SUPPLEMENTAL FEASIBILITY STUDY REPORT FOR OPERABLE UNIT NO. 2

FORMER ANACONDA WIRE AND CABLE PLANT SITE
1 RIVER STREET
HASTINGS-ON-HUDSON, NEW YORK

Prepared for:

ATLANTIC RICHFIELD COMPANY

and

ARCO ENVIRONMENTAL REMEDIATION, LLC

28100 Torch Parkway
Warrenville, Illinois 60555

Prepared by:

PARSONS

290 Elwood Davis Road, Suite 312
Liverpool, New York 13088

April 2006

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(Site No. 3-60-022)

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APRIL 2006

Note: In April 2006, Atlantic Richfield submitted this draft Supplemental Feasibility Study for the Harbor at Hastings site to the New York Department of Environmental Conservation ("NYSDEC"). The report evaluates potential remedies and describes Atlantic Richfield's preferred remedy for Hudson River sediments adjacent to the site (the OU-2 portion of the site). The site is the former Anaconda Wire and Cable Company plant site located at One River Street.

NYSDEC is reviewing this draft report, and may ask Atlantic Richfield to modify the report before it is finalized. Next, NYSDEC will identify its proposed remedy in a Proposed Remedial Action Plan (PRAP) for OU-2, and make its proposal available for public comment. The PRAP will identify NYSDEC's preferred remedy, summarize the alternatives considered, and discuss the reasons for NYSDEC's preference. After careful consideration of all comments received during the public comment period, NYSDEC will select a remedy for the site and incorporate that remedy into a Record of Decision.

Atlantic Richfield wishes to move forward with remediation and anticipates that NYSDEC will issue its revised Proposed Remedial Action Plan this fall.

CERTIFICATION STATEMENT

SUPPLEMENTAL FEASIBILITY STUDY REPORT
HARBOR AT HASTINGS OPERABLE UNIT NUMBER 2
HASTINGS-ON-HUDSON, NEW YORK

The undersigned, on behalf of the Atlantic Richfield Company certifies: that I am and at all pertinent times hereinafter mentioned was a Professional Engineer licensed or otherwise authorized under Article 145 of the Education Law of the State of New York to practice engineering; that I am the person who had primary direct responsibility for the preparation of this report; and that all activities described in this report have been performed in full accordance with the National Contingency Plan (40 CFR Part 300) and applicable guidance.

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David B. Babcock, P.E. Date
New York State Professional Engineer
License No. 065209-1

TABLE OF CONTENTS

Page

TABLE OF CONTENTS
(CONTINUED)

Page

TABLE OF CONTENTS
(CONTINUED)

Page

TABLE OF CONTENTS
(CONTINUED)

Page

TABLE OF CONTENTS
(CONTINUED)

Page

TABLE OF CONTENTS
(CONTINUED)

Page

TABLE OF CONTENTS
(CONTINUED)

Page

TABLE OF CONTENTS
(CONTINUED)

Page

LIST OF TABLES

TABLE OF CONTENTS
(CONTINUED)

LIST OF TABLES - continued

Page

TABLE OF CONTENTS
(CONTINUED)

LIST OF TABLES - continued

Page

LIST OF FIGURES

TABLE OF CONTENTS
(CONTINUED)

Page

LIST OF FIGURES - continued

TABLE OF CONTENTS
(CONTINUED)

Page

LIST OF FIGURES - continued

LIST OF APPENDICES

LIST OF ACRONYMS

AERL	-	ARCO Environmental Remediation Limited
AR	-	Atlantic Richfield
ARCO	-	Atlantic Richfield Company
AVS	-	acid volatile sulfides
AWC	-	Anaconda Wire and Cable
BS	-	boat slip
CFR	-	Code of Federal Regulations
DRET	-	dredge elutriate test
ESI	-	Environmental Standards, Inc
ESB	-	equilibrium partitioning sediment benchmark
FS	-	feasibility study
Ft	-	feet/foot
NAVD	-	North American Vertical Datum
NW	-	Northwest Corner Area
NYCRR	-	New York Code of Rules and Regulations
NYSDEC	-	New York State Department of Environmental Conservation
OM	-	Old Marina Area
OU	-	operable unit
PCBs	-	polychlorinated biphenyls
ppb	-	part per billion (also a microgram per liter in water – ug/L)
ppm	-	part per million(also a milligram per kilogram in sediment– mg/kg)
PRAP	-	proposed remedial action plan
PRG	-	preliminary remedial goal
RCRA	-	Resource Conservation and Recovery Act (federal)
RI	-	remedial investigation
ROD	-	Record of Decision
SA	-	Southern Area
SEM	-	simultaneously extracted metal
TOC	-	total organic carbon
TSCA	-	Toxic Substances Control Act (federal)
USACE	-	United States Army Corps of Engineers
USEPA	-	United States Environmental Protection Agency
USGS	-	United States Geological Survey

EXECUTIVE SUMMARY

REASONS FOR THE DEVELOPMENT OF THIS SUPPLEMENTAL FEASIBILITY STUDY

Operable Unit 2 (OU-2) of the Harbor at Hastings Site (Site) is a contaminated sediment site, approximately 31 acres of size, located in the lower Hudson River, next to a former copper wire and cable plant in Hastings-On-Hudson, New York. Polychlorinated biphenyls (PCBs) and copper are the primary contaminants of concern.

The New York State Department of Environmental Conservation (NYSDEC) issued a proposed remedial action plan (PRAP) in 2003 that recommended the removal of all contaminated sediments above certain Preliminary Remediation Goals ("PRGs") within approximately 100 feet (ft) of the shoreline

After reviewing public comments on the proposed remedy, the Department agreed that additional data and investigation was needed before proceeding with remedy selection. Accordingly, Atlantic Richfield Company, working with the Department, engaged in extensive additional field work in the Hudson River to collect data to:

- Determine the extent of fill material and debris in the near shore portion of the river, and evaluate its impact on dredging remedies;
- Delineate the extent of PCB contamination in the Old Marina, on the north side of the plant site, and evaluate appropriate remedies for that area;
- Determine the level of copper and other metals observed on site that are in a bioavailable and potentially harmful form, and evaluate remedies for those metals;
- Develop a three-dimensional model of contaminant distribution in sediment that incorporates new and existing data, to determine the volume of impacted sediment, its location and depth, and to show where most of the PCB and copper mass is located; and
- Evaluate how remedy options for the river (OU-2) may be coordinated with the selected remedy for the plant site (Operable Unit 1 [OU-1]), focusing on the area around the shoreline bulkhead, which divides the two operable units, and on surrounding geotechnical and river conditions (sediment shear strength, slope, water velocity and depth, and other factors).

AR gathered these data in 2004-2005, and submitted them to NYSDEC in a series of short reports. These new data, and the technical conclusions that result from them, form the basis for this Supplemental Feasibility Study.

SIGNIFICANT TECHNICAL FINDINGS

The additional data shows that four site conditions have a significant impact on the range of feasible remedy options. These are:

River Fill

Much of the contaminated sediment is found in a submerged berm of fill material, pilings, and debris that is 20 to 40 ft thick at the western shoreline. The fill is steeply sloped near shore, and then slopes more gradually down to the natural river bottom, which is over 40 ft deep. The plant site was built in the mid 1800's and early 1900's by placing fill material (silt, sand, gravel, rip-rap, ash, slag, glass, metal debris, wood, crushed stone, brick fragments, and other debris) into areas of the river that were up to 40 ft deep, and the submerged river berm along the shoreline is an integral part of the structure that holds the plant site in place. Remedy options that seek to remove all or most of the berm present extraordinary geotechnical challenges.

PCB Location/Mass

Most of the PCB mass (99 percent) is found along the northwest shoreline of the site. Moreover, most of that contamination is located within a few feet of the shoreline in the top 7 to 9 ft of sediment and fill material (approximately 60 percent to 75 percent of the PCB mass). However, PCB contamination does extend along the northwest shoreline to depths of nearly 40 ft below the mudline,[1] which is consistent with the depth of PCB contamination found in the northwest corner of the adjacent OU-1 plant site. Although all PCBs in the river were found in solid form, there are areas of PCBs still in non-aqueous phase liquid (NAPL) form on the plant site. The depth of PCBs in this area, and the presence of NAPL near the shoreline, present unusual challenges to the complete removal of PCBs from the OU-2 Northwest Corner area.

Only 1 percent of the PCB mass was found outside the OU-2 Northwest Corner Area, generally at low levels near the 1 part per million (ppm) preliminary remedial goal (PRG). Indeed, the area-weighted average level of PCBs outside the northwest shoreline area is below the 1 ppm PRG. To remove this material would require removal of large volumes of harmless material (including fill material) at great expense to reach the small mass of PCBs found there.

Metal Location/Mass

Most of the metal mass above proposed PRGs is concentrated in a small area near the plant shoreline, approximately 20,000 square feet in total size (0.5 acre), in the top 6 to 8 ft of sediment and fill material. The likely source of the concentrated metal contamination is shoreline outfall discharge points that released copper and related metals (lead, nickel, zinc) into the river when the wire and cable plant was in operation from 1919 to until the plant closed and the discharge terminated in the 1970's.

This localized area of elevated metal contamination should be distinguished from low levels of copper and other metals that were found throughout the Site, both on shore and in the river, in surface and in deeper fill material, at levels that exceed NYSDEC's stated background level for the Hudson River.

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1 The river bottom surface varies across the site. At the shoreline edge the river bottom surface is made of rocky fill material (the berm) with sediment in between. As one moves away from shore, a layer of river sediments collects on top of the berm, with the thickest sediment layer found near the toe of the berm. "Mudline" is used to refer to the river bottom surface throughout this area.

Recent USEPA studies and guidance (2005) found that bulk metal concentrations do not accurately predict whether contaminated sediment will be harmful to aquatic life. Instead, USEPA found there is a close relationship between the bioavailable fraction of metals and harm to aquatic life. The bioavailable fraction of metals can be measured in pore water and predicted based on the concentrations of organic carbon, acid volatile sulfide (AVS) and simultaneously extracted metals (SEM). Over the past two years, these data have been developed for the Hastings site.

At the Hastings site, the only metals detected in pore water samples were well below NYSDEC water quality standards, suggesting that metals are not bioavailable or harmful. In addition, the data demonstrate that natural sources of AVS/SEM and organic carbon found in the river sediments are binding the metals throughout most of the Site and preventing them from becoming bioavailable. As a result, the data support a conclusion that sediment copper concentrations below 982 ppm are not bioavailable and are not toxic to benthic organisms. The data also indicate that copper is an acceptable marker for site-related metals contamination. All remedy options in this Supplemental Feasibility Study address those areas where copper in sediment is in excess of 982 ppm.

Geotechnical Limits

The upland or "OU-1" remedy includes a 40+ foot tall bulkhead wall along the entire plant shoreline. This wall will anchor a containment system designed for PCBs present in the Northwest Corner of the upland site. It is also critical for the structural stability of the upland portion of the property. The bulkhead requires a submerged berm of fill material in the river to help stabilize and support it. While the berm size varies with the bulkhead design, a berm is therefore an essential component of every river remedy option. It is possible to incorporate capping and containment options into the shoreline berm required to support OU-1. This Supplemental Feasibility Study evaluates the factors needed to construct and maintain a cap/berm that will remain effective when exposed to floods, ice, and other potential damage.

REMEDY SELECTION

This Supplemental Feasibility Study divides the OU-2 Site into a number of smaller areas of concern. These smaller areas are: (a) the Northwest Corner Area; (b) the Southern Area, (c) the Boat Slips, (d) the Old Marina Area; and (e) the Offshore Area. Each of these units has unique characteristics -- different contaminant distributions, different geotechnical concerns, different remedial implementability risks -- that impact remedy consideration.

This Supplemental Feasibility Study developed a range of remedy options for each of the smaller areas of concern. In general, the remedy options included dredging to the maximum depth feasible, limited dredging with a cap for remaining materials, and monitoring in areas where other remedy options are not feasible.

Northwest Corner Area

Because most of the PCBs (99 percent) are concentrated in this 3-acre area, all remedy options include significant dredging to remove these materials from the river. Most of the PCBs are close to shore (within 20 ft), and near the surface, making it possible to remove a large percentage with near shore dredging of the upper layer of sediments. All remedies would also include the installation of a temporary rigid containment barrier out beyond the shoreline to provide containment of PCBs that will be suspended in the water column during dredging

Twenty-two percent of the elevated copper on site is also found in the Northwest Corner Area, in the top 6 to 8 ft of sediment. Most of the copper in the Northwest Corner Area can be removed from the river in option NW-1, and all of it can be removed in options NW-2 through NW-4.

Remedy Alternative	Description	PCBs Removed	Estimated Cost (net present worth)
NW-1	Dredge to elev. -7 ft along the shore where PRGs are exceeded and cap remainder *(recommended alternative)*	61 percent	$23.0 Million
NW-2A	Dredge to elev. -9 ft along the shore where PRGs are exceeded and deeper away from shore, then cap remainder	75 percent	$52.3 Million
NW-2B	Dredge to elev. -14 ft along the shore where PRGs are exceeded and deeper away from shore, then cap remainder	82 percent	$59.9 Million
NW-3	Incorporate material near shore into OU-1 remedy, and dredge all material exceeding PRGs remaining in river	99 percent[2]	$57.1 Million
NW-4	After piercing the basal sand with the shore-line bulkhead, dredge to elev. -32 ft along the shore where PRGs are exceeded and deeper away from shore, then cap remainder	99 percent	$96.2 Million

While NW-4 shows that there is a way to remove almost all of the deeper PCBs at this site as well, deep dredging along the shoreline bulkhead would create a risk of shoreline collapse that could only be controlled by installing an even deeper bulkhead into the basal sand. This bulkhead would pierce the protective aquitard that has contained PCB contamination in place for over 50 years, and create a 800-foot long pathway along both sides of the steel sheeting along the Northwest Corner for high levels of PCBs to migrate from above the aquitard into the Hudson groundwater aquifer below, violating federal guidelines, federal and state water quality

2 Under Alternative NW-3 some of the PCB contamination would be incorporated into OU-1, which would require removal of the upper layer of contaminated sediment, and containment of the remainder in an above-ground protective cap and containment system, rather than the submerged protective cap used in NW-1, 2 and 4.

standards, and sound engineering practices. Remedy options that violate such standards are usually rejected in the FS screening process, but this Supplemental Feasibility Study evaluates the option in order to explain the risks and the reasons why deep dredging option is not an appropriate remedy for this site.

This Supplemental Feasibility Study proposes Alternative NW-1 for this remedy. Alternative NW-1 is protective of human health and the environment. Alternative NW-1 is a significant dredging remedy that requires substantial construction activity to implement. It would result in the removal of approximately 5,900 cubic yards of contaminated sediments, and numerous pilings, obstructions, and debris. NW-1 would also remove approximately 61 percent of the PCBs and provide a robust armored protective cap over the PCBs left in place, thereby ensuring that living organisms will not come into contact with the PCBs and that they will not be released into the environment. Alternative NW-1 can be implemented safely within the geotechnical stability constraints resulting from the load placed on the bulkhead by the upland portion of the site. In addition, NW-1 does not present the unacceptable risk of contaminating the basal sand and its clean groundwater aquifer.

The Southern Area

Less than 1 percent of the PCB mass is found along the rest of the plant shoreline, in a 2.3-acre area called the Southern Area to distinguish it from the rest of the site. PCBs in this area are intermittent, close to the 1 ppm PRG, and mostly found in the upper layers of sediment and fill material, although areas that had deep open water at the time of the PCB release (the boat slips and channels leading into them) may have PCBs at greater depths.

The primary contaminant in this area is copper. Including an area adjacent to the Southern Area further from shore, approximately 78 percent of the copper mass exceeding the PRG proposed for copper is concentrated into three areas totaling approximately 20,000 square feet in area, in the upper 6 to 8 ft of sediment and fill material.

All of the proposed remedies seek to remove and/or contain copper in excess of the 982 ppm PRG proposed for copper. Doing so would also address other site-related metals.

Remedy Alternative	Description	Copper Removed Based on Proposed PRG	Estimated Cost (net present worth)
SA-1	Cap the entire area as needed to contain PCBs and copper within 60 to 80 ft of the remaining shore *(recommended alternative)*	0	$5.1 million
SA-2	Dredge up to the top 2 ft of sediment and fill material where PRGs are exceeded within a temporary silt curtain located 60 to 80 ft away from shore, then cap as needed	10 percent	$19.0 million

Remedy Alternative	Description	Copper Removed Based on Proposed PRG	Estimated Cost (net present worth)
SA-3A	Remove the top 4 ft of fill from OU-1 within 100 ft of the shoreline and replace with lightweight fill. Dredge in the river to elev. -9 ft along the shore where PRGs are exceeded and deeper up to 60 ft away from shore, then cap as needed	19 percent	$20.8 million
SA-3B	Same as S-3A, but dredge in the river to elev. -14 ft along the shore where PRGs are exceeded and deeper up to 60 to 80 ft away from shore, then cap as needed. [3]	19 percent	$21.3 million
SA-4	Install a deep bulkhead wall into basal sand aquifer, dredge to elev. -23 ft at the shore where PRGs are exceeded and deeper up to 60 ft from shore to reach deep PCBs, and then cap as needed.	29 percent (and less than 0.1 percent PCBs)	$34.9 million

This Supplemental Feasibility Study recommends Alternative SA-1 for the Southern Area. This alternative will successfully contain those areas of PCB and copper contamination found above PRGs in the southern area. During remedial design, selective dredging would be considered if needed to maintain water depth as a result of capping.

Boat Slips and Old Marina: A total of less than 1 percent of the PCB mass is found in the former boat slips at the plant site (1.4 acres), and in the former marina located on the north side of the plant site (2.2 acres). The contamination is diffuse and close to the 1 ppm PRG for PCBs in most areas, although higher levels of PCB are found where the North Boat Slip, Old Marina, and Northwest Corner shoreline all meet. There is no copper above the proposed 982 ppm PRG in these areas.

