | 0-5 | 4.8 | 71.4 | 2.5 | 51 | 92 | 120 | 0.25 | 38 | 0.05 | 350 |
| MNS-99-03 | 0-5 | 4.8 | 70.4 | 2.5 | 42 | 94 | 100 | 0.14 | 31 | 0.05 | 300 |
| MNS-99-04 | 0-5 | 3.6 | 32.7 | 2.5 | 28 | 47 | 62 | 0.07 | 21 | 0.05 | 170 |
| MNS-99-05 | 0-5 | 5.4 | 62.9 | 2.5 | 45 | 99 | 110 | 0.16 | 33 | 0.05 | 320 |
| MNS-99-06 | 0-5 | 0.71 | 7.77 | 2.5 | 19 | 22 | 10 | 0.016 | 19 | 0.05 | 85 |
| Level I SQT |  |  |  | 0.99 | 43 | 32 | 36 | 0.18 | 23 |  | 120 |
| Level II SQT |  |  |  | 5 | 110 | 150 | 130 | 1.1 | 49 |  | 460 |

TOC $=$ total organic carbon
SQT = sediment quality target (Crane et al. 2000)

* Cadmium concentrations represent one-half the reporting level specified by the Minnesota Department of Health. The interpretation of these values, in reference to the corresponding Level I SQT value, should be made with caution.

Table 11. Continued

| Site <br> Location | Core <br> Section (cm) | $\begin{gathered} \text { T. PCBs } \\ (\mu \mathrm{g} / \mathrm{kg}) \\ (\text { dry wt. }) \\ \hline \end{gathered}$ |  | SEM (mg/kg dry wt.) |  |  |  |  |  | TotalSEM( $\mu \mathrm{mole} / \mathrm{g}$ )(dry wt.) | Total <br> SEM - AVS <br> ( $\mu \mathrm{mole} / \mathrm{g}$ ) <br> (dry wt.) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | AVS $(\mu \mathrm{mole} / \mathrm{g}$ dry wt.) | Cadmium | Copper | Lead | Mercury | Nickel | Zinc |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
| MNS-99-01 | 0-5 | 187 | 5.15 | 1.1 | 49 | 126 | 0.027 | 9.3 | 206 | 4.71 | -0.44 |
| MNS-99-02 | 0-5 | 123 | 1.72 | 0.81 | 42 | 109 | 0.019 | 7.2 | 176 | 4.02 | 2.3 |
| MNS-99-03* | 0-5 | 186 | 2.30 | 1.45 | 99 | 168 | 0.036 | 14 | 346 | 7.91 | 5.6 |
| MNS-99-04 | 0-5 | 63.4 | 1.03 | 0.32 | 44 | 54 | 0.02 | 6.6 | 121 | 2.92 | 1.9 |
| MNS-99-05 | 0-5 | 183 | 2.06 | 1.4 | 102 | 181 | 0.039 | 15 | 375 | 8.47 | 6.4 |
| MNS-99-06 | 0-5 | 29.9 | 0.245 | 0.21 | 15 | 16 | 0.008 | 102 | 56 | 2.92 | 2.7 |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Level I SQT |  | 60 |  |  |  |  |  |  |  |  |  |
| Level II SQT |  | 680 |  |  |  |  |  |  |  |  |  |

*average of analytical duplicates for AVS and SEM
AVS $=$ acid volatile sulfide
SEM = simultaneously extractable metals
SQT $=$ sediment quality target (Crane et al. 2000)

Table A7: Copy of Table 14 from "Sediment Remediation Scoping Project in Minnesota Slip, Duluth Harbor" Crane et al., 2002.

Table 14. Summary of LMW, HMW, and Total PAHs (Based on a Subset of 13 PAH Compounds) for Sediment Samples Collected from Minnesota Slip. Total PAH Concentrations in Bold Italics Exceed the Level I SQT, Whereas Shaded Values Exceed the Level II SQT

| Site <br> Location | Core <br> Section (cm) | Total LMW PAHs ( $\mathrm{mg} / \mathrm{kg}$ dry wt .) | Total HMW PAHs ( $\mathrm{mg} / \mathrm{kg}$ dry wt.) | Total PAHs (13) (mg/kg dry wt.) |
| :---: | :---: | :---: | :---: | :---: |
| 98-MNS-02 | 0-5 | 9.51 | 43.6 | 53.1 |
| 98-MNS-03 | 0-5 | 7.40 | 33.8 | 41.2 |
| 98-MNS-04 | 0-5 | 5.45 | 19.1 | 24.5 |
| MNS-99-01 | 0-5 | 6.38 | 23.6 | 30.0 |
| MNS-99-02* | 0-5 | 4.95 | 22.0 | 27.0 |
| MNS-99-03 | 0-5 | 5.92 | 22.9 | 28.8 |
| MNS-99-04 | 0-5 | 19.7 | 41.2 | 60.9 |
| MNS-99-05 | 0-5 | 6.13 | 24.3 | 30.4 |
| MNS-99-06 | 0-5 | 12.0 | 33.6 | 45.6 |
| 98-MNS-02 | 0-15 | 8.42 | 40.7 | 49.1 |
| MNS-99-01 | 0-15 | 5.33 | 20.1 | 25.4 |
| MNS-99-02 | 0-15 | 7.55 | 28.7 | 36.3 |
| MNS-99-03* | 0-15 | 8.88 | 30.9 | 39.7 |
| MNS-99-04* | 0-15 | 16.5 | 45.7 | 62.2 |
| MNS-99-04R | 0-15 | 11.3 | 37.3 | 48.6 |
| mean (04 \& 04R) | 0-15 | 13.9 | 41.5 | 55.4 |
| RPD (04 \& 04R) | 0-15 | 37.1\% | 20.2 \% | 24.5\% |
| MNS-99-07 | 0-15 | 3.16 | 10.6 | 13.8 |
| MNS-99-08 | 0-15 | 7.83 | 28.1 | 36.0 |
| MNS-99-09 | 0-15 | 3.23 | 12.8 | 16.0 |
| MNS-99-10 | 0-15 | 8.99 | 26.9 | 35.9 |
| MNS-99-11 | 0-15 | 1.95 | 5.12 | 7.07 |
| MNS-99-12 | 0-15 | 14.2 | 44.9 | 59.1 |
| MNS-99-13 | 0-15 | 10.9 | 37.3 | 48.2 |
| MNS-99-13R | 0-15 | 10.3 | 35.2 | 45.5 |
| mean (13 \& 13R) | 0-15 | 10.6 | 36.3 | 46.8 |
| RPD (13 \& 13R) | 0-15 | 5.3 \% | $5.8 \%$ | $5.7 \%$ |
| MNS-99-14 | 0-15 | 7.10 | 26.2 | 33.3 |
| MNS-99-15* | 0-15 | 8.01 | 31.2 | 39.2 |
| MNS-99-16 | 0-15 | 8 | 22.3 | 30.3 |
| MNS-99-17* | 0-15 | 8.24 | 31.1 | 39.4 |
| MNS-99-18 | 0-15 | 6.81 | 27.5 | 34.3 |
|  |  |  |  |  |
| 98-MNS-02 | 15-30 | 7.35 | 29.4 | 36.7 |
| 98-MNS-03 | 15-30 | 10.3 | 37.7 | 48.0 |
| MNS-99-01 | 15-30 | 8.87 | 32.2 | 41.1 |

Table 14. Continued

| Site <br> Location | Core <br> Section (cm) | $\begin{gathered} \text { Total } \\ \text { LMW PAHs } \\ \text { (mg/kg dry wt.) } \end{gathered}$ | HMW PAHs ( $\mathrm{mg} / \mathrm{kg}$ dry wt.) | Total PAHs (13) (mg/kg dry wt.) |
| :---: | :---: | :---: | :---: | :---: |
| MNS-99-02 | 15-28 | 9.01 | 20.8 | 29.8 |
| MNS-99-03 | 15-30 | 9.69 | 31.8 | 41.5 |
| MNS-99-04 | 15-30 | 6.86 | 26.2 | 33.0 |
| MNS-99-04R | 15-30 | 7.81 | 25.3 | 33.1 |
| mean (04 \& 04R) | 15-30 | 7.33 | 25.7 | 33.1 |
| RPD (04 \& 04R) | 15-30 | 13.0\% | 3.4 \% | 0.2 \% |
| MNS-99-07 | 15-30 | 13.7 | 40.0 | 53.7 |
| MNS-99-08* | 15-30 | 15.7 | 41.1 | 56.8 |
| MNS-99-09 | 15-30 | 4.81 | 13.4 | 18.2 |
| MNS-99-10 | 15-30 | 9.73 | 37.4 | 47.1 |
| MNS-99-11* | 15-30 | 1.93 | 5.93 | 7.86 |
| MNS-99-12 | 15-30 | 11.7 | 32.3 | 44.0 |
| MNS-99-13 | 15-30 | 11.2 | 38.8 | 50.0 |
| MNS-99-13R | 15-30 | 59.3 | 96.9 | 156 |
| mean (13 \& 13R) | 15-30 | 35.2 | 67.9 | 103 |
| RPD (13 \& 13R)) | 15-30 | 136\% | 85.6\% | 103\% |
| MNS-99-14 | 15-30 | 10.3 | 39.7 | 50.0 |
| MNS-99-15 | 15-30 | 9.67 | 29.1 | 38.8 |
| MNS-99-16 | 15-30 | 8.89 | 24.4 | 33.3 |
| MNS-99-17 | 15-30 | 10.8 | 37.7 | 48.5 |
| MNS-99-18 | 15-30 | 6.75 | 27.3 | 34.0 |
|  |  |  |  |  |
| 98-MNS-02 | 30-45 | 41.7 | 85 | 127 |
| 98-MNS-03 | 30-45 | 11.2 | 38.4 | 49.6 |
| MNS-99-03 | 30-45 | 12.4 | 37.1 | 49.5 |
| MNS-99-04 | 30-45 | 13.0 | 46.5 | 59.5 |
| MNS-99-04R | 30-45 | 7.42 | 27.4 | 34.9 |
| mean (04 \& 04R) | 30-45 | 10.2 | 37.0 | 47.2 |
| RPD (04 \& 04R) | 30-45 | 55.0\% | 51.6 \% | 52.3 \% |
| MNS-99-08 | 30-45 | 12.0 | 40.5 | 52.5 |
| MNS-99-09 | 30-45 | 10.2 | 22.9 | 33.1 |
| MNS-99-13 | 30-45 | 14.6 | 33.0 | 47.6 |
| MNS-99-14 | 30-45 | 221 | 343 | 564 |
| MNS-99-15 | 30-45 | 12.7 | 38.6 | 51.3 |
| MNS-99-17 | 30-45 | 10.6 | 39.2 | 49.8 |
|  |  |  |  |  |
| MNS-99-03 | 45-60 | 17.9 | 60.2 | 78.1 |
| MNS-99-04 | 45-60 | 129 | 209 | 337 |
| MNS-99-04R | 45-60 | 172 | 280 | 452 |
| mean (04 \& 04R) | 45-60 | 150 | 244 | 395 |
| RPD (04 \& 04R) | 45-60 | 28.8\% | 29.3\% | 29.1\% |

Table 14. Continued

| Site <br> Location | Core <br> Section (cm) | Total LMW PAHs (mg/kg dry wt.) | Total HMW PAHs (mg/kg dry wt.) | Total PAHs (13) ( $\mathrm{mg} / \mathrm{kg}$ dry wt .) |
| :---: | :---: | :---: | :---: | :---: |
| MNS-99-13* | 45-60 | 17.4 | 37.6 | 55.1 |
| MNS-99-14 | 45-60 | 7.69 | 22.5 | 30.2 |
| MNS-99-15 | 45-60 | 21.0 | 68.7 | 89.7 |
| MNS-99-17 | 45-60 | 17.7 | 62.2 | 79.9 |
| MNS-99-03 | 60-75 | 15.5 | 51.6 | 67.1 |
| MNS-99-04 | 60-75 | 453 | 606 | 1059 |
| MNS-99-15 | $60-75$ | 26.6 | 88.3 | 115 |
| MNS-99-17 | 60-75 | 32.8 | 87.6 | 120 |
| MNS-99-03 | 75-90 | 10.4 | 34.4 | 44.8 |
| MNS-99-04 | 75-90 | 470 | 718 | 1188 |
| MNS-99-15 | 75-90 | 16.6 | 57.3 | 73.9 |
| MNS-99-17 | 75-90 | 38.8 | 93.4 | 132 |
| MNS-99-03 | 90-120 | 15.1 | 42.3 | 57.4 |
| MNS-99-04* | 90-120 | 268 | 422 | 691 |
| MNS-99-15 | 90-120 | 35.5 | 75.8 | 111 |
| MNS-99-17 | 90-120 | 26.6 | 68 | 94.6 |
| MNS-99-03 | 120-140 | 41.6 | 72.2 | 114 |
| MNS-99-04 | 120-150 | 90.7 | 166 | 256 |
| MNS-99-15 | 120-150 | 25.4 | 68.7 | 94.1 |
|  |  |  |  |  |
| MNS-99-15 | 150-180 | 125 | 243 | 368 |
| MNS-99-15 | 180-210 | 44.6 | 123 | 168 |
|  |  |  |  |  |
| Level I SQT |  |  |  | 1.6 |
| Level II SQT |  |  |  | 23 |

* average of analytical duplicates
$R=$ field replicate sample
$R P D=$ relative percent difference
SQT $=$ sediment quality target (Crane et al. 2000)
Low Molecular Weight (LMW) PAHs = Sum of 2-Methylnaphthalene, Acenapthene, Acenapthylene,
Anthracene, Fluorene, Napthalene, and Phenanthrene
High Molecular Weight (HMW) PAHs = Sum of Benz[a]anthracene, Benzo[a]pyrene, Chrysene,
Dibenzo[a,h,]anthracene, Fluoranthene, and Pyrene
Total PAHs = the sum of the 13 PAH compounds comprising the LMW and HMW PAHs

Table A8: Copy of Table 18 from "Sediment Remediation Scoping Project in Minnesota Slip, Duluth Harbor" Crane et al., 2002.

Table 18. Summary of Sediment Toxicity Test Results, Compared to the Test Control, and Mean PEC-Q Values for Surficial Sediments Collected from Minnesota Slip

| Site Location | Core Section (cm) | Mean PEC-Q* | 10-day C. tentans Tests |  | 28-42 day H. azteca Tests |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Survival | Growth | Survival | Growth | Reproduction |
| MNS-99-01 | 0-5 | 0.72 | NT | NT | NT | NT | NT |
| MNS-99-02 | 0-5 | 0.68 | NT | NT | NT | NT | NT |
| MNS-99-03 | 0-5 | 0.71 | NT | NT | T | -- | -- |
| MNS-99-04 | 0-5 | 1.1 | NT | NT | NT | NT | NT |
| MNS-99-05 | 0-5 | 0.75 | NT** | NT | T | -- | -- |
| MNS-99-06 | 0-5 | 0.76 | NT | NT | NT | NT | NT |

* for each sample, the only contaminant of concern to exceed its corresponding PEC value was total PAHs.
**survival in MNS-99-05 was significantly reduced when compared to MNS-99-01.
$\mathrm{NT}=$ not toxic
$\mathrm{T}=$ toxic at $\alpha=0.05$

Table A9 Copy of Table A3 from "Detailed Investigation of the Minnesota Slip, Duluth Minnesota" Streitz and Johnson, 2005.
TABLE A 1: Metals Concentrations
Laboratory Results- Metals
MN Slip- West Central Environmental Consultants

| Sample Location | Sample Name | $\begin{aligned} & \text { DRO } \\ & (\mathrm{ppm}) \end{aligned}$ | Arsenic (ppm) | $\begin{gathered} \text { Barium } \\ (\mathrm{ppm}) \end{gathered}$ | $\begin{aligned} & \text { Boron } \\ & (\mathrm{ppm}) \end{aligned}$ | $\begin{gathered} \text { Cadmium } \\ (\mathrm{ppm}) \end{gathered}$ | $\underset{(p p m)}{C h}$ | Lead (ppm) | Mercury (ppm) | Silver (ppm) | $\begin{aligned} & \text { Zinc } \\ & (\mathrm{ppm}) \end{aligned}$ | Total Solids (\%) | Selenium (ppm) | $\begin{aligned} & \text { TOC } \\ & \text { (ppm) } \end{aligned}$ | $\begin{aligned} & \text { PCB } \\ & (\mathrm{ppm}) \\ & \hline \end{aligned}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | WC-TH3 (8' heave) | 130* | 5** | 92 | <50 | <2 | 22.4 | 459 | 0.6 | <4 | 478 | 43 | 1.7** | 42500 | <0.04\# |
| 3 | WC-TH3 (6-7') | 26* | $1.2^{* *}$ | 13.1 | <25 | <2 | 3.6 | 47 | <0.2 | <4 | 73.5 | 80 | $<0.4 * *$ | <2000 | <0.04\# |
|  | WC-TH10 (1-3') | 11* | 1.5** | 24.9 | <50 | <2 | 11.2 | 87.9 | <0.2 | <4 | 83.2 | 87 | $<0.4{ }^{* *}$ | 10900 | <0.04\# |
| 10 | WC-TH10 (6-8') | <10 | $0.6 * *$ | 6.3 | 25 | <2 | 2.1 | <7 | <0.2 | <4 | 7.8 | 81 | $<0.4 * *$ | <2000 | <0.04\# |
|  | WC-TH14 (2-4') | 57* | 1.7** | 49.2 | <25 | <2 | 10.8 | 90.6 | 0.3 | <4 | 110 | 72 | $<0.4{ }^{* *}$ | 15700 | <0.04\# |
|  | WC-TH14 (6-8') | 160* | 1** | 10.4 | <25 | <2 | 5 | 8.2 | <0.2 | <4 | 14 | 70 | $<0.5^{* *}$ | 3770 | <0.04\# |
| 14 | WC-TH14 (10-12') | <10 | 0.9** | 13.6 | <25 | <2 | 5.6 | 10.3 | $<0.2$ | <4 | 17.4 | 80 | $<0.4 * *$ | 9130 | <0.04\# |
|  | WC-TH18 (0-4') | 31* | 3.2 ** | 145 | <75 | 3.6 | 40.8 | 320 | 0.4 | <4 | 0.4 | 56 | $<0.4{ }^{\star *}$ | 16800 | <0.04\# |
| 18 | WC-TH18 (4-8') | 58* | 3.8 | 150 | <50 | <2 | 25.2 | 220 | 3.3 | <4 | 366 | 63 | $0.5{ }^{\wedge}$ | 36400 | <0.04\# |
| 23 | WC-TH23 (4-8') | 230* | 4.3 | 162 | <50 | 2.5 | 26.9 | 544 | 1.6 | <4 | 559 | 56 | $0.4 \wedge$ | 49900 | <0.04\# |
|  | WC-TH27 (3-5') | 17* | 1.5 | 33.8 | <50 | <2 | 22 | 67.2 | <0.2 | <4 | 94.7 | 72 | $<0.2$ | 4960 | <0.04\# |
| 27 | WC-TH27 (6-7') | $<10^{*}$ | 0.8 | 13 | <25 | <2 | 4.8 | <7 | <0.2 | <4 | 11.8 | 67 | $<0.2$ ^ | 17500 | <0.04\# |
|  | WC-TH28 (5' heave) | 210* | 1.8 | 62.1 | <25 | <2 | 8.8 | 108 | 0.4 | <4 | 105 | 68 | 0.3 ^ | 40300 | <0.04\# |
|  | WC-TH28 (6-9')! | 46* | 1 | 53.4 | <25 | <2 | 7.1 | 66.2 | <0.2 | <4 | 76.1 | 79 | $<0.2$ ^ | 2860 | <0.04\# |
| 28 | WC-TH49 (6-9')! | 48* | 1.4 | 40.8 | <25 | <2 | 6.14 | 52.5 | 0.2 | <4 | 59.3 | 79 | $<0.2$ ^ | 4420 | <0.04\# |
|  | WC-TH29 (6-8') | 10* | 0.7 | 20 | <25 | <2 | 4.8 | 22 | <0.2 | $<4$ | 49.2 | 77 | $<0.2$ ^ | <2000 | <0.04\# |
|  | WC-TH29 (9' heave) | $<10$ | 0.8 | 9.5 | <25 | <2 | 3.6 | $<7$ | <0.2 | <4 | 14 | 80 | $<0.2^{\wedge}$ | <2000 | <0.04\# |
| 29 | WC-TH29 (11') | <10 | 0.6 | 6.69 | <25 | <2 | 4.5 | <7 | <0.2 | <4 | 15.2 | 79 | $<0.2$ ^ | <2000 | <0.04\# |
| Waste | WC-Comp.Waste | <10 | 1.2 \$ | 21.7 | <15 | <2.5 | 5.3 | 22 | $<0.2$ | <2.5 | 40.1 | 76 | <0.3 | 3300 | <0.04\# |
|  | Level 1 SQT |  | 9.8 |  |  | 0.99 | 43 | 36 | 0.18 |  | 120 |  |  |  | 0.060 |
|  | Level II SQT |  | 33 |  |  | 5.0 | 110 | 130 | 1.1 |  | 460 |  |  |  | 0.680 |

[^0]** Matrix spike not within control limits selenium-69\%, arsenic-63\%
! Duplicate Samples
\# PCBs were not detected in any of the samples. The laboratory's reporting limit varied between 0.02 and 0.04 ppm for the various PCBs.
Please refer to the laboratory report for exact reporting limit values.
$\$$ Arsenic was detected in the method blank at 0.0021 ppm
All analytical results presented as dry weight concentrations

Table A10: Copy of Table A4 from "Detailed Investigation of the Minnesota Slip, Duluth Minnesota" Streitz and Johnson, 2005.

| TABLE A 4: PAH Concentrations <br> Laboratory Results- PAH - MN Slip- West Central Environmental Consultants All results- ppm |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Sample Location | Sample | Total | Acenap h-thene | Acenaphthylene | Anthra -cene | Benzo (a) anthracene | Benzo <br> (a) pyrene | Benzo (b) fluoranthene | $\begin{gathered} \text { Benzo } \\ \text { (ghi) } \\ \text { perylene } \end{gathered}$ | Benzo (k) fluoranthene | Chrysene | $\begin{gathered} \text { Dibenzo } \\ (\mathrm{a}, \mathrm{~h}) \\ \text { anthracene } \\ \hline \end{gathered}$ |
| 3 | WC-TH3 (8' heave) | 21.38 | 0.548 | <0.034 | 0.888 | 1.583 | 1.330 | 1.302 | 0.556 | 1.155 | 1.736 | 0.127 |
|  | WC-TH3 (6-7') | 4.86 | 0.140 | <0.034 | 0.193 | 0.318 | 0.267 | 0.195 | 0.159 | 0.198 | 0.360 | <0.09 |
| 10 | WC-TH10 (1-3') | 19.27 | 0.264 | <0.034 | 0.797 | 1.704 | 1.366 | 1.462 | 0.476 | 1.500 | 1.697 | 0.123 |
|  | WC-TH10 (6-8') | 0.00 | <0.036 | <0.034 | <0.032 | <0.031 | <0.038 | $<0.035$ | <0.03 | <0.031 | <0.034 | <0.09 |
| 14 | WC-TH14 (2-4') | 269.95 | 8.961 | $<0.034$ * | 13.19 | 19.09 | 14.12 | 11.17 | 7.154 | 11.64 | 19.49 | 1.867 |
|  | WC-TH14 (6-8') | 67.63 | 2.398 | 0.051 | 3.064 | 4.748 | 3.847 | 3.635 | 1.588 | 2.232 | 4.872 | 0.435 |
|  | WC-TH14 (10-12') | 0.61 | <0.036 | <0.034 | <0.032 | 0.056 | 0.050 | 0.036 | <0.09 | 0.046 | 0.060 | <0.09 |
| 18 | WC-TH18 (0-4') | 14.44 | 0.251 | <0.034 | 0.560 | 1.087 | 0.900 | 1.049 | 0.491 | 0.825 | 1.243 | 0.147 |
|  | WC-TH18 (4-8') | 19.98 | 0.333 | <0.034 | 0.678 | 1.622 | 1.350 | 1.199 | 0.644 | 1.175 | 1.815 | 0.158 |
| 23 | WC-TH23 (4-8') | 45.17 | 1.151 | <0.17 \# | 1.901 | 3.272 | 2.302 | 1.755 | 1.281 | 2.228 | 3.526 | <0.45 \# |
| 27 | WC-TH27 (3-5') | 8.78 | 0.181 | $<0.034$ | 0.347 | 0.676 | 0.552 | 0.479 | 0.245 | 0.541 | 0.736 | <0.09 |
|  | WC-TH27 (6-7') | 0.00 | <0.036 | <0.034 | <0.032 | <0.031 | <0.038 | <0.035 | <0.09 | <0.031 | <0.034 | <0.09 |
| 28 | WC-TH28 (5' heave) | 56.36 | 1.404 | 0.106 | 1.895 | 4.169 | 3.497 | 3.456 | 1.564 | 3.165 | 4.554 | 0.380 |
|  | WC-TH28 (6-9') ! | 32.00 | 0.699 | <0.034 | 1.123 | 2.383 | 2.030 | 2.085 | 0.924 | 1.920 | 2.726 | 0.247 |
|  | WC-TH49 (6-9') ! | 14.50 | 0.273 | <0.034 | 0.445 | 1.102 | 0.912 | 0.878 | 0.508 | 1.033 | 1.249 | <0.09 |
| 29 | WC-TH29 (6-8') | 1.25 | <0.036 | <0.034 | 0.071 | 0.100 | 0.081 | 0.058 | <0.09 | 0.062 | 0.105 | <0.09 |
|  | WC-TH29 (9' heave) | 1.25 | <0.036 | <0.034 | 0.044 | 0.101 | 0.077 | 0.061 | <0.09 | 0.103 | 0.121 | <0.09 |
|  | WC-TH29 (11') | 0.00 | $<0.036$ | <0.034 | <0.032 | <0.031 | <0.038 | <0.035 | <0.09 | <0.031 | <0.034 | <0.09 |
| Waste | WC-Comp.Waste | 5.82 | 0.144 | <0.034 | 0.184 | 0.405 | 0.331 | 0.296 | 0.182 | 0.321 | 0.475 | <0.09 |
|  | Level 1 SQT | 1.6 | 0.0067 | 0.0059 | 0.057 | 0.110 | 0.150 |  |  |  | 0.170 | 0.033 |
|  | Level II SQT | 23 | 0.089 | 0.130 | 0.850 | 1.100 | 1.500 |  |  |  | 1.300 | 0.140 |

! Duplicate sample
\# Elevated "less than result" due to sample matrix

* Elevated "less than result" due to sample concentration

Bolded values are individual PAH compounds above the reporting limit
All analytical results presented as dry weight concentrations

Table A11 Copy of Table A3 from "Detailed Investigation of the Minnesota Slip, Duluth Minnesota" Streitz and Johnson, 2005. Continued

! Duplicate sample
\# Elevated "less than result" due to sample matrix

* Elevated "less than result" due to sample concentration

Bolded values are individual PAH compounds above the reporting limit
All analytical results presented as dry weight concentrations

Table A12 Copy of Table 14 from "Development of a Framework for Evaluating Numerical Sediment Quality Targets and Sediment", Crane et al., 2000.

Table 14. Recommended Level I and Level II Sediment Quality Targets for the Protection of Sediment-dwelling Organisms

| Chemical | Aquatic Life |  |  |
| :---: | :---: | :---: | :---: |
|  | Level I SQT | Level II SQT | Source ${ }^{\dagger}$ |
| Metals (in mg/kg DW) |  |  |  |
| Arsenic ${ }^{\text {§ }}$ | 9.8 | 33 | MacDonald et al. (2000a) |
| Cadmium ${ }^{* 5}$ | 0.99 | 5.0 | MacDonald et al. (2000a) |
| Chromium ${ }^{\text {§ }}$ | 43 | 110 | MacDonald et al. (2000a) |
| Copper ${ }^{* 5}$ | 32 | 150 | MacDonald et al. (2000a) |
| Lead* ${ }^{\text {¢ }}$ | 36 | 130 | MacDonald et al. (2000a) |
| Mercury | 0.18 | 1.1 | MacDonald et al. (2000a) |
| Nickel ${ }^{\text { }}$ | 23 | 49 | MacDonald et al. (2000a) |
| Zinc* ${ }^{\text {5 }}$ | 120 | 460 | MacDonald et al. (2000a) |
| PAHs (in $\mu \mathrm{g} / \mathrm{kg}$ DW) |  |  |  |
| 2-Methylnaphthalene | 20 | 200 | CCME (1999) |
| Acenaphthene | 6.7 | 89 | CCME (1999) |
| Acenaphthylene | 5.9 | 130 | CCME (1999) |
| Anthracene* | 57 | 850 | MacDonald et al. (2000a) |
| Fluorene | 77 | 540 | MacDonald et al. (2000a) |
| Naphthalene*5 | 180 | 560 | MacDonald et al. (2000a) |
| Phenanthrene ${ }^{* 1}$ | 200 | 1200 | MacDonald et al. (2000a) |
| Benz(a)anthracene ${ }^{* 5}$ | 110 | 1100 | MacDonald et al. (2000a) |
| Benzo(a)pyrene ${ }^{* 5}$ | 150 | 1500 | MacDonald et al. (2000a) |
| Chrysene*s | 170 | 1300 | MacDonald et al. (2000a) |
| Dibenz(a,h)anthracene | 33 | 140 | MacDonald et al. (2000a); CCME (1999 |
| Fluoranthene* | 420 | 2200 | $\mathrm{MacDonald} \mathrm{et} \mathrm{al}. \mathrm{(2000a)}$ |
| Pyrene*V | 200 | 1500 | MacDonald et al. (2000a) |
| Total PAHs* ${ }^{\text {5 }}$ | 1600 | 23000 | MacDonald et al. (2000a) |
| PCBs (in $\mu \mathrm{g} / \mathrm{kg}$ DW) |  |  |  |
| Total PCBs* ${ }^{\text { }}$ | 60 | 680 | MacDonald et al. (2000a) |
| Pesticides (in $\mu \mathrm{g} / \mathrm{kg}$ DW) |  |  |  |
| Chlordane* | 3.2 | 18 | MacDonald et al. (2000a) |
| Dieldrin* | 1.9 | 62 | MacDonald et al. (2000a) |
| Sum DDD* | 4.9 | 28 | MacDonald et al. (2000a) |

Table A12 continued
Table 14. Continued

|  | Aquatic Life |  |  |
| :--- | :---: | :---: | :---: |
| Chemical | Level I <br> SQT | Level II <br> SQT | Source ${ }^{\dagger}$ |
|  |  |  |  |
| Pesticides (continued) | 3.2 | 31 | MacDonald et al. (2000a) |
| Sum DDE |  | MacDonald et al. (2000a) |  |
| Sum DDT* | 4.2 | 63 | MacDonald et al. (2000a) |
| Total DDT* | 5.3 | 570 | MacDonald et al. (2000a) |
| Endrin | 2.2 | 210 | MacDonald et al. (2000a) |
| Heptachlor epoxide ${ }^{*}$ | 2.5 | 16 | MacDonald et al. (2000a) |
| Lindane (gamma-BHC) | 2.4 | 5 | NYSDEC (1999) ${ }^{*}$ |
| Toxaphene | 0.1 | 32 | USEPA 2000a |
| Mean PEC-Q | 0.1 | 0.6 |  |

$S Q T=$ sediment quality target; $T E Q=$ toxic equivalent; $P E C-Q=$ probable effect concentration quotient.
${ }^{\top}$ Some SQT values were rounded to two significant figures from the original source.

* Reliable consensus-based TEC values that were adopted as Level I SQTs [i.e., predictive ability $\geq 75 \%$ and $\geq 20$ samples below the TEC (MacDonald et al. 2000a)].
${ }^{5}$ Reliable consensus-based PEC values that were adopted as Level II SQTs [i.e., predictive ability $\geq 75 \%$ and $\geq 20$ samples predicted to be toxic (MacDonald et al. 2000a)].
$\%$ originally based on $\mu \mathrm{g} / \mathrm{g} \mathrm{OC}$; assumed $\mathrm{TOC}=1 \%$.

Figure A1: Copy of Figure 7: Location of LIF Probes and Sediment Cores from "Detailed Investigation of the Minnesota Slip, Duluth Minnesota" Streitz and Johnson, 2005.


Figure A2: Copy of Figure 11: Cross-section Through the Middle of the Slip, Featuring LIF Response Records from "Detailed Investigation of the Minnesota Slip, Duluth Minnesota" Streitz and Johnson, 2005.


## Appendix B

## July 25, 2005, Task 1 Volume Calculations and Task 2 List of Alternatives for the Minnesota Slip, Duluth, Minnesota

August 4, 2005
Ms. Susan R. Johnson
Minnesota Pollution Control Agency
525 South Lake Avenue
Duluth, Minnesota 55802

## Re: Task 1 Volume Calculations and Task 2 List of Alternatives for the Minnesota Slip, Duluth, Minnesota.

Dear Ms. Johnson:
In accordance with the July 11, 2005 Scope of Work/Cost Estimate for the Feasibility Study at the Minnesota Slip, located in Duluth, Minnesota, Bay West Inc. (Bay West) has prepared the following enclosed Memorandums:

- Task 1 Volume Calculations
- Task 2 List of Alternatives

The contaminated sediment volumes presented in the Task 1 Volume Calculation Memorandum represent the volume of sediment between the top surface of the sediment and the $2 \%$ LIF response cut-off depths. The use of the $2 \%$ LIF response cut-off depths were approved by Andrew Streitz of the MPCA prior to completing the volume calculations.

In a conference call on July 19, 2005 with the MPCA, the MPCA directed Bay West to estimate contaminated sediment volumes by subtracting the surfical clean sediment, if present. In conjunction with the LIF data, Bay West reviewed previous investigation data to determine if clean sediment is present on top of the deeper, contaminated sediment. In the June 2005 Detailed Investigation of the Minnesota Slip, LIF data showed a response less than $2 \%$ in some surface sediment locations. However, many of these would likely exceed the Level I SQTs and therefore would still be considered contaminated if removed from their current location. In addition, based on the February 2002 Sediment Remediation Scoping Project, EPA, most of the surficial sediments are contaminated with PCBs, mercury and other metals that exceed Level 1 SQTs and Level II SQTs. Since limited surficial analytical data was collected in the most recent sampling event, there is no way to correlate LIF responses to the known contaminants in the surfical sediments. In addition, without additional analytical data, Bay West can not accurately calculate clean surficial sediment volumes, if present.

Ms. Susan R. Johnson
August 4, 2005
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Bay West looks forward to meeting with the MPCA to discuss the results presented in the enclosed memorandums. Bay West will proceed with the preparation of the Feasibility Study after the MPCA approves the List of Alternatives.

Bay West appreciates the opportunity to complete the Memorandums for the MPCA. If you have any questions please call me or Bruce Lieffring at 406-994-0560.

Sincerely,


Brenda Winkler, PG
Project Manager
brendaw@baywest.com
Enclosures

BW J040375
Docs\#80129

## MEMORANDUM

RE: Task 1, Contaminated Sediment Volume Calculation, Scope of Work/Cost Estimate for Feasibility Study at the Minnesota Slip, Duluth, Minnesota, Dated July 11, 2005

To: Susan Johnson, MPCA
From: Bruce Lieffring, Bay West, Inc.
Date: July 25, 2005
In accordance with Task 1 of the July 11, 2005 Scope of Work/Cost Estimate for the Feasibility Study at the Minnesota Slip, located in Duluth, Minnesota, Bay West Inc. (Bay West) has performed volume calculations on the contaminated sediment located in the slip. The volumes were calculated based on the LIF probe data presented in the Detailed Investigation of the Minnesota Slip, MPCA, June, 2005 (Detailed Investigation report).
Volumes were calculated using two methods: Golden Software's Surfer, Version 8; a prismoidal formula within a spread sheet. The prismoidal formula used is from Surveying, Theory and Practice, Anderson J. M.; Mikhail E. M., 1998.

## Results

Surfer calculated the sediment using three methods:

$$
\begin{array}{ll}
\text { Trapezoidal: } & 32,475 \mathrm{cu} . \text { yds. } \\
\text { Simpson's Rule: } & 32,433 \mathrm{cu} . \text { yds. } \\
\text { Simpson's 3/8 Rule: } & 32,456 \mathrm{cu} . \text { yds. }
\end{array}
$$

The prismoidal formula calculated the volume as: 33, $158 \mathrm{cu} . \mathrm{yds}$.

## Methods

During the Detailed Investigation, probe sites and slip geometry were located in UTM coordinates along with water, ice and probe depths. The UTM coordinates were converted to feet prior to starting the analyses.
The sediment contamination depths were interpolated from the 29 LIF probe analysis figures presented in Appendix C of the Detailed Investigation report. Contamination depths were determined using a $2 \%$ LIF response cut-off. The volumes presented here represent the volume of sediment between the top surface of the sediment and the $2 \%$ LIF response cut-off depths. The use of the $2 \%$ LIF response cut-off depths were approved by Andrew Streitz of the MPCA prior to completing the volume calculations.
Surfer: The elevations of the top sediment surface and the $2 \%$ LIF response cut-off depths were determined by assuming a water surface elevation of 601 feet. The converted UTM coordinates and sediment elevations were put into a table (Table 1) and were used as XYZ coordinate inputs into the Surfer software. Figures 1 and 2 are Surfer generated contour maps showing the top contour of the sediment surface and the bottom contour of the $2 \%$ LIF Response cut-off depth. Figure 3 is a three dimensional drawing created by Surfer showing the surfaces depicted in Figures 1 and 2. The volume of contaminated sediment is the space between the two surfaces.
For each of the surfaces used for determining the sediment volumes (the sediment surface and the $2 \%$ cutoff surface), an XY grid was created that encompassed the entire extent of the slip. The areas of the grid outside of the slip area were then blanked out using a blanking file created from the slip geometry

## Bay West

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coordinates. Contour and surface maps were then created from the remaining slip surface grids. As a final step, the sediment volume was calculated from the remaining grids. Table 2 shows the Surfer volume output data.
Prismoidal Formula: Cross sections were selected where 3 LIF probes fell roughly in a line transverse to the slip major dimension. This resulted in 9 cross sections using 24 of the 29 probe locations. The cross sections are:

$$
\begin{array}{ll}
\text { A - A' } & 19,18,21 \\
\text { B - B' } & 20,17,23 \\
\text { C - C' } & 29,16,24 \\
\text { D - D' } & 28,14,25 \\
\text { E - E' } & 3,6,7 \\
\text { F - F' } & 2,4,5 \\
\text { G - G' } & 1,8,9 \\
\text { H - H' } & 12,11,10
\end{array}
$$

In addition, a cross section was used at the inside of the bridge assuming the spacing and depths of Section $\mathrm{H}-\mathrm{H}^{\prime}$. The triangular shaped area on the northeast end of the slip assumed the depth of probe 22.
The cross section spacing and prism distances were measured and scaled from Figure 7 of the Detailed Investigation report.
At each cross section, 4 trapezoids were used for calculating the sediment volume:


The east and west prisms assumed the sediment depths of the closest probes. The end area of each trapezoid was calculated and from those areas, the prism volumes were calculated according to the prismoidal formula:

$$
\mathrm{V}=\mathrm{L} / 6\left(\mathrm{~A}_{1}+\mathrm{A}_{\mathrm{m}}+\mathrm{A}_{2}\right)
$$

Where:
$\mathrm{L}=$ distance between sections
$\mathrm{A}_{1}=$ Area of trapezoid in the first section.
$A_{m}=$ Area of trapezoid in the second section.
$\mathrm{A}_{2}=$ Area of a trapezoid determined from the average of the two section trapezoid dimension averages.

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In addition, the triangular area volume at the north end was calculated. The prism volumes were then summed. The prismoidal calculation supporting documentation is presented in Table 3. This calculation has significant but incalculable error in it due to the assumptions stated and determining the dimensions of the probes and slip from Figure 7 of the Detailed Investigation report.

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Figure 1
Contour Map of Sediment Top Surface


## Bay West

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Figure 2
Contour Map of Bottom of 2\% LIF Response


## Bay West

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Figure 3
Sediment Surfaces


## Table 1

Sample Point Input Data

|  | $\mathbf{X}$ |  |  |  |  |
| :--- | ---: | ---: | ---: | :---: | :---: |
|  | $\mathbf{Y}$ | $\mathbf{Z}$ | $\mathbf{Z}$ | $\mathbf{Z}$ |  |
| Sample Point | UTM-E ft | UTM-N ft | Sed_Elev | Water Elev | Bottom Elev |
| WCLIF01 | 1866660.2 | 16999033.2 | 585.5 | 601.0 | 580.0 |
| WCLIF02 | 1866622.5 | 16999107.1 | 586.3 | 601.0 | 580.3 |
| WCLIF03 | 1866571.6 | 16999190.2 | 584.0 | 601.0 | 576.5 |
| WCLIF04 | 1866676.2 | 16999140.6 | 584.0 | 601.0 | 579.0 |
| WCLIF05 | 1866732.1 | 16999169.3 | 582.5 | 601.0 | 582.5 |
| WCLIF06 | 1866633.9 | 16999232.8 | 582.0 | 601.0 | 576.0 |
| WCLIF07 | 1866686.1 | 16999261 | 583.0 | 601.0 | 579.5 |
| WCLIF08 | 1866711.7 | 16999057.6 | 584.5 | 601.0 | 580.0 |
| WCLIF09 | 1866771.7 | 16999077.4 | 585.2 | 601.0 | 582.2 |
| WCLIF10 | 1866811.4 | 16998987 | 587.0 | 601.0 | 585.0 |
| WCLIF11 | 1866752.9 | 16998967 | 584.0 | 601.0 | 577.0 |
| WCLIF12 | 1866704.0 | 16998943.8 | 583.0 | 601.0 | 583.0 |
| WCLIF13 | 1866599.3 | 16999329.6 | 584.8 | 601.0 | 577.8 |
| WCLIF14 | 1866549.3 | 16999415.9 | 586.0 | 601.0 | 578.0 |
| WCLIF15 | 1866499.4 | 16999518.3 | 586.0 | 601.0 | 577.5 |
| WCLIF16 | 1866453.5 | 16999593.7 | 586.8 | 601.0 | 576.8 |
| WCLIF17 | 1866420.7 | 16999672.5 | 587.7 | 601.0 | 577.7 |
| WCLIF18 | 1866394.4 | 16999725 | 587.3 | 601.0 | 575.3 |
| WCLIF19 | 1866341.9 | 16999688.9 | 596.2 | 601.0 | 596.2 |
| WCLIF20 | 1866351.8 | 16999646.2 | 590.7 | 601.0 | 583.7 |
| WCLIF21 | 1866427.2 | 16999751.2 | 589.0 | 601.0 | 579.0 |
| WCLIF22 | 1866394.4 | 16999761 | 587.5 | 601.0 | 575.0 |
| WCLIF23 | 1866466.2 | 16999707.1 | 588.0 | 601.0 | 577.0 |
| WCLIF24 | 1866516.7 | 16999617.6 | 583.3 | 601.0 | 579.3 |
| WCLIF25 | 1866586.1 | 16999430.8 | 586.2 | 601.0 | 575.7 |
| WCLIF26 | 1866645.1 | 16999345.5 | 587.7 | 601.0 | 580.2 |
| WCLIF27 | 1866555.0 | 16999532.8 | 579.8 | 601.0 | 576.3 |
| WCLIF28 | 1866483.9 | 16999384.5 | 584.7 | 601.0 | 575.7 |
| WCLIF29 | 1866384.6 | 16999560.9 | 584.1 | 601.0 | 575.6 |
|  |  |  |  |  |  |

## Table 2

Surfer Volume Output Table
All area and volume units in feet except where indicated.


| \par | Net | Volume | [Cut-Fill]:\tab | 876816.3334 |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| \par |  |  |  |  |  |  |
| \par |  |  |  |  |  |  |
| \par | \blfs30 | Areas |  |  |  |  |
| \par | \bOifs20 |  |  |  |  |  |
| \par | \b | Planar | Areas |  |  |  |
| \par | \b0 |  |  |  |  |  |
| \par | Positive | Planar | Area | [Cut]: | \tab | 121864.4892 |
| \par | Negative | Planar | Area | [Fill]: | \tab | 0 |
| \par | Blanked | Planar | Area: | \tab | 393 |  |
| \par | Total | Planar | Area: | $\backslash t a b$ |  |  |
| \par |  |  |  |  |  |  |
| \par | \b | Surface | Areas |  |  |  |
| \par | \b0 |  |  |  |  |  |
| \par | Positive | Surface | Area | [Cut]: | \tab | 122028.0476 |
| \par | Negative | Surface | Area | [Fill]: | \tab | 0 |
| \par | \cfo |  |  |  |  |  |
| \par | \} |  |  |  |  |  |

## Minnesota Slip Contaminated Sediment Calculation

Center Prisms
All units in feet except at final voume.