The choice of a remedy for the boat slips and marina depends partly on whether they will be used for navigation in the future. Since AR does not plan to use the boat slips for navigation, and its affiliate owns and controls the submerged lands below, capping is an appropriate remedy for the boat slips. This Supplemental Feasibility Study proposes to use a man-made cap for the North Boat Slip where there is some contamination at the surface and at depth, and a natural

3 A variation on Alternative SA-3 would target capping in those areas offshore adjacent to the Southern Area that have elevated levels of metals that may be bioavailable. This would result in capping two areas approximately 10,000 square feet in area. This additional capping would contain 35 percent of the total site copper mass exceeding the proposed PRG. The estimated capital cost for this additional capping is $0.2 million.

sediment cap in the South Boat Slip, where the top 8 ft of material are clean, and the area is filling in with river sediment.

A man-made cap could also be used to cover low level PCB contamination in the marina; although it would limit future navigation opportunities in this area by limiting water depth. Further discussion with the marina owner is needed to ensure that the remedy is compatible with future marina use plans.

Remedy Alternative	Description	PCBs Removed	Estimated Cost (net present worth)
NSlip-1	Dredge up to the top 2 ft of sediment and fill material exceeding PRGs only if needed, then cap *(recommended option)*	Less than 0.1 percent	$4.8 million
NSlip-2	Dredge to elev. -9 ft along the shore and deeper away from shore where sediment exceeds PRGs, then cap as needed (same as NW-2A)	0.1 percent	$13.1 million
OM-1	Dredge up to the top 2 ft of sediment and fill material exceeding PRGs, only if needed, then cap *(recommended alternative)*	Less than 0.1 percent	$9.3 million
OM-2	Dredge to elev. -9 ft along the shore and deeper away from shore, then cap as needed (same as NW-2A)	0.2 percent	$16.3 million

Offshore Area

Approximately 0.2 percent of the PCB contamination is found farther away from the plant shoreline in a 22 acre area of the main river channel. Copper exceeding the proposed PRG is limited to one 10,000 square foot area and one much smaller area within 100 to 150 ft of the shoreline. Other sources up and down river appear to have caused or contributed to contamination in the main channel. A substantial fraction of the PCBs here do not match the type of PCBs used at the wire and cable plant.

The contamination is found at low levels close to the PRGs, and conditions in the main channel make it very difficult to remove. The water is over 40 ft deep and flows at a high velocity. Silt curtains are not effective here, and solid containment structures are not feasible. Under these conditions, it is not feasible to remove these low levels of contamination with dredging. This Supplemental Feasibility Study proposes monitoring of natural recovery (ongoing natural capping) as the appropriate remedy for this area.

Summary

This Supplemental Feasibility Study recommends a remedy that combines an ambitious dredging project in the Northwest Corner area with a containment remedy that would isolate the remaining PCBs under a cap and berm system, and cap metals in near shore areas where copper exceeds 982 ppm.

The proposed remedy is protective of human health and the environment. It would remove over 60 percent of the PCBs and isolate metals that have any potential to be bioavailable. It would provide long term isolation of any remaining contaminated sediments, thereby protecting aquatic life.

Moreover, the combination of dredging and capping is particularly appropriate because dredging alone is unlikely to achieve a PCB level of 1 ppm or less. Experience at other sites has demonstrated that the sloughing of sediments into dredged areas and settlement of sediment suspended during dredging generally results in residual sediment levels in excess of 1 ppm. Those problems would likely be exacerbated at the Hastings site where the presence of significant debris, pilings, and obstructions on unstable slopes makes dredging difficult.

The proposed remedy would also avoid potential safety issues raised by the OU-1 geotechnical constraints and would allow for coordination of the OU-2 and OU-1 remedy. Other remedial alternatives present a greater risk of bulkhead instability and would likely result in significant delays in the implementation of the upland OU-1 remedy.

Finally, and importantly, the proposed remedy would not risk contamination of the basal sand aquifer. It thus meets an important consideration of doing no additional environmental harm and, unlike other remedies, meets New York state standards, criteria, and guidelines.

The net present worth of the proposed remedy is estimated to be $44 million, including capital costs and long term monitoring and maintenance. Cap maintenance would be incorporated into the bulkhead and containment system maintenance plan required as part of the remedy for OU-1.

SECTION 1

INTRODUCTION

This report supplements and updates the feasibility study report prepared by the New York State Department of Environmental Conservation (NYSDEC) during 2003 for OU-2 of the Harbor at Hastings Site. Its purpose is to evaluate remedial action alternatives based on additional information and engineering analyses developed after the original feasibility study report was issued. NYSDEC has agreed that a Supplemental Feasibility Study Report is needed for this purpose.

1.1 SITE LOCATION AND CONDITIONS

The Harbor at Hastings site is located along the riverfront at 1 River Street in the Village of Hastings-on-Hudson, New York. It contains two operable units: a former wire and cable plant located on shore (OU-1), and a portion of the Hudson River located next to the plant (OU-2). The site is situated on the east shore of the Hudson River in the Town of Greenburgh, Westchester County between Yonkers and Tarrytown. The Site is located at river mile 21.5 to 22 as measured upstream from the southern tip of Manhattan (see Figure 1.1). The river is approximately one mile wide at this location.

Like the Tappan Terminal property to the south, this site was created in the late 1800's and early 1900's by placing fill in the river behind a series of wood pilings and bulkheads. The source of much of the fill is unknown, but visual observation and sampling identified large stone, gravel, ash, slag, broken concrete, brick and glass, and other debris. The fill material is 20 to 40 ft thick at the western shore of the plant site (OU-1), and recent investigations confirmed the presence of similar fill material in the river (OU-2), sloping downward from the shoreline bulkhead to the natural river bottom, forming a wedge-shaped underwater berm that supports the plant site.

1.1.1 Plant Site (OU-1)

NYSDEC divided the site into two operable units (See Figure 1.2). OU-1 is a 26-acre man-made plant site constructed of fill material deposited along approximately 2,500 ft (ft) of shoreline, and extending approximately 450 ft into the Hudson River.

The plant site has been used for industrial and commercial purposes since it was created in the mid-1800's. Early uses include a sugar manufacturing plant, pavement manufacturing plant, and cable manufacturing by the National Conduit and Cable Company. From 1919 to 1977, the property was owned and operated by the Anaconda Wire and Cable Company and its predecessor, the Hastings Wire and Cable Company (collectively "AWC"), and was used for manufacturing copper wire and cable, including a unique type of polychlorinated biphenyl (PCB) insulated cable made for the United States Navy during the World War II era.

There have been no significant industrial operations at the plant site since wire and cable manufacturing ceased. However, after AWC sold this property in 1978, subsequent owners and operators used it as an unpermitted waste storage and transfer station for a few years during the 1980's. More recent uses include truck and auto storage.

ARCO Environmental Remediation Limited (AERL), an affiliate of Atlantic Richfield Company (AR), purchased the plant site and submerged lands containing the supporting underwater berm in 1998. AERL arranged to remove dilapidated buildings from the site, clearing most of the site for the remedial actions described below.

NYSDEC issued a Record of Decision for OU-1 in 2004 (NYSDEC, 2004a) which calls for excavation of the top 9 to 12 ft of PCB-impacted soil, along with a limited volume of elevated metals. Deeper PCBs and remaining metals will be contained at the plant site behind a sealed shoreline bulkhead around PCBs that will remain in the northwest corner of the plant site, and beneath at least 2 ft of clean cover over the entire site. AR is currently conducting a predesign investigation for this remedy at OU-1, and is required to submit a draft 50 percent remedial design in August of 2006.

The Village of Hastings-on-Hudson has developed a waterfront plan (Regional Planning Association, 2001) which proposes multiple future land uses for the former plant site and the adjacent Tappan Terminal, including commercial uses, a community center, waterfront plaza, park, and multi-family housing units (apartments and/or condominiums). Institutional controls were outlined in the OU-1 Record of Decision (ROD) to ensure that the remedy is consistent with proposed future development at the site.

1.1.2 River Site (OU-2)

OU-2 is a 31-acre portion of the Hudson River and river sediments next to OU-1. OU-2 begins at the plant shoreline and extends up to 400 ft into the river. Its southern boundary is the south end of the former wire and cable plant, and its northern boundary is the north end of the Old Marina Area.

The nearshore portion of OU-2 contains a submerged berm of wooden pilings and fill material that supports the plant site. The fill ranges in thickness from 10 to 20 ft along the eastern boundary of the plant site (near the natural river shoreline) to 20 to 40 ft along the western boundary of the plant site (the man-made shoreline). The fill includes large stone, gravel, silt, sand ash, slag, sand, broken concrete, brick and glass, wood and other debris. It appears typical of similar filled areas created in the late 1800s and early 1900s, and contains substantial quantities of large objects that will be difficult to remove in any dredging remedy.

Parts of the berm are covered with soft river sediments of silt and clayey silt, described in some locations as "soupy" and "having the consistency of toothpaste," emphasizing their low solids content. The thickness of the soft sediment varies considerably. At the shoreline this material is found in the spaces between rip rap, pilings, gravel and other large fill material that is visible along the shoreline at low tide (see Figure 2.1 photos of the shoreline). As you move away from the shoreline the soft river sediment layer increases up to a maximum of 5 to 10 ft, with the deepest sediment found around the toe of the berm. The soft sediment layer declines as you move away from the berm, and in parts of the Offshore Area it is 1 foot or less in thickness. The berm sits on top of a layer of marine grey silt, which represents the original Hudson River sediments. The marine silt is a plastic low permeability clayey silt, with estimated conductivities of 10^{-5} to 10^{-7} centimeters per second. The marine silt ranges in thickness from 10 ft on the eastern side of OU-1, and 40 to 50 ft along the western side of OU-1 and n the middle of OU-2 in the Hudson River. Due to its low permeability, the marine silt serves as a confining unit or aquitard between the fill and sediment layers above and the groundwater below. Structurally, the marine silt is highly compressible and has low shear strength, which limits it capacity to serve as a bearing surface for structures.

Below the marine silt is a basal sand unit of medium to dense coarse sands and gravels that varies in thickness from approximately 10 ft on the eastern side of OU-1 up to approximately 70 ft along the western side of OU-1 and into OU-2 in the river. This unit has a higher shear strength than the clayey silt layer above it, and provides structural support for pilings and pile-supported buildings at the plant site. The basal sand unit contains a large groundwater aquifer that is under artesian pressure at portions of the site.

1.1.3 Tappan Terminal

The Tappan Terminal is located along the south boundary of OU-1 and OU-2. It is an inactive hazardous waste disposal site (NYSDEC site number 3-60-015) formerly used for petroleum storage and the manufacture of dyes, pigments and photographic chemicals. Like the OU-1 and OU-2 site next door, the Tappan Terminal was constructed of fill material placed in the river behind a series of pilings and bulkheads, beginning in the mid 1800's and continuing, at that site, until 1970. The primary contaminants of concern at the terminal include chlorobenzene, semi-volatile organic compounds, and metals including copper, nickel and zinc.

NYSDEC released a Proposed Remedial Action Plan for the Tappan Terminal in December 2005 (NYSDEC, 2005a), proposing excavation of soil that is visibly or grossly contaminated, air sparging and soil vapor extraction to remove chlorobenzene, and a two foot thick cap over contamination remaining on shore, at an estimated cost of $4.23 million. NYSDEC did not propose any remedy for contamination in the river next to the terminal, although it noted that elevated levels of metals were found throughout the fill material used to build the terminal, and stated that such contaminants are "commonly associated with historic fill containing ash and furnace slag." (NYSDEC Fact Sheet, Remedial Actions Proposed for Tappan Terminal, December 2005).

1.2 CONTAMINANTS OF CONCERN

The primary contaminants of concern in the river at OU-2 are PCBs and copper. Elevated levels of lead, nickel, silver, and zinc were also found in OU-2 sediment.

The highest concentrations of PCBs, and most of the PCB mass (99 percent), are located near the northwest corner of the plant site. While most of the PCB mass is found in the top 7 ft of sediment and fill material (60 percent), or the top 9 ft of sediment and fill material (75 percent), PCBs have been detected nearly 40 ft below the mudline in the river, and at similar depths at the plant site on shore.

Former AWC plant employees and historic documents indicate that PCBs and similar chlorinated compounds were used at the plant site during the World War II era to make fireproof, waterproof shipboard cable for the US Navy. PCBs, polychlorinated terphenyls (PCTs) and polychlorinated naphthalenes (PCNs) arrived on site in a solid form. They were mixed with a solvent, and the mixture was used to saturate, insulate and coat cables. A small fraction of this mixture was released into the environment, mostly near the northwest corner shoreline. Samples show that some of this mixture entered the river through outfall pipes, and some migrated downward through the fill material at the plant site until it reached the impermeable marine silt layer, then migrated outward into the river, at depths up to 40 ft below the surface of the fill.

Low levels of PCBs were found in intermittently in sediments along the rest of the plant shoreline, in the Old Marina north of the plant site, and up to 400 ft off the plant shoreline. Approximately 1 percent of the total PCB mass was found in this broader 28 acre area. The surface weighted average concentration of PCBs in this larger area is below the 1 ppm preliminary remedial goal (PRG) that NYSDEC has selected for the Hudson River.

Elevated metals were concentrated in three small areas near former wire and cable plant outfall pipes. Much of the elevated copper mass (approximately 78 percent) is found in these areas, which total approximately 20,000 square feet in size (one half of an acre). Other metals associated with the wire and cable plant (lead, nickel, and zinc) were concentrated in the same locations, suggesting they came from the same source. Lower levels of metals were found throughout the fill material in the plant site and river berm, and are likely to be components of ash and furnace slag used to create the entire site (OU-1, OU-2 and the Tappan Terminal) in the late 1800's and early 1900's.

1.3 PRIOR STUDIES AND PROPOSALS FOR REMEDIAL ACTION

This Supplemental Feasibility Study Report has been prepared as a follow-up to the Feasibility Study (FS) Report for OU-2 prepared for NYSDEC by Earth Tech of New York and issued in March 2003 (Earth Tech, 2003). The 2003 FS Report was based on the 2000 Remedial Investigation (RI) Report for OU-2 (Earth Tech, 2000). Information about adjacent land use, results from additional investigations, remedial action objectives, applicable or relevant and appropriate requirements (called standards, criteria and guidelines in New York State), a technology screening, and an evaluation of remedial alternatives are all presented in the Earth Tech FS report. NYSDEC proposed a remedy for OU-2 in October 2003 based on Alternative 6A of the 2003 FS. Under Alternative 6A, NYSDEC recommended a sediment dredging remedy for OU-2 that consisted of removing nearshore sediment containing more than 1 ppm PCBs or exceeding any of the 2003 preliminary remediation goals (PRGs) for metals, which were set at NYSDEC's reported background levels for metals in the lower Hudson River.

AR and other parties including the National Oceanic and Atmospheric Administration, Village of Hastings-On-Hudson, Scenic Hudson, Riverkeeper, and the Hudson Valley Health & Tennis Club provided comments to NYSDEC on the October 2003 PRAP in December 2003.

1.4 PURPOSE OF SUPPLEMENTAL FEASIBILITY STUDY

AR and NYSDEC have worked together since 2003 to continue to assess OU-2. Various supplemental field investigations and technical analyses have been completed during 2004 and 2005. The primary reasons for providing this Supplemental FS Report at this time are as follows:

- Additional data collected in 2004 and 2005 provides significant new information needed to evaluate remedial action alternatives for OU-2, including information about the extent of fill material in the river, the location of contamination within the fill, geotechnical limits on the ability to remove all of the fill material that supports the plant site, and additional data on the bioavailability and toxicity of metals at the site.
- Recent site technical analyses show that the deepest dredging near the shoreline as would be required by Alternative 6A (Earth Tech, 2003) is not implementable without slope failure that would result in unacceptable risk to the environment and pose additional safety concerns. Geotechnical site constraints preclude removing the deepest contamination near the shoreline even if the shoreline bulkhead is driven through the underlying basal sand or the excavation at OU-1 is left open below its existing grade while river sediment is dredged.
- Results from dredging at other sites have shown that a PRG of 1 ppm for PCBs in site sediment is not achievable at this site by any dredging technology operated alone (i.e., without the application of a post dredging cap).
- Contaminated sediments are found within fill material that contains large rock, timbers, and other significant obstructions and debris, requiring the use of mechanical dredging in any sediment removal alternative. The impacted sediments that would be resuspended during mechanical dredging would make the 1 ppm PRG for PCBs even harder to attain without follow-up capping.
- The 2003 FS substantially underestimated the volume of material that would have to be dredged to meet the sediment remediation goals proposed in that document. Sediment dredging volumes needed to be adjusted upwards, and revised sediment volumes directly affect estimates of remedy impacts and remediation costs.
- Sediment capping projects at other sites with PCB and/or metal contamination have demonstrated that capping can be a durable, environmentally protective alternative.
- USEPA recently released new guidance stating that bulk metal concentrations in sediments are a poor predictor of toxicity (USEPA Equilibrium Partitioning Sediment Benchmarks (ESB) Guidance (USEPA, 2005a)). USEPA found that toxicity is more closely related to bioavailability, and that bioavailability can be predicted by examining metal levels in pore water, and acid volatile sulfide and total organic carbon levels in sediments. Following this guidance, supplemental site investigation identified high levels of natural acid volatile sulfides and total organic carbon in sediments of OU-2, providing substantial capacity to sequester (bind) metals and limit their bioavailability and toxicity (see Appendix C). Use of acid volatile sulfides and simultaneously extracted metals results to assess metals toxicity is encouraged in the most recent USEPA guidance on contaminated sediment (USEPA, 2005a).