## Cross Section A - A'

| East Sediment Thickness | 10.0 |
| :--- | ---: |
| Center Line Sediment Thickness | 12.0 |
| West Sediment Thickness | 0.0 |
| Distance East | 42.0 |
| Distance West | 63.7 |


|  | Distance B |
| :--- | ---: |
| Cross Section B - B' |  |
| East Sediment Thickness | 11.0 |
| Center Line Sediment Thickness | 10.0 |
| West Sediment Thickness | 7.0 |

Distance East 57.2
Distance West 73.7
Distance Between Cross Sections 93.1

Cross Section C-C'

| East Sediment Thickness | 4.0 |
| :--- | ---: |
| Center Line Sediment Thickness | 10.0 |
| West Sediment Thickness | 8.5 |


| Distance East | 67.6 |
| :--- | :--- |
| Distance West | 76.3 |

Distance Between Cross Sections 201.3

Cross Sectiond D - D'

| East Sediment Thickness | 10.5 |
| :--- | ---: |
| Center Line Sediment Thickness | 8.0 |
| West Sediment Thickness | 9.0 |


| Distance East | 39.7 |
| :--- | :--- |
| Distance West | 72.6 |

Cross Section E-E'

| East Sediment Thickness | 3.5 |
| :--- | :--- |
| Center Line Sediment Thickness | 6.0 |
| West Sediment Thickness | 7.5 |


| Distance East | 59.3 |
| :--- | :--- |
| Distance West | 75.5 |

East Sediment Thickness
Distance Between Cross Sections
100.5

Center Line Sediment Thickness
West Sediment Thickness 6.0

Distance East 62.8
Distance West 63.3

Cross Section G-G'
East Sediment Thickness

| Center Line Sediment Thickness | 4.5 |  |
| :---: | :---: | :---: |
| West Sediment Thickness | 5.5 |  |
| Distance East 63.1 |  |  |
| Distance West 57.1 |  |  |
|  | Distance Between Cross Sections | 99.3 |
| Cross Section H-H' |  |  |
| East Sediment Thickness | 2.0 |  |
| Center Line Sediment Thickness | 7.0 |  |
| West Sediment Thickness | 0.0 |  |
| Distance East 61.7 |  |  |
| Distance West 54.1 |  |  |
|  | Distance Between Cross Sections | 49.2 |
| Cross Section at Bridge |  |  |
| East Sediment Thickness | 2.0 |  |
| Center Line Sediment Thickness | 7.0 |  |
| West Sediment Thickness | 0.0 |  |
| Distance East 61.7 |  |  |
| Distance West 54.1 |  |  |

## East Side and West Side Prisms



## North Triangle

| Height | 49.2 |
| :--- | ---: |
| Base | 131.3 |

Sediment Thickness

## Minnesota Slip Contaminated Sediment Calculation

Volume Calculations

| Cross Section A - A' |  |
| :--- | ---: |
| Area of West Center Prism | 382.2 |
| Area of East Center Prism | 462.2 |
| Area of West Side Prism | 0.0 |
| Area of East Side Prism | 164.0 |

## Volumes A-B

| Volume of West Center Prism | 26904.6 |
| :--- | ---: |
| Volume of East Center Prism | 28645.1 |
| Volume of West Side Prism | 2939.5 |
| Volume of East Side Prism | 4558.7 |


| Cross Section B - B' |  |
| :--- | ---: |
| Area of West Center Prism | 626.7 |
| Area of East Center Prism | 600.6 |
| Area of West Side Prism | 88.7 |
| Area of East Side Prism | 0.0 |

Volumes B - C
Volume of West Center
Volume of East Center
Volume of West Side P
Volume of East Side Pris
Total Volume of B-C

Prism
Prism
rism
ism

## Volumes C-D

| Volume of West Center Prism | 132994.1 |
| :--- | ---: |
| Volume of East Center Prism | 86633.1 |
| Volume of West Side Prism | 4472.4 |
| Volume of East Side Prism | 22283.9 |
| Total V |  |


| Cross Section D - D' |  |
| :--- | ---: |
| Area of West Center Prism | 616.7 |
| Area of East Center Prism | 366.9 |
| Area of West Side Prism | 97.9 |
| Area of East Side Prism | 215.3 |

## Volumes D-E

| Volume of West Center Prism | 115061.8 |
| :--- | ---: |
| Volume of East Center Prism | 69148.7 |
| Volume of West Side Prism | 16587.4 |
| Volume of East Side Prism | 17076.5 |
| Total Volume of D - E | 217874.4 |

Cross Section B-B'

| Area of West Center Prism | 626.7 |
| :--- | ---: |
| Area of East Center Prism | 600.6 |
| Area of West Side Prism | 88.7 |
| Area of East Side Prism | 0.0 |


| Area of West Center Prism | 509.8 | Area of West Center Prism | 348.2 |
| :--- | ---: | :--- | ---: |
| Area of East Center Prism | 281.7 | Area of East Center Prism | 157.1 |
| Area of West Side Prism | 65.8 | Area of West Side Prism | 104.7 |
| Area of East Side Prism | 0.0 | Area of East Side Prism | 0.0 |

Minnesota Slip Contaminated Sediment Calculation
Volume Calculations

Volumes E-F

| Volume of West Center Prism | 42863.5 |
| :--- | ---: |
| Volume of East Center Prism | 22185.4 |
| Volume of West Side Prism | 8784.1 |
| Volume of East Side Prism | 0.0 |
| Total Volume of E - F | 73833.0 |


| Cross Section F - F' |  |
| :--- | ---: |
| Area of West Center Prism | 348.2 |
| Area of East Center Prism | 157.1 |
| Area of West Side Prism | 104.7 |
| Area of East Side Prism | 0.0 |

Volumes F-G

| Volume of West Center Prism | 28801.8 |
| :--- | ---: |
| Volume of East Center Prism | 17932.5 |
| Volume of West Side Prism | 9613.3 |
| Volume of East Side Prism | 373.5 |
| Total Volume of F - G | 56721.1 |


| Cross Section G - G' |  |
| :--- | ---: |
| Area of West Center Prism | 277.9 |
| Area of East Center Prism | 236.8 |
| Area of West Side Prism | 106.1 |
| Area of East Side Prism | 12.3 |


| Volumes G -H |  |
| :--- | ---: |
| Volume of West Center Prism | 23375.5 |
| Volume of East Center Prism | 25570.7 |
| Volume of West Side Prism | 4915.0 |
| Volume of East Side Prism | 1967.8 |
| Total Volume of G -H | 55829.0 |

Cross Section H-H'

| Area of West Center Prism | 189.4 |
| :--- | ---: |
| Area of East Center Prism | 277.9 |
| Area of West Side Prism | 0.0 |
| Area of East Side Prism | 24.6 |


| Volumes H - Bridge |  |
| :--- | ---: |
| Volume of West Center Prism | 9317.8 |
| Volume of East Center Prism | 13665.8 |
| Volume of West Side Prism | 0.0 |
| Volume of East Side Prism | 1210.3 |
| Total Volume of H - Bridge | 24194.0 |


| North Triangle Volume |  |
| :--- | ---: |
| Sediment Depth | 12.5 |
| Triangle Height | 49.2 |
| Triangle Base | 131.3 |
| Volume | 40374.8 |

## MEMORANDUM

RE: Task 2 List of Alternatives, Scope of Work/Cost Estimate for Feasibility Study at the Minnesota Slip, Duluth, Minnesota, Dated July 11, 2005

To: Susan Johnson, MPCA
From: Brenda Winkler, Bay West, Inc.
Date: Revised August 4, 2005
In accordance with Task 2 of the July 11, 2005 Scope of Work/Cost Estimate for the Feasibility Study at the Minnesota Slip, located in Duluth, Minnesota, Bay West Inc. (Bay West) has prepared the following list of potential alternatives for evaluation in a feasibility study for the remediation of sediment contamination:

- No Action.
- Partial Dredging with In-Situ Capping.
- Dredging and Off-Site Disposal.

This memorandum identifies the technologies and response action components screened by Bay West for the development of the potential list of alternatives. This memorandum also briefly describes each potential alternative and the technologies and response action components recommended for evaluation under each potential alternative.

## Screening of Technologies and Response Action Components

Major technologies and response action components were reviewed and screened for their suitability in the remediation of contaminated sediments. The primary consideration in retaining a technology or response action component was based on its overall protectiveness of human health and the environment and its suitability to site conditions including its ability to maintain current and potential future water uses.

| Technology or Response Action <br> Component | Discussion | Retained for Further <br> Consideration |
| :--- | :--- | :--- |
| No Action | The no-action alternative is generally <br> considered at all sites for a baseline <br> comparison (See Notes 1 and 2). | Yes |
| Monitored Natural Recovery <br> (MNR) | MNR would not meet overall <br> protection of human health and the <br> environment (See Notes 1 and 2). | No |
| Enhanced Monitored Natural <br> Recovery | MNR would not meet overall <br> protection of human health and the <br> environment (See Note 1 and 2). | No |
| In-Situ Treatment | There are technical limitations in the <br> effectiveness of in -situ treatments. <br> Several demonstration projects <br> currently under development may show <br> promising results. However, the <br> electrochemical geo-oxidation <br> treatability study performed ex-situ on | No |

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| Technology or Response Action <br> Component | Discussionthe Slip Sediments (USACE 2002) did <br> not show a reduction in overall <br> contaminant concentration. Other Further <br> potential inn-situ treatment <br> technologies (phytoremediation, <br> multiple reactive caps) are not <br> compatible with current use of the Slip <br> or suitable for this Site. |  |
| :--- | :--- | :--- |
| Ex-Situ Treatment | See In-situ Treatment discussion above. | Ex-Situ treatment will not be <br> retained for further consideration in <br> the FS. However, Ex-Situ |
| treatment may be evaluated at a |  |  |
| later date by the facility receiving |  |  |
| the sediment. |  |  |$|$| Dredging |
| :--- |
| Wet |
| Debris Removal |
| There are two types of wet dredging: <br> Mechanical and Hydraulic. Within <br> these two types there are many <br> different types of dredges that have <br> different operational characteristics. <br> These characteristics are too varied to <br> discuss in this memorandum. <br> However, the MPCA has stated that <br> based on the previous dredging for the <br> treatability study (USACE 2002), a <br> considerable amount of debris is <br> present in the Slip. Therefore, <br> hydraulic dredging would be cost <br> prohibitive. |
| Debris removal would be necessary for <br> hydraulic or mechanical dredging. <br> Debris removal could be performed in |

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| Technology or Response Action Component | Discussion | Retained for Further Consideration |
| :---: | :---: | :---: |
|  | conjunction with mechanical dredging. |  |
| Sediment Transportation (Pipeline, Barge, Conveyor, railcar, truck/trailer) | If sediments are removed, they would be transported and may be staged, dewatered or treated prior to disposal. The type of transportation would be selected based on its compatibility with the type of dredging as well as the location of the water treatment and disposal facility. | Yes |
| Confined Disposal Facility (CDF) |  |  |
| Upland Off-Site Disposal | Several potential of-site disposal facilities have been identified by the MPCA including Erie Pier and Veit Industrial Landfill | Yes |
| In-Water On-Site Disposal | Current use and proposed use of the slip would prohibit the creation of a CDF within the Slip (See Note 2). | No |
| Sediment Dewatering and Water Treatment | Sediment dewatering and treatment may be necessary if sediments are dredged and disposed of in a CDF. | Yes |
| Post-Dredge Cover | Although dredging residuals can be minimized, some residuals may remain. In addition, contaminated sediment exceeding Level 1 SQT will remain after dredging is complete. Therefore, a post dredge cover would be necessary to provide a suitable substrate for the benthic community and to enhance natural biodegradation. | Yes |
| In-Situ Capping | In-situ capping alone may be protective but would not allow current use of the Slip to continue (See Note 2). | Yes - only with partial dredging to increase overall water depth |
| Air Emission Control | Previous removal actions have not identified a need for controlling air emissions due to the lack of volatile contaminants in the sediments. | No |
| Surface Water Control | Surface water control structures (i.e. silt curtains, water filled dam, sheet piling) would be necessary during dredging or capping alternatives. | Yes |
| Environmental and Physical Monitoring during Remedy Implementation | Environmental and physical monitoring would be necessary during remedial actions except the No Action Alternative. Types of monitoring may include: bathometry, borrow material, air quality, dredge water, surface water, cap thickness, post dredge verification | Yes |

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| Technology or Response Action <br> Component | Discussion | Retained for Further <br> Consideration |
| :--- | :--- | :--- |
|  | sampling, |  |
| Long-term Monitoring | Long-term monitoring would be <br> necessary if contaminated sediments <br> remain in place. | Yes. Long-term monitoring will be <br> evaluated for 30 years and 100 <br> years. |
| Institutional Controls | Institutional Controls would be <br> necessary if contaminated sediments <br> remain in place. | Yes |
| Habitat Restoration | Although there is limited habitat due to <br> the depth of the slip, it would be <br> necessary to create/restore habitat for <br> the existing aquatic community. | Yes |

Note 1: No Action would not meet overall protection of human health and the environment. Current conditions show that there is a risk to human and aquatic receptors. As described in Note 2, sediments are regularly being mixed into the water column increasing the overall risk to human and aquatic receptors.

Note 2: Current and future use indicate that the Slip is and will remain a docking facility for the former United States Steel flag ship the SS. William A. Irvin, the US Coast Guard Cutter, Sundew, and the US Army Corps of Engineers Tug Boat, Lake Superior. Remaining space in the Slip is occupied in the summer by charter fishing boats and docks and a harbor tour boat. In a July 21, 2005, conversation with Bob Hom, Mr. Hom indicated that vessels currently berthed in Minnesota Slip have a maximum draft depth of approximately 10 feet. However, a working Tug Boat is needed to move the Lake Superior. The working Tug Boat has a draft of 14 feet. The Lake Superior is moved twice a year and according to Mr. Hom, there is a considerable amount of sediment moved into suspension from the tug boat maneuvering operations during the moving of the Lake Superior. The working Tug Boat only enters approximately 250 feet into the Slip to move the Lake Superior. However, it is unknown if a working Tug Boat will be required to access the entire slip at some later date. Based on the current use of the Slip, it appears that 15 feet (the approximate depth to the top of the sediment) is marginal at best for the current use. Therefore, monitored natural recovery and capping remedies would be prohibitive unless partial dredging is completed first. It will be necessary to identify an adequate navigation depth for the complete evaluation in the FS.

## Brief Description of Proposed Alternatives

The following is a brief description of the proposed alternatives:

1. Alternative 1. No Action. Based on current analytical data, the No Action Alternative is not protective of human health and the environment 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, engineering controls, or institutional controls. The No Action Alternative will include long-term monitoring.
2. Alternative 2. Partial Dredging with In-Situ Capping. In-Situ Capping alone would 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. The amount of dredging required prior to cap placement would need to be evaluated in conjunction with the property owners, users and other potential stakeholders. Major components of this remedy include:

- Dredging (wet) mechanical with debris removal. The specific dredge types would be evaluated in the FS.
- Sediment transportation and staging.


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- Sediment dewatering.
- Sediment disposal at an off-site containment facility.
- Water treatment and disposal.
- In-Situ Cap. The in-situ cap would consist of an Isolation Zone (IZ) and a Bioactive Zone (BAZ). The IZ is the portion of the cap that is applied directly over the contaminated sediments and is designed to isolate and attenuate contaminants that could potentially be transported upward into the BAZ at concentrations harmful to the aquatic community 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 St. Louis River/Interlake/Duluth Tar Site established a Site-specific BAZ thickness of 0.5 meters in waters greater than $\sim 8$ foot post cap water depth (MPCA 2004). The MPCA requested two capping scenarios be evaluated in the FS, a two foot and six foot cap. 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.
- Surface water control during remedy implementation.
- Environmental and physical monitoring during remedy implementation.
- Review of previous ground water interaction with surface water studies on the St. Louis River, within the Duluth area, to evaluate potential for ground water flow to surface water in the cap area. Review of bathymetry data outside of the slip to evaluate potential slope stability issues during dredging and after cap placement. Review available data to evaluate stability of the dock walls and the potential for undermining of the dock walls during dredging activities.
- 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, and biota would be necessary. A thicker cap (i.e., 6 foot cap) may require less monitoring than a thinner cap (i.e., 2 foot cap).
- Institutional Controls. Because contaminated sediments would remain institutional controls would be necessary to maintain the cap integrity.
- Habitat Restoration.

3. Alternative 3. Dredging and Off-Site Disposal. This alternative includes dredging contaminated sediments exceeding the criteria or depth specified by the MPCA, transporting, dewatering, and placing the sediments in a containment facility. 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. The major components of this remedy include:

- Dredging (wet) mechanical with debris removal. The specific dredge types would be evaluated in the FS.
- Review of bathymetry data outside of the slip to evaluate potential slope stability issues during dredging and restoration of bathymetry. Review available data to evaluate stability of the dock walls and the potential for undermining of the dock walls during dredging activities.


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- Sediment Transportation and Staging.
- Sediment Dewatering.
- Sediment disposal at an off-site containment facility.
- Water Treatment and Disposal.
- Surface water control during remedy implementation.
- Environmental and Physical Monitoring during remedy implementation.
- One round of environmental and physical monitoring after remedy implementation.
- Habitat Restoration. This will include restoring the slip to near its current bathymetry (approximate elevation of 585 Mean Sea Level (MSL). Elevation 585 MSL is the current sediment elevation at the mouth of MN Slip).


## References:

MPCA 2004, Record of Decision for the Sediment Operable Unit, St. Louis River/Interlake/Duluth Tar Site, Duluth, Minnesota, August.
US Army Corp of Engineers (USACE) 2002, Evaluation of Electrochemical Geo-Oxidation as a means to treat sediments contaminated with polycyclic Aromatic Hydrocarbons (PAHs).

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## Appendix C

## Technical Memorandum

C1 Mechanical Dredging Options and Dredging Productivity and Equipment Requirements
C2 Sediment Management at Former Hallett Dock \#7 and Sediment Disposal Options
C3 Capping, Bathymetry, and Habitat Restoration Productivity and Equipment Requirements

C4 Turbidity Barriers for Protection of Surface Water Quality during Remedy Implementation
Appendix C was updated as part of the February 2014 revision of the 2005 Focused Feasibility Study. Information and assumptions were updated, as appropriate, to determine the estimated costs for each alternative identified in the feasibility study.

## APPENDIX C1

## MECHANICAL DREDGING OPTIONS AND <br> DREDGING PRODUCTIVITY AND EQUIPMENT REQUIREMENTS

## MINNESOTA SLIP, DULUTH, MN

The process of selecting mechanical dredging equipment and production rates at this conceptual stage was based on the current understanding of site conditions, equipment capacity and productivity assumptions, and direction from the MPCA and USEPA. The equipment capacity and productivity assumptions were based on experience, communications with dredging contractors, and published values for similar sites and settings.
In the event that the selected remedy includes dredging, final specifications of dredging methods and equipment will be prepared during remedy design and implementation. Assumptions incorporated into the mechanical dredging equipment evaluation for purposes of this Revised FFS include the following: stabilize

- Dredging will be conducted through a water column ranging from approximately 5 to 27 feet.
- Sediments will be removed from the Slip to depths ranging from approximately 0 to 12 feet below the current sediment surface to a target elevation ranging from approximately 574 feet amsl to 588 feet amsl, depending upon the dredging alternative. Surface water elevation is approximately 601 feet amsl.
- Approximately 18,000 cubic yards of contaminated sediment will be excavated under Alternative 2 - Partial Dredging with 0.8 meter Cap.
- Approximately 36,750 cubic yards of contaminated sediment will be excavated under Alternative 3 - Total Dredging with 0.3-Meter Cover.
- Approximatly 2,500 cubic yards of sediment will be transferred from two shallow areas of the slip to deep areas of the slip under Alternative 4-Slip Leveling with 0.8-meter Cap
- Contaminated sediment will be removed with a 5 cubic yard (approximately 4 cubic meters) clamshell bucket (or equivalent).
- The clamshell bucket will be capable of "cutting" sediments to the target depth.
- Hopper barges will be utilized to transport the dredged sediment for processing at Former Hallett Dock \#7, which is not an assured final processing location.
- There will be no handling and processing limitations at the Former Hallett Dock \#7 due to wharf limitations and/or available land area.
- Dredged sediment will be mechanically screened on the Hopper barge for removal of oversize debris. Debris will be stockpiled on City or DECC property adjacent to Minnesota Slip (Slip) for transportation and disposal at a landfill.
- There will be potential stability/construction issues associated with potential undermining of dock walls during dredging activities; however, Bay West has assumed that a predredge inspection of the dock walls will be performed as part of this project. Bay West has also assumed that nominal repair of the dock walls adjacent to areas of excavation. More significant structural repairs to the dock walls may be necessary if major damage is observed. A cost of approximately $\$ 2,500$ per lineal foot was incurred on repair of a dock wall on a project completed by Bay West for St. Paul Port Authority. Considering that the Slip has over 2,000 lineal feet of dock wall, inspection and repairs could add a significant increase to the overall project costs. The risk of added cost increases as dredging volume increases, exposing more dock wall in both vertical and horizontal dimensions.

The cost for dock wall repair and inspections included in the cost estimates is considered a best case estimate.
Dredge removal productivity has been based on the following assumptions; however, if the Irvin is not moved out of the Slip, the reach of the dredging bucket to the hopper barge would be limited and would impact productivity.

- Dredging operations would be conducted through 12-hour shifts (7am to 7pm) with actual dredging being conducted for a period of approximately 8.4 hours/day (70\% operational efficiency).
- Dredging operations would be conducted 6 days per week.
- Dredge fill and dump cycle would be 3 minutes (Mersay, 2005).
- Each bucket load would be $80 \%$ full (Palermo, 2005).
- One week would be added to the dredge duration to account for miscellaneous delays (Mersay, 2005).

| Dredge Productivity with 5 Cubic Yard Bucket |  |  |
| :---: | :---: | :---: |
| $\mathrm{CY} / \mathrm{HR}=(5 \mathrm{cy} / 3 \mathrm{~min} \text { cycle })^{*}(60 \mathrm{~min} / \mathrm{hr})^{*} 0.80(\%$ bucket full - Palermo, 2005) |  |  |
| In-Situ Sediment Removal Rate |  |  |
| Cubic Yards/Hour | Cubic Yards/Day (8.4 hour <br> dredge days) | Cubic Yards/Week (6 day <br> dredge weeks) |
| 80 | 672 | 4,032 |

The amount of entrained and interstitial water requiring handling for this project is an important consideration in the conceptual design and cost estimate. An environmental bucket was initially considered as a means to reduce turbidity within the Slip during the dredging operations. However, due to the amount of debris present in the Slip, this analysis assumes that a clamshell bucket will be utilized. 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. Per the USEPA's/MPCA's direction in 2005, this FFS analyses also assumes that physical removal and treatment of interstitial and entrained water will not be required. If $r$ more active treatment of water is required, it will be included in the design and not included in this estimate. Stabilization agents will be added to further desiccate the sediments prior to disposal.
Based on the dredge volumes, the duration of the dredging activities for each of the alternatives is summarized below.

Dredging Durations

| Alternative | Dredge Sediment <br> Volume <br> (cubic yards) | Dredging Duration in <br> Days (without 1 week <br> additional delay) | Dredging Duration in <br> Weeks (with 1 week <br> additional delay) |
| :--- | :---: | :---: | :---: |
| Alternative 2- <br> Partial Dredging with <br> 0.8 meter Cap | 18,000 | 27 | 5.5 |
| Alternative 3-Total <br> Dredging with 0.3 <br> meter Cover | 36,750 | 55 | 10.2 |
| Alternative 4-Slip <br> Leveling 0.8 with <br> meter Cap | 2,500 | 3.75 | $1.0^{*}$ |

*a 3 day delay was included for Alt. 4 because of the more limited scope.

Dredged sediment will be placed into hopper barges for transportation to Former Hallett Dock \#7. It has been assumed that the 1,800-ton capacity barges will be filled to approximately $75 \%$ of capacity to allow for freeboard. In-river transit time to Former Hallet Dock \#7 was estimated to be, on average, 1.5 hours, and time to unload hopper barges was estimated to be 6 hours. The total turnaround time for a hopper barge with unloading was estimated to be 8 hours. Therefore, it was concluded that two hopper barges would be required so that one barge can be loaded at the work site while the second is being unloaded at Former Hallett Dock \#7.
Although two hopper barges will be required for the dredging component, we have assumed that only one tow/tug boat will be required due to the short transit time to the Slip from Former Hallett Dock \#7. In addition, we have assumed two work boats (one each at Former Hallett Dock \#7 and one at the Slip) will be required.
Dredging costs incorporated into this analysis are based on the following unit costs:

- Tugboat, crew, and operating costs for channel crossings of the barges - \$7,270 per day (The Great Lakes Towing Company, 2013).
- Dredging - $\$ 30$ per cubic yard (estimate provided by Marine Tech [Smith, 2013]). Estimate assumes productivity delays associated with the Irvin restricting site access and delays associated with moving silt curtains for barge access. For reference, the dredging estimate for the nearby SLRIDT site was $\$ 23$ per cubic yard (Service, 2003).
Barge Costs - $\$ 400$ per day per barge (Smith, 2013).
Inspection of the Slip dock wall - Lump Sum of $\$ 10,750$. Estimate is based on the dock wall inspections completed by Bay West for the St. Paul Port Authority.


## REFERENCES

Mersay, W., 2005. USACE, e-mail to MPCA, October.
Palermo, M., 2005. "Environmental Dredging - Equipment Capabilities and Selection Factors," http://el.erdc.usace.army.mil/workshops/05Apr-SeattleDredge/TabG-Palermo.pdf, downloaded August 22. .
Service Engineering Group, 2003. Feasibility Study St. Louis River/Interlake/Duluth Tar Site Remediation, Sediment Operable Unit, December.
Smith, T., 2013. President - Marine Tech, personal communication, January.
The Great Lakes Towing Company, 2013. Full Service Lakes-Wide Towing Contract Schedule of Contract Rates and Conditions. March 2013. Retrieved from http://thegreatlakesgroup.com/wp-content/uploads/2012/12/GLT_2012_Schedule_of_ Contract_Rates_Conditions.pdf, January 2014.

## APPENDIX C2

## SEDIMENT MANAGEMENT AT FORMER HALLETT DOCK \#7 AND SEDIMENT DISPOSAL OPTIONS MINNESOTA SLIP, DULUTH, MN

No contaminated sediment processing facility currently exists in the harbor and presents some unknowns. While a processing location has not been finalized, this analysis assumes that dredged sediments will be transported via barge to Former Hallett Dock \#7 for on-site management and staging for off-site disposal. Principal facilities/systems that may need to be constructed at Former Hallett Dock \#7 include:

- Barge mooring and berthing facility;
- Barge unloading;
- Gravel-covered area for stockpiling stabilizing agents;*
- Bermed and lined area for stabilized sediment staging;* and
- Load-out area for off-site transportation/disposal.*
*Included in the cost estimate
Former Hallett Dock \#7's capacity for processing sediments is a function of both the sediment delivery rates from the Slip and the scale of the equipment and systems that can reasonably be placed at the Slip based on available land area and site access. A general discussion of the above systems as related to conceptual operations and pricing is contained below.


## Barge Mooring and Berthing Facility

Barge mooring and berthing facilities are needed for incoming barges loaded with dredge material. In the case of the Slip dredging operations, it is assumed that hopper barges loaded with approximately 1,350 tons ( $75 \%$ of their 1,800 ton capacity) of dredged sediment and water will arrive at Former Hallett Dock \#7 throughout the working day. Loaded hopper barges will likely draw approximately 9 feet of water, and therefore a basin depth of approximately 12 feet will be required to accommodate the barges and tug boats (Smith, 2005). The barges that are anticipated to be utilized are approximately 195 feet in length and 35 feet wide. Therefore, the dock required to unload one barge at a time should be approximately 250 feet long. Former Hallett Dock \#7 is not currently used for barge mooring, berthing, or as a staging area, but has served similar purposes in the past. The facilities are currently in fair to poor condition and may require repairs before use (Sharrow, 2014). Past remediation activities included capping sediment near the dock; however, a sufficient water depth exists for planned site activities (approximately 15 to 20 feet deep). The cap in the slip adjacent to the dock have not been armored to protect the cap from prop wash from tugs or large work boats. Therefore, loading from the end of the dock is assumed for this FFS. The Former Hallett Dock \#7 is currently being considered as a likely staging facility for future cleanup projects in the upper harbor area (Sharrow, 2013). Bay West has assumed that the barge mooring and berthing facilities will be updated or rebuilt by others prior to the project start date, requiring no additional cost incorporated into this Revised FFS. The cost of leasing the facility was also not considered for the purposes of this FFS since it is unknown. The cost for construction of the bermed and line sediment staging area and gravel covered area for stockpiling stabilizing agents was included in the costs. For the purposes of our analysis, it is assumed that one barge will be off loaded per day, and the required stabilization amendment (Portland Cement) will be added and mixed with dredge sediments at Former Hallett Dock \#7 prior to sediment unloading.

## Dredged Sediment Processing/Stabilization

Bay West has assumed that $5 \%$ of the dredged material (by volume) will contain debris that will require management and off-site disposal. For the purposes of this analysis, the debris will be segregated and staged adjacent to the Slip on City property. The debris will then be subsequently transported for disposal to the Vonco V Waste Management facility at a price of $\$ 53.61$ per cubic yard (price includes a wheel loader, transport, and disposal).
The moisture content of mechanically dredged sediments will reflect both its in-situ condition and the water that has been entrained during dredging operations. It is assumed for this estimate that a majority of the free water will be removed and drained to the Slip through gravity dewatering from the clamshell during dredging. However, even with this dewatering, the mechanically dredged sediment will contain entrained and interstitial water which will complicate the handling and disposal of the sediments. To minimize the need to dewater the sediments and treat and dispose of water, additional solidification agents will be added to desiccate the sediments. In addition, to dispose the material off-site, the sediments will be required to pass the paint filter test (essentially no free water). It is possible the off-site disposal facility may require the incoming material to be stackable. This section of the Technical Analysis discusses methods to improve the properties of the dredged sediments to minimize the need for water treatment and render them suitable for disposal.

Solidification methods include the use of binders that generate a cementitious reaction with the available water and solid matrix. Binders can be generally categorized as Inorganic or Organic. Common inorganic binders include Portland Cement, fly ash, mixture of Portland Cement and fly ash, lime cement, and lime kiln dusts.

The inorganic (pozzolan-Portland Cement-type materials) binders create cementitious compounds upon hydration, causing material strength to gain over time. They are powder materials that require enclosed transport and storage systems to reduce dust migration and premature hydration. Some materials, such as fly ash, may be available locally at a substantially reduced cost relative to Portland Cement. The drawbacks to solidification methods include the price of the additive and the bulking of the material being solidified, which results in increased transportation and disposal costs.
Preliminary data on sediment characteristics indicate that the dredged material may sufficiently gravity drain and would not require solidification; however, due to the variability in sediment properties, we have assumed solidification with $15 \%$ Portland Cement in the cost analysis. A bench scale test of sediments could provide a more accurate estimate for the amount of Portland Cement required. Reagents are assumed to be placed in the hopper barges at Former Hallett Dock \#7 and mixed prior to off-loading. It is recommended that the selection of a reagent be based on pilot scale or treatability studies with locally available materials to evaluate cost impacts to the project. Further water treatment is not included in this FFS.

## Sediment Unloading

Once barges arrive at Former Hallett Dock \#7, they will be tied to the dock, and stabilization/solidification agents will be mixed with the sediment prior to unloading. Assumptions associated with the dredged sediment unloading activities are as follows:

## Unload Sediment from Barge

- Assume 4 cubic yard clamshell used to unload barge.
- The cycle time of the clamshell is 1 minute with $75 \%$ efficiency.
- Time to unload hopper barge (approximately 1,000 cubic yards of sediment) - 250 minutes; 4.2 hours.
- Assume clamshell will unload sediments to 15 ton off-road articulating dump trucks for transportation to a material handling pad. Sediments will be loaded and transported to the landfill upon receipt of disposal sample analytical data.
Two trucks are assumed to maximize unloading efficiency.
Following unloading, the barge would be transported back to the Slip to be positioned for the following day's dredging activity.


## Transportation and Disposal

We have assumed that the stabilized sediment will be loaded into 15 -ton end dump trailers and transported to the Vonco V Waste Management facility in Duluth, Minnesota for use as daily cover material. The estimated cost for the transportation and disposal is $\$ 19.12$ per ton. Estimated cost includes hauling, analytical, environmental fees, solid wasted tax, and disposal.

Off-Site Transportation and Disposal Cost Summary

| Alternative | Volume Requiring Disposal <br> (cubic yards; adjusted for bulking <br> factors) | Total Transportation and <br> Disposal Cost |
| :--- | :---: | :---: |
| Alternative 2- Partial <br> Dredging with 0.8 <br> meter Cap | 23,674 | $\$ 626,000$ |
| Alternative 3-Total <br> Dredging with 0.3- <br> Meter Cover | 46,207 | $\$ 1,102,000$ |

## REFERENCES

Palermo, M., 2005. "Environmental Dredging - Equipment Capabilities and Selection Factors," http://el.erdc.usace.army.mil/workshops/05Apr-SeattleDredge/TabG-Palermo.pdf, downloaded August 22.

Smith, T., 2005. President - Marine Tech, personal communication, August.

## APPENDIX C3

## CAPPING, BATHYMETRY, AND HABITAT RESTORATION PRODUCTIVITY AND EQUIPMENT REQUIREMENTS MINNESOTA SLIP, DULUTH, MN

Alternative 2 in this Revised FFS involves the dredging of sediment to 582 feet amsl (totaling approximately 18,000 cubic yards) followed by the placement of a 0.8 -meter cap. Alternative 4 of this Revised FFS includes the placement of a 0.8 -meter cap with no dredging of sediment. In both cases, the in-place volume of cap material required is 12,800 cubic yards. Alternative 3 includes the dredging of approximately 36,750 cubic yards of sediment, followed by the placement of a 0.3 -meter cover of an environmental medium to provide a protective aquatic substrate and isolate dredge residual. The volume of restoration material required in-place for Alternative 3 is approximately 4,800 cubic yards. It is important to note that cap/sediment consolidation calculations were not performed as part of this analysis and should be considered in the design phase of the project.
Significant evaluation of capping procedures and methods was performed by Service Engineering Group and the MPCA for the SLRIDT site located approximately 5.5 miles southwest of the Slip. As a result, the capping methods and scaled costs were used to develop the capping cost estimate for the Slip for this Technical Analysis.

As outlined in the revised SLRIDT FS (Costello, 2003), important cap features include:

- Control of contaminant transport through the Slip;
- Protection of aquatic ecology;
- Erosion control for the surface of the cap;
- Cap stability during placement on slopes and flat areas;
- Sediment gas management; and
- Maintenance of existing water depths, wherever possible.

As taken from the SLRIDT cap design, we have assumed for this analysis that the Slip cap will be constructed using:

- Initial lifts of 15 to 30 centimeters thick placed evenly across the capping area. The thin lifts prevent significant mixing with contaminated sediment and prevent foundation failures so all material remains in place.
- A base cap of fine to medium sand and armoring with larger sized material, where necessary, to protect against potential erosive forces.
This analysis assumes that the restoration or cap material would be placed mechanically using a 5 -cubic yard bucket and derrick crane. The derrick crane would cast the material from a scow barge into the water, spreading the material by slowly opening the bucket while swinging the bucket over the area to be capped. On slopes, the cap would be placed from the toe upward to prevent potential slumping.

Material handling and loading facilities currently exist within the harbor that can be used for the cap material. We have assumed clean restoration or cap material would be delivered to a staging area located within the Duluth Harbor Basin from an off-site source. Significant cost savings could be achieved by staging the clean cap materials at a location close to the Slip, as opposed to a location up river. The cost analysis assumes that a hopper barge would be filled at the staging location, and a tug would tow/push the barge to the Slip for unloading at the following productivity rates.

## Load Cap Sediment onto Barge at Staging Location

Assume stockpiled material near a barge loading station.

- Assume barge capacity of 1,500 tons of sediment (approximately 1,070 cubic yards at 1.4 tons per cubic yard).
- Assume 4 cubic yard clamshell used to load barge.
- The cycle time of the clamshell is one minute with $75 \%$ efficiency.
- Time to load hopper barge (approximately 1,070 cubic yards of sediment) - 356 minutes; 5.9 hours.
Time to tow barge to the Slip - approximately 0.5 hours.


## Placement of Restoration or Cap Material

Assume 5 cubic yard clamshell used to place material.
The cycle time of the clamshell is 1.5 minutes with $75 \%$ efficiency.

- Time to unload hopper barge (approximately 1,070 cubic yards of sediment) - 428 minutes; 7.1 hours, 151 cubic yards per hour.
Two barges would be utilized during the restoration or capping project to allow one barge to be loaded as the second barge is unloaded at the Slip. Based on a 10-hour day, approximately 1,500 cubic yards of cap material would be loaded and placed per day. The total number of days projected to be required for capping and/or placement of isolation/restoration material are summarized below.

Capping And Cover Durations

| Alternative | Restoration/Capping <br> Volume <br> (cubic yards) | Duration in <br> Days | Duration in <br> Weeks |
| :--- | :---: | :---: | :---: |
| Alternative 2, - Partial Dredging <br> with 0.8 meter Cap | 12,800 | 8.5 | 1.4 |
| Alternative 3 - Total Dredging with <br> 0.3 meter Cover | 4,800 | 3.2 | .5 |
| Alternative 4 - Slip Leveling with <br> 0.8 meter Cap | 12,800 | 8.5 | 1.4 |

Unit costs for Isolation/Restoration and capping incorporated into this analysis include the following:

Tugboat, crew, and operating costs with Duluth Harbor Basin- \$4,831 per day (The Great Lakes Towing Company, 2013).

Placement of Cap Material - \$15 to $\$ 18$ per cubic yard (lower range of dredging estimate provided by Marine Tech due to the use of similar equipment to dredging work [Smith, 2013]).

Barge Costs - $\$ 400$ per day per barge (Smith, 2013).

## REFERENCES

Costello, M., 2003. Feasibility Study St. Louis River/Interlake/Duluth Tar Site Remediation, Sediment Operable Unit, December.
Smith, T., 2013. President - Marine Tech, personal communication, August .
The Great Lakes Towing Company, 2013. Full Service Lakes-Wide Towing Contract Schedule of Contract Rates and Conditions. March 2013. Retrieved from http://thegreatlakesgroup.com/wp-content/uploads/2012/12/GLT_2012_Schedule_of_ Contract_Rates_Conditions.pdf, January 2014.

## APPENDIX C4

## TURBIDITY BARRIERS FOR PROTECTION OF SURFACE WATER QUALITY DURING REMEDY IMPLEMENTATION MINNESOTA SLIP, DULUTH, MN

Sediment re-suspension will occur during the mechanical dredging process. The use of a specialty environmental bucket would help reduce the amount of sediment re-suspended in the water column; however, there is a significant amount of debris present in the Slip that could interfere with the bucket closure and cause an increase in turbidity to the surface water and reduced production rates. In addition, the volume of dredged sediment interstitial and entrained water requiring management and treatment with the use of an environmental bucket would increase the project costs significantly. Therefore, at the USEPA's and MPCA's direction, a clamshell bucket was used in this analysis. If water quality standards are exceeded outside of the work area, additional best management practices, including increased turbidity controls (i.e., turbidity curtains) would likely be necessary. Various types of turbidity barriers have been used to limit downstream migration of re-suspended sediments. This analysis provides an overview of turbidity barrier types and provides the basis for the turbidity barrier selected for the cost estimate.

For the purpose of this analysis, the barriers will be placed into two classifications: structural and non-structural (TAMS Consultants Inc., 2000). Structural barriers are typically utilized as a permanent feature for in-situ sediment containment and control. Structural barriers such as sheet piling are often used when dewatering operations occur. Sheet piling consists of a series of interlocking steel sections. To provide stability, sheet piling is typically driven a significant depth below the sediment surface, increasing the amount of steel required for the structure. Structural barriers are typically expensive to install. The installation expense of a structural barrier coupled with the reduction in access for the required hopper barges results in structural turbidity barriers being removed from consideration in the analysis.

Non-structural containment barriers include oil booms, silt curtains, and silt screens. Oil booms are utilized in situations where the dredged sediments could release oily residues. Silt curtains are constructed of impervious materials that block or deflect the passage of water and sediments. Silt screens are similar to silt curtains, with the exception that these barriers allow water to flow through while impeding the migration of a portion of the suspended load. Silt curtains and silt screens are typically suspended by a flotation unit (or, in the case of the Slip, could be additionally anchored to the east and west sides of the slip) and held in a vertical position by a ballast chain within the lower hem of the skirt.

The advantage of non-structural barriers is that they can be relocated as work progresses at a project site and have substantially lower costs relative to structural barriers. Bay West has assumed that two sets of non-structural barriers will be utilized at the Slip, with each set consisting of an oil absorbent boom and a full height turbidity/silt curtain anchored to the bed and a permeable fabric at the upper 5 feet to accommodate flow across the curtain. It is important to note that the ultimate turbidity barrier and/or turbidity barrier configuration may vary from what is priced in this technical analysis based on the final remedial design. The first turbidity barrier will be placed within approximately 15 feet of the dredge on the entrance side of the slip and will be periodically moved as the dredge works southward from the northern end of the slip toward the slip entrance. The second turbidity barrier will be placed near the mouth of the slip and will require a modified installation to allow rapid deployment for the hopper barges and other required on-water access.

Each turbidity curtain configuration has assumed 150 linear feet of a 30 -foot deep heavyweight curtain, with anchoring devices deployed at each end of the curtain, and at a spacing of 50 feet. For this configuration, six marker buoys will be required, and the absorbent boom will be replaced on a weekly basis. The unit prices are summarized in the following table:

| Item | Source | Quantity | Unit Price | Total Cost |
| :--- | :---: | :---: | :---: | :---: |
| 150-foot by 30-foot <br> heavyweight <br> turbidity curtain | Boom Environmental <br> Products | 300 LF | $\$ 90 / \mathrm{LF}$ | $\$ 27,000$ |
| Absorbent Boom | Bay West, Internal | $1,500 \mathrm{LF}$ | $\$ 0.50 / \mathrm{LF}$ | $\$ 750$ |
| Anchors | Bay West, Internal | 8 | $\$ 150$ | $\$ 1,200$ |
| Markers | Bay West, Internal | 6 | $\$ 100$ | $\$ 600$ |
| LF - linear foot/feet |  |  |  |  |

## REFERENCES

Boom Environmental Products, 2013. Personal communication. January.
TAMS Consultants, Inc., 2000. "Hudson River PCB’s Reassessment RI/FS Phase 3 Report: Feasibility Study," December.