Remedial action alternatives are evaluated separately in this report for the specific areas that comprise OU-2: the Northwest Corner Area, the Southern Area, the North and South Boat Slips, the Old Marina Area, and the Offshore Area. Figure 1.3 shows how OU-2 has been divided for the purpose of this evaluation of remedial alternatives. The Northwest Corner Area has a surface area of approximately 2.9 acres in size that extends along the northernmost one third of the site shoreline and out into the river approximately 140 ft, as presented in the October 2003 Feasibility Study, to a temporary rigid containment barrier alignment. The purpose of the temporary rigid containment barrier would be to reduce losses of impacted sediments that are suspended during dredging (containment of suspended sediment is discussed in depth later in Section 2). The Southern Area has a surface area of approximately 2.3 acres along the site shoreline south of the Northwest Corner Area excluding the two boat slips. The Southern Area extends approximately 60 to 80 ft from shore to a location corresponding to a mean tidal water depth of 15 ft, which is the maximum average water depth at which silt curtains (used to temporarily contain suspended sediment) have been proven to be effective. The two boat slips together cover a surface area of approximately 1.4 acres adjacent to the north and south ends of the former Building 15, which was the largest site building in the center portion of OU-1 prior to being demolished in 2005. The Old Marina Area is located adjacent to the north end of the Northwest Corner Area and covers a surface area of approximately 2.2 acres. The Offshore Area lies beyond the Northwest Corner Area and Southern Areas to the west and covers an area of 22 acres to a distance 400 ft offshore.

The individual areas within OU-2 have unique characteristics such as contaminant concentrations, hydrodynamic conditions, and geographical location. These characteristics warrant individual consideration when developing remedial action alternatives.

- The Northwest Corner Area has been broken out as an individual area based on the concentration and depth of PCBs in sediment in this area.
- The Southern Area makes up the rest of the shoreline outside the boat slips. The Southern Area has much lower levels of PCBs in sediment, along with limited areas of concentrated sediment metal contamination.
- The Old Marina Area and the two boat slips are evaluated separately because of their confined locations. PCB concentrations in Old Marina Area sediment are less than 10 ppm, which means that material removed from the Old Marina Area could possibly be used as fill either at OU-1 or at an offsite location. The North Boat Slip has sediment concentrations similar to the Old Marina Area. The South Boat Slip, while grouped with the North Boat Slip and Old Marina Area, is relatively free of contaminant concentrations as the only sediment sample with a PCB concentration greater than 1 ppm measured at depths of 8 ft or more below the sediment surface.
- The Offshore Area is outside of the areas where temporary containment can be practicably implemented and includes sediment which appear to have not been greatly impacted by former site industrial activities. Additional characteristics of each area are provided in subsequent sections of this report.

Table 1.1 provides the area-weighted average sediment PCB concentrations, by depth, in each of the OU-2 areas. A comparison of these profiles helps to distinguish between these areas.

For example, area-weighted average PCB concentrations in the Northwest Area are several hundred parts per million in the upper eight ft of sediment, and varies between 7.9 and 31.3 ppm below ten ft. In contrast, the area-weighted average sediment concentration for PCBs in the Southern Area is 0.4 ppm within the upper two ft of sediment and is lower below two ft.

Section 2 of this report updates the remedial technologies evaluation presented in the 2003 FS Report. Section 3 presents remedial action alternatives for the Northwest Corner Area. Section 4 summarizes the evaluation of alternatives for the Northwest Corner Area. Sections 5 and 6 present and then evaluate the remedial technologies and alternatives applicable to the Southern Area. Sections 7 and 8 present and then evaluate the remedial technologies and alternatives applicable to the North and South Boat Slips and the Old Marina Area. Sections 9 and 10 present and then evaluate the remedial technologies and alternatives applicable to the Offshore Area. Section 11 presents the basis for preferred remedial action alternatives.

Elevations are presented throughout this Supplemental FS Report based on the North American Vertical Datum of 1988 (NAVD88). From the US Geological Survey's water level gage at Hastings-on-Hudson, and based on NAVD88, the river water level elevation at the minimum low tide averaged over each tidal cycle from nearly 13 years of continuous data (data from May 1992 through February 2005) is -2.0 ft, while the average maximum high tide river water level elevation is +2.2 ft. The difference in low and high tide elevations is therefore 4.2 ft. The mean tidal water level, or mean sea level, based on NAVD88 is +0.1 ft. OU-2 river bathymetry is based primarily on a 1997 survey by Alpine Ocean Seismic Survey, Inc. (see Appendix A-1 in Earth Tech, 2000).

1.5 SUMMARY OF SUPPLEMENTAL INVESTIGATIONS

Following the 2003 OU-2 FS Report, additional data was collected to further assess conditions at OU-2. Investigation work efforts were reviewed with NYSDEC and performed in three steps: the Fall 2004 Supplemental Investigation, the Summer 2005 Supplemental Investigation, and the Fall 2005 Supplemental Investigation. Each of these investigation efforts was based on a work plan that included documented field and laboratory procedures approved by NYSDEC. In addition, Earth Tech (under the supervision of NYSDEC) collected and analyzed sediment samples from OU-2 for dredge elutriate tests as described in Section 2.1.

1.5.1 Fall 2004 Supplemental Investigation Scope

The Fall 2004 Supplemental Investigation consisted of the following components;

- Geophysical side scan sonar and magnetometer surveys at OU-2 used to better evaluate the extent of debris in portions of OU-2;
- Cone penetrometer investigation used to help assess sediment shear strength;
- A two-month hydrodynamic survey within OU-2 that included long-term and short-term measurements of water velocities, wave heights, water levels, and water quality (turbidity, conductivity, temperature, dissolved oxygen, oxidation-reduction potential, and pH);

- Column settling and dredge elutriate analyses using US Army Corps of Engineers methods to provide sound data to support assessments of the short-term impacts of dredging on water quality and handling of dredged materials. In addition, NYSDEC conducted dredge elutriate testing of two additional OU-2 sediment samples.
- PCB porewater sampling and analysis from the top foot of sediment at five OU-2 locations;
- Porewater metals, acid volatile sulfides (AVS), simultaneously extracted metals (SEM), and organic carbon analyses of samples from the top foot of sediment at 17 OU-2 locations to assess metals bioavailability and toxicity based on USEPA's ESB methodology (USEPA, 2005a); and
- Radioisotope dating analysis of sediment samples from the top five ft at four OU-2 locations to better assess sediment deposition to supplement previous sediment rate measurements reported in the 2000 RI Report.

Results from the Fall 2004 OU-2 Supplemental Investigation were presented in Volumes 1 and 2 of a field work summary report (Parsons, 2005a) and in a separate oceanographic investigation report (Parsons, 2005b).

1.5.2 Summer 2005 Supplemental Investigation Scope

The Summer 2005 Supplemental Investigation consisted of additional sediment sampling at 19 OU-2 locations using a vibracore up to a depth of 30 ft below the mudline (as measured from the top of the sediment) as well as supplemental geophysical and manual probing work. The purpose of the additional sediment sampling was to improve understanding of sediment PCB and metal concentration distributions, organic carbon content, and particle size in sediment from selected locations in the Old Marina Area in the Northwest Corner Area and the two boat slip areas. The purpose of the additional geophysical and manual probing work was to provide additional information about the extent of metallic and other debris directly adjacent to the OU-2 shoreline. The Summer 2005 geophysical work consisted of high resolution side-scan sonar and magnetometer surveys along the OU-2 shoreline. It also included a physical probing study, metal detector survey, and underwater imaging all in very limited (not site-wide) areas. Field procedures were executed in conformance with a sampling work plan (Parsons, 2005c) and a physical site characterization work plan (Parsons, 2005d). Results from the Summer 2005 Supplemental Investigation have been reported separately (Parsons, 2005e).

1.5.3 Fall 2005 Supplemental Investigation Scope

The Fall 2005 Supplemental Investigation was conducted during November 2005 to provide further evaluation of AVS, SEM and organic carbon analyses to sequester metals and limit their bioavailability and toxicity (USEPA, 2005b). This investigation evaluated sediment in the 0 to 3-inch depth range and intervals in the 3 to 12-inch depth range at sampling locations where previous studies had demonstrated the highest metal concentrations. A work plan was submitted to NYSDEC for this effort (AR, 2005a) and approved by NYSDEC Results from the Fall 2005 Supplemental Investigation have been reported separately (Parsons, 2006).

1.5.4 Summary of 2004-2005 Supplemental Investigation Results

These three investigation efforts together provide better definition and understanding of PCB distribution in OU-2 sediments; the relationship between the presence of metals and sediment toxicity; and the nature of the sediments themselves. Specifically:

- Both the area and depth of PCB distribution in OU-2 sediment off the Northwest Corner Area and in the Old Marina Area have been characterized. The characterization has included the statistical determination of PCB concentrations, mass, and volume. Vertically, PCBs in sediment sampled off the Northwest Corner Area and in the Old Marina Area do not extend beyond the top of the marine silt (see Appendix A).
- Approximately 60 ft off the northern portion of the Northwest Corner Area in the vicinity of RB-20 (see SD-52 on Figure 1.3), the depth to the marine silt and the depth of PCBs in sediment measured during 2005 using continuous vibracoring with high percent sample recovery were significantly shallower than previously was reported in the RI report for RB-20. The original sediment testing from RB-20 was collected using drive and wash drilling techniques that resulted in poor sediment sample recovery.
- Porewater and dissolved organic carbon results show that the bioavailable concentrations of PCBs in OU-2 sediment are limited.
- Within the Old Marina Area, sediment PCB concentrations are generally between less than 1 and 7 ppm.
- Additional estimates of sediment shear strength were obtained using a cone penetrometer at various locations and depths. These results were incorporated into the geotechnical analysis (see Appendix B).
- Concentrations of metals in OU-2 sediment porewater are below NYSDEC chronic saltwater water quality standards for protecting benthic marine organisms (see Appendix C and Table 7 in AR, 2005c).
- Evaluation of the AVS, SEM, and total organic carbon (TOC) site data collected in the Fall 2004 and Fall 2005 based on USEPA's (2005) equilibrium partitioning sediment benchmark (ESB) guidance demonstrates that metals are not bioavailable or toxic at copper concentrations ranging up to at least 982 ppm in OU-2 sediments. These new ESB based analyses, in combination with site-specific toxicity and benthic community studies conducted previously at OU-2, demonstrate that 982 ppm is an appropriate and conservative site-specific PRG proposed for copper in OU-2 sediment (see Appendices C and D).
- Evaluation of the spatial distributions of metals demonstrated that areas with elevated concentrations copper correspond well with those of nickel, lead and zinc.
- On a daily basis, the average measured river water velocity exceeded 1.5 ft per second at some depth in the water column nearly each day during the Fall 2004 investigation at the five locations monitored.

- Extensive metal and non-metallic debris (such as timber pilings, concrete, wire cable, tires, and general fill debris) were identified at the mudline and in the sediment subsurface throughout OU-2 but concentrated in the nearshore areas.
- Based on the column settling results, slow settling of OU-2 sediment (1.5 to 2 vertical ft of clarification over a 6-hour tidal period) would take place following resuspension of sediment due to dredging operations.
- Dredge elutriate test data used to predict PCB concentrations in surface water during dredging activities showed approximately 0.3 parts per billion of dissolved and suspended PCBs after 12 hours of settling from a sediment containing 3 ppm PCBs.
- Radioisotope dating results showed a net accumulation of sediment in the four locations tested.
- Geophysical analyses and physical probing show the presence of significant debris intermixed with site sediment.

1.5.5 Sediment Contaminant Distribution Modeling for OU-2

All of the new data, along with existing data, was analyzed for quality assurance purposes and incorporated into a three-dimensional contaminant distribution model has been developed for OU-2. Environmental Standards, Inc. (ESI) developed the model for AR using the latest version of the Environmental Visualization System software package developed by Ctech, Inc. (Ctech, 2005). This Environmental Visualization System software package models and displays environmental site data in a three-dimensional framework, and it has been used extensively by USEPA, other regulatory agencies, and industry. ESI used this software to integrate data for OU-2 from a wide variety of project data sources, including the database of analytical results, project boring log files, site AutoCAD maps, and GIS shapefile layers. Historical site data validated by ESI in 2004-2005 have been incorporated into the contaminant distribution model in addition to OU-2 data collected and validated during 2004 and 2005. These three dimensional modeling processes are presented in Appendix A.

Contaminant distribution modeling results for OU-2 constituents are displayed as three-dimensional sampling locations, three-dimensional sediment volumes based on action levels for PCBs and metals, and three-dimensional kriged geological surfaces produced by geostatistical analysis. The contaminant distribution model for OU-2 consists of approximately one million grid cells, each 10 ft by 10 ft by 2 ft deep. Horizontal and vertical variations were extensively evaluated and have been set to a reasonable value based on available site data, professional judgment based on Environmental Standards' previous contaminant distribution modeling experience, and Ctech's peer review. Predicted chemical volume and mass calculations from each of these cells have been used to develop remedial sediment volume and contaminant mass estimates for each remedial alternative. Animations of the contaminant distribution modeling output have also been created to display site conditions from different three-dimensional views (see Appendix A).

1.5.6 Application of a Hudson River Estuary Hydrodynamic Model to OU-2

AR and its consultants have worked during 2005 with Hydroqual, Inc. to apply Hydroqual's hydrodynamic model of the Hudson River for the purpose of developing the erosion protection requirements for an underwater cap within OU-2. A preliminary analysis of the shear stresses induced by extreme events in the river was conducted employing the calibrated, validated, and peer-reviewed hydrodynamic model developed by Hydroqual for the Hudson River Estuary. The model is described in a paper by Blumberg et al. (1999).

1.6 LEGAL FRAMEWORK

The Harbor at Hastings site (Number 3-60-022) is an inactive hazardous waste disposal site being regulated under the New York State Environmental Conservation Law and New York State rules and regulations for inactive hazardous waste disposal sites set forth in Title 6, Part 375 (Subpart 1) of the Codes, Rules and Regulations of the State of New York (6 NYCRR Part 375 et seq.). NYSDEC's Division of Environmental Remediation has primary regulatory responsibility for the site under NYCRR.

The Comprehensive Environmental Response Compensation and Liability Act (CERCLA, 40 USC 9601 et. seq.) and associated federal regulations such as the National Contingency Plan (40 CFR Part 300 et seq.) are also relevant in the remedy selection process, and have been largely incorporated into state law.

This Supplemental Feasibility Study Report has been prepared in accordance with US Environmental Protection Agency (USEPA) and NYSDEC guidance documents, including Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (USEPA 1988); New York's, Guidelines for Remedial Investigations/Feasibility Studies, HWR-89-4024 (NYSDEC 1989); and Technical and Administrative Guidance Memorandum (TAGM),_4030 Selection of Remedial Actions at Inactive Hazardous Waste Sites (NYSDEC 1990) as amended or expanded by later guidance.

There are two existing settlement agreements that have an impact on the selection of a remedy for OU-2. A judicially approved consent decree is in place between AR, the Village of Hastings-On-Hudson, and the Hudson Riverkeeper, requiring AR to implement a state-approved remedy for OU-1 in a timely manner.[4] An administrative settlement between AR and NYSDEC requires AR to implement the remedy selected in the March 2004 Record of Decision for OU-1, and to submit a draft 50 percent remedial design for that remedy by August of 2006. Both agreements require an OU-1 remedy with a shoreline bulkhead, and initial designs indicate that a substantial berm will be needed in the river to support the bulkhead and plant site land mass. The remedy for OU-1 affects the range of feasible remedies for OU-2.

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4 Federal consent decree requirements include raising the OU-1 ground surface elevation up to a final grade 5 ft above its original (pre-excavation) grade. The average original grade at OU-1 is +4 ft. The federal consent decree also specifies that new buildings in the future be placed with a minimum setback of 100 ft from the river shoreline and that AR establish a minimum of 6.25 acres of the site as open space.

The bulkhead and berm are an important structural component of the remedy options for both OU-1 and OU-2. Excavation of fill from OU-1 and removal of sediment and fill material from OU-2 both affect the stability of the shoreline bulkhead. Remedy components such as lightweight fill within OU-1, the extent of the berm in OU-2, and potential coordination of excavation on both sides of the bulkhead at the same time, need to be evaluated together to select an appropriate remedy for the site as a whole, and to avoid incompatible remedies that cannot feasibly be implemented at the site.

1.7 REMEDIAL ACTION OBJECTIVES

The remediation goals for OU-2 as presented in the October 2003 PRAP (also called remedial action objectives) are to eliminate or reduce to the extent practicable:

- Unacceptable human and wildlife exposures to PCBs based on humans and wildlife consumption of fish and shellfish;
- Toxicity of site sediments to sediment-dwelling (benthic) organisms; and
- Potential for humans to be exposed from incidental ingestion of river water and direct contact with site sediment.

The 2003 PRAP also sought to eliminate exceedances of NYSDEC surface water quality standards for PCBs, currently set at 0.000001 parts per billion to protect humans that may consume fish and 0.00012 parts per billion to protect fish-eating wildlife. However, these standards for PCBs are well below laboratory detection limits and well below background water quality measured to be 0.04 parts per billion in the lower Hudson River (Earth Tech, 2005), which indicates that it is not feasible to use these standards as remedial goals at this site.

During 2003, NYSDEC proposed a numeric sediment PCB remedial goal of 1 ppm, based on background sediment concentrations of PCBs in the lower Hudson River. Figure 1.3 shows the extent of OU-2 sediment exceeding the PRG of 1 ppm PCBs. This figure presents contaminant distribution modeling results from a three-dimensional modeling effort and does not indicate the depth at which elevated concentrations of PCBs were found.

During the World War II era, certain chlorinated compounds were used at the wire and cable plant site to manufacture shipboard cable for the US Navy. In addition to Aroclors 1260 and higher, which consist of PCBs, Aroclor 4465, which contained both PCBs and PCTs, and Halowax, which contained a mixture of PCBs and PCNs, were all used to manufacture this product. PCTs and PCNs have similar chemical structures and environmental fate and transport characteristics as PCBs. Because they were found commingled with PCBs, this Supplemental FS uses PCBs as a marker for the presence of all three compounds.

The former wire and cable plant site is now contaminated with PCBs, and most of the contamination in OU-1 is found in the northwest corner of the plant site. Most of the PCB contamination in OU-2 in the river is also found here, near the northwest shoreline of the plant site (Earth Tech, 2000). This conclusion was more recently confirmed using the AR contaminant distribution model and additional site data collected during 2004 and 2005. The 2003 FS used Aroclor 1260 to indicate whether PCBs detected in the river sediments are associated with historical operations at the plant site, and this Supplemental Feasibility Study continues this practice. Less chlorinated PCB such as Aroclors 1242, 1248, and 1254 are associated with upriver sources (Earth Tech, 2003), and with different types of manufacturing operations or products.

In addition, NYSDEC has considered numeric PRGs for several different metals in OU-2 sediment. PRGs were proposed by NYSDEC in 2003 based on estimates of background concentrations of metals in sediments in the Lower Hudson River, which were derived from a limited number of samples collected as part of the earlier Remedial Investigation (Earth Tech, 2003, Table 2.11). This Supplemental FS uses the spatial distribution of elevated concentrations of copper in sediments as a surrogate for the distribution of nickel, lead and zinc when establishing sediment remedial areas and volumes. As explained in Appendix C , copper was chosen as a surrogate for the other metals, because it: (i) has the highest frequency of PRG exceedances of the metals for which PRGs were established in the 2003 FS; (ii) is the primary metal in OU-2 sediments driving exceedances of the 130 micromoles per gram of organic carbon ESB threshold (USEPA, 2005a); (iii) constitutes the highest metal concentration in the site porewater relative to State water quality standards; and (iv) locations elevated sediment concentrations of copper correspond well with locations showing elevated concentrations of nickel, lead and zinc.

Figure 1.4 shows how copper is distributed in OU-2 sediment. Similar to Figure 1.3, the copper distribution depicted in Figure 1.4 is from three-dimensional contaminant distribution modeling conducted as part of this Supplemental FS and does not indicate the depth of elevated metals (see Section 1.3 and Appendix A). Figures showing the distribution of lead, nickel and zinc in OU-2 sediment are presented in Appendix A.

Data presented in the 2000 RI and the 2003 FS indicate that copper, lead, nickel, and zinc are present in OU-2 sediments. The RI identified copper as the primary metal in OU-2 sediments that may be considered site-related (Earth Tech 2000, Page 6-13). Copper was the primary metal used at the site in the production of copper wire and cable. The RI also noted that lead, mercury, nickel, silver, and zinc are present at concentrations above background in localized areas of OU-2 and suggested further evaluation of these metals (Earth Tech 2000). Lead was used onsite and the spatial distribution of elevated concentrations of lead in OU-2 sediments is consistent with that of copper with the highest concentrations found at isolated locations: 1) south of the South Boat Slip; 2) offshore of former Building 15; and 3) in the Northwest Corner Area within the fill. Although there is no evidence of nickel and zinc being used onsite, the distribution of elevated concentrations of nickel and zinc is similar to those of copper and lead (see Appendix A or C). The industrial fill used to create this and the Tappan Terminal properties is a likely source for low levels of all of these metals. In contrast, the 2003 OU-2 FS found that concentrations of mercury were consistent with upstream conditions not related to the site, and therefore, associated with an upstream source rather than a site-related source. The pattern of silver distribution was also found to be inconsistent with a site-related source. These data indicate that OU-1 is not a source for mercury or silver. Based on these data, copper is clearly the primary metal of concern in sediments of OU-2. In addition, copper serves as an indicator for the other metals. The spatial distributions of elevated concentrations of copper, zinc, lead, and nickel in the southern portion of the Site are very consistent, being focused primarily on areas offshore of the sluice and the SPDES discharge pipe at former Building 15 (see Appendix A figures). Therefore, focusing the metal remedy on areas with elevated copper concentrations should also address the more limited areas of elevated lead, nickel, and zinc concentrations.

With the focus on copper as the primary metal of concern in OU-2 sediments, the USEPA (2005a) ESB methodology was applied to the Fall 2004 and Fall 2005 AVS, SEM, and TOC data. As presented in Appendix C, the threshold for exceeding the 130 micromoles per gram of organic carbon ESB benchmark below which toxicity is never observed lies between sediment copper concentrations of 982 and 1,230 milligrams per kilogram (mg/kg) or ppm. The 982 ppm copper concentration, which corresponds to 69 micromoles per gram of organic carbon is over 40-fold lower than the 3,000 micromoles per gram of organic carbon ESB benchmark that indicates predicted toxicity. Based on these data, 982 ppm represents an appropriately conservative site-specific ESB-based PRG proposed for copper in OU-2 sediment. Use of 88.7 ppm copper as a PRG would be excessively conservative, however the sediment copper concentration of 88.7 ppm is also given consideration as an estimate of background copper levels for local sediments based on the OU-2 RI analysis.

Proposed site-specific ESB-based PRGs for sediment were also developed for lead, nickel and zinc (see figures at the end of Appendix C). The values for the proposed ESB-based PRGs for lead, nickel and zinc were 379, 160, and 1,050 mg/kg, respectively. Spatial distributions of concentrations of nickel, lead and zinc in excess of these proposed PRGs correspond well with that of copper in excess of its proposed PRG. These data reinforce the appropriateness of using the proposed copper PRG as a surrogate for these other metals (see Appendix C).

Goals and requirements associated with the extent of sediment to be evaluated for remediation are based on 1 ppm PCBs and 982 ppm copper concentrations in sediment. Other goals and requirements for OU-2, such as environmental protection requirements during remediation, are presented in the 2003 FS Report for OU-2 with the exception of the local village noise control requirements and the recent federal consent decree. The code of the Village of Hastings-on-Hudson (updated in December 2003) includes in Chapter 217 specific noise control requirements that limit construction activities to the hours of 7:30 AM to 8:00 PM each Monday through Saturday and to the hours of 10:00 AM to 5:00 PM each Sunday.

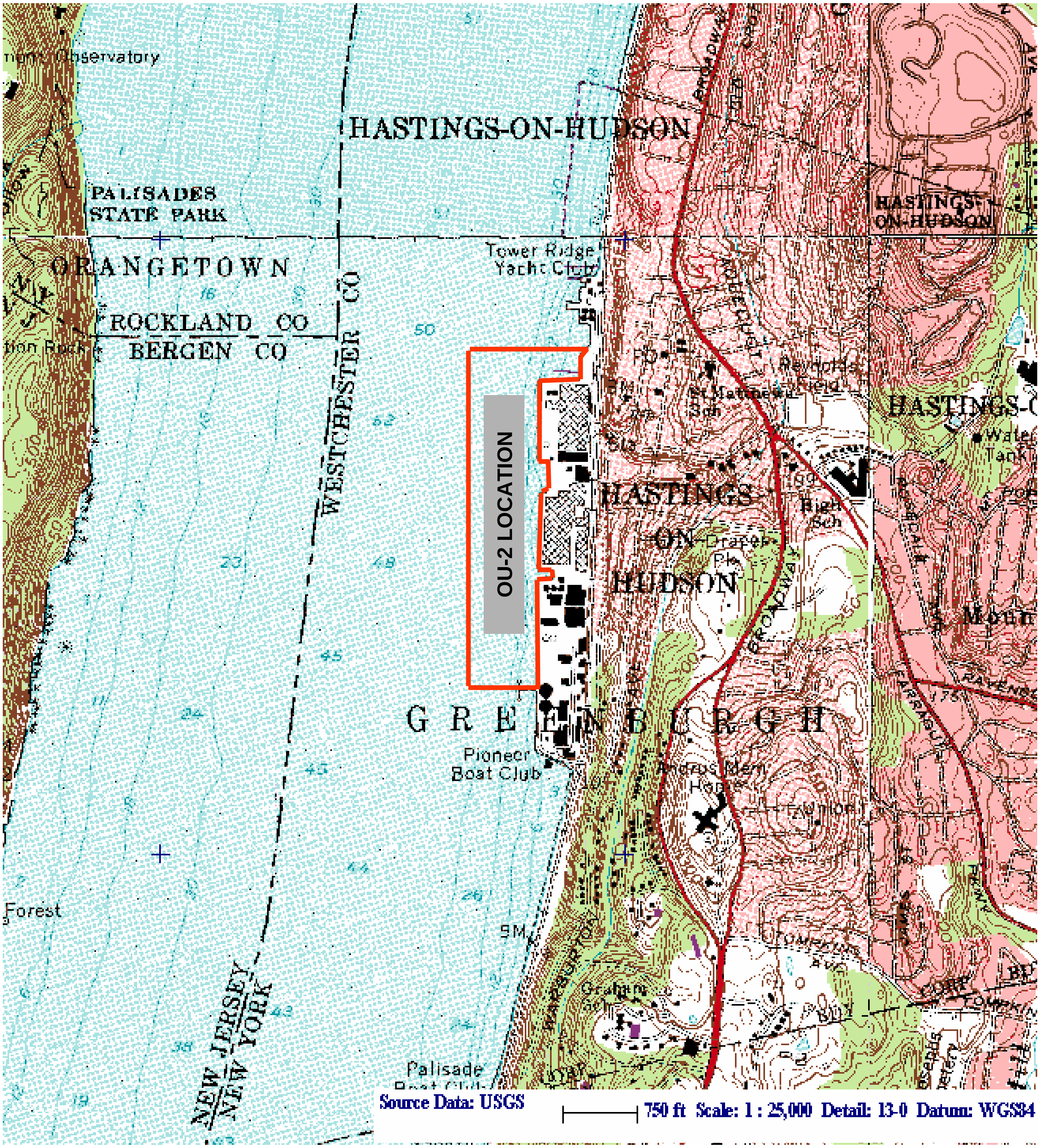
TABLE 1.1

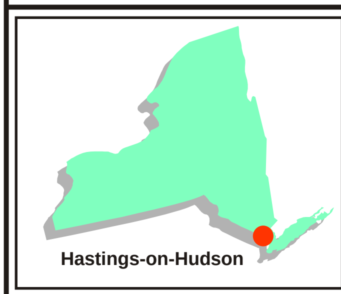
AREA WEIGHTED AVERAGE SEDIMENT PCB CONCENTRATIONS BY AREA (1)

Depth	Northwest Corner Area AWA	Southern Area AWA	South Boat Slip AWA	North Boat Slip AWA	Old Marina Area AWA	Offshore Area AWA
0 to 2’	211	0.40	Less than 0.01	1.88	0.68	0.20
2’ to 4’	210	0.33	Less than 0.01	1.25	0.87	0.10
4’ to 6’	244	0.24	Less than 0.01	0.61	0.47	0.05
6’ to 8’	152	0.18	Less than 0.01	0.62	0.11	0.01
8’ to 10’	57.2	0.15	0.16	1.29	0.04	Less than 0.01
10’ to 12’	31.3	0.13	0.38	5.23	0.02	Less than 0.01
12’ to 14’	19.5	0.09	0.53	8.84	0.02	Less than 0.01
14’ to 16’	14.1	0.03	0.18	3.81	0.02	Less than 0.01
16’ to 18’	10.0	0.01	0.02	0.96	0.01	-
18’ to 20’	7.93	0.01	-	0.67	0.01	-
20’ to 22’	8.94	Less than 0.01	-	0.40	Less than 0.01	-
22’ to 24’	10.4	Less than 0.01	-	0.07	Less than 0.01	-
24’ to 26’	12.4	Less than 0.01	-	Less than 0.01	Less than 0.01	-
26’ to 28’	16.7	Less than 0.01	-	Less than 0.01	-	-
28’ to 30’	22.6	Less than 0.01	-	-	-	-

(1) From AR contaminant distribution model output. Concentrations are in parts per million (or milligrams per kilogram).

(2) An “-” entry indicates the absence of any sediment PCB concentrations at this depth interval greater than 1 ppm.





New York

LATITUDE: N40° 59' 30"
LONGITUDE: W73° 53' 07"

N

SOURCE: DeLORME 3-D
TOPOQUAD PROGRAM

FIGURE 1.1

HARBOR AT HASTINGS OU-2

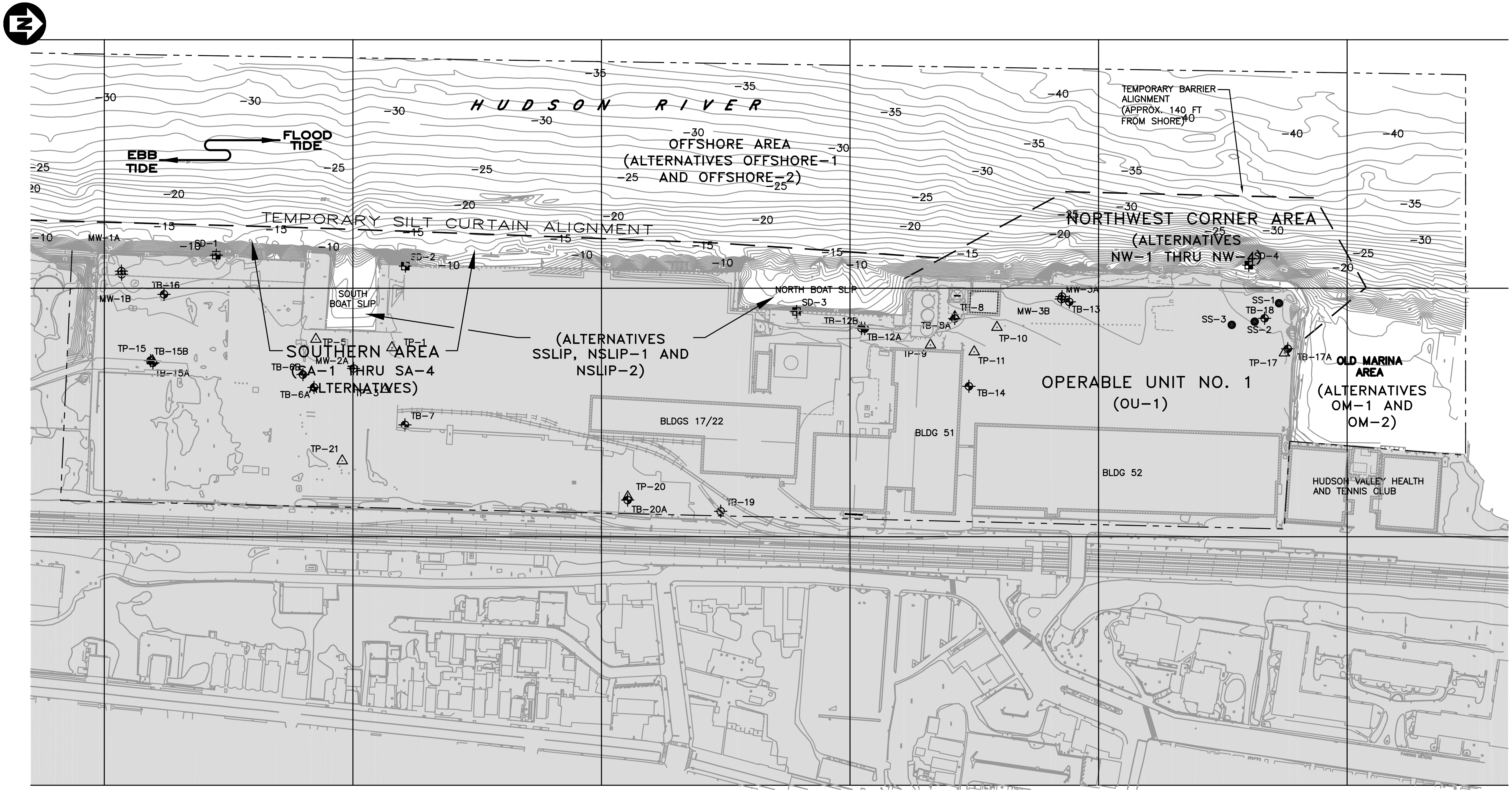
HASTINGS-on-HUDSON, NEW YORK

OU-2 LOCATION MAP

PARSONS

290 ELWOOD DAVIS ROAD, SUITE 312, LIVERPOOL, NY 13088 PHONE: (315) 451-9560

P:\441532\GRAPHICS\SITEMAP.PPT



NOTES:

1.) BASE MAP GENERATED BY BOSWELL, 2005.

2.) RIVER BATHYMETRY BASED ON ALPINE, 1997. VERTICAL DATUM IS BASED ON NAVD88.

3.) SHADED AREA IS OU-1 (ON SHORE).

LEGEND:

—— – – ——	APPROXIMATE STUDY AREA BOUNDARY
— — — —	TEMPORARY SILT CURTAIN OR BARRIER ALIGNMENT
(shaded)	OPERABLE UNIT NO.1 (OU-1)

APPROXIMATE SCALE

200 100 0 200 400

SCALE: 1"=200'

FIGURE 1.2

OU-2 AREAS
HASTINGS-ON-HUDSON, NEW YORK

PARSONS

290 ELWOOD DAVIS ROAD, SUITE 312, LIVERPOOL, N.Y. 13088, PHONE: 315-451-9560

441532.01000 ** 1532C001A(FIG 1).DWG ** JTS **3/17/06

FORMER ANACONDA PLANT SITE
OPERABLE UNIT No. 2

Atlantic Richfield Company and
ARCO Environmental Remediation, LLC

Village of Hastings on Hudson
Westchester County, New York

N

Legend

- Shoreline
- Piling Line
- Piling
- PCB SAMPLE LOCATIONS
- 10'x10' GRID

DEFINED AREAS

- OLD MARINA
- NORTHWEST CORNER
- NORTH BOATSLIP
- SOUTHERN AREA
- SOUTH BOATSLIP
- OFFSHORE AREA

PCB Concentration

- 100,000 mg/kg
- 10,000 mg/kg
- 1,000 mg/kg
- 100 mg/kg
- 10 mg/kg
- 1 mg/kg

FIGURE 1.3 MAP OF PCB CONCENTRATIONS IN SEDIMENT ABOVE 1 MG/KG (PPM) WITH DEFINED AREAS

0 100 200 300 400 500 600

SCALE IN FEET

APRIL 7, 2006 rev. 3
(PCB IMAGE 04/06/06)

ENVIRONMENTAL STANDARDS

FORMER ANACONDA PLANT SITE
OPERABLE UNIT No. 2

Atlantic Richfield Company and
ARCO Environmental Remediation, LLC

Village of Hastings on Hudson
Westchester County, New York

Legend

- SHORELINE
- PILING LINE
- PILING
- COPPER SAMPLE LOCATIONS
- 10'x10' GRID

DEFINED AREAS

- OLD MARINA
- NORTHWEST CORNER
- NORTH BOATSLIP
- SOUTHERN AREA
- SOUTH BOATSLIP
- OFFSHORE AREA

Copper Concentration

982 mg/kg — 1,000 mg/kg

FIGURE 1.4 MAP OF COPPER CONCENTRATIONS IN SEDIMENT ABOVE 982 MG/KG (PPM) WITH DEFINED AREAS

0 100 200 300 400 500 600
Feet

APRIL 7, 2006 rev. 3

ENVIRONMENTAL STANDARDS

SECTION 2

REMEDIAL TECHNOLOGIES UPDATE

This section updates the evaluation of remedial technologies presented in the OU-2 FS Report (Earth Tech, 2003) with new information and analyses of remedial technologies that were not presented in the 2003 OU-2 FS Report.