## Appendix D

## Present Value Calculations

## Table D-1 Present Value Calculations <br> Alternative 1: No Action <br> Revised Focused Feasibility Study <br> Minnesota Slip <br> Minnesota Pollution Control Agency

Inflation Rate
7.0\%

|  | Physical <br> Monitoring/Reporting |  |  |
| :---: | :---: | :---: | :---: |
| Year | Extended <br> Value | Present <br> Value | PVIF |
| 2014 |  |  |  |
| 2015 | 9,800 | 9,159 | 0.9346 |
| 2016 | 9,800 | 8,560 | 0.8734 |
| 2017 | 9,800 | 8,000 | 0.8163 |
| 2018 | 9,800 | 7,476 | 0.7629 |
| 2019 | 9,800 | 6,987 | 0.7130 |
| 2020 | 9,800 | 6,530 | 0.6663 |
| 2021 | 9,800 | 6,103 | 0.6227 |
| 2022 | 9,800 | 5,704 | 0.5820 |
| 2023 | 9,800 | 5,331 | 0.5439 |
| 2024 | 9,800 | 4,982 | 0.5083 |
| 2025 | 9,800 | 4,656 | 0.4751 |
| 2026 | 9,800 | 4,351 | 0.4440 |
| 2027 | 9,800 | 4,067 | 0.4150 |
| 2028 | 9,800 | 3,801 | 0.3878 |
| 2029 | 9,800 | 3,552 | 0.3624 |
| 2030 | 9,800 | 3,320 | 0.3387 |
| 2031 | 9,800 | 3,102 | 0.3166 |
| 2032 | 9,800 | 2,899 | 0.2959 |
| 2033 | 9,800 | 2,710 | 0.2765 |
| 2034 | 9,800 | 2,533 | 0.2584 |
| 2035 | 9,800 | 2,367 | 0.2415 |
| 2036 | 9,800 | 2,212 | 0.2257 |
| 2037 | 9,800 | 2,067 | 0.2109 |
| 2038 | 9,800 | 1,932 | 0.1971 |
| 2039 | 9,800 | 1,806 | 0.1842 |
| 2040 | 9,800 | 1,688 | 0.1722 |
| 2041 | 9,800 | 1,577 | 0.1609 |
| 2042 | 9,800 | 1,474 | 0.1504 |
| 2043 | 9,800 | 1,378 | 0.1406 |
| 2044 | 9,800 | 1,287 | 0.1314 |
| 2045 |  | - | 0.1228 |
| 2046 |  | - | 0.1147 |
| 2047 |  | - | 0.1072 |
| 2048 |  | - | 0.1002 |
| 2049 | 9,800 | 918 | 0.0937 |
| 2050 |  | - | 0.0875 |
| 2051 |  | - | 0.0818 |
| 2052 |  | - | 0.0765 |
| 2053 |  | - | 0.0715 |
| 2054 | 9,800 | 654 | 0.0668 |
| 2055 |  | - | 0.0624 |
| 2056 |  | - | 0.0583 |
| 2057 |  | - | 0.0545 |
| 2058 |  | - | 0.0509 |
| 2059 | 9,800 | 467 | 00.0476 |
| 2060 |  | - | 0.0445 |
| 2061 |  | - | 0.0416 |
| 2062 |  | - | 0.0389 |
| 2063 |  | - | 0.0363 |
| 2064 | 9,800 | 333 | 0.0339 |
| 2065 |  | - | 0.0317 |
| 2066 |  | - | 0.0297 |
| 2067 |  | - | 0.0277 |
| 2068 |  | - | 0.0259 |
|  |  |  |  |


| Sediment Survey |  |  |
| :---: | :---: | :---: |
| Extended <br> Value | Present <br> Value | PVIF |
|  |  |  |
| 7,500 | 7,010 | 0.9346 |
| 7,500 | 6,551 | 0.8734 |
| 7,500 | 6,122 | 0.8163 |
| 7,500 | 5,722 | 0.7629 |
| 7,500 | 5,348 | 0.7130 |
|  | - | 0.6663 |
|  | - | 0.6227 |
|  | - | 0.5820 |
|  | - | 0.5439 |
| 7,500 | 3,812 | 0.5083 |
|  | - | 0.4751 |
|  | - | 0.4440 |
|  | - | 0.4150 |
|  | - | 0.3878 |
| 7,500 | 2,718 | 0.3624 |
|  | - | 0.3387 |
|  | - | 0.3166 |
|  | - | 0.2959 |
|  | - | 0.2765 |
| 7,500 | 1,938 | 0.2584 |
|  | - | 0.2415 |
|  | - | 0.2257 |
|  | - | 0.2109 |
|  | - | 0.1971 |
| 7,500 | 1,382 | 0.1842 |
|  | - | 0.1722 |
|  | - | 0.1609 |
|  | - | 0.1504 |
| 7,500 | - | 0.1406 |
|  | 985 | 0.1314 |
|  |  |  |


| Sampling \& Analysis |  |  |
| :---: | :---: | :---: |
| Extended Value | Present Value | PVIF* |
| 31,500 | 29,440 | 0.9346 |
| 31,500 | 27,512 | 0.8734 |
| 31,500 | 25,713 | 0.8163 |
| 31,500 | 24,031 | 0.7629 |
| 31,500 | 22,460 | 0.7130 |
|  | - | 0.6663 |
|  | - | 0.6227 |
|  | - | 0.5820 |
|  | - | 0.5439 |
| 31,500 | 16,011 | 0.5083 |
|  | - | 0.4751 |
|  | - | 0.4440 |
|  | - | 0.4150 |
|  | - | 0.3878 |
| 31,500 | 11,416 | 0.3624 |
|  | - | 0.3387 |
|  | - | 0.3166 |
|  | - | 0.2959 |
|  | - | 0.2765 |
| 31,500 | 8,140 | 0.2584 |
|  | - | 0.2415 |
|  | - | 0.2257 |
|  | - | 0.2109 |
|  | - | 0.1971 |
| 31,500 | 5,802 | 0.1842 |
|  | - | 0.1722 |
|  | - | 0.1609 |
|  | - | 0.1504 |
|  | - | 0.1406 |
| 31,500 | 4,138 | 0.1314 |


| 75,000 | 41,587 |
| :--- | :--- | :--- | :--- |$\quad$ Totals $=\underline{ }$

* PVIF=1 / $(1+r)^{n}$

Where:
PVIF = present value interest factor
$r$ = interest rate per period
$\mathrm{n}=$ number of periods

# Table D-1 Present Value Calculations <br> Alternative 1: No Action <br> Revised Focused Feasibility Study <br> Minnesota Slip <br> Minnesota Pollution Control Agency 

|  | Physical <br> Monitoring/Reporting |  |  |
| :---: | :---: | :---: | :---: |
| Year | Extended Value | Present Value | PVIF* |
| 2069 | 9,800 | 237 | 0.0242 |
| 2070 |  | - | 0.0226 |
| 2071 |  | - | 0.0211 |
| 2072 |  | - | 0.0198 |
| 2073 |  | - | 0.0185 |
| 2074 | 9,800 | 169 | 0.0173 |
| 2075 |  | - | 0.0161 |
| 2076 |  | - | 0.0151 |
| 2077 |  | - | 0.0141 |
| 2078 |  | - | 0.0132 |
| 2079 | 9,800 | 121 | 0.0123 |
| 2080 |  | - | 0.0115 |
| 2081 |  | - | 0.0107 |
| 2082 |  | - | 0.0100 |
| 2083 |  | - | 0.0094 |
| 2084 | 9,800 | 86 | 0.0088 |
| 2085 |  | - | 0.0082 |
| 2086 |  | - | 0.0077 |
| 2087 |  | - | 0.0072 |
| 2088 |  | - | 0.0067 |
| 2089 | 9,800 | 61 | 0.0063 |
| 2090 |  | - | 0.0058 |
| 2091 |  | - | 0.0055 |
| 2092 |  | - | 0.0051 |
| 2093 |  | - | 0.0048 |
| 2094 | 9,800 | 44 | 0.0045 |
| 2095 |  | - | 0.0042 |
| 2096 |  | - | 0.0039 |
| 2097 |  | - | 0.0036 |
| 2098 |  | - | 0.0034 |
| 2099 | 9,800 | 31 | 0.0032 |
| 2100 |  | - | 0.0030 |
| 2101 |  | - | 0.0028 |
| 2102 |  | - | 0.0026 |
| 2103 |  | - | 0.0024 |
| 2104 | 9,800 | 22 | 0.0023 |
| 2105 |  | - | 0.0021 |
| 2106 |  | - | 0.0020 |
| 2107 |  | - | 0.0019 |
| 2108 |  | - | 0.0017 |
| 2109 | 9,800 | 16 | 0.0016 |
| 2110 |  | - | 0.0015 |
| 2111 |  | - | 0.0014 |
| 2112 |  | - | 0.0013 |
| 2113 |  | - | 0.0012 |
| 2114 | 9,800 | 11 | 0.0011 |

Totals $=431,200 \quad 124,778$

Table D-2 Present Value Calculations Alternative 2: Partial Dredging with 1-Meter Cap

Inflation Rate $\quad 7.0 \%$

|  | Physical <br> Monitoring/Reporting |  |  |
| :---: | :---: | :---: | :---: |
| Year | Extended <br> Value | Present <br> Value | PVIF $^{*}$ |
| 2014 |  |  |  |
| 2015 | 9,800 | 9,159 | 0.9346 |
| 2016 | 9,800 | 8,560 | 0.8734 |
| 2017 | 9,800 | 8,000 | 0.8163 |
| 2018 | 9,800 | 7,476 | 0.7629 |
| 2019 | 9,800 | 6,987 | 0.7130 |
| 2020 | 9,800 | 6,530 | 0.6663 |
| 2021 | 9,800 | 6,103 | 0.6227 |
| 2022 | 9,800 | 5,704 | 0.5820 |
| 2023 | 9,800 | 5,331 | 0.5439 |
| 2024 | 9,800 | 4,982 | 0.5083 |
| 2025 |  | - | 0.4751 |
| 2026 |  | - | 0.4440 |
| 2027 |  | - | 0.4150 |
| 2028 |  | - | 0.3878 |
| 2029 | 9,800 | 3,552 | 0.3624 |
| 2030 |  | - | 0.3387 |
| 2031 |  | - | 0.3166 |
| 2032 |  | - | 0.2959 |
| 2033 |  | - | 0.2765 |
| 2034 | 9,800 | 2,533 | 0.2584 |
| 2035 |  | - | 0.2415 |
| 2036 |  | - | 0.2257 |
| 2037 |  | - | 0.2109 |
| 2038 |  | - | 0.1971 |
| 2039 | 9,800 | 1,806 | 0.1842 |
| 2040 |  | - | 0.1722 |
| 2041 |  | - | 0.1609 |
| 2042 |  | - | 0.1504 |
| 2043 |  | - | 0.1406 |
| 2044 | 9,800 | 1,287 | 0.1314 |
| 2045 |  | - | 0.1228 |
| 2046 |  | - | 0.1147 |
| 2047 |  | - | 0.1072 |
| 2048 |  | - | 0.1002 |
| 2049 | 9,800 | 918 | 0.0937 |
| 2050 |  | - | 0.0875 |
| 2051 |  | - | 0.0818 |
|  |  |  |  |


| Chemical Monitoring/Reporting |  |  |
| :---: | :---: | :---: |
| Extended Value | Present Value | PVIF* |
|  | - | 0.935 |
|  | - | 0.8734 |
| 31,492 | 25,707 | 0.8163 |
|  | - | 0.7629 |
|  | - | 0.7130 |
| 31,492 | 20,983 | 0.6663 |
|  | - | 0.6227 |
|  | - | 0.5820 |
|  | - | 0.5439 |
|  | - | 0.5083 |
| 31,492 | 14,962 | 0.4751 |
|  | - | 0.4440 |
|  | - | 0.4150 |
|  | - | 0.3878 |
|  | - | 0.3624 |
|  | - | 0.3387 |
|  | - | 0.3166 |
|  | - | 0.2959 |
|  | - | 0.2765 |
|  | - | 0.2584 |
|  | - | 0.2415 |
|  | - | 0.2257 |
|  | - | 0.2109 |
|  | - | 0.1971 |
|  | - | 0.1842 |
|  | - | 0.1722 |
|  | - | 0.1609 |
|  | - | 0.1504 |
|  | - | 0.1406 |
|  | - | 0.1314 |
|  | - | 0.1228 |
|  | - | 0.1147 |
|  | - | 0.1072 |
|  | - | 0.1002 |
|  | - | 0.0937 |
|  | - | 0.0875 |
|  | - | 0.0818 |

## Construction Cost

Construction assumed to occur in 2015.
All construction costs calcuated using a PVIF* of 0.9346 .

Table D-2 Present Value Calculations Alternative 2: Partial Dredging with 1-Meter Cap Revised Focused Feasibility Study

Minnesota Slip
Minnesota Pollution Control Agency

|  | Physical <br> Monitoring/Reporting |  |  |
| :---: | :---: | :---: | :---: |
| Year | Extended <br> Value | Present <br> Value | PVIF $^{*}$ |
| 2052 |  | - | 0.0765 |
| 2053 |  | - | 0.0715 |
| 2054 | 9,800 | 654 | 0.0668 |
| 2055 |  | - | 0.0624 |
| 2056 |  | - | 0.0583 |
| 2057 |  | - | 0.0545 |
| 2058 |  | - | 0.0509 |
| 2059 | 9,800 | 467 | 0.0476 |
| 2060 |  | - | 0.0445 |
| 2061 |  | - | 0.0416 |
| 2062 |  | - | 0.0389 |
| 2063 |  | - | 0.0363 |
| 2064 | 9,800 | 333 | 0.0339 |
| 2065 |  | - | 0.0317 |
| 2066 |  | - | 0.0297 |
| 2067 |  | - | 0.0277 |
| 2068 |  | - | 0.0259 |
| 2069 | 9,800 | 237 | 0.0242 |
| 2070 |  | - | 0.0226 |
| 2071 |  | - | 0.0211 |
| 2072 |  | - | 0.0198 |
| 2073 |  | - | 0.0185 |
| 2074 | 9,800 | 169 | 0.0173 |
| 2075 |  | - | 0.0161 |
| 2076 |  | - | 0.0151 |
| 2077 |  | - | 0.0141 |
| 2078 |  | - | 0.0132 |
| 2079 | 9,800 | 121 | 0.0123 |
| 2080 |  | - | 0.0115 |
| 2081 |  | - | 0.0107 |
| 2082 |  | - | 0.0100 |
| 2083 |  | - | 0.0094 |
| 2084 | 9,800 | 86 | 0.0088 |
| 2085 |  | - | 0.0082 |
| 2086 |  | - | 0.0077 |
| 2087 |  | - | 0.0072 |
| 2088 |  | - | 0.0067 |
| 2089 | 9,800 | 61 | 0.0063 |
| 2090 |  | - | 0.0058 |
| 2091 |  | - | 0.0055 |
|  |  |  |  |


| Maintenance |  |  |
| :---: | :---: | :---: |
| Extended Value | Present Value | PVIF* |
|  | - | 0.0765 |
|  | - | 0.0715 |
| 53,750 | 3,589 | 0.0668 |
|  | - | 0.0624 |
|  | - | 0.0583 |
|  | - | 0.0545 |
|  | - | 0.0509 |
|  | - | 0.0476 |
|  | - | 0.0445 |
|  | - | 0.0416 |
|  | - | 0.0389 |
|  | - | 0.0363 |
| 53,750 | 1,825 | 0.0339 |
|  | - | 0.0317 |
|  | - | 0.0297 |
|  | - | 0.0277 |
|  | - | 0.0259 |
|  | - | 0.0242 |
|  | - | 0.0226 |
|  | - | 0.0211 |
|  | - | 0.0198 |
|  | - | 0.0185 |
| 53,750 | 928 | 0.0173 |
|  | - | 0.0161 |
|  | - | 0.0151 |
|  | - | 0.0141 |
|  | - | 0.0132 |
|  | - | 0.0123 |
|  | - | 0.0115 |
|  | - | 0.0107 |
|  | - | 0.0100 |
|  | - | 0.0094 |
| 53,750 | 472 | 0.0088 |
|  | - | 0.0082 |
|  | - | 0.0077 |
|  | - | 0.0072 |
|  | - | 0.0067 |
|  | - | 0.0063 |
|  | - | 0.0058 |
|  | - | 0.0055 |


| Chemical <br> Monitoring/Reporting |  |  |
| :---: | :---: | :---: |
| Extended <br> Value | Present <br> Value | PVIF* $^{*}$ |
|  | - | 0.0765 |
|  | - | 0.0715 |
|  | - | 0.0668 |
|  | - | 0.0624 |
|  | - | 0.0583 |
|  | - | 0.0545 |
|  | - | 0.0509 |
|  | - | 0.0476 |
|  | - | 0.0445 |
|  | - | 0.0416 |
| 31,492 | - | 0.0389 |
|  | - | 0.0363 |
|  | 1,069 | 0.0339 |

otals $=\underline{ }$

Construction Cost

Construction assumed to occur in 2015. All construction costs calcuated using a PVIF* of 0.9346.

Table D-2 Present Value Calculations Alternative 2: Partial Dredging with 1-Meter Cap Revised Focused Feasibility Study

Minnesota Slip
Minnesota Pollution Control Agency

|  | Physical <br> Monitoring/Reporting |  |  |
| :---: | :---: | :---: | :---: |
| Year | Extended <br> Value | Present <br> Value | PVIF |
| 2092 |  | - | 0.0051 |
| 2093 |  | - | 0.0048 |
| 2094 | 9,800 | 44 | 0.0045 |
| 2095 |  | - | 0.0042 |
| 2096 |  | - | 0.0039 |
| 2097 |  | - | 0.0036 |
| 2098 |  | - | 0.0034 |
| 2099 | 9,800 | 31 | 0.0032 |
| 2100 |  | - | 0.0030 |
| 2101 |  | - | 0.0028 |
| 2102 |  | - | 0.0026 |
| 2103 |  | - | 0.0024 |
| 2104 | 9,800 | 22 | 0.0023 |
| 2105 |  | - | 0.0021 |
| 2106 |  | - | 0.0020 |
| 2107 |  | - | 0.0019 |
| 2108 |  | - | 0.0017 |
| 2109 | 9,800 | 16 | 0.0016 |
| 2110 |  | - | 0.0015 |
| 2111 |  | - | 0.0014 |
| 2112 |  | - | 0.0013 |
| 2113 | 9,800 | - | 0.0012 |
| 2114 | 9,80 |  |  |


| Maintenance |  |  |
| :---: | :---: | :---: |
| Extended <br> Value | Present <br> Value | PVIF $^{*}$ |
|  | - | 0.0051 |
|  | - | 0.0048 |
| 53,750 | 240 | 0.0045 |
|  | - | 0.0042 |
|  | - | 0.0039 |
|  | - | 0.0036 |
|  | - | 0.0034 |
|  | - | 0.0032 |
|  | - | 0.0030 |
|  | - | 0.0028 |
|  | - | 0.0026 |
| 53,750 | - | 0.0024 |
|  | - | 0.0023 |
|  | - | 0.0021 |
|  | - | 0.0020 |
|  | - | 0.0019 |
|  | - | 0.0017 |
|  | - | 0.0016 |
|  | - | 0.0015 |
|  | - | 0.0013 |
| $53, / 50$ | - | 0.0012 |
|  | 58 | 0.0011 |


| Chemical |  |  |
| :---: | :---: | :---: |
| Monitoring/Reporting |  |  |
| Extended <br> Value | Present <br> Value | PVIF** $^{*}$ | Construction Cost

Construction assumed to occur in 2015. All construction costs calcuated using a PVIF* of 0.9346

Table D-3 Present Value Calculations Alternative 3: Total Dredging with 0.5-Meter Cover

Revised Focused Feasibility Study
Minnesota Slip
Minnesota Pollution Control Agency

| Inflation Rate = |  | 7.0\% |  |
| :---: | :---: | :---: | :---: |
| Year | Chemical Monitoring/Reporting |  |  |
|  | Extended Value | Present Value | PVIF* |
| 2014 |  |  |  |
| 2015 |  | - | 0.9346 |
| 2016 | 31,000 | 27,077 | 0.8734 |

Totals $=$| $31,000 \quad 27,077$ |
| :---: |

Table D-4 Present Value Calculations
Alternative 4: Cap Only
Revised Focused Feasibility Study
Minnesota Slip
Minnesota Pollution Control Agency

Inflation Rate
7.0\%

|  |  | PhysicalMonitoring/Reporting |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  | Year | Extended Value | Present <br> Value | PVIF* |
|  | 2014 |  |  |  |
| 1 | 2015 | 9,800 | 9,159 | 0.9346 |
| 2 | 2016 | 9,800 | 8,560 | 0.8734 |
| 3 | 2017 | 9,800 | 8,000 | 0.8163 |
| 4 | 2018 | 9,800 | 7,476 | 0.7629 |
| 5 | 2019 | 9,800 | 6,987 | 0.7130 |
| 6 | 2020 | 9,800 | 6,530 | 0.6663 |
| 7 | 2021 | 9,800 | 6,103 | 0.6227 |
| 8 | 2022 | 9,800 | 5,704 | 0.5820 |
| 9 | 2023 | 9,800 | 5,331 | 0.5439 |
| 10 | 2024 | 9,800 | 4,982 | 0.5083 |
| 11 | 2025 |  | - | 0.4751 |
| 12 | 2026 |  | - | 0.4440 |
| 13 | 2027 |  | - | 0.4150 |
| 14 | 2028 |  | - | 0.3878 |
| 15 | 2029 | 9,800 | 3,552 | 0.3624 |
| 16 | 2030 |  | - | 0.3387 |
| 17 | 2031 |  | - | 0.3166 |
| 18 | 2032 |  | - | 0.2959 |
| 19 | 2033 |  | - | 0.2765 |
| 20 | 2034 | 9,800 | 2,533 | 0.2584 |
| 21 | 2035 |  | - | 0.2415 |
| 22 | 2036 |  | - | 0.2257 |
| 23 | 2037 |  | - | 0.2109 |
| 24 | 2038 |  | - | 0.1971 |
| 25 | 2039 | 9,800 | 1,806 | 0.1842 |
| 26 | 2040 |  | - | 0.1722 |
| 27 | 2041 |  | - | 0.1609 |
| 28 | 2042 |  | - | 0.1504 |
| 29 | 2043 |  | - | 0.1406 |
| 30 | 2044 | 9,800 | 1,287 | 0.1314 |
| 31 | 2045 |  | - | 0.1228 |
| 32 | 2046 |  | - | 0.1147 |
| 33 | 2047 |  | - | 0.1072 |
| 34 | 2048 |  | - | 0.1002 |
| 35 | 2049 | 9,800 | 918 | 0.0937 |
| 36 | 2050 |  | - | 0.0875 |


| Maintenance |  |  |
| :---: | :---: | :---: |
| Extended Value | Present Value | PVIF* |
|  |  |  |
|  | - | 0.9346 |
|  | - | 0.8734 |
|  | - | 0.8163 |
|  | - | 0.7629 |
|  | - | 0.7130 |
|  | - | 0.6663 |
|  | - | 0.6227 |
|  | - | 0.5820 |
|  | - | 0.5439 |
| 53,750 | 27,321 | 0.5083 |
|  | - | 0.4751 |
|  | - | 0.4440 |
|  | - | 0.4150 |
|  | - | 0.3878 |
|  | - | 0.3624 |
|  | - | 0.3387 |
|  | - | 0.3166 |
|  | - | 0.2959 |
|  | - | 0.2765 |
| 53,750 | 13,889 | 0.2584 |
|  | - | 0.2415 |
|  | - | 0.2257 |
|  | - | 0.2109 |
|  | - | 0.1971 |
|  | - | 0.1842 |
|  | - | 0.1722 |
|  | - | 0.1609 |
|  | - | 0.1504 |
|  | - | 0.1406 |
| 53,750 | 7,061 | 0.1314 |
|  | - | 0.1228 |
|  | - | 0.1147 |
|  | - | 0.1072 |
|  | - | 0.1002 |
|  | - | 0.0937 |
|  | - | 0.0875 |


| Chemical <br> Monitoring/Reporting <br> Extended <br> Value |  |  |
| :---: | :---: | :---: |
| Present <br> Value | PVIF* |  |
|  |  |  |
|  | - | 0.9346 |
|  | - | 0.8734 |
| 31,492 | 25,707 | 0.8163 |
|  | - | 0.7629 |
|  | - | 0.7130 |
| 31,492 | 20,983 | 0.6663 |
|  | - | 0.6227 |
|  | - | 0.5820 |
|  | - | 0.5439 |
|  | - | 0.5083 |
| 31,492 | 14,962 | 0.4751 |
|  | - | 0.4440 |
|  | - | 0.4150 |
|  | - | 0.3878 |
|  | - | 0.3624 |
|  | - | 0.3387 |
|  | - | 0.3166 |
|  | - | 0.2959 |
|  | - | 0.2765 |
|  | - | 0.2584 |
|  | - | 0.2415 |
|  | - | 0.2257 |
|  | - | 0.2109 |
|  | - | 0.1971 |
|  | - | 0.1842 |
|  | - | 0.1722 |
|  | - | 0.1609 |
|  | - | 0.1504 |
|  | - | 0.1406 |
|  | - | 0.1228 |
|  | - | 0.1147 |
|  | - | 0.1072 |
|  | 0.1002 |  |
|  | - | 0.0937 |
|  | 0.0875 |  |
|  | - |  |
|  | - | -1 |

Construction Cost

Construction assumed to occur in 2015. All construction costs calcuated using a PVIF* of 0.9346.