The remedial action alternatives for OU-2 presented beginning in Section 3 are based on removal of contaminated sediment and/or capping to isolate contaminated sediment.

2.1 SEDIMENT REMOVAL (DREDGING)

Dredging has been performed at many environmental sites in the Northeast, Midwest and West Coast of the United States and at other sites around the world. Mechanical and hydraulic dredging and stream diversion “in-the-dry” excavation techniques have all been implemented at different contaminated sediment sites, depending on the differing conditions present at each site. Key elements in a dredging operation typically include onshore support zone preparation, removal of debris and obstructions, sediment removal, staging and transport, treatment/ dewatering, and disposal. This report subsection focuses on sediment dredging and removal of debris and obstructions but the evaluations of sediment removal alternatives in Sections 4, 6, and 8 also address impacts associated with removal, staging, treatment/dewatering, transport, and disposal of sediment.

The primary adverse environmental impact of debris and sediment removal is normally the particulate and dissolved contaminant releases that occur from sediments resuspended into the overlying water column. Resuspension losses during sediment removal can be reduced or controlled to some extent with dredging management practices and also through the use of temporary containment structures, but resuspension can not be prevented. Resuspension, as the term is used in this document includes dredge head losses, as well as releases occurring during a whole range of necessary ancillary activities including removal of debris and obstructions, barge prop wash, barge handling, and anchoring a barge into sediment. During a dredging operation, measures are needed to control resuspension and meet site remediation goals or, if goals are not achievable, to control resuspension to an extent that is technically practicable.

As noted above, dredging is often accomplished using mechanical or hydraulic means. In some cases dredging is undertaken via diversion and in-the-dry mechanical excavation; however this technique is not viewed as being applicable to OU-2. The relative success of dredging is dependant on site-specific factors and the effectiveness of engineering controls implemented while dredging. The discussion in this subsection focuses on site-specific factors affecting dredging, impacts of dredging on OU-2, and engineering controls potentially applicable to a dredging operation at OU-2.

2.1.1 Site-Specific Factors and Impacts of Dredging at OU-2

At Hastings OU-2, conditions for dredging impacted sediment would be extremely challenging. Numerous site-specific conditions that would make dredging difficult are anticipated to be the abundant presence of assorted debris and wood pilings as described in recent AR field investigation reports (Parsons, 2005a and 2005b), steep and irregular sediment slopes on the order of 2.5 horizontal to 1 vertical to a water depth of up to 25 ft, fluctuating water levels due to tidal and wind-wave actions, the fine-grained silty nature of OU-2 sediment, weak soil strengths, and the depth of contaminated sediment. These site-specific factors, coupled with the concentrations of PCBs present, would make environmental dredging less effective than has been demonstrated at other sites. These site factors would most likely result in two conditions resulting from dredging: (1) significant resuspension of residual sediment during removal of debris and obstructions and dredging operations; and (2) a low likelihood of achieving a 1 ppm PCB remedial goal except through capping based on dredging limitations such as resuspension and slow settling of resuspended sediment while dredging (see Section 2.1.1.2).

2.1.1.1 Site Specific Factors

Presence of Debris

The abundance of fill material and debris is a major consideration at this site. The RI and FS (reference) documented the presence of some debris, however, the extent and nature of this material was not fully defined until the 2004 and 2005 geophysical surveys identified large quantities of surface and subsurface fill material and debris in OU-2. The presence of this material within OU-2 sediment would have a significant impact on dredging operations, including the resuspension and release of contaminated sediments, the generation of residuals, and the costs for dredging. A separate operation would be required to remove large debris and obstructions, and removal of debris and obstructions within the sediments would result in increased sediment resuspension during dredging.

The 2004 and 2005 site geophysical surveys documented innumerable overlapping large objects in the near-shore areas. Side scan sonar data identified over 500 nearshore targets as well as additional targets further than 150 ft from the shoreline. The magnetic survey data identified 231 magnetic anomalies within 150 ft of the shore as well as a number of targets greater than 150 ft from shore. These objects appear to be both surficial and sub-surficial. The 2005 metal detector survey indicated that metallic debris was both ferrous and non-ferrous in nature (Parsons, 2005c).

The geophysical surveys documented two clusters with higher debris density. The first cluster is along the northern shoreline and includes two derelict piers or docks. The second cluster is adjacent to former Building 15. While the side-scan sonar results suggest that some of the debris may be natural (e.g., logs, branches, boulders), the data conclusively demonstrates the presence of abundant anthropogenic debris including pilings, tires, and sections of sheet pile. Side-scan data also suggests the presence of significant rocks, rip rap, rubble, and concrete extending from the shoreline outward to approximately 50 to 140 ft in the Northwest Corner Area of the site. Magnetic data confirms that some of the debris observed on sonar data is ferrous, and these data further suggest the presence of additional ferrous and non-ferrous debris beneath the sediment surface (Parsons, 2005c). Photos of the shoreline further show the presence of boulders, rip rap, pilings, piers, metal objects, and other large objects that would impede dredging along the entire western shore of the plant site (see Figure 2.1).

Slope and Shoreline Stability

Bathymetry data collected in 1997 by Alpine Ocean Seismic Survey, Inc. show slopes in the NW corner of OU-2 close to shore are typically on the order of 2.5 horizontal to 1 vertical. Slopes of this magnitude extend along the western shoreline of the plant site. Typically in the Northwest Corner Area, these steep slopes extend approximately 70 ft out from the shoreline. In the southern portion of the site, the slope becomes more gradual approximately 30 ft from shore. The bathymetry further from shore indicates a relatively flat bottom with slopes on the order of approximately 15 horizontal to 1 vertical. Bathymetry data are an essential component in assessing potential dredging operations at a site. In addition to allowing for dredge volume calculations, bathymetric variations at a site impact sediment resuspension, residual concentrations of contaminants following dredging, and containment design.

Dredging immediately adjacent to the OU-2 shoreline bulkhead at significant depths below the existing mudline has the potential to adversely impact shoreline stability. At a minimum, a more robust design for the shoreline bulkhead would be required to prevent shoreline bulkhead failure and associated contaminant losses. The associated increase in shoreline bulkhead costs are included in evaluations of remedial action alternatives involving dredging presented in Sections 4, 6, and 8. In addition, an assessment of the impact of weak soils on slope and shoreline bulkhead stability is included in Appendix B. This assessment concludes the following regarding OU-2 geotechnical conditions applicable to all evaluated remedies:

- Global stability (also called slope stability) controls allowable dredge depth. There are geotechnical limits on the dredge depth immediately next to a shoreline bulkhead and offshore from the shoreline bulkhead without causing a slope failure where the shoreline bulkhead and contaminated upland soil collapses into the river (see Figure 2.2). These limits are primarily due to low soil shear strength in the marine silt layer supporting the toe of shoreline bulkhead and topography.
- Global stability analysis includes consideration of stability during seismic events. This analysis is relatively complex and often requires data collected during remedial design. In addition, global stability under seismic conditions for OU-2 will require complex evaluations involving the interaction of landward (OU-1) soils, the shoreline bulkhead and riverside (OU-2) sediments and engineered structures that must be undertaken as part of the OU-1 remedial design.
- The allowable shoreline and offshore dredge depth can be increased somewhat by unloading (excavating) the upland (OU-1) area and supporting the proposed shoreline bulkhead with an onshore anchor system.
- All alternatives would involve construction of a supporting mass of coarse-grained natural materials (hereafter called a berm) located in the river. The berm requires

substantial thickness to support the shoreline bulkhead and landward loading in the long term, and once the plant site grade is raised (as part of the OU-1 capping remedy), the resulting final mudline grade after dredging and capping is likely to exceed the existing grade in areas. This is addressed in Sections 3, 5, and 7.

Tidal Fluctuations and Currents

OU-2 is located in a tidally influenced section of the Lower Hudson River. Flood (northerly) and ebb (southerly) flows generally occur twice daily approximately every 6 to 6.5 hours, typical ebb flows are larger than flood flows. Typical water velocities measured throughout the site and at various depths during the Fall 2004 Supplemental Investigation were 1 to 3 ft per second (Parsons, 2005).

Large tidal fluctuations and the currents present in OU-2 would significantly affect efforts to design measures to reduce resuspension losses of contaminated sediments in the river during dredging.

Fine-Grained Sediment

Data from the remedial investigation (Earth Tech, 2000) alleged that the thickness of soft sediment at the site near shore typically ranges from 5 to 10 ft, with an average of about 6 to 7 ft. This sediment was reported to be poorly consolidated, fine-grained river bottom deposits comprised of uniform, dark gray to black, very soft, non-plastic silt to clayey silt, rarely with thin sandy layers. Over 60 percent of the samples collected during the OU-2 RI had a silt-plus-clay content of greater than 80 percent. All of the samples collected during the Supplemental RI were reported as fine grained. The thin surficial layer of the soft sediment was frequently described as “fluffy” or “soupy,” confirming its low solids content (Earth Tech, 2003).

While the fine-grained nature of soft sediments at OU-2 was confirmed in the Summer 2005 Supplemental Investigation (Parsons, 2005b), studies of the fill material and debris near shore demonstrated that much of the sediment is interspersed within the fill material near shore, and many efforts to collect core sediment samples in this area failed when the coring device struck rock or other hard debris. One of the most significant findings from this investigation is that most of the PCB contamination in OU-2 is concentrated near shore, and it is not found in a soft upper layer of 5 to 10 ft of fluffy sediment, but rather, in sediments mixed into a steeply sloped berm of fill material and debris that will be difficult to remove.

The soft sediment has a silt-plus-clay content of 80 to 90 percent by weight. The fine grained nature of the OU-2 sediment has an impact on projected resuspension as well as on reasonable expectations for post-dredging residual concentrations, which are discussed further in Section 2.1.1.2.

Depth and Location of Contamination

The depth and location of contaminated sediment relative to the shoreline can affect the effectiveness and feasibility of dredging. The extent of contaminated sediment in each area within OU-2 is discussed in the beginning of Sections 3, 5, 7 and 9 of this Supplemental FS Report.

The depth of contaminated sediment has been assessed for OU-2 based on laboratory analyses of sediment samples and contaminant distribution modeling of PCB and copper distribution in sediment. As shown in Table 1.1, sediment in the Northwest Corner Area is contaminated with PCBs near the mudline, and at least 30 ft below the mudline, with the highest concentrations near the shoreline. The depth of contamination in this area is consistent with both surface and deep on-shore sources. PCBs were found up to 40 ft below the ground surface in the northwest corner of the plant site, and AR's contaminant distribution modeling predicts that PCBs may be found at or near the same depth in the river in this area below the mudline.

Laboratory data and contaminant distribution modeling for the other areas of OU-2 indicate PCB and metal contaminants are generally shallower and lower in concentration, which is consistent with a surface source. Data and contaminant distribution modeling by AR for the rest of the plant site shoreline (Southern Area) show PCBs in sediment above 1 ppm appear to be limited to the top 4 to 6 ft below the mudline, and these concentrations are far lower than in the Northwest Corner Area. In the Old Marina Area, PCBs are limited to the top 8 to 10 ft of sediment, except in the area where the Northwest corner and Old Marina overlap). In the Offshore Area, PCBs are generally less than 1 ppm, and the few exceptions are near-surface samples many of which are below the top 6 inches of sediment. The area weighted average sediment PCB concentration for the surface of the Offshore Area is only 0.20 ppm.

A small area of copper above the proposed 982 ppm PRG is co-located with PCBs in the top 6 to 8 ft of the Northwest Corner Area, as shown on Figures 1.3 and 1.4. Two more small areas of copper above the proposed 982 ppm PRG are found in the top 6 to 8 ft of sediment next to the northern half of former Building 15, and near a former sluice outfall located south of the South Boat Slip, as shown on Figure 1.4.

2.1.1.2 Environmental Impacts of Dredging

Sediment Resuspension During Dredging Operations

All dredging equipment types and operations result in resuspension of sediments and associated releases of contaminants. In the context of dredging, resuspended sediment may be defined as that portion of the dislodged sediment not picked up by the dredging process that becomes dispersed in the water column and transported by current as a suspended solids plume (Palermo, 2003). However, in a remedial evaluation, other sources of resuspension such as removal of debris and obstructions, propeller wash, sediment sloughing, etc., also need to be considered as they also contribute significantly to sediment resuspension.

Resuspension of sediment while dredging could be significant at Hastings OU-2 due to the abundant presence of debris, the fine-grained nature of the soft sediments, the steep nearshore slope, the possible depths of the dredge cuts, and the hydrodynamic forces present at OU-2 from tides and winds. Resuspended fine-grained sediments normally settle very slowly, leading to greater resuspension losses. These sediments can also partially settle to form a layer near the bottom which then migrates down the bathymetric slope (due to gravity), leaving the primary response area(s).

The National Academy of Sciences concluded in its 2001 report "A Risk Management Strategy for PCB-Contaminated Sediments" (NRC, 2001) that resuspension losses are 0.5 to 5 percent for single pass dredging conducted in the absence of significant debris or sediment heterogeneities. Resuspension of dredged sediment has also been reported to range from less than 1 percent to nearly 10 percent (Patamont, 2005b).

The US Geological Survey conducted a study (USGS, 2000) of such losses during the dredging of the Fox River Sediment Management Unit 56/57 area. This project was conducted under very controlled conditions designed to minimize resuspension losses. Sediment removal was conducted using horizontal auger hydraulic dredging conducted behind silt curtain controls. The USGS found that 2.2 percent of the PCBs were lost to the aqueous environment by either becoming soluble or resuspending in solid form into the water column. Losses using a mechanical dredge are typically higher than losses using a hydraulic dredge. Mechanical dredging with conventional open clam buckets has traditionally been viewed as being at a substantial disadvantage when compared to hydraulic dredging with respect to resuspending sediment and not being able to achieve a remedial goal of 1 ppm PCBs (Palermo, 2003a). However, mechanical dredging with environmental buckets is viewed, where debris and obstructions are sparse enough to permit reliable bucket closure, as being more comparable to hydraulic dredging with respect to sediment resuspension and ability to achieve a remedial goal.

The presence of abundant debris and underwater obstructions would necessitate that mechanical removal techniques be used, particularly in the near-shore areas where most of these contaminated sediments are located. While modern sealed environmental bucket designs have contributed to the advancements in dredging effectiveness, they offer fewer advantages when used to remove a sediment-debris matrix that prevents the buckets from completely closing and results in damage to the bucket. Debris such as wire, scrap metal and concrete destroys the seals on the edges of the bucket. Repeated closing a bucket with debris in the jaws will lead to twisting and metal failure so that the bucket becomes distorted and does not close completely. Also, the lighter weight environmental buckets may not be effective in penetrating sediment that is laden with debris.

In addition to debris, a wide variety of field activities must be performed to accomplish a dredging remedy, all of which would contribute some amount of resuspended sediment to the water column. These various activities include several forms of disturbance losses which occur at the dredge head; leakage losses from mechanical buckets/clamshells; sloughing along cut line edges; removal of pilings, debris or boulders; disturbances occurring as a consequence of dredge spudding, positioning, and maneuvering; propeller wash from tugs moving barges; losses that occur when control devices such as sheet pile walls and silt curtains are deployed, moved, removed, or cycle with rising/falling tides each day; propeller wash losses from tugs from deploying and moving silt curtains. Figure 2.3 shows an example of resuspension caused when a dredge bucket is not able to close due to large debris caught in the bucket opening.

Resuspension is a concern at any site with debris even when significant debris is removed prior to dredging. Some debris is embedded in sediment and can not be removed prior to dredging.

The fine-grained texture of sediment means that settling of resuspended sediment inside an enclosure would be relatively slow. The FS for OU-2 (Earth Tech, 2003) indicated that resuspended sediments would settle relatively quickly, based on column settling tests, but the column settling tests reported in the OU-2 FS were performed using non-standardized, non-verified procedures. Column settling test procedures have been incorporated into US Army Corps of Engineers' design guidance for confined disposal facilities (USACE, 1987 and 2003). Using these standard procedures during the Fall 2004 investigation (Parsons, 2005c) data from five Fall 2004 column settling tests were analyzed using the USACE SETTLE computer program (Hayes and Schroeder 1992). The Fall 2004 column settling test results provide a basis for comparing settling properties of the Hastings OU-2 sediment with other sediments. Fall 2004 column settling results indicate the Hastings OU-2 sediments are fairly slow to clarify as compared with most estuarine sediments, with an average required settling time of 45 hours needed to achieve total suspended solids (TSS) values less than 100 mg/l in the test column supernatant water. By comparison, 9 of 12 estuarine sediments tested by the USACE (from various sites across the U.S.) required less than 45 hours to reduce suspended solids levels below 100 mg/l TSS, with an average time required of 16 hours (Averett, Palermo, and Wade, 1988).

Resuspension arising from the sloughing of sediment around dredge cuts during dredging is always a potentially significant resuspension source. Particularly in the Northwest Corner Area, very deep dredge cuts would be required into the comparatively steep slope that extends outward from the shoreline bank. Local hydrodynamic forces primarily from winds and tidal fluctuations would also increase sediment resuspension during dredging. The existing nearshore bank slope at the Northwest Corner Area of OU-2 is typically 2.5 horizontal to 1 vertical. Any dredging on the slope would result in sloughing of remaining undredged sediment down the slope and into the cut as the dredging progresses. Water depths within the areas of concern can be as high as 30 ft.

Typical water velocities measured throughout the site and at various water depths during the Fall 2004 Supplemental Investigation were 1 to 3 ft per second. The tidal variation at Hastings-on-Hudson is, on average, 4.2 ft within a single tidal cycle. The wind fetch from the north at this site is over a mile. Efforts to collect sediment samples during the supplemental river investigations were often delayed or disturbed by river conditions.

Residual Sediment Concentrations Following Dredging

Dredging operations can remove substantial volumes of sediments, but after the dredging is concluded, residual levels of contaminants invariably remain ("residual sediment contamination").. Resettlement of resuspended and sloughed sediments may also contribute to residuals in areas downcurrent (Palermo, 2003).

Environmental dredging to achieve the proposed 1 ppm PRG for PCBs does not appear to be technically practicable based on results from other sites with similar levels of contamination and given the difficult dredge conditions of mudline slope, abundant debris, and difficult water conditions noted above.

Residual PCBs concentrations achieved at other dredge sites are summarized in Table 2.1. Nearly half of the sites listed in Table 2.1 did not achieve a residual PCB sediment concentration of 10 ppm and at only two of the eleven sites achieved residual sediment concentrations less than 2 ppm. The 1 ppm total PCB remedial goal was not achieved at any of the sites. Site conditions causing potentially higher residuals are more severe at OU-2 than at several of the sites referenced in Table 2.1. Additionally, only one of the sites included in Table 2.1 had the added complication of tidal fluctuations similar to those present at Hastings OU-2.

Dredge Elutriate Test (DRET) procedures were developed by the US Army Corps of Engineers as a predictive tool for estimating the degree of contaminant release from sediments due to the portion of resuspension that arises at the point of dredging (DiGiano, Miller, and Yoon 1995). The dredge elutriate test consists of mixing sediment and site water at a total suspended solids concentration of 10 grams per liter (considered representative of resuspended sediment as generated at the dredge head source), allowing the slurry to settle for a period of 1 hour, and analyzing the elutriate for suspended solids and dissolved and total concentrations of contaminants. Dredge elutriate results only apply to releases due to dredging-induced resuspension, and would not necessarily be representative of releases resulting from efforts to remove debris and obstructions, propeller wash, spudding/anchoring activities, and other potential resuspended and dissolved contaminant loss sources.

Both total and dissolved concentrations of PCBs were determined as parts of the fall 2004 dredge elutriate tests, allowing for evaluation of both dissolved and particle-associated contaminant releases. The results for PCBs show a relatively low release to the dissolved phase that averaged 0.059 microgram per liter (or part per billion), indicative of the relatively low concentrations of PCBs in the samples tested (an average of 3 ppm PCBs) and the hydrophobic nature of PCBs. The combined dissolved and suspended PCB concentrations in the dredge elutriate following 12 hours of settling were approximately 0.3 microgram per liter. The sediments being considered for dredging from the Northwest Corner Area are estimated to have PCB concentrations up to 1,000 times higher locally than the 3 ppm PCB sediment concentration evaluated in the Fall 2004 dredge elutriate tests. Test results for samples from other areas and other depths within the Northwest Corner Area might therefore be expected to show substantially higher release of PCBs than those tested for the Fall 2004 AR Offshore Investigation. In addition, results from any dredge elutriate test do not account for effects from removing debris and obstructions, prop wash, bank slope, barge anchoring, or effects of sloughing of bed sediment resulting from dredging.

Dredge elutriate tests were also performed for NYSDEC after the FS report being completed, on three OU-2 sediment samples for metals, two of which were samples from the Southern Area of OU-2. Dredge elutriate results sponsored by NYSDEC were compared to New York State saltwater quality standards for metals; detection limits for copper, lead and other analytes were set below NYS water quality standards. Copper was not detected in the filtered samples for which detection limits were below NYS water quality standards. Copper in unfiltered samples exceeded the NYS water quality standard by more than a factor of two, and the maximum copper exceedance in unfiltered samples was by a factor of 19. Starting sediment copper concentrations for these elutriate analyses ranged from 45 to 1,400 ppm.

2.1.2 Dredging Technologies

Mechanical and Hydraulic Dredging

Sediment removal methods typically fall under two categories, mechanical removal and hydraulic removal. Mechanical forms of dredging would be used at OU-2 given the documented abundance of debris in the material to be dredged. The current lack of on-site dewatering and disposal capacity suggests that upland facilities will have to be integrated into the OU-1 construction schedule and the shoreline bulkhead design process. The nature of upland facilities required differs for mechanical and hydraulic dredging because hydraulic dredging generates a much larger volume of water that has to be separated from the sediment. Therefore, more upland area would be needed to support hydraulic dredging than mechanical dredging. The lesser upland facilities requirements are an additional factor favoring use of mechanical dredging at this site. Hydraulic dredging may be more appropriate at this site for any sediment to be removed from the part of the Old Marina Area where debris and obstructions seem to be less abundant.

Use of heavier conventional clam buckets rather than lighter-weight environmental buckets will be required due to the extensive presence of debris in the sediments. Removal of debris and obstructions and mechanical dredging may need to proceed together in an alternating sequence as the shallow debris is removed and then deeper debris becomes exposed through dredging of the overlying shallower sediments. Such removal would likely to be more difficult on a sloped surface (such as nearshore at the Northwest Corner Area) than if the bathymetric surface were relatively flat (as in the Old Marina Area).

Caisson Dredging

Dredging small areas within a temporary vertical steel cylindrical containment structure called a caisson is another dredging technique that is sometimes possible, particularly in locations with limited debris where a caisson can be driven sufficiently into sediment to support itself. A caisson would need to be comprised of substantial steel driven through the marine fill materials into the marine silt (see the discussion of temporary rigid containment barrier in Section 2.1.3.2). The 2004 and 2005 geophysical surveys and probing study indicate that pushing caissons through the shallower fill materials may not be implementable in much of OU-2 due to the presence of debris and other obstructions. In addition, one dredging contractor has indicated the mobilization and set up costs for caisson dredging at this site would be excessive (over $400 per cubic yard). Applying caisson dredging, even for limited areas of OU-2, is unlikely to be technically implementable and would not be cost effective.

2.1.3 Dredging Control Measures

River water velocities, the tidal range, the presence of significant debris underwater, the fine-grained nature of OU-2 sediment, and the steep slope in the river within the Northwest

Corner Area of OU-2 would all contribute to migration of dredge residuals away from any OU-2 area being dredged. Therefore, containment during any dredging operation should be considered. Releases of soluble metals from OU-2 sediments do not appear to be a water quality concern based on metals porewater and metals DRET results available for OU-2, so temporary silt curtains are likely appropriate where dredging may be implemented but PCB concentrations are relatively low, such as in the Southern Area of OU-2. However, PCB levels present in sediments within the Northwest Corner Area would result in releases significantly above statewide water quality standards. On this basis, a temporary rigid containment barrier in the Northwest Corner Area to reduce losses has been evaluated even though costs for such a temporary rigid containment barrier would be substantial.

2.1.3.1 Silt Curtains

The impact of sediment and contaminants resuspended at the point of dredging can be reduced by the addition of temporary silt curtains around the area to be dredged. Silt curtains are designed to increase the residence time of suspended solids around the dredgehead, encouraging settling and reducing the amounts of resuspended sediments reaching the main body of water. Figure 2.4 presents two pictures of a typical silt curtain. Temporary silt curtains are normally constructed of vinyl or polyurethane held in position along the outer extent of a dredging area; and are not capable of eliminating flow between the areas inside and outside the temporary silt curtain. Although potentially effective on suspended particles, temporary silt curtains are not normally expected to reduce contaminant loss in dissolved form (NRC 2001).

The 2003 Feasibility Study for OU-2 included the use of temporary silt curtains (sometimes called turbidity curtains) to control resuspension losses from dredging along the Southern Area of OU-2. Temporary silt curtain effectiveness depends on the nature of the operation, the quantity and type of material in suspension, the method of deployment, and the hydrodynamic conditions at the site. Under ideal conditions, turbidity levels in the water column outside the curtain can be as much as 80 to 90 percent lower than those inside of the curtain (JBF Scientific 1978).

At OU-2, an average tidal water depth of approximately 15 ft along the silt curtain alignment (corresponding to a curtain alignment at a water elevation of -15 ft based on NAVD88 datum) appears to be a reasonable outer limit for effectively implementing a reinforced silt curtain. On this alignment, the water depth at high tide would be approximately 17 to 18 ft. This alignment would vary based on bathymetry, but would generally lie approximately 60 to 80 ft from shore.

Francingues and Palermo (2005) list five site conditions that reduce the effectiveness of silt curtains: high water velocities, high winds, changing water levels, excessive wave heights (including ship wakes), and drifting debris and/or ice. The 2003 FS found the control technology to be effective in water depths up to 20 ft and current velocities up to 1.5 ft per second. These site conditions and others, such as steep slope and imbedded debris, would need to be considered during Remedial Design if this technology is selected for use at OU-2.

Water velocities as measured during AR's Fall 2004 Supplemental Investigation at a station located within the Southern Area typically ranged from 1 to 2 fps and were generally less than 1.5 fps (Parsons, 2005a).

The up to 20 ft depth constraint is not independent of hydrodynamic conditions, as a 20-ft deep silt curtain would be more impacted by the river currents, wave actions, and ship wakes as compared to, for example, a 6-ft deep silt curtain. When tidal currents cause a poorly deployed curtain to sweep back and forth, for example, the turbidity levels outside the curtain may actually be higher than the levels inside the curtain (JRB Scientific 1978).

A 1.5 ft per second water velocity generally reduces the effective depth of a silt curtain by 20 percent or more due to the flaring configuration of a silt curtain. Inadequate tensioning or ballasting or a faster current can result in a reduction of the effective depth of 50 percent or more (JBF, 1978). Therefore, for example, a conventional silt curtain could be effective at reducing turbidity in the upper 10 to 15 ft of the water column when using a 20-ft silt curtain, but a conventional silt curtain would have less effectiveness reducing turbidity losses at average water depths over 15 ft, because of these tidal and curtain flaring considerations.

The presence of a 4-ft tidal range will be one of the OU-2 feasibility and effectiveness Remedial Design considerations. If the silt curtain must extend throughout the entire water column at all times in order to contain the settling contaminated solids, then the curtain itself has to rise and fall with the tide.

Tidal action would reduce silt curtain effectiveness at this site because the OU-2 sediment samples dominantly contain fine-grained (silt or clay-sized) particles. These particles would settle and consolidate over time periods longer than a tidal cycle, based on column settling test results. With each ebbing tide, a fraction of the turbid water contained inside the curtain area would exit the curtain contained area. If the maximum water depth inside the containment is 15 ft, for example, each tidal exchange at this site would cause about 30 percent of the contained water to be released beyond the curtain. Thus, about 30 percent of the unsettled resuspended fine solids in the water column would be released beyond the curtain boundary with each tidal cycle.

Wind-wave action presents additional implementation problems with a silt curtain that would need to be considered during Remedial Design. Without adequate flotation, waves can overtop the silt curtain, allowing small releases of turbid water from elsewhere within the contained area. Resuspension of bottom sediments can also occur from wave action if wave induced motion of the curtain excessively disturbs the sediment bottom. At Hastings OU-2, periodic ship wakes would be the normal condition, rather than being an infrequent occurrence, and Remedial Design will need to incorporate these factors in order to provide adequate anchoring and slack. Wave heights measured at the site between October 6 and December 7, 2004 were consistently in the range of 0.5 to 1 ft with some wave heights from 1 to 2.2 ft measured occasionally over the two-month period.

A silt curtain deployment at OU-2 would necessarily include at least some length aligned on the "downhill" side of a sloped nearshore area of sediment. If a substantial amount of fluid mud were produced by the settlement of resuspended particles, this material may move downslope to the toe of the curtain and make the curtain perform less effectively. Remedial Design would need to consider these factors and establish appropriate field management practices to be followed during Remedial Construction.

Sediment at OU-2 is known to contain substantial amounts of both large and medium-sized solid materials. During Remedial Design, the planned silt curtain alignment will need to be examined to determine whether limited obstruction removal may need to precede deployment in some areas, or if other adaptive responses may be useful to address this concern.

Floating hazards are another concern relevant to evaluating temporary use of a silt curtain along the lower Hudson River. After deployment, anything substantive which drifts into a silt curtain becomes operationally problematic. Remedial Design will need to consider the Remedial Construction field practices that will manage simple materials such as branches, logs, and other discarded items. The silt curtain control technology is unlikely to be operationally consistent with floating ice, so its deployment will be seasonally constrained.

The most recent guidance on silt curtains from the U.S. Army Corps of Engineers (Francingues and Palermo, 2005) indicates the effectiveness of silt curtains is incompletely understood, and that conventional silt curtain deployments are generally not effective for water depths deeper than 15 ft and for current velocities greater than 1.5 ft per second.

At OU-2, an average water depth of approximately 15 ft along the silt curtain alignment at an average tide water level (corresponding to a curtain alignment at a water elevation of -15 ft based on NAVD88 datum) appears to be a reasonable outer limit for effectively implementing a reinforced silt curtain. A water depth of 15 ft is based the most recent Corps guidance cited above, as well as on a maximum water depth under ideal conditions of 20 ft, the overall tidal elevation range of 4 ft at this site, and a 20 percent loss of effective depth due to high site river water velocities based on use of silt curtains at other sites.

The assessment of a silt curtain within this Supplemental FS is based on technical information and material costs provided by a company with experience implementing silt curtain at environmental dredging sites (Wilkie 2005). This company recently provided a custom-designed, reinforced silt curtain containment system successfully implemented in 2004 for a dredging project at a former manufactured gas plant in Tarrytown, NY which is on the eastern side of the lower Hudson River approximately 10 miles north of OU-2. The containment system could consist of two parallel rows of barriers around the dredge area. The outer barrier would likely be a permeable woven geotextile fabric or equivalent designed to absorb the current and wave forces. The inner barrier would likely be an impermeable PVC fabric or equivalent that would be the primary suspended sediment containment barrier. These would be held in place with anchors likely spaced 20 to 30 ft apart along the length of the containment system.

Even with an outer and inner barrier, the company reported that there were three storm events during a four-month period on the Tarrytown project where the fabric had to be pulled up (and dredging stopped) to avoid damage. The same company advises that spare sections of the containment system should be purchased and stored on site due to potential for damage due to the current and wave conditions in the Lower Hudson River area.

2.1.3.2 Temporary Rigid Containment Barrier

A temporary rigid containment barrier is a second technology for reducing the losses of resuspended sediments. A number of site-specific difficulties are apparent with installing a temporary rigid containment barrier as presented in the 2003 FS for OU-2. These difficulties include: river water depth above 30 ft, 40 to 55 vertical ft of soft marine silt, and the need for the barrier to extend above high tide water levels due to storm flows and wind-wave action which in total would result in a total barrier height of approximately 100 to 110 ft.

Both AR and NYSDEC retained geotechnical consultants to assess the implementability of a temporary barrier located approximately 140 ft from shore parallel to the shoreline at the Northwest Corner Area based on the alignment proposed in the 2003 FS Report. Practically, the temporary barrier would need to be maintained with a water level differential of approximately 1 ft on both sides of the barrier to account for the delayed action of tidal water entering and leaving the contained area. In order to maintain a relatively constant water level differential, an opening would be needed either at the top of the temporary barrier and/or along a portion of the barrier alignment. Even with a 1-ft water level differential, the barrier would need to withstand water velocity and impact forces.

Analyses conducted by two engineering firms (Haley & Aldrich and YU & Associates) during 2005 show that a temporary rigid containment barrier would need to penetrate vertically through the marine silt into the underlying basal sand. The temporary barrier would also need to have an alignment that is outside areas with significant PCB concentrations in sediment to avoid the potential transport of PCBs into the underlying basal sand. Although some dredging immediately adjacent to the temporary containment barrier will be included, it is prudent that dredging along this structure be limited to reduce the design requirements for the wall.

A temporary rigid containment barrier approximately 140 ft from shore to be used over a single construction season would consist of a king pile wall. A king pile wall is comprised of a combination of interlocking H-piles and sheet piles. If the temporary barrier along the same alignment needs to be in place over a winter season and be subjected to ice loads, the barrier supports would need to be more substantial, which would increase the cost. Figure 2.5 includes two pictures of steel sheeting. The large crane in Figure 2.5 is hammering the piles into place.

2.1.3.3 Monitoring -- Point of Compliance

Short-term impacts on water quality during dredging are often assessed during dredging operations by monitoring a far-field point of compliance established some distance away from the dredging operation. Establishing a far-field point of compliance and a far-field compliance concentration permits the monitoring of short-term impacts over a far-field area of influence.

Previous environmental dredging projects within New York State have employed such far-field points of compliance concentration at 2 micrograms per liter of PCBs. During the 2005

Grasse River pilot study, the point of compliance for dredging was approximately one mile downstream from the dredge area, and the compliance PCB concentration one mile downstream is 2 micrograms per liter (Alcoa, 2005). A similar far-field point of compliance and compliance concentration were implemented in the 1990's at the Alcoa East and General Motors remediation sites near Massena, NY. The PCB point of compliance for the Hudson River remediation work by General Electric is also being established one mile downstream. The General Electric PCB compliance concentration along the Hudson River is lower than 2 micrograms per liter due to a water supply intake that is not a factor for Hastings OU-2. Water quality standards for PCBs are the same for estuarine waters as they are for fresh waters. Therefore, the standards applied during the Alcoa and General Motors dredging projects are used in performing these remedial alternatives analyses.