Table D-4 Present Value Calculations
Alternative 4: Cap Only
Revised Focused Feasibility Study
Minnesota Slip
Minnesota Pollution Control Agency

|  |  | PhysicalMonitoring/Reporting |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  | Year | Extended Value | Present Value | PVIF* |
| 37 | 2051 |  | - | 0.0818 |
| 38 | 2052 |  | - | 0.0765 |
| 39 | 2053 |  | - | 0.0715 |
| 40 | 2054 | 9,800 | 654 | 0.0668 |
| 41 | 2055 |  | - | 0.0624 |
| 42 | 2056 |  | - | 0.0583 |
| 43 | 2057 |  | - | 0.0545 |
| 44 | 2058 |  | - | 0.0509 |
| 45 | 2059 | 9,800 | 467 | 0.0476 |
| 46 | 2060 |  | - | 0.0445 |
| 47 | 2061 |  | - | 0.0416 |
| 48 | 2062 |  | - | 0.0389 |
| 49 | 2063 |  | - | 0.0363 |
| 50 | 2064 | 9,800 | 333 | 0.0339 |
| 51 | 2065 |  | - | 0.0317 |
| 52 | 2066 |  | - | 0.0297 |
| 53 | 2067 |  | - | 0.0277 |
| 54 | 2068 |  | - | 0.0259 |
| 55 | 2069 | 9,800 | 237 | 0.0242 |
| 56 | 2070 |  | - | 0.0226 |
| 57 | 2071 |  | - | 0.0211 |
| 58 | 2072 |  | - | 0.0198 |
| 59 | 2073 |  | - | 0.0185 |
| 60 | 2074 | 9,800 | 169 | 0.0173 |
| 61 | 2075 |  | - | 0.0161 |
| 62 | 2076 |  | - | 0.0151 |
| 63 | 2077 |  | - | 0.0141 |
| 64 | 2078 |  | - | 0.0132 |
| 65 | 2079 | 9,800 | 121 | 0.0123 |
| 66 | 2080 |  | - | 0.0115 |
| 67 | 2081 |  | - | 0.0107 |
| 68 | 2082 |  | - | 0.0100 |
| 69 | 2083 |  | - | 0.0094 |
| 70 | 2084 | 9,800 | 86 | 0.0088 |
| 71 | 2085 |  | - | 0.0082 |
| 72 | 2086 |  | - | 0.0077 |
| 73 | 2087 |  | - | 0.0072 |
| 74 | 2088 |  | - | 0.0067 |
| 75 | 2089 | 9,800 | 61 | 0.0063 |


| Maintenance |  |  | Chemical <br> Monitoring/Reporting |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Extended Value | Present Value | PVIF* | Extended Value | Present Value | PVIF* |
|  | - | 0.0818 |  | - | 0.0818 |
|  | - | 0.0765 |  | - | 0.0765 |
|  | - | 0.0715 |  | - | 0.0715 |
| 53,750 | 3,589 | 0.0668 |  | - | 0.0668 |
|  | - | 0.0624 |  | - | 0.0624 |
|  | - | 0.0583 |  | - | 0.0583 |
|  | - | 0.0545 |  | - | 0.0545 |
|  | - | 0.0509 |  | - | 0.0509 |
|  | - | 0.0476 |  | - | 0.0476 |
|  | - | 0.0445 |  | - | 0.0445 |
|  | - | 0.0416 |  | - | 0.0416 |
|  | - | 0.0389 |  | - | 0.0389 |
|  | - | 0.0363 |  | - | 0.0363 |
| 53,750 | 1,825 | 0.0339 | 31,492 | 1,069 | 0.0339 |
|  | - | 0.0317 |  |  |  |
|  | - | 0.0297 | 125,968 | 62,721 |  |
|  | - | 0.0277 |  |  |  |
|  | - | 0.0259 |  |  |  |
|  | - | 0.0242 |  |  |  |
|  | - | 0.0226 |  |  |  |
|  | - | 0.0211 |  |  |  |
|  | - | 0.0198 |  |  |  |
|  | - | 0.0185 |  |  |  |
| 53,750 | 928 | 0.0173 |  |  |  |
|  | - | 0.0161 |  |  |  |
|  | - | 0.0151 |  |  |  |
|  | - | 0.0141 |  |  |  |
|  | - | 0.0132 |  |  |  |
|  | - | 0.0123 |  |  |  |
|  | - | 0.0115 |  |  |  |
|  | - | 0.0107 |  |  |  |
|  | - | 0.0100 |  |  |  |
|  | - | 0.0094 |  |  |  |
| 53,750 | 472 | 0.0088 |  |  |  |
|  | - | 0.0082 |  |  |  |
|  | - | 0.0077 |  |  |  |
|  | - | 0.0072 |  |  |  |
|  | - | 0.0067 |  |  |  |
|  | - | 0.0063 |  |  |  |

Construction Cost

Construction assumed to occur in 2015 All construction costs calcuated using a PVIF* of 0.9346 .

Table D-4 Present Value Calculations
Alternative 4: Cap Only
Revised Focused Feasibility Study
Minnesota Slip
Minnesota Pollution Control Agency

|  |  | Physical <br> Monitoring/Reporting |  |  | Maintenance |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Year | Extended Value | Present Value | PVIF* | Extended Value | Present Value | PVIF* |
| 76 | 2090 |  | - | 0.0058 |  | - | 0.0058 |
| 77 | 2091 |  | - | 0.0055 |  | - | 0.0055 |
| 78 | 2092 |  | - | 0.0051 |  | - | 0.0051 |
| 79 | 2093 |  | - | 0.0048 |  | - | 0.0048 |
| 80 | 2094 | 9,800 | 44 | 0.0045 | 53,750 | 240 | 0.0045 |
| 81 | 2095 |  | - | 0.0042 |  | - | 0.0042 |
| 82 | 2096 |  | - | 0.0039 |  | - | 0.0039 |
| 83 | 2097 |  | - | 0.0036 |  | - | 0.0036 |
| 84 | 2098 |  | - | 0.0034 |  | - | 0.0034 |
| 85 | 2099 | 9,800 | 31 | 0.0032 |  | - | 0.0032 |
| 86 | 2100 |  | - | 0.0030 |  | - | 0.0030 |
| 87 | 2101 |  | - | 0.0028 |  | - | 0.0028 |
| 88 | 2102 |  | - | 0.0026 |  | - | 0.0026 |
| 89 | 2103 |  | - | 0.0024 |  | - | 0.0024 |
| 90 | 2104 | 9,800 | 22 | 0.0023 | 53,750 | 122 | 0.0023 |
| 91 | 2105 |  | - | 0.0021 |  | - | 0.0021 |
| 92 | 2106 |  | - | 0.0020 |  | - | 0.0020 |
| 93 | 2107 |  | - | 0.0019 |  | - | 0.0019 |
| 94 | 2108 |  | - | 0.0017 |  | - | 0.0017 |
| 95 | 2109 | 9,800 | 16 | 0.0016 |  | - | 0.0016 |
| 96 | 2110 |  | - | 0.0015 |  | - | 0.0015 |
| 97 | 2111 |  | - | 0.0014 |  | - | 0.0014 |
| 98 | 2112 |  | - | 0.0013 |  | - | 0.0013 |
| 99 | 2113 |  | - | 0.0012 |  | - | 0.0012 |
| 100 | 2114 | 9,800 | 11 | 0.0011 | 53,750 | 58 | 0.0011 |
|  | tals= | 274,400 | 81,178 |  | 537,500 | 55,504 |  |

* PVIF=1 / $(1+r)^{n}$


## Where:

PVIF = present value interest factor
$r=$ interest rate per period
$\mathrm{n}=$ number of periods

| Chemical |  |  |
| :---: | :---: | :---: |
| Monitoring/Reporting |  |  | \left\lvert\, | Mended |
| :---: |
| Value | | Present |
| :---: |
| Value |$\quad\right.$ PVIF $^{\text {Extend }}$|  |
| :--- |

Construction Cost

Construction assumed to occur in 2015 All construction costs calcuated using a PVIF* of 0.9346 .

Table D-5 Unit Rate Calculations
Revised Focused Feasibility Study
Minnesota Slip
Minnesota Pollution Control Agency

## Volume Calculations Alternative 2

| Neat Excavation Volume | 18,000 | cubic yards | Excavation to planned lines \& grade |
| :--- | ---: | :--- | :--- |
| Excavation | 1,700 | cubic yards | Unplanned excavation beyond planned dimensions |
| Excavation Volume | 19,700 | cubic yards | Subtotal |
| Oversized Debris (5\%) | $(985)$ | cubic yards | Oversize debris segregated from sediment |
| Fluff Factor (10\%) | 1,872 | cubic yards | Desegregation \& Reduction of Density |
| Transport Volume | 20,587 | cubic yards | Subtotal |
| Solidification Agent (15\%) | 3,088 | cubic yards | Volume of solidification agent |
| Final Volume | 23,674 | cubic yards | TOTAL |
|  |  |  |  |
| Daily Transport Volume, 27 dredge days | 762.46 | cubic yards |  |
| Daily Sediment Unloading, 27 dredge days | 876.83 | cubic yards |  |

## Volume Calculations Alternative 3

| Neat Excavation Volume | 36,750 | cubic yards | Excavation to planned lines \& grade (with 5\% added) |
| :--- | ---: | :--- | :--- |
| Over Excavation | 1,700 | cubic yards | Unplanned excavation beyond planned dimensions |
| Excavation Volume | 38,450 | cubic yards | Subtotal |
| Oversized Debris (5\%) | $(1,923)$ | cubic yards | Oversize debris segregated from sediment |
| Fluff Factor (10\%) | 3,653 | cubic yards | Desegregation \& Reduction of Density |
| Transport Volume | 40,180 | cubic yards | Subtotal |
| Solidification Agent (15\%) | 6,027 | cubic yards | Volume of solidification agent |
| Final Volume | 46,207 | cubic yards | TOTAL |


| Mobilization/Demobilization |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Description | Unit | Estimated Unit Cost |  | Estimated Quantity | Extended Value |  |  |  |
| Submittals/Plans/Permits | Lump Sum | \$ | 22,000.00 | 1 | \$ | 22,000.00 | \$ | 15,400.00 |
| Mob/Demob Dredge to MN Slip | Event | \$ | 2,800.00 | 2 | \$ | 5,600.00 | \$ | 5,600.00 |
| Mob/Demob Tug to MN Slip | Event | \$ | 280.00 | 2 | \$ | 560.00 | \$ | 560.00 |
| Mob/Demob Barges to MN Slip | Event | \$ | 280.00 | 2 | \$ | 560.00 | \$ | 560.00 |
| Mob/Demob Crane to Staging Area | Event | \$ | 2,800.00 | 2 | \$ | 5,600.00 | \$ | 5,600.00 |
| Mob/Demob Dozer to Staging Area | Event | \$ | 350.00 | 2 | \$ | 700.00 |  |  |
| Mob/Demob Trucks to Staging Area | Event | \$ | 350.00 | 4 | \$ | 1,400.00 |  |  |
| Mob/Demob Wheel Loader to Staging Area | Event | \$ | 350.00 | 2 | \$ | 700.00 |  |  |
| Mob/Demob Office Trailer to Staging Area | Event | \$ | 700.00 | 2 | \$ | 1,400.00 |  |  |
| Mob/Demob Silt Curtain to Staging Area | Event | \$ | 1,120.00 | 2 | \$ | 2,240.00 | \$ | 2,240.00 |
| Setup MN Slip Site | Lump Sum | \$ | 70,000.00 | 1 | \$ | 70,000.00 | \$ | 70,000.00 |
| Setup Former Hallett \#7 Site | Lump Sum | \$ | 105,000.00 | 1 | \$ | 105,000.00 |  |  |
|  |  |  |  | Alt 2 \& 3= | \$ | $\begin{array}{r} 215,760.00 \\ \text { Alt } 4= \end{array}$ | \$ | 99,960.00 |

Sediment Controls at MN Slip

| Description | Unit | Estimated Unit Cost |  | Estimated Quantity | Extended Value |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Turbidity Curtain | Linear Feet | \$ | 90.00 | 300 | \$ | 27,000.00 |
| Absorbent Boom | Linear Feet | \$ | 1.00 | 1,500 | \$ | 1,500.00 |
| Anchors | Each | \$ | 150.00 | 8 | \$ | 1,200.00 |
| Markers | Each | \$ | 100.00 | 6 | \$ | 600.00 |

Table D-5 Unit Rate Calculations
Revised Focused Feasibility Study
Minnesota Slip
Minnesota Pollution Control Agency

Transport Sediment to Former Hallett \#7

| Description | Unit | Estimated Unit Cost |  | Estimated Quantity | Extended Value |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Tug \& Crew above channel crossing | Day | \$ | 7,270.00 | 1 | \$ | 7,270.00 |  |
| Material Barge | Day | \$ | 400.00 | 2 | \$ | 800.00 |  |
| Work Boats with Crew | Day | \$ | 1,075.00 | 2 | \$ | 2,150.00 |  |
|  |  |  |  |  | \$ | 10,220.00 |  |
|  |  | Daily Production |  |  |  | 762 | Cubic Yards |
|  |  | Estimated Unit Rate |  |  | \$ | 13.40 | \$/Cubic Yard |


| Solidification in Hopper Barge |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Description | Unit | Estimated Unit Cost |  | Estimated Quantity | Extended Value |  |  |
| Excavator | Day | \$ | 1,525.00 | 1 | \$ | 1,525.00 |  |
| Deck Barge | Day | \$ | 500.00 | 1 | \$ | 500.00 |  |
| Portland Storage Silo | Day | \$ | 125.00 | 1 | \$ | 125.00 |  |
| Portland 15\% add rate | Ton | \$ | 130.00 | 145 | \$ | 18,867.53 |  |
| \$ 21,017.53 |  |  |  |  |  |  |  |
| Daily Production <br> Estimated Unit Rate |  |  |  |  |  | 762 | Cubic Yards |
|  |  |  |  |  | \$ $\quad 27.57$ \$/Cubic Yard |  |  |


| Sediment Unloading at Former Hallett \#7 |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Description | Unit | Estimated Unit Cost |  | Estimated Quantity | Extended Value |  |  |
| Crane w/clamshell Bucket | Day | \$ | 4,225.00 | 1 | \$ | 4,225.00 |  |
| 25 Ton Off-Road Truck | Day | \$ | 1,594.00 | 2 | \$ | 3,188.00 |  |
| Wheel Loader | Day | \$ | 1,750.00 | 1 | \$ | 1,750.00 |  |
| Office Trailer | Day | \$ | 65.00 | 1 | \$ | 65.00 |  |
| Support Vehicles | Day | \$ | 85.00 | 2 | \$ | 170.00 |  |
|  |  |  |  |  | \$ | 9,398.00 |  |
|  |  |  |  | ily Production | \$ | 876.83 | Cubic Yards |
|  |  |  | Estim | ted Unit Rate | \$ | 10.72 | \$/Cubic Yard |


| MN Slip Cap Materials |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Description | Unit | Estimated Unit Cost |  | Estimated Quantity | Extended Value |  |  |
| MN Slip Cap Materials per day | Ton | \$ | 9.00 | 1498 | \$ | 13,482.00 |  |
| Crane w/clamshell Bucket | Day | \$ | 4,225.00 | 1 | \$ | 4,225.00 |  |
| Wheel Loader | Day | \$ | 1,750.00 | 1 | \$ | 1,750.00 |  |
| Tug \& Crew within Duluth Harbor Basin | Day | \$ | 4,831.00 | 1 | \$ | 4,831.00 |  |
| Material Barge | Day | \$ | 400.00 | 2 | \$ | 800.00 |  |
| Work Boats with Crew | Day | \$ | 1,050.00 | 2 | \$ | 2,100.00 |  |
|  |  |  |  |  | \$ | 27,188.00 |  |
|  |  |  |  | ily Production |  | 1,070 | Cubic Yards |
|  |  |  | Estim | ted Unit Rate | \$ | 25.41 | \$/Cubic Yard |

Table D-5 Unit Rate Calculations
Revised Focused Feasibility Study
Minnesota Slip
Minnesota Pollution Control Agency

## Alternative 2 Sediment Disposal at Vonco V in Duluth, MN




Alternative 2 Oversized Material Disposal at Vonco V Waste Management Facility

| Description | Unit | Estimated Unit Cost |  | Estimated Quantity | Extended Value |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Wheel Loader | Day | \$ | 1,750.00 | 1 | \$ | 1,750.00 |  |
| Hauling | Ton | \$ | 6.30 | 1,379 | \$ | 8,687.70 |  |
| Environmental Fee | 15 Ton Load | \$ | 4.00 | 92 | \$ | 367.73 |  |
| Industrial Solid Waste Tax | Ton | \$ | 0.46 | 1,379 | \$ | 634.34 |  |
| Disposal | Ton | \$ | 30.00 | 1,379 | \$ | 41,370.00 |  |
|  |  |  |  |  | \$ | 52,809.77 |  |
|  |  | Daily Production |  |  |  | 985 | Cubic Yards |
|  |  | Estimated Unit Rate |  |  | \$ | 53.61 | \$/Cubic Yard |

Alternative 3 Oversized Material Disposal at Vonco V Waste Management Facility

| Description | Unit | Estimated Unit Cost |  | Estimated Quantity | Extended Value |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Wheel Loader | Day | \$ | 1,750.00 | 1 | \$ | 1,750.00 |  |
| Hauling | Ton | \$ | 6.30 | 2,692 | \$ | 16,956.45 |  |
| Environmental Fee | 15 Ton Load | \$ | 4.00 | 179 | \$ | 717.73 |  |
| Industrial Solid Waste Tax | Ton | \$ | 0.46 | 2,692 | \$ | 1,238.09 |  |
| Disposal | Ton | \$ | 30.00 | 2,692 | \$ | 80,745.00 |  |
|  |  |  |  |  | \$ | 101,407.27 |  |
|  |  | Daily Production |  |  |  | 1,923 | Cubic Yards |
|  |  | Estimated Unit Rate |  |  | \$ | 52.75 | \$/Cubic Yard |

## Appendix E

## 2014 Toxicity Characteristic Leaching Procedure Sampling Results

December 16, 2013

Matt Schemmel
Bay West, Inc.
5 Empire Drive
Saint Paul, MN 55103

RE: Project: J130485 MN SLIP
Pace Project No.: 10250888

Dear Matt Schemmel:
Enclosed are the analytical results for sample(s) received by the laboratory on November 27, 2013.
The results relate only to the samples included in this report. Results reported herein conform to the most current TNI standards and the laboratory's Quality Assurance Manual, where applicable, unless otherwise noted in the body of the report.

If you have any questions concerning this report, please feel free to contact me.