Predictions for achieving the far-field compliance concentration for PCBs would depend on the extent of sediment resuspension, effectiveness of containment around the dredging operation, and the varying hydrodynamics of the lower Hudson River. Resuspended sediment concentrations vary in all three dimensions away from the source. Such predictions are not able to be reliably made at this time. Monitoring of water quality will be needed during dredging to assess its short term impact on water quality and to adjust dredging operations as warranted based on monitoring results.

Earth Tech has provided preliminary estimates of far-field impacts based on contaminant distribution modeling results they presented in a white paper in 2005 (Earth Tech, 2005a). Table 26 from the Earth Tech white paper shows predicted dissolved PCB concentrations 1 mile downstream of OU-2 that would range from 3 to 15 percent of the source area dissolved PCB concentration (for example, from dredge elutriate test results). At the Grasse River site in northern New York State during 2005, of 160 water quality compliance samples collected approximately one mile downstream of dredging operations, 8 samples exceeded the 2 microgram per liter compliance concentration for PCBs corresponding to 5 percent of the compliance samples (USEPA, personal communication, December 2005).

2.1.4 Shoreline Bulkhead Effect on Dredging

A sealed shoreline bulkhead needs to be installed according to the provisions of the OU-1 consent order. The primary purpose of this shoreline bulkhead is to help contain PCBs in deep soil and groundwater inside OU-1. At the Northwest Corner Area, this bulkhead is to be installed into the marine silt as specified in the Record of Decision for OU-1 (NYSDEC, 2004). The design of this bulkhead is underway by AR. The depth of this shoreline bulkhead along the Southern Area will be determined during remedial design.

2.1.4.1 DNAPL Penetration to the Basal Sand

There is a potential for PCBs to migrate into the deeper basal sand aquifer in the Northwest Corner Area, if piles and/or other materials are installed through high levels of PCBs, and through the marine silt aquitard, and pierce into the confined basal sand aquifer below. The installation of excavation support structures into the basal sand could drive PCBs downward into the aquifer, and the presence of these piles throughout the dredging process would likely provide a continuing preferential pathway for downward PCB migration through the opening along the support structure-soil interface. USEPA (1996) and other guidance documents require remedial activities at sites with subsurface DNAPL to include precautions to minimize the potential for further DNAPL migration from such activities. The best precaution at this site is to not install the shoreline bulkhead at the Northwest Corner Area into the basal sand. Any PCBs associated with site DNAPL that would reach the basal sand would result in a violation of the statewide groundwater quality standard for PCBs.

DNAPL "layers" are typified by extremely heterogeneous distributions and unpredictable transport pathways. A small amount of DNAPL in the subsurface may be virtually impossible to locate and still lead to widespread and long-lasting plumes.

Information from OU-1 gathered during site investigations indicates that PCB-containing DNAPL was released during manufacturing operations at OU-1 and flowed downward under gravity through the fill. Once the DNAPL encountered the marine silt, the DNAPL fluid pressures (particularly governed by gravity and density) were not sufficient to overcome the marine silt pore entry pressures and DNAPL flow halted. The termination of DNAPL flow at the top few feet of the marine silt is supported by the fact that the basal sand is not contaminated by PCBs and by field observations of DNAPL depth of occurrence made during drilling. Based on DNAPL flow mechanics, the PCB DNAPL at OU-1 is in a state of equilibrium held at its current location because the downward (gravitational) forces of the DNAPL fluid cannot overcome the pore entry pressures of the marine silt. Remobilization of PCB DNAPL is not expected to occur unless this equilibrium is disturbed. As discussed in the OU-1 Feasibility Study (Shaw Environmental and Haley & Aldrich Inc., September, 2002), two equilibrium disruptors that have the potential to remobilize DNAPL and thereby potentially cause contamination of the basal sand are:

1. A change in the porosity/permeability of the marine silt; and
2. Creation of preferred flow pathways through the marine silt along the driven bulkhead sheeting and support piles.

An on-site example that highlights the potential for DNAPL mobilization is the accumulation of DNAPL in monitoring well MW-12 after its installation. Installation of this monitoring well disturbed the equilibrium and caused DNAPL to flow into the well. This OU-1 example demonstrates that once equilibrium is disturbed at OU-1, PCB DNAPL has the potential to mobilize.

A steel pile shoreline bulkhead would also provide a much larger lateral space for vertical migration than would a vertical well. In fact, the 800 linear feet of the shoreline bulkhead along the Northwest Corner Area is equivalent to the lateral distance created by 800 un-grouted 4-inch diameter wells drilled through fill and debris and then through the marine silt into the basal sand. The installation of a single un-grouted well through a confining layer is contrary to USEPA guidance, so the installation of 800 linear feet of bulkhead would similarly be inadvisable. Furthermore, the 800 linear feet of bulkhead would provide lateral space for DNAPL movement on both sides of the steel sheeting so the effect would be more significant than even the effect of 800 4-inch diameter monitoring wells.

2.1.4.2 Shoreline Bulkhead Installation Considerations

This shoreline bulkhead will need to be keyed into the underlying marine silt and its joints will need to be sealed to cut off lateral groundwater flow through the wall. The top of the marine silt varies in elevation along the shoreline bulkhead alignment from approximately -14 ft to over -25 ft. Design of this shoreline bulkhead is underway with the 50 percent design submittal for OU-1 scheduled to be submitted to NYSDEC by August 2006.

The ground elevations and geotechnical characteristics of the fill and marine silt provide a physical limitation on how deeply sediments can be removed from OU-2 without jeopardizing soil stability at OU-1, even with strong or deeply embedded wall materials and significant bulkhead anchorage. Calculations have been made by Haley & Aldrich (see Appendix B) and by YU & Associates to assess the limits of the shoreline bulkhead to allow dredging in the river along the shoreline (see YU Associates, 2005b). The estimated maximum allowable dredge depth along the Northwest Corner Area with a shoreline bulkhead in place is to an elevation of approximately -14 ft if the shoreline bulkhead depth would be installed into the marine silt and supported by an anchor system. If the shoreline bulkhead would penetrate into the basal sand beneath the marine silt, then deeper dredging would be possible, as described in Section 3.

Obstructions and abandoned waterfront structures in the fill will make installation of the shoreline bulkhead very difficult all along its length. It may not be possible to drive steel sheet piling without first removing or cutting through obstructions. The obstructions cannot all be located in advance, so multiple delays should be expected in this portion of the work. Obstructions to placing this shoreline bulkhead are evident. OU-1 is on land that was built out from the original river shoreline with imported fill. Visible timber pilings and large riprap are evident along the Northwest Corner Area and evidence has been documented of past obstructions that are no longer visible but may still exist in the subsurface (Parsons, 2005a/b). Subsurface debris has been encountered during the Summer 2005 OU-2 investigation and during this Fall's pre-design test pits and borings at OU-1.

The federal consent decree discussed briefly in Section 1.4 requires AR to add sufficient fill to raise the current shoreline elevation by 5 ft in order to raise the OU-1 ground surface above the land elevation flooded once in 100 years. The Village requested raising the ground surface above the 100 year floodplain in order to make it suitable for wider variety of future land uses, however, the additional 5 ft of fill material on shore will put more soil pressure on the shoreline bulkhead, and that will need to be counteracted in some way to stabilize the shoreline bulkhead over the long term. Two ways to counteract the additional pressure of a higher ground surface include placing lightweight fill within 100 to 120 ft of the shoreline in areas excavated to place the anchors, and use of a berm within the river to support the weight of the additional on-shore fill material pushing on the shoreline bulkhead (see Appendix B). The berm would reduce water depth along the shoreline, and would require regulator approval to fill portions of the river near the shoreline. By comparison, the use of lightweight fill along the nearshore area would also reduce this soil pressure on the shoreline bulkhead, and make the shoreline area more appealing and useful in the long term, by leaving the shoreline at a level that is close to the natural water line. This option would require an amendment to the federal consent decree to allow the final

OU-1 land surface to be set at elevation of +4 ft along the shoreline (close to the natural water level), with a gradual rise to +9 ft at a distance approximately 100 to 120 ft inland from the shoreline bulkhead, where all land would be filled to above the 100-year floodplain. A shoreline elevation of +4 ft is approximately 2 ft above the water level of the average daily maximum tide and is also approximately the same as the existing ground surface elevation along the shoreline.

Within the Southern Area of OU-2, an additional berm may be required in the river to support the shoreline bulkhead in the long term, or a second bulkhead may be needed. It is possible to reduce the size of the river berm by moving the shoreline inland into OU-1 approximately 30 ft, but this would eliminate approximately 0.5 to 1 acre of land from the site and return them to the river, and this 30-foot strip of land would need to be evaluated for remediation as part of OU-2, rather than OU-1. Since elevated metals have been detected in this area, additional sampling would be needed to determine the appropriate remedy for this area. Installing a second inland bulkhead would have a similar effect on stabilizing the shoreline bulkhead as a berm, since the soil between the mudline and the shoreline bulkhead would become a berm, but the soil would remain part of OU-1, rather than becoming part of OU-2. Furthermore, the soil is fully consolidated and therefore stronger because it has been at its current depth for decades.

2.1.5 Dredging Summary

Dredging is a technically feasible component of a final remedy at this site, but a full dredging remedy can only be implemented with extreme difficulty and with potentially significant impacts related to shoreline stability, sediment resuspension, contaminant release, and post-dredging residual sediments.

Mechanical dredging to limited depths inside a rigid containment barrier or inside a silt curtain is technically feasible as long as (a) the containment barrier or curtain is conservatively designed and installed to account for the large tidal range, water velocities, and possible ice effects, and other constraints; (b) the vertical extent of dredging is coordinated with shoreline bulkhead geotechnical limitations; and (c) a far-field point of compliance is enacted with tolerance for some exceedances as long as reasonable steps are being taken to reduce environmental impacts. Hydraulic dredging may be possible at this site in some areas with less bathymetric slope and away from debris, however additional facilities would be needed onshore to manage larger quantities of water from dredging operations.

Given the abundance of debris at this site and the high probability of contaminant residuals in sediment following dredging, it is most likely that dredging would be followed by capping.

2.2 SUBAQUEOUS CAPPING

Subaqueous capping (hereafter called capping) has been employed successfully as a remedial measure at many sites around the country under a variety of conditions. A sediment cap is a technically feasible and efficient remedial approach for OU-2 based on successful applications at other sites and based on analyses of conditions at OU-2. USEPA (2005) notes that sediment caps have been selected in at least 15 Superfund RODs; and they are capable (on a site-specific basis) of providing long-term effectiveness and permanence. Capping has therefore been retained for further assessment within the remedial alternatives for OU-2.

Caps typically consist of clean natural sand and/or gravel obtained from local sources and placed from a barge located above the area to be capped. Other cap materials can also be used to enhance cap performance if needed. A typical cap thickness is 12 to 24 inches.

Caps are constructed at different sites for any of several reasons – to physically isolate contaminated sediment from the aquatic environment, to stabilize contaminated sediment to prevent resuspension and transport of contaminants, to reduce the transport of dissolved and clay-size particle contaminants into surface cap materials and the overlying water column, and/or to replace aquatic habitat. A cap can be designed to maximize long-term effectiveness by accounting for sediment mixing due to burrowing behavior of benthic organisms (bioturbation), vertical consolidation, and potential erosive forces due to ice abrasion, wind-induced waves, flood flows, and abrasion from boat propeller wash.

Short-term adverse impacts of cap materials mixing with the water column during cap placement can be controlled by assessing the geotechnical properties of the sediment to determine the likelihood of mixing and ways to minimize mixing.

Once placed, subaqueous caps like upland caps can be monitored over the long term to document effectiveness. Institutional controls may be needed to protect a cap from unnecessary damage from outsides forces, such as large boats. Cap monitoring and maintenance efforts are typically not extensive but depend upon site conditions.

The performance parameters for a cap at OU-2 include the following:

- The cap would provide physical isolation of the contaminated sediment from the aquatic environment, including benthic organisms and other receptors.
- The cap would be physically stable and not susceptible to unacceptable erosion, thereby preventing resuspension and transport of chemicals of concern.
- The cap would reduce or eliminate the potential for transport of contaminants into surface cap materials and the overlying water column. For example, the cap would have a limiting upper layer concentration of site-related PCBs of 1 ppm, such that the long term maximum sediment PCB concentration with respect to chemical isolation performance did not exceed 1 ppm.
- Aquatic habitat considerations would be accounted for during the cap design.

Each of these four cap performance objectives are assessed separately in the next four sub-sections.

2.2.1 Physical Isolation With A Cap

The thickness of a cap is conservatively designed based on a "layer approach." As each cap layer is defined, the total cap thickness is assumed to be the sum of the thicknesses for each layer. The various "layers" address bioturbation, consolidation, erosion control, and chemical isolation. Bioturbation and consolidation are presented in this subsection, while erosion control and chemical isolation are addressed separately in the next two subsections.

To provide long-term protection, an isolation cap should be sufficiently thick to prevent any significant direct contact by burrowing organisms with the underlying contaminated sediment A habitat layer should be included that would facilitate recolonization of benthic spies and focus associated bioturbation on this surface habitat layer of the cap. As indicated in Section 2.2.4 below, to facilitate application of the top portion of a cap, the habitat layer would likely be somewhat coarser than the fine grained sediments that now cover much of OU-2. Epibenthic organisms, which forage on organic materials in the water column, would likely initially populate this initial habitat layer soon after placement, and benthic species, which forage on organic material within the sediments would ultimately populate redeposited fine-grain sediment.

The depth to which species will burrow depends on the species' behavior and the characteristics of the substrate (e.g., grain size, compaction, and organic content. The types of organisms likely to colonize a capped site and the normal behavior of these organisms are generally well known (*e.g.,* Thoms *et. al.,* 1995). The Hudson River at Hastings-on-Hudson is an estuarine system, and the potential depths of bioturbation are generally limited to the upper few inches as shown from the Fall 2004 investigation results (Parsons, 2005a). Fall 2004 OU-2 investigation observations from box core samplers show a distinct color change indicative of a transition from toxic sediment (containing oxygen) to anoxic sediment at a depth of one to four inches or less at OU-2.

Cap materials and those native sediments beneath them both often consolidate somewhat once placed. Monitoring of cap thickness during construction typically takes short-term consolidation during placement into account, allowing relatively rapid consolidation of granular caps to occur following cap placement but before cap thickness is confirmed. Long-term consolidation of cap materials, which is typically minimal, and long-term consolidation of sediment beneath cap materials can be addressed using standard laboratory tests and computerized models (Palermo, *et al.*, 1998a; Palermo *et al*., 1998b). In areas of OU-2 to be dredged, a cap may be placed after dredging, or a cap may be placed directly over sediment that is not dredged. In dredged areas, there would be less consolidation of native sediments, because these sediments would have been pre-consolidated under the weight of the sediment removed. In areas not dredged, there would be more consolidation settlement due to the weight of the cap material than in dredged areas.

Physical isolation can be provided by sediment originating from outside OU-2 that deposit naturally within OU-2. Radioisotope dating results from AR's 2004 investigation work show sediment is generally depositing nearshore outside steep sloped fill areas. Similarly radiodating results from the OU-2 RI work show deposition is occurring in the North Boat Slip at a rate of one to two inches per year.

2.2.2 Cap Stabilization / Erosion Protection

A cap stabilizes underlying sediment in a physical manner by preventing access to the native sediments for potential resuspension and transported via river flow. The cap element designed to provide stabilization incorporates consideration of and protection from erosive forces.

There are three processes that were evaluated for the potential to cause abrasion/erosion of a constructed cap at Hastings OU-2. These are: (1) river energy stress during episodic wind and rain storm events; (2) propeller wash from vessels; and (3) ice forces. In some waterbodies, the resulting water depth following any partial dredging and cap construction can be a consideration in determining the erosive force resulting from an episodic event such as a flood or storm. However, the available flow area of the Hudson at the Hastings site would not be appreciably affected by any of the remedial alternatives being evaluated in this document, so no enhancements or diminishment of bottom flow velocities are expected.

Abrasion from river energy stress - A preliminary analysis of the shear stresses induced by high flow events in the river was conducted by Hydroqual, Inc. applying a hydrodynamic model to the lower Hudson River Estuary based upon the ECOM model of Blumberg et al. (1991). The hydrodynamic model has been calibrated and employed to evaluate contaminant transport and fate and eutrophication in the lower Hudson River estuary, respectively. The hydrodynamic simulations included data records from river years 1988-89, 1994-95, 1998-99, 1999-2000, 2000-01, and 2001-02, which included the major storm event of over six inches of rain from Hurricane Floyd in September 1999. The limiting stress conditions based on these six years of data were identified as November 3, 1994; January 23, 2000; and December 13, 2000; all of which were related to the combination of high winds, tides and current rather than being related to high river flows from upstream. The maximum estimated shear stress in the vicinity of OU-2 for the limiting stress conditions is approximately 21 dynes per square centimeter or 0.044 pounds per square foot. A cap grain size that would be stable in such a shear stress can be determined by a relationship presented by the Highway Research Board (1970):

Grain diameter (in ft) = 0.75 times shear stress (in pounds per square foot)

The sediment stable grain particle diameter corresponding to a nearshore shear stress of 0.044 pounds per square foot is 0.033 ft or 0.4 in. (fine gravel) to ensure overall stability of a cap erosion protection layer to the river flow.

Localized effects at the river bank including ice abrasion or breaking wind-generated waves may result in the need for larger cap particle size along the land-river interface (see the analysis below). In addition, the analysis of particle size defines the threshold of cap erosion. During any short-term stress on a cap, only a portion of the cap would likely be eroded even above this threshold. Such a loss of cap armor-layer thickness would be replaced when detected during periodic monitoring efforts.