Sincerely,


Lori Castille
lori.castille@pacelabs.com
Project Manager

Enclosures

## CERTIFICATIONS

Project: J130485 MN SLIP

Pace Project No.: 10250888

Minnesota Certification IDs
1700 Elm Street SE Suite 200, Minneapolis, MN 55414
A2LA Certification \#: 2926.01
Alabama Dept of Environmental Management \#40770
Alaska Certification \#: UST-078
Alaska Certification \#MN00064
Arizona Certification \#: AZ-0014
Arkansas Certification \#: 88-0680
California Certification \#: 01155CA
Colorado Certification \#Pace
Connecticut Certification \#: PH-0256
EPA Region 5 \#WD-15J
EPA Region 8 Certification \#: Pace
Florida/NELAP Certification \#: E87605
Georgia Certification \#: 959
Hawaii Certification \#Pace
Idaho Certification \#: MN00064
Illinois Certification \#: 200011
Indiana Certification\#C-MN-01
Iowa Certification \#: 368
Kansas Certification \#: E-10167
Kentucky Dept of Envi. Protection - DW \#90062
Louisiana Certification \#: 03086
Louisiana Certification \#: LA080009
Maine Certification \#: 2007029
Maryland Certification \#: 322

Michigan DEQ Certification \#: 9909
Minnesota Certification \#: 027-053-137
Mississippi Certification \#: Pace
Montana Certification \#: MT CERT0092
Nevada Certification \#: MN_00064
Nebraska Certification \#: Pace
New Jersey Certification \#: MN-002
New York Certification \#: 11647
North Carolina Certification \#: 530
North Dakota Certification \#: R-036
Ohio VAP Certification \#: CL101
Oklahoma Certification \#: 9507
Oregon Certification \#: MN200001
Oregon Certification \#: MN300001
Pennsylvania Certification \#: 68-00563
Puerto Rico Certification
Tennessee Certification \#: 02818
Texas Certification \#: T104704192
Utah Certification \#: MN00064
Virginia/DCLS Certification \#: 002521
Virginia/VELAP Certification \#: 460163
Washington Certification \#: C754
West Virginia Certification \#: 382
Wisconsin Certification \#: 999407970

## SAMPLE SUMMARY

| Project: | J130485 MN SLIP |
| :--- | :--- |
| Pace Project No.: | 10250888 |


| Lab ID | Sample ID | Matrix | Date Collected | Date Received |
| :---: | :---: | :---: | :---: | :---: |
| 10250888001 | WC-01 (4'-6') | Solid | 11/26/13 14:00 | 11/27/13 16:33 |
| 10250888002 | WC-02 (1'-3') | Solid | 11/27/13 10:00 | 11/27/13 16:33 |

## SAMPLE ANALYTE COUNT

| Project: | J130485 MN SLIP |
| :--- | :--- |
| Pace Project No.: | 10250888 |


| Lab ID | Sample ID | Method | Analysts | Analytes Reported |
| :---: | :---: | :---: | :---: | :---: |
| 10250888001 | WC-01 (4'-6') | EPA 6010 | IP | 1 |
|  |  | EPA 6010 | IP | 10 |
|  |  | EPA 7470A | WBS | 1 |
|  |  | ASTM D2974 | JDL | 1 |
|  |  | EPA 8270 | JLR | 18 |
| 10250888002 | WC-02 (1'-3') | EPA 6010 | IP | 1 |
|  |  | EPA 6010 | IP | 10 |
|  |  | EPA 7470A | WBS | 1 |
|  |  | ASTM D2974 | JDL | 1 |
|  |  | EPA 8270 | JLR | 18 |

## PROJECT NARRATIVE

| Project: | J130485 MN SLIP |
| :--- | :--- |
| Pace Project No.: | 10250888 |

Method: EPA 6010
Description: 6010 MET ICP
Client: Bay West, Inc.
Date: December 16, 2013

## General Information:

2 samples were analyzed for EPA 6010. All samples were received in acceptable condition with any exceptions noted below.

## Hold Time:

The samples were analyzed within the method required hold times with any exceptions noted below.

## Sample Preparation:

The samples were prepared in accordance with EPA 3050 with any exceptions noted below.

Initial Calibrations (including MS Tune as applicable):
All criteria were within method requirements with any exceptions noted below.

## Continuing Calibration:

All criteria were within method requirements with any exceptions noted below.

## Method Blank:

All analytes were below the report limit in the method blank, where applicable, with any exceptions noted below.

## Laboratory Control Spike:

All laboratory control spike compounds were within QC limits with any exceptions noted below.

## Matrix Spikes:

All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.
QC Batch: MPRP/43595
A matrix spike and/or matrix spike duplicate (MS/MSD) were performed on the following sample(s): 10251001001
M1: Matrix spike recovery exceeded QC limits. Batch accepted based on laboratory control sample (LCS) recovery.

- MS (Lab ID: 1589128)
- Lead


## Additional Comments:

## REPORT OF LABORATORY ANALYSIS

## PROJECT NARRATIVE

| Project: | J130485 MN SLIP |
| :--- | :--- |
| Pace Project No.: | 10250888 |

Method: EPA 6010
Description: 6010 MET ICP, TCLP
Client: Bay West, Inc.
Date: December 16, 2013

## General Information:

2 samples were analyzed for EPA 6010. All samples were received in acceptable condition with any exceptions noted below.

## Hold Time:

The samples were analyzed within the method required hold times with any exceptions noted below.

## Sample Preparation:

The samples were prepared in accordance with EPA 3010 with any exceptions noted below.

Initial Calibrations (including MS Tune as applicable):
All criteria were within method requirements with any exceptions noted below.

## Continuing Calibration:

All criteria were within method requirements with any exceptions noted below.

## Method Blank:

All analytes were below the report limit in the method blank, where applicable, with any exceptions noted below.

## Laboratory Control Spike:

All laboratory control spike compounds were within QC limits with any exceptions noted below.

## Matrix Spikes:

All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.

## Additional Comments:

## REPORT OF LABORATORY ANALYSIS

## PROJECT NARRATIVE

| Project: | J130485 MN SLIP |
| :--- | :--- |
| Pace Project No.: | 10250888 |

Method: EPA 7470A
Description: 7470 Mercury, TCLP
Client: Bay West, Inc.
Date: December 16, 2013

## General Information:

2 samples were analyzed for EPA 7470A. All samples were received in acceptable condition with any exceptions noted below.

## Hold Time:

The samples were analyzed within the method required hold times with any exceptions noted below.

## Sample Preparation:

The samples were prepared in accordance with EPA 7470A with any exceptions noted below.

Initial Calibrations (including MS Tune as applicable):
All criteria were within method requirements with any exceptions noted below.

## Continuing Calibration:

All criteria were within method requirements with any exceptions noted below.

## Method Blank:

All analytes were below the report limit in the method blank, where applicable, with any exceptions noted below.

## Laboratory Control Spike:

All laboratory control spike compounds were within QC limits with any exceptions noted below.

## Matrix Spikes:

All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.

## Additional Comments:

## REPORT OF LABORATORY ANALYSIS

## PROJECT NARRATIVE

| Project: | J130485 MN SLIP |
| :--- | :--- |
| Pace Project No.: | 10250888 |

## Method: EPA 8270

Description: 8270 MSSV TCLP
Client: Bay West, Inc.
Date: December 16, 2013

## General Information:

2 samples were analyzed for EPA 8270. All samples were received in acceptable condition with any exceptions noted below.

## Hold Time:

The samples were analyzed within the method required hold times with any exceptions noted below.

## Sample Preparation:

The samples were prepared in accordance with EPA 3520 with any exceptions noted below.

Initial Calibrations (including MS Tune as applicable):
All criteria were within method requirements with any exceptions noted below.

## Continuing Calibration:

All criteria were within method requirements with any exceptions noted below.

Internal Standards:
All internal standards were within QC limits with any exceptions noted below.

## Surrogates:

All surrogates were within QC limits with any exceptions noted below.
QC Batch: OEXT/23865
S0: Surrogate recovery outside laboratory control limits.

- BLANK (Lab ID: 1591747)
- Nitrobenzene-d5 (S)


## Method Blank:

All analytes were below the report limit in the method blank, where applicable, with any exceptions noted below.

## Laboratory Control Spike:

All laboratory control spike compounds were within QC limits with any exceptions noted below.

## Matrix Spikes:

All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.

## Additional Comments:

This data package has been reviewed for quality and completeness and is approved for release.

## REPORT OF LABORATORY ANALYSIS

## ANALYTICAL RESULTS

| Project: | J130485 MN SLIP |
| :--- | :--- |
| Pace Project No.: | 10250888 |

Sample: WC-01 (4'-6') Lab ID: 10250888001 Collected: 11/26/13 14:00 Received: 11/27/13 16:33 Matrix: Solid
Results reported on a "dry-weight" basis

| Parameters | Results | Units | Report <br> Limit | MDL | DF | Prepared | Analyzed | CAS No. |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 6010 MET ICP | Analytical Method: EPA 6010 Preparation Method: EPA 3050 |  |  |  |  |  |  |  |
| Lead |  |  | 1.1 | 0.076 | 1 | 12/05/13 12:43 | 12/06/13 18:51 | 7439-92-1 |
| 6010 MET ICP, TCLP | Analytical Method: EPA 6010 Preparation Method: EPA 3010 |  |  |  |  |  |  |  |
| Leachate Method/Date: EPA 1311; 12/05/13 10:18 |  |  |  |  |  |  |  |  |
| Arsenic |  |  | 100 | 27.4 | 5 | 12/05/13 16:36 | 12/09/13 11:09 | 7440-38-2 |
| Barium |  |  | 50.0 | 0.65 | 5 | 12/05/13 16:36 | 12/09/13 11:09 | 7440-39-3 |
| Cadmium |  |  | 15.0 | 1.4 | 5 | 12/05/13 16:36 | 12/09/13 11:09 | 7440-43-9 |
| Chromium |  |  | 50.0 | 3.6 | 5 | 12/05/13 16:36 | 12/09/13 11:09 | 7440-47-3 |
| Copper |  |  | 50.0 | 3.8 | 5 | 12/05/13 16:36 | 12/09/13 11:09 | 7440-50-8 |
| Lead |  |  | 0.050 | 0.0062 | 5 | 12/05/13 16:36 | 12/09/13 11:09 | 7439-92-1 |
| Nickel |  |  | 100 | 10.7 | 5 | 12/05/13 16:36 | 12/09/13 11:09 | 7440-02-0 |
| Selenium |  |  | 100 | 30.7 | 5 | 12/05/13 16:36 | 12/09/13 11:09 | 7782-49-2 |
| Silver |  |  | 50.0 | 4.8 | 5 | 12/05/13 16:36 | 12/09/13 11:09 | 7440-22-4 |
| Zinc | 1760 |  | 100 | 22.0 | 5 | 12/05/13 16:36 | 12/16/13 13:18 | 7440-66-6 |

Analytical Method: EPA 7470A Preparation Method: EPA 7470A
Leachate Method/Date: EPA 1311; 12/13/13 09:53
Mercury
Dry Weight
Percent Moisture
8270 MSSV TCLP

1,4-Dichlorobenzene
2,4-Dinitrotoluene
Hexachloro-1,3-butadiene
Hexachlorobenzene
Hexachloroethane
2-Methylphenol(o-Cresol)
3\&4-Methylphenol
Nitrobenzene
Pentachlorophenol
Pyridine
2,4,5-Trichlorophenol
2,4,6-Trichlorophenol

## Surrogates

Nitrobenzene-d5 (S)
2-Fluorobiphenyl (S)
Terphenyl-d14 (S)
Phenol-d6 (S)
2-Fluorophenol (S)
2,4,6-Tribromophenol (S)

## REPORT OF LABORATORY ANALYSIS

## ANALYTICAL RESULTS

| Project: | J130485 MN SLIP |
| :--- | :--- |
| Pace Project No.: | 10250888 |

Sample: WC-02 (1'-3') Lab ID: 10250888002 Collected: 11/27/13 10:00 Received: 11/27/13 16:33 Matrix: Solid
Results reported on a "dry-weight" basis

| Parameters | Results | Units | Report <br> Limit | MDL | DF | Prepared | Analyzed | CAS No. |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 6010 MET ICP | Analytical Method: EPA 6010 Preparation Method: EPA 3050 |  |  |  |  |  |  |  |
| Lead |  |  | 1.4 | 0.10 | 1 | 12/05/13 12:43 | 12/06/13 18:57 | 7439-92-1 |
| 6010 MET ICP, TCLP | Analytical Method: EPA 6010 Preparation Method: EPA 3010 |  |  |  |  |  |  |  |
| Leachate Method/Date: EPA 1311; 12/05/13 10:18 |  |  |  |  |  |  |  |  |
| Arsenic |  |  | 100 | 27.4 | 5 | 12/05/13 16:36 | 12/10/13 09:35 | 7440-38-2 |
| Barium |  |  | 50.0 | 0.65 | 5 | 12/05/13 16:36 | 12/10/13 09:35 | 7440-39-3 |
| Cadmium |  |  | 15.0 | 1.4 | 5 | 12/05/13 16:36 | 12/10/13 09:35 | 7440-43-9 |
| Chromium |  |  | 50.0 | 3.6 | 5 | 12/05/13 16:36 | 12/10/13 09:35 | 7440-47-3 |
| Copper |  |  | 50.0 | 3.8 | 5 | 12/05/13 16:36 | 12/10/13 09:35 | 7440-50-8 |
| Lead | 0.07 |  | 0.050 | 0.0062 | 5 | 12/05/13 16:36 | 12/10/13 09:35 | 7439-92-1 |
| Nickel |  |  | 100 | 10.7 | 5 | 12/05/13 16:36 | 12/10/13 09:35 | 7440-02-0 |
| Selenium |  |  | 100 | 30.7 | 5 | 12/05/13 16:36 | 12/10/13 09:35 | 7782-49-2 |
| Silver |  |  | 50.0 | 4.8 | 5 | 12/05/13 16:36 | 12/10/13 09:35 | 7440-22-4 |
| Zinc | 1800 |  | 100 | 22.0 | 5 | 12/05/13 16:36 | 12/16/13 13:25 | 7440-66-6 |

Analytical Method: EPA 7470A Preparation Method: EPA 7470A
Leachate Method/Date: EPA 1311; 12/13/13 09:53
Mercury
Dry Weight
Percent Moisture
8270 MSSV TCLP

1,4-Dichlorobenzene
2,4-Dinitrotoluene
Hexachloro-1,3-butadiene
Hexachlorobenzene
Hexachloroethane
2-Methylphenol(o-Cresol)
3\&4-Methylphenol
Nitrobenzene
Pentachlorophenol
Pyridine
2,4,5-Trichlorophenol
2,4,6-Trichlorophenol

## Surrogates

Nitrobenzene-d5 (S)
2-Fluorobiphenyl (S)
Terphenyl-d14 (S)
Phenol-d6 (S)
2-Fluorophenol (S)
2,4,6-Tribromophenol (S)

## REPORT OF LABORATORY ANALYSIS

## QUALITY CONTROL DATA

Project: J130485 MN SLIP

Pace Project No.: 10250888

| QC Batch: | MERP/9839 | Analysis Method: | EPA 7470A |
| :--- | :--- | :--- | :--- |
| QC Batch Method: | EPA 7470A | Analysis Description: | 7470 Mercury TCLP |
| Associated Lab Samples: 10250888001,10250888002 |  |  |  |

Associated Lab Samples: 10250888001, 10250888002

| METHOD BLANK: 1594189 |  | Matrix: Water |  |
| :--- | :--- | :--- | :--- | :--- |
| Associated Lab Samples: 10250888001,10250888002 |  |  |  | | Blank |
| :---: |
| Parameter |


| LABORATORY CONTROL SAMPLE: | 1594190 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Parameter |  |



## REPORT OF LABORATORY ANALYSIS

## QUALITY CONTROL DATA

Project: J130485 MN SLIP

Pace Project No.: 10250888

| QC Batch: | MPRP/43595 | Analysis Method: | EPA 6010 |
| :--- | :--- | :--- | :--- |
| QC Batch Method: | EPA 3050 | Analysis Description: | 6010 MET |
| Associated Lab Samples: 10250888001,10250888002 |  |  |  |

METHOD BLANK: 1589126 Matrix: Solid
Associated Lab Samples: 10250888001,10250888002

| Lead | Parameter |
| :--- | :--- |
| $\mathrm{mg} / \mathrm{kg}$ | Units |$\frac{$|  Blank  |
| :---: |
|  Result  |}{|  Reporting  |
| :---: |
|  Limit  |}$\frac{\text { Analyzed }}{0.95} \frac{\text { Qualifiers }}{12 / 06 / 1317: 46}$


| LABORATORY CONTROL SAMPLE: 1589127 |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Spike | LCS | LCS | \% Rec |  |
| Parameter | Units | Conc. | Result | \% Rec | Limits | Qualifiers |
| Lead | $\mathrm{mg} / \mathrm{kg}$ | 46.3 | 47.0 | 101 | 80-120 |  |



## REPORT OF LABORATORY ANALYSIS

## QUALITY CONTROL DATA

Project: J130485 MN SLIP

Pace Project No.: 10250888

| QC Batch: | MPRP/43607 | Analysis Method: | EPA 6010 |
| :--- | :--- | :--- | :--- |
| QC Batch Method: | EPA 3010 | Analysis Description: | 6010 MET TCLP |
| Associated Lab Samples: 10250888001,10250888002 |  |  |  |

METHOD BLANK: 1589624 Matrix: Water
Associated Lab Samples: 10250888001,10250888002

| Parameter | Units | Blank <br> Result | Reporting Limit | Analyzed | Qualifiers |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Arsenic | ug/L | ND | 100 | 12/09/13 10:49 |  |
| Barium | ug/L | ND | 50.0 | 12/09/13 10:42 |  |
| Cadmium | ug/L | ND | 15.0 | 12/09/13 10:49 |  |
| Chromium | ug/L | ND | 50.0 | 12/09/13 10:49 |  |
| Copper | ug/L | ND | 50.0 | 12/09/13 10:49 |  |
| Lead | $\mathrm{mg} / \mathrm{L}$ | ND | 0.050 | 12/09/13 10:49 |  |
| Nickel | ug/L | ND | 100 | 12/09/13 10:49 |  |
| Selenium | ug/L | ND | 100 | 12/09/13 10:49 |  |
| Silver | ug/L | ND | 50.0 | 12/09/13 10:49 |  |
| Zinc | ug/L | ND | 100 | 12/09/13 10:49 |  |


| LABORATORY CONTROL SAMPLE: 1589625 |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Spike Conc | LCS <br> Result | LCS \% Rec | \% Rec <br> Limits | Qualifiers |
| Arsenic | ug/L | 1000 | 950 | 95 | 80-120 |  |
| Barium | ug/L | 1000 | 1060 | 106 | 80-120 |  |
| Cadmium | ug/L | 1000 | 1010 | 101 | 80-120 |  |
| Chromium | ug/L | 1000 | 978 | 98 | 80-120 |  |
| Copper | $\mathrm{ug} / \mathrm{L}$ | 1000 | 1050 | 105 | 80-120 |  |
| Lead | mg/L | 1 | 0.93 | 93 | 80-120 |  |
| Nickel | ug/L | 1000 | 958 | 96 | 80-120 |  |
| Selenium | $u g / L$ | 1000 | 994 | 99 | 80-120 |  |
| Silver | ug/L | 500 | 508 | 102 | 80-120 |  |
| Zinc | $u g / L$ | 1000 | 918 | 92 | 80-120 |  |


| MATRIX SPIKE \& MATRIX SPIKE DUPLICATE: |  |  |  |  | 1589627 |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  | MSD |  |  |  |  |  |  |  |  |
|  | 10250888001 |  | Spike | Spike | MS | MSD | MS | MSD | \% Rec | Max |  |  |
| Parameter | Units | Result | Conc. | Conc. | Result | Result | \% Rec | \% Rec | Limits | RPD | RPD | Qual |
| Arsenic | ug/L | ND | 1000 | 1000 | 1100 | 1090 | 109 | 108 | 75-125 | . 8 | 30 |  |
| Barium | ug/L | 500 | 1000 | 1000 | 1540 | 1530 | 104 | 103 | 75-125 | . 8 | 30 |  |
| Cadmium | ug/L | 171 | 1000 | 1000 | 1080 | 1070 | 91 | 90 | 75-125 | 1 | 30 |  |
| Chromium | ug/L | ND | 1000 | 1000 | 1030 | 1030 | 103 | 103 | 75-125 | . 4 | 30 |  |
| Copper | ug/L | ND | 1000 | 1000 | 1090 | 1080 | 106 | 104 | 75-125 | 1 | 30 |  |
| Lead | $\mathrm{mg} / \mathrm{L}$ | 0.14 | 1 | 1 | 1.2 | 1.2 | 105 | 104 | 75-125 | . 9 | 30 |  |
| Nickel | ug/L | ND | 1000 | 1000 | 1030 | 1020 | 100 | 99 | 75-125 | . 7 | 30 |  |
| Selenium | ug/L | 124 | 1000 | 1000 | 1200 | 1200 | 108 | 108 | 75-125 | . 02 | 30 |  |
| Silver | ug/L | ND | 500 | 500 | 523 | 519 | 103 | 103 | 75-125 | . 7 | 30 |  |
| Zinc | ug/L | 1760 | 1000 | 1000 | 2970 | 2880 | 121 | 112 | 75-125 | 3 | 30 |  |

## REPORT OF LABORATORY ANALYSIS

1700 Elm Street - Suite 200

## QUALITY CONTROL DATA

Project: J130485 MN SLIP

Pace Project No.: 10250888

| QC Batch: | MPRP/43586 | Analysis Method: | ASTM D2974 |
| :--- | :--- | :--- | :--- |
| QC Batch Method: | ASTM D2974 | Analysis Description: | Dry Weight/Percent Moisture |
| Associated Lab Samples: | 10250888001,10250888002 |  |  |



## QUALITY CONTROL DATA

Project: J130485 MN SLIP

Pace Project No.: 10250888

| QC Batch: | OEXT/23865 | Analysis Method: | EPA 8270 |
| :--- | :---: | :--- | :--- |
| QC Batch Method: | EPA 3520 | Analysis Description: | 8270 TCLP MSSV |
| Associated Lab Samples: 10250888001,10250888002 |  |  |  |

METHOD BLANK: 1591742 Matrix: Water
Associated Lab Samples: 10250888001,10250888002

| Parameter | Units | Blank Result | Reporting Limit | Analyzed | Qualifiers |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 1,4-Dichlorobenzene | ug/L | ND | 100 | 12/10/13 12:46 |  |
| 2,4,5-Trichlorophenol | ug/L | ND | 100 | 12/10/13 12:46 |  |
| 2,4,6-Trichlorophenol | ug/L | ND | 100 | 12/10/13 12:46 |  |
| 2,4-Dinitrotoluene | ug/L | ND | 100 | 12/10/13 12:46 |  |
| 2-Methylphenol(o-Cresol) | ug/L | ND | 100 | 12/10/13 12:46 |  |
| 3\&4-Methylphenol | ug/L | ND | 100 | 12/10/13 12:46 |  |
| Hexachloro-1,3-butadiene | ug/L | ND | 100 | 12/10/13 12:46 |  |
| Hexachlorobenzene | ug/L | ND | 100 | 12/10/13 12:46 |  |
| Hexachloroethane | ug/L | ND | 100 | 12/10/13 12:46 |  |
| Nitrobenzene | ug/L | ND | 100 | 12/10/13 12:46 |  |
| Pentachlorophenol | ug/L | ND | 230 | 12/10/13 12:46 |  |
| Pyridine | ug/L | ND | 100 | 12/10/13 12:46 |  |
| 2,4,6-Tribromophenol (S) | \%. | 93 | 71-125 | 12/10/13 12:46 |  |
| 2-Fluorobiphenyl (S) | \%. | 81 | 67-125 | 12/10/13 12:46 |  |
| 2-Fluorophenol (S) | \%. | 83 | 58-125 | 12/10/13 12:46 |  |
| Nitrobenzene-d5 (S) | \%. | 74 | 62-125 | 12/10/13 12:46 |  |
| Phenol-d6 (S) | \%. | 81 | 64-125 | 12/10/13 12:46 |  |
| Terphenyl-d14 (S) | \%. | 88 | 61-125 | 12/10/13 12:46 |  |

METHOD BLANK: 1591746
Matrix: Water
Associated Lab Samples: 10250888001,10250888002

| Parameter | Units | Blank <br> Result | Reporting Limit | Analyzed | Qualifiers |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 1,4-Dichlorobenzene | ug/L | ND | 100 | 12/10/13 13:14 |  |
| 2,4,5-Trichlorophenol | ug/L | ND | 100 | 12/10/13 13:14 |  |
| 2,4,6-Trichlorophenol | ug/L | ND | 100 | 12/10/13 13:14 |  |
| 2,4-Dinitrotoluene | ug/L | ND | 100 | 12/10/13 13:14 |  |
| 2-Methylphenol(o-Cresol) | ug/L | ND | 100 | 12/10/13 13:14 |  |
| 3\&4-Methylphenol | ug/L | ND | 100 | 12/10/13 13:14 |  |
| Hexachloro-1,3-butadiene | ug/L | ND | 100 | 12/10/13 13:14 |  |
| Hexachlorobenzene | ug/L | ND | 100 | 12/10/13 13:14 |  |
| Hexachloroethane | ug/L | ND | 100 | 12/10/13 13:14 |  |
| Nitrobenzene | ug/L | ND | 100 | 12/10/13 13:14 |  |
| Pentachlorophenol | ug/L | ND | 230 | 12/10/13 13:14 |  |
| Pyridine | ug/L | ND | 100 | 12/10/13 13:14 |  |
| 2,4,6-Tribromophenol (S) | \%. | 90 | 71-125 | 12/10/13 13:14 |  |
| 2-Fluorobiphenyl (S) | \%. | 84 | 67-125 | 12/10/13 13:14 |  |
| 2-Fluorophenol (S) | \%. | 85 | 58-125 | 12/10/13 13:14 |  |
| Nitrobenzene-d5 (S) | \%. | 77 | 62-125 | 12/10/13 13:14 |  |
| Phenol-d6 (S) | \%. | 88 | 64-125 | 12/10/13 13:14 |  |
| Terphenyl-d14 (S) | \%. | 89 | 61-125 | 12/10/13 13:14 |  |

## REPORT OF LABORATORY ANALYSIS

## QUALITY CONTROL DATA

Project: J130485 MN SLIP
Pace Project No.: 10250888
METHOD BLANK: 1591747 Matrix: Water

Associated Lab Samples: 10250888001, 10250888002

| Parameter | Units | Blank Result | Reporting Limit | Analyzed | Qualifiers |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 1,4-Dichlorobenzene | ug/L | ND | 100 | 12/11/13 11:45 |  |
| 2,4,5-Trichlorophenol | ug/L | ND | 100 | 12/11/13 11:45 |  |
| 2,4,6-Trichlorophenol | ug/L | ND | 100 | 12/11/13 11:45 |  |
| 2,4-Dinitrotoluene | ug/L | ND | 100 | 12/11/13 11:45 |  |
| 2-Methylphenol(o-Cresol) | ug/L | ND | 100 | 12/11/13 11:45 |  |
| 3\&4-Methylphenol | ug/L | ND | 100 | 12/11/13 11:45 |  |
| Hexachloro-1,3-butadiene | ug/L | ND | 100 | 12/11/13 11:45 |  |
| Hexachlorobenzene | ug/L | ND | 100 | 12/11/13 11:45 |  |
| Hexachloroethane | ug/L | ND | 100 | 12/11/13 11:45 |  |
| Nitrobenzene | ug/L | ND | 100 | 12/11/13 11:45 |  |
| Pentachlorophenol | ug/L | ND | 230 | 12/11/13 11:45 |  |
| Pyridine | ug/L | ND | 100 | 12/11/13 11:45 |  |
| 2,4,6-Tribromophenol (S) | \%. | 85 | 71-125 | 12/11/13 11:45 |  |
| 2-Fluorobiphenyl (S) | \%. | 69 | 67-125 | 12/11/13 11:45 |  |
| 2-Fluorophenol (S) | \%. | 61 | 58-125 | 12/11/13 11:45 |  |
| Nitrobenzene-d5 (S) | \%. | 61 | 62-125 | 12/11/13 11:45 | S0 |
| Phenol-d6 (S) | \%. | 65 | 64-125 | 12/11/13 11:45 |  |
| Terphenyl-d14 (S) | \%. | 81 | 61-125 | 12/11/13 11:45 |  |

METHOD BLANK: 1591748
Matrix: Water
Associated Lab Samples: 10250888001, 10250888002

| Parameter | Units | Blank <br> Result | Reporting Limit | Analyzed | Qualifiers |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 1,4-Dichlorobenzene | ug/L | ND | 100 | 12/10/13 14:11 |  |
| 2,4,5-Trichlorophenol | ug/L | ND | 100 | 12/10/13 14:11 |  |
| 2,4,6-Trichlorophenol | ug/L | ND | 100 | 12/10/13 14:11 |  |
| 2,4-Dinitrotoluene | ug/L | ND | 100 | 12/10/13 14:11 |  |
| 2-Methylphenol(o-Cresol) | ug/L | ND | 100 | 12/10/13 14:11 |  |
| 3\&4-Methylphenol | ug/L | ND | 100 | 12/10/13 14:11 |  |
| Hexachloro-1,3-butadiene | ug/L | ND | 100 | 12/10/13 14:11 |  |
| Hexachlorobenzene | ug/L | ND | 100 | 12/10/13 14:11 |  |
| Hexachloroethane | ug/L | ND | 100 | 12/10/13 14:11 |  |
| Nitrobenzene | ug/L | ND | 100 | 12/10/13 14:11 |  |
| Pentachlorophenol | ug/L | ND | 230 | 12/10/13 14:11 |  |
| Pyridine | ug/L | ND | 100 | 12/10/13 14:11 |  |
| 2,4,6-Tribromophenol (S) | \%. | 87 | 71-125 | 12/10/13 14:11 |  |
| 2-Fluorobiphenyl (S) | \%. | 77 | 67-125 | 12/10/13 14:11 |  |
| 2-Fluorophenol (S) | \%. | 77 | 58-125 | 12/10/13 14:11 |  |
| Nitrobenzene-d5 (S) | \%. | 70 | 62-125 | 12/10/13 14:11 |  |
| Phenol-d6 (S) | \%. | 77 | 64-125 | 12/10/13 14:11 |  |
| Terphenyl-d14 (S) | \%. | 85 | 61-125 | 12/10/13 14:11 |  |

## REPORT OF LABORATORY ANALYSIS

## QUALITY CONTROL DATA

Project: J130485 MN SLIP
Pace Project No.: 10250888

| LABORATORY CONTROL SAMPLE: <br> Parameter | 1591743 |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Spike Conc. | LCS <br> Result | $\begin{gathered} \text { LCS } \\ \% \text { Rec } \end{gathered}$ | \% Rec Limits | Qualifiers |
| 1,4-Dichlorobenzene | ug/L | 500 | 404 | 81 | 58-125 |  |
| 2,4,5-Trichlorophenol | ug/L | 500 | 455 | 91 | 67-125 |  |
| 2,4,6-Trichlorophenol | ug/L | 500 | 457 | 91 | 68-125 |  |
| 2,4-Dinitrotoluene | ug/L | 500 | 470 | 94 | 69-125 |  |
| 2-Methylphenol(o-Cresol) | ug/L | 500 | 398 | 80 | 62-125 |  |
| 3\&4-Methylphenol | ug/L | 500 | 392 | 78 | 63-125 |  |
| Hexachloro-1,3-butadiene | ug/L | 500 | 437 | 87 | 58-125 |  |
| Hexachlorobenzene | ug/L | 500 | 468 | 94 | 70-125 |  |
| Hexachloroethane | ug/L | 500 | 404 | 81 | 56-125 |  |
| Nitrobenzene | ug/L | 500 | 442 | 88 | 63-125 |  |
| Pentachlorophenol | ug/L | 500 | 475 | 95 | 52-125 |  |
| Pyridine | ug/L | 500 | 222 | 44 | 30-125 |  |
| 2,4,6-Tribromophenol (S) | \%. |  |  | 87 | 71-125 |  |
| 2-Fluorobiphenyl (S) | \%. |  |  | 81 | 67-125 |  |
| 2-Fluorophenol (S) | \%. |  |  | 68 | 58-125 |  |
| Nitrobenzene-d5 (S) | \%. |  |  | 74 | 62-125 |  |
| Phenol-d6 (S) | \%. |  |  | 65 | 64-125 |  |
| Terphenyl-d14 (S) | \%. |  |  | 83 | 61-125 |  |


| MATRIX SPIKE \& MATRIX SPIKE DUPLICATE: 1591744 |  |  |  |  | 1591745 |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Parameter | 10250888001 |  | MS Spike | MSD Spike | MS | MSD | MS | MSD | \% Rec | Max |  |  |
|  | Units | Result | Conc. | Conc. | Result | Result | \% Rec | \% Rec | Limits | RPD | RPD | Qual |
| 1,4-Dichlorobenzene | ug/L | ND | 500 | 500 | 420 | 399 | 84 | 80 | 56-125 | 5 | 30 |  |
| 2,4,5-Trichlorophenol | ug/L | ND | 500 | 500 | 456 | 465 | 91 | 93 | 65-125 | 2 | 30 |  |
| 2,4,6-Trichlorophenol | ug/L | ND | 500 | 500 | 469 | 443 | 94 | 89 | 66-125 | 6 | 30 |  |
| 2,4-Dinitrotoluene | ug/L | ND | 500 | 500 | 488 | 487 | 98 | 97 | 67-125 | . 1 | 30 |  |
| 2-Methylphenol(o-Cresol) | ug/L | ND | 500 | 500 | 413 | 388 | 83 | 78 | 61-125 | 6 | 30 |  |
| 3\&4-Methylphenol | ug/L | ND | 500 | 500 | 427 | 398 | 85 | 80 | 58-125 | 7 | 30 |  |
| Hexachloro-1,3-butadiene | ug/L | ND | 500 | 500 | 448 | 423 | 90 | 85 | 57-125 | 6 | 30 |  |
| Hexachlorobenzene | ug/L | ND | 500 | 500 | 488 | 483 | 98 | 97 | 68-125 | 1 | 30 |  |
| Hexachloroethane | ug/L | ND | 500 | 500 | 412 | 410 | 82 | 82 | 49-125 | . 3 | 30 |  |
| Nitrobenzene | ug/L | ND | 500 | 500 | 445 | 432 | 89 | 86 | 58-125 | 3 | 30 |  |
| Pentachlorophenol | ug/L | ND | 500 | 500 | 503 | 504 | 101 | 101 | 48-125 | . 2 | 30 |  |
| Pyridine | ug/L | ND | 500 | 500 | 279 | 253 | 56 | 51 | 30-125 | 10 | 30 |  |
| 2,4,6-Tribromophenol (S) | \%. |  |  |  |  |  | 90 | 89 | 71-125 |  |  |  |
| 2-Fluorobiphenyl (S) | \%. |  |  |  |  |  | 79 | 80 | 67-125 |  |  |  |
| 2-Fluorophenol (S) | \%. |  |  |  |  |  | 76 | 67 | 58-125 |  |  |  |
| Nitrobenzene-d5 (S) | \%. |  |  |  |  |  | 79 | 72 | 62-125 |  |  |  |
| Phenol-d6 (S) | \%. |  |  |  |  |  | 74 | 70 | 64-125 |  |  |  |
| Terphenyl-d14 (S) | \%. |  |  |  |  |  | 84 | 86 | 61-125 |  |  |  |

## REPORT OF LABORATORY ANALYSIS

## QUALIFIERS

Project: J130485 MN SLIP

Pace Project No.: 10250888

## DEFINITIONS

DF - Dilution Factor, if reported, represents the factor applied to the reported data due to changes in sample preparation, dilution of the sample aliquot, or moisture content.
ND - Not Detected at or above adjusted reporting limit.
J-Estimated concentration above the adjusted method detection limit and below the adjusted reporting limit.
MDL - Adjusted Method Detection Limit.
PRL - Pace Reporting Limit.
RL - Reporting Limit.
S - Surrogate
1,2-Diphenylhydrazine (8270 listed analyte) decomposes to Azobenzene.
Consistent with EPA guidelines, unrounded data are displayed and have been used to calculate \% recovery and RPD values.
LCS(D) - Laboratory Control Sample (Duplicate)
MS(D) - Matrix Spike (Duplicate)
DUP - Sample Duplicate
RPD - Relative Percent Difference
NC - Not Calculable.
SG - Silica Gel - Clean-Up
U - Indicates the compound was analyzed for, but not detected.
N-Nitrosodiphenylamine decomposes and cannot be separated from Diphenylamine using Method 8270. The result reported for each analyte is a combined concentration.
Pace Analytical is TNI accredited. Contact your Pace PM for the current list of accredited analytes.
TNI - The NELAC Institute.

## ANALYTE QUALIFIERS

M1 Matrix spike recovery exceeded QC limits. Batch accepted based on laboratory control sample (LCS) recovery.
S0 Surrogate recovery outside laboratory control limits.

## REPORT OF LABORATORY ANALYSIS

## QUALITY CONTROL DATA CROSS REFERENCE TABLE

| Project: | J130485 MN SLIP |
| :--- | :--- |
| Pace Project No.: | 10250888 |


| Lab ID | Sample ID | QC Batch Method | QC Batch | Analytical Method | Analytical Batch |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 10250888001 | WC-01 (4'-6') | EPA 3050 | MPRP/43595 | EPA 6010 | ICP/18340 |
| 10250888002 | WC-02 (1'-3') | EPA 3050 | MPRP/43595 | EPA 6010 | ICP/18340 |
| 10250888001 | WC-01 (4'-6') | EPA 3010 | MPRP/43607 | EPA 6010 | ICP/18343 |
| 10250888002 | WC-02 (1'-3') | EPA 3010 | MPRP/43607 | EPA 6010 | ICP/18343 |
| 10250888001 | WC-01 (4'-6') | EPA 7470A | MERP/9839 | EPA 7470A | MERC/11307 |
| 10250888002 | WC-02 (1'-3') | EPA 7470A | MERP/9839 | EPA 7470A | MERC/11307 |
| 10250888001 | WC-01 (4'-6') | ASTM D2974 | MPRP/43586 |  |  |
| 10250888002 | WC-02 (1'-3') | ASTM D2974 | MPRP/43586 |  |  |
| 10250888001 | WC-01 (4'-6') | EPA 3520 | OEXT/23865 | EPA 8270 | MSSV/10082 |
| 10250888002 | WC-02 (1'-3') | EPA 3520 | OEXT/23865 | EPA 8270 | MSSV/10082 |

CHAIN-OF-CUSTODY / Analytical Request Document
The Chain-of-Custody is a LEGAL DOCUMENT. All relevant field's must be completed accurately.


10250888
Section C
Invoice information:
Attention:
Commend Nomen Section $A$
Section A
Required Ci


*Important Note: By signing this form you are accepting Pace's NET 30 day payment terms and agreeing to late charges of $1.5 \%$ per month for any invoices not paid whin 30 days.

| PaceAnalytical | Document Name: <br> Sample Condition Upon Receipt form | Document Revised: 07Nov2013 Page 1 of 1 |
| :---: | :---: | :---: |
|  | Document No:: <br> F-MN-L-213-rev.08 | Issuing Authority: <br> Pace Minnesota Quality Office |



Note: Whenever there is a discrepancy affecting North Carolina compliance samples, a copy of this form will be sent to the North Carolina DEHNR Certification Office (i.e out of hold, incorrect preservative, out of temp, incorrect containers)

## Appendix F

## Correspondence

F1 August 17, 2005 Telephone Record from Bay West to Marine Iron \& Shipbuilding Co.
F2 August 08, 2005, E-mail from the City of Duluth to the MPCA

## Appendix F1

Telephone Record
Date: August 17, 2005
From: Brenda Winkler, Bay West, Inc.
To: Bill Meierhoff, Marine Iron \& Shipbuilding Co.
marineiron@aol.ocm
325 S Lake Av
Duluth, MN 55802-2323
(218) 722-0571

As suggested by Susan Johnson, I called Bill Meierhoff to inquire about the construction of the Slip dock walls. I asked Bill if he had any records on the dock walls but he did not. Bill did provide me with the following information.

## Dock Wall

West Side - Irvin Side. The dock wall on the Irvin side is wood cribbing. Bill believes it extends down to approximately 23 feet. It may be greater than that but he is basing the depth on his records on the last time it was dredged. In 1930's it was dredged down to 23 feet and overtime it has slowly filled in to its current depth.
Before the Irvin was put into the slip, the cribbing collapsed (rotting wood) and had to be rebuilt. The City rebuilt the wall. Bill said they did a poor job of this because there are sink holes all along the dock wall.
North Side. The NE corner of the Slip was filled in with concrete at one of the storm sewer discharge points by Northland Construction to approximately 5 feet below the water surface. This is by the water hydrant for the steam plant. Bill said boat owners were notified not to take there boats in this area.

East Side. The east dock wall is a concrete cap over pilings. The sediment washes out between the pilings. Sink holes are present in the parking lot - Bill has them occasionally filled in but they keep coming back.
Bill stated that a 200 -foot concrete wall was probably installed at the north end of the east side, maybe to a depth of five feet below the water surface. A building used to be in this location and the building had a basement so Bill believes the concrete wall would have been extended down to 5 feet below the water surface.

In approximately 1980, about 100 feet of steel sheet piling (maximum depth of 20 feet) was installed on the north end of the east side of the slip.
Bill stated that $1 / 2$ way down on the east side is the eddy of the slip. This is where he believes most of the contamination is present.

## North East Winds

Bill said that the North East winds will create 3 - to 4 -foot waves in the slip. There is a greater frequency for 3 - to 4 -foot waves in the fall, and not as much in the spring. He said that special anchoring had to be done to keep the Irvin from walking away. Bill suggested that a simple double piling wall be built if sediments are going to be removed so that we avoid discharge of contaminated sediments to the harbor during remediation. The double wall would prevent contaminant migration resulting from wave/water surges in both directions.

## Appendix F2

August 08, 2005, E-mail from the City of Duluth to the MPCA Telephone Record
-----Original Message-----
From: Dick Larson [mailto:Dlarson@ci.duluth.mn.us]
Sent: Friday, August 12, 2005 5:36 PM
To: Streitz, Andrew
Cc: Marion Lonsdale; Steve Lipinski; Johnson, Susan
Subject: RE: Minnesota Slip
Andrew,
Yes, I would like to receive updates on the dredging plans. It would be best to send updates to Marnie Lonsdale. She will review them and advise me and/or others of significant events/decisions in the project. Thanks for including us in the loop.
>>> "Streitz, Andrew" [Andrew.Streitz@state.mn.us](mailto:Andrew.Streitz@state.mn.us) 8/11/2005 6:13 PM >>> Thanks Dick. It is indeed good to know the worst case. As the Agency moves toward a possible dredging of the Slip would you or a representative care to receive updates on our plans? Andrew
-----Original Message-----
From: Dick Larson [mailto:Dlarson@ci.duluth.mn.us]
Sent: Monday, August 08, 2005 3:51 PM
To: Streitz, Andrew
Cc: Bob Bruce; Gary Minck; Jim Benning ; Marion Lonsdale; Mike Metso
Subject: Re: Minnesota Slip
Andrew,
Unfortunately I can't at this time predict the future of the Minnesota
Slip. Here's what I know:
The City has engaged an engineering consultant for the purpose of evaluating the condition of the pedestrian drawbridge and making recommendations relative to what they find. Also the consultant is to evaluate and recommend an improved (and more reliable) mechanical system to operate the bridge. Very likely these recommendations will have an expensive price tag associated with them.

If so, the City will find itself in a situation where it would be prudent to consider alternatives such as removing most of the marine activity from the Slip to reduce the number of bridge operations and permit less expensive repairs to be made. Such consideration is certainly a number of months off from now.

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 Ped Bridge began operations. This I would suspect is the "worst case" scenario.

I hope this information is useful. Do not hesitate to contact me (730-5115) to discuss further, if necessary.
>>> "Streitz, Andrew" [Andrew.Streitz@state.mn.us](mailto:Andrew.Streitz@state.mn.us) 8/5/2005 1:12 PM >>> Mr. Larson

My name is Andrew Streitz and I work for the Minnesota Pollution Control Agency here in Duluth. I am working on the cleanup of Minnesota Slipthe harbor home of the Irvin and Sundew. As the Agency moves toward selecting a remedy for the contaminated sediments it would be helpful to know what the City's plans are for the Slip. For instance, I have heard rumors that the pedestrian bridge may not have a long lifespan, which would limit future uses of the Slip. Does the City have plans to bring the active use of the Slip to a close? Please advise. Thanks. Andrew

## Andrew Streitz

Environmental Outcomes
Minnesota Pollution Control Agency
NE Regional Office- Duluth
andrew.streitz@pca.state.mn.us
(218) 723-4929 Voice
(800) 657-3864 Voice
(218) 723-4727 Fax


[^0]:    * Heavy hydrocarbon compounds detected outside the DRO window