Abrasion from propeller wash - A variety of vessels operate in the lower Hudson River, including tugs and a variety of private recreational vessels. However, Hastings OU-2 is not in the main navigation channel, and there are no industrial facilities on the property that use commercial vessels. Therefore, the only vessels that may be operating over the cap area would be recreation vessels that would be traveling near the shoreline. The characteristics of the various recreational boats have been considered, and representative recreational boat characteristics have been selected for the analysis of possible effects of boats on a cap.

As part of the evaluation of the erosion cap component, an analysis of prop wash has been conducted to determine if this limits erosion protection layer design. The analysis was conducted based on the equations developed by Blaauw and van de Kaa (1978) and Verhey (1983), as generally recommended in the USEPA guidance document *Guidance for In situ Capping of Contaminated Sediments* (Palermo, *et al*., 1998a). This analysis considers vessel characteristics (e.g., propeller diameter, depth of shaft, and shaft horsepower) and determines bottom velocities at various distances behind the propeller at specific water depths.

A propeller wash analysis was run for OU-2 to provide the grain size required to resist the long-term, steady-state prop wash from vessels. This analysis of prop wash is conservative since, in reality, the propeller wash force is transient in nature, only impacting the cap for a short time while a boat passes by a location. Information about recreational boats that could be in use within OU-2 was obtained during late 2005 from local marinas and from contacts at *Boating on the Hudson* Magazine (personal communication, 2005). Typical recreational power-boat draft requirements are 7 to 8 ft of water depth at low tide. Typical characteristics for large lower Hudson River recreational boats include a 24-inch propeller shaft depth, a propeller diameter of up to 15 inches, and, at most, two motors operating with 225 horsepower each. It was assumed for this propeller wash analysis for personal safety and property protection reasons that large recreational boats in the boat slips and in the Old Marina Area would be operating at no greater than 10 percent of their maximum power, while in the river within 50 ft of shore boats would be operating at no greater than 25 percent of their maximum horsepower. The results of the analysis for OU-2 show, for typical operating characteristics of the vessels on the Hudson River, a minimum sediment cap particle diameter of 0.5 inches (gravel) would be sufficient to ensure overall stability of a cap erosion protection layer within the river. Within the boat slips or within the Old Marina Area where the water depth is assumed to be shallower and a maximum of 10 percent of available horsepower would likely be used, a minimum sediment cap particle diameter of 2.0 inches (cobbles) would be sufficient to ensure overall stability of a cap erosion protection layer.

Abrasion from ice forces - The potential for ice related abrasion has been assessed for OU-2 with assistance from Dr. George Ashton and the conclusion is that no significant potential for ice abrasion on a cap at depth exists. However, near to the shore, in shallow waters the cap would require protection. Ice pilings nearshore are expected to be limited to water depths of 1 to 2 ft. To resist ice piling action in water depths of less than 2 ft with no displacement of an armor riprap material, the armor size should be twice the ice thickness for shallow slopes. Based on the coldest time periods from 1995 to 2005, Dr. Ashton has estimated a maximum ice thickness in protected areas at OU-2 of 8.8 inches. In unprotected areas, the maximum ice thickness is predicted to be 6.5 inches based on the coldest seven day periods of record since 1995. The projected armoring size is equivalent to the current bank protection at the site.

2.2.3 Cap Chemical Isolation

The chemical isolation component of the cap controls the movement of contaminants by advection and diffusion. Advection refers to the flow of sediment porewater or underlying groundwater resulting from consolidation of the contaminated sediment layer due to cap placement or upward flow of groundwater. Advection transports dissolved and colloidally bound contaminants. Diffusion is a very slow process in which ionic and molecular species in water are transported by random molecular motion due to a concentration gradient.

A model of chemical fate and transport, such as that described in Appendix B of the standard guidance for *in situ* subaqueous capping (Palermo *et al*., 1998a), is typically used to evaluate the long-term effectiveness of a cap as defined by its ability to provide chemical isolation in a sub-aqueous environment. For OU-2, an analytical version of this model using conservative assumptions was applied. The model is based on the following principles:

- The cap is physically stable (armored if required) such that erosion of the cap does not influence the rate of contaminant migration;
- The biologically-active zone in which contaminants are transported by organisms reworking the sediment is confined to a surface layer of a cap above the chemical isolation layer which can be within or above the erosion control layer;
- The primary means of contaminant transport are the physical-chemical processes of advection and diffusion in the porewater of the capping layer. Active sediment movement from resuspension or bioturbation is restricted, by design, to the surface layer of a cap above the isolation layer;
- The model results are calculated for steady state conditions, which are conservative since the contaminant flux is a maximum at steady state and attainment of steady-state conditions may require thousands of years;
- The concentration in the underlying sediment is assumed constant, without degradation or reduction due to chemical migration out of the sediments;
- Conservative degradation rates of any reactive compounds are considered; and
- The model results are described in terms of predicted sediment concentrations in the biologically active zone at steady state for purposes of comparison to sediment quality guidelines.

The principle contaminants of potential concern at this site are PCBs and copper for reasons presented in Section 1. The effect of metals potentially migrating upward through a cap into the Hudson River is not a concern at OU-2, because site results show metals concentrations in porewater are below the NYS chronic saltwater quality standards associated with fish propagation. The discussion below therefore pertains to PCBs.

A preliminary analysis was conducted to determine the chemical containment effectiveness of a cap at Hastings OU-2. The actual cap thickness to be employed at OU-2 is expected to be controlled by the final desired sediment slope but the calculations herein can be used in a preliminary assessment of chemical protectiveness. In this analysis, chemical isolation layer effectiveness was evaluated based on the ability of the cap to prevent concentrations in excess of 1 ppm PCBs for a conservative design life in the upper layers of the cap where benthic exposure might occur.

PCB migration through a cap at OU-2 was estimated using the model described in Appendix B of Palermo *et al.*, 1998a. The model is conservative in that it generally over predicts concentration and flux because it assumes no change in PCB concentration immediately below the cap due to either degradation or transport. The model was used to predict the transient behavior in the cap isolation layer and also the steady state or long-time maximum concentration that might be achieved in the biological active layer. As a result of the high sorption rate of PCBs to cap materials and the relatively low rate of groundwater advection the time to reach steady state at this site is on the order of hundreds to thousands of years. Modeling input parameters were defined based on the following assumptions and evaluations:

- Cap material is assumed to sorb PCBs only to the extent expected with 0.1 percent organic carbon since cap materials from offsite may not have as high of an organic carbon content as OU-2 sediment.
- The underlying (existing) sediment and the habitat surface layer of the cap were assumed to contain 3.75 percent organic carbon based on the average organic carbon content observed in surface sediment analyzed during AR's Fall 2004 Supplemental Investigation.
- The logarithm of the average organic carbon normalized PCB partition coefficient was calculated to be 6.36 by calculating the ratio of the solid phase concentration of total PCBs to pore water concentration divided by the organic carbon concentration during the Fall 2004 Supplemental Investigation and this was used to estimate pore water concentrations in the sediment.
- Bioturbation of the habitat surface layer was assumed to occur at an average rate of 0.4 inch of surface sediment reworked per year (Thoms *et. al.*, 1995).
- The 2003 FS for OU-2 provided an estimate of 10 inches of consolidation of underlying sediment or an equal volume of porewater expression. The resulting PCB migration into the cap, however, is much less than 0.1 inches due to the sorption of PCBs onto the cap material based on a cap material organic carbon content of 0.1 percent.
- Effective diffusion coefficients were estimated based on the Millington and Quirk model as described in Palermo *et al.*, 1998a).
- Values for dispersivity were estimated based on an assumed grain size diameter of the cap material (Palermo *et al.*, 1998a).

Long-time cap protectiveness was evaluated by estimating the concentration in the biologically active zone under steady state conditions. Sediment concentrations less than 100 ppm would not result in a concentration above 1 ppm in the biologically active zone as long as the cap containment layer thickness (that is the thickness over and above that influenced by bioturbation) was at least 1.2 inches. Sediment concentrations of 500 ppm would not result in surface sediment concentrations greater than 1 ppm if the cap containment layer was at least 6 inches thick.

Protectiveness can be further assessed by evaluating the time required for migration through the chemical isolation layer due to groundwater seepage (residual seepage after control of OU-1 estimated conservatively at 1 inch per year) and diffusion. For an isolation layer thickness of 6 inches and a sediment concentration of 500 ppm immediately below it, more than 1300 years is required to achieve a concentration of greater than 1 ppm at the top of the chemical isolation layer using the transient model of Palermo et al. (1998). If the sediment concentration is maintained at 1000 ppm immediately below the isolation layer (6-inch isolation layer thickness), approximately 1000 years is required before concentrations of greater than 1 ppm would be detected at the top of the chemical isolation layer. Of course, even relatively refractory compounds such as PCBs would be expected to show at least partial degradation over these time scales. This analysis shows that a cap at this site can provide long-term effectiveness and permanence. A cap can be designed to contain the PCB levels that might remain in OU-2.

Although it does not appear warranted at OU-2, other cap materials can be incorporated into the chemical isolation layer if needed to further isolate chemicals within a cap. For example, granular bituminous coal or other granular forms of carbon could be added as a mat or other type of blend with sand so the carbon would remain on the river bottom once placed. Phosphate-based materials could be added to further isolate metals such as copper. Cap additives such as these are in the test stage at this time. The largest scale testing of these types of additives is ongoing at a site within the Anacostia River near Washington, DC (SMWG, 2005).

2.2.4 Cap Habitat Surface Layer

For OU-2, a habitat surface layer would provide appropriate sediment substrate for recolonization by benthic organisms once the cap is placed. The habitat surface layer of the cap would be subject to bioturbation and could be underlain by or combined with the erosion protection layer depending upon desired substrate conditions. This habitat surface layer would ultimately equilibrate with surface water conditions. This habitat surface layer would be subject to some exchange during varying flow events and over the long-term it would incorporate naturally deposited organic carbon and sediment.

Variations in substrate particle size play a significant role in benthic community composition. As previously mentioned, assessments of potential shear stress and stability requirements have indicated that an armoring cap consisting of material with a grain size of approximately 4 mm in diameter (e.g., fine gravel) would be necessary to ensure stability during peak river flows or a non-typical storm event. However, a fine gravel would not likely facilitate a quick recovery of benthic communities similar to reference conditions within the Hudson River

Estuary. Reference conditions within the Hudson River Estuary do not exist for extensive sediment beds consisting predominantly of fine to coarse gravel. This is supported by mapping of the sedimentary floor as provided by the Hudson River Estuary Benthic Mapper.

http://wwwapps.dec.state.ny.us/website/imsmaps/benthic/webpages/index.html#viewer

A habitat surface layer consisting of mid-to-coarse grained sand (e.g., 0.25 to 1 millimeter in diameter) is proposed as a basis for the final habitat layer to be placed over the armoring layer of the engineering cap. As previously mentioned, current sediments throughout the Site are characterized by extensive areas of soft mud dominated by silt. The placement of a habitat layer consisting of soft mud/silt is not practicable given difficulties in application of fine sediments within an open water habitat with significant currents. A habitat layer consisting of mid- to coarse-grained sand has several advantages. It can be constructed in an open water habitat such as that of OU-2. In addition, sandy substrates have been shown to facilitate the rapid re-colonization of diverse benthic communities (Dernie et al. 2003).

Commencement Bay in Tacoma, Washington provides an excellent example of a successful application of a sand based cap in an estuarine subtidal environment. Monitoring demonstrated relative quick recovery times, with over 100 different forms of benthic invertebrates being observed during the first year of monitoring. Following ten years of monitoring activities, the constructed habitat has shown to equal natural production in both number of species and abundance of individuals living in the cap habitat as compared to reference areas within Commencement Bay.

2.2.5 Overall Cap Thickness

For OU-2, an underwater cap would likely consist of the habitat surface layer which would support rapid recolonization by aquatic organisms and provide for bioturbation, a physical isolation and stability (erosion layer), chemical isolation, and operational considerations. A 6-inch chemical isolation layer, an erosion protection layer, and a habitat surface layer are proposed. The total volume of placed material may be as much as double this however due to intermixing with the underlying sediment, which would compromise the lower layers of the chemical isolation layer, and due to operational considerations that may require additional material placement to ensure achievement of the 6-inch chemical isolation layer and 6-inch erosion protection and habitat surface layer in all locations. As indicated above, a 6-inch chemical isolation layer would ensure effective isolation (as indicated by a concentration of less than 1 ppm at the top of the chemical isolation layer) for at least 1000 years for underlying sediment exhibiting a concentration of equal to or less than 1000 ppm PCBs.

Consistent with evaluations conducted as part of the 2003 FS, 6 inches of cap thickness could be allocated for intermixing and/or stabilization of the underlying sediments to ensure the integrity of the chemical isolation layer, the erosion protection layer, and the habitat surface layer. The amount of additional material needed could be largely defined on the basis of economic considerations balancing the time and effort needed for placement, monitoring and possible additional placement with the material costs of placing additional material at the outset.

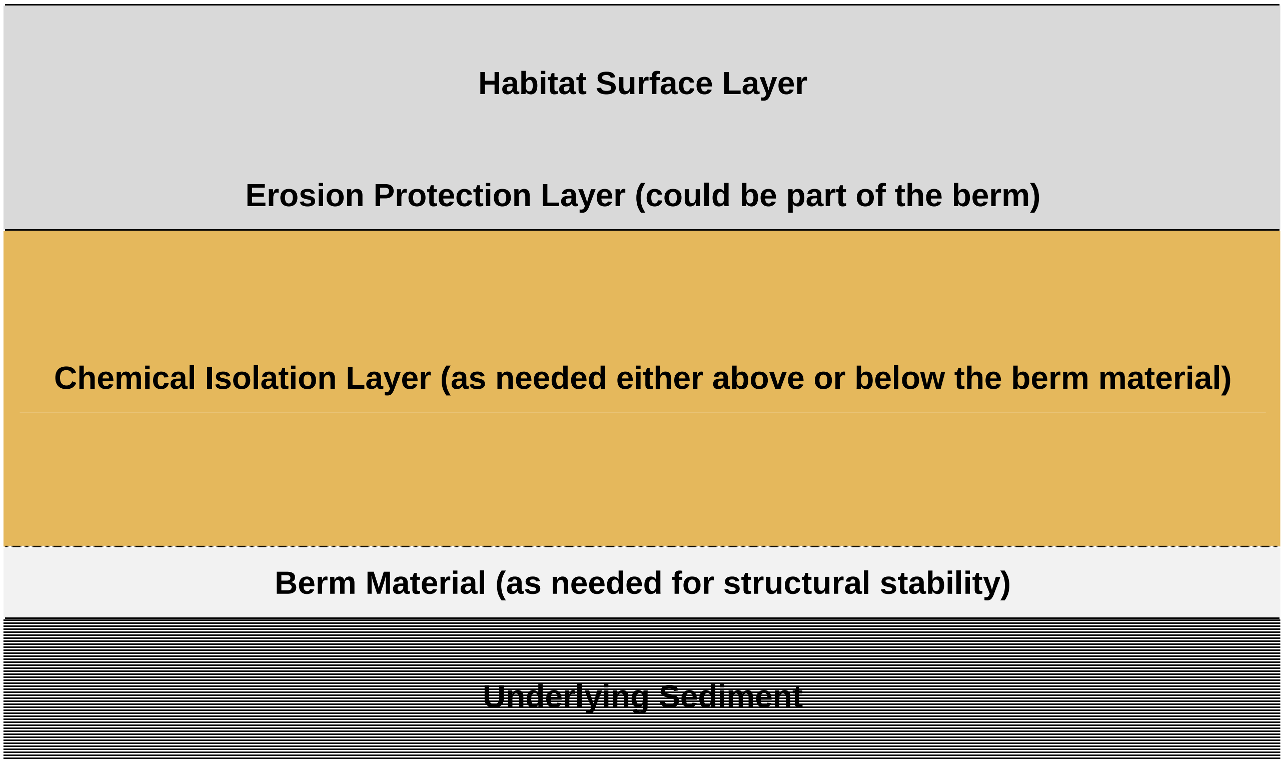
A 6-inch thickness allocated for mixing and/or stabilization is conservatively larger than typically assumed and larger than would be expected given the strength of the surface sediments and the likelihood that stronger sediments would form the foundation of a cap after removal of surface sediments. Reible et al. (2005) typically observed an intermixing depth of less than 2 inches in the Anacostia active capping demonstration which was conducted in sediments similar in strength to those at the OU-2 site.

A summary of the material considerations in each of these cap layers is included below. Cap layers from top to bottom would likely include:

- Erosion protection and habitat surface layer – consisting of a mixture of gravel and coarse sand with a likely thickness of 6 to 12 inches. Finer sediment cap material could be mixed in for habitat restoration, and possibly added to the top of the armoring material with some risk of erosion. In the boat slips and in the Old Marina Area, the erosion protection portion of this layer of a cap would need to have a particle diameter of at least 2 inches (cobbles) to protect against prop wash abrasion based on a 10 percent maximum horsepower motor energy. Additional armoring would be needed throughout OU-2 where water depths are 2 ft or less to protect the shoreline against the potential for ice abrasion; this additional armoring is consistent with current bank protection armoring.
- Chemical isolation layer (as needed) – A layer of sand or finer-grained material at least 6 inches thick with sufficient carbon content would provide effective containment for any sediment PCB concentration up to approximately 1000 ppm for at least 1000 years. For ease in placement and to provide 6 inches as a potential intermixing and stabilization layer with the underlying sediment, a cap volume equivalent to a target layer thickness of 12 inches would be desirable. Because intermixing is expected to take place over 2 to 4 inches or less, a target layer thickness of 12 inches would likely ensure an isolation layer thickness greater than 6 inches even considering placement variability.
- Berm backfill layer – fill as needed to adjust the slope angle for cap stability and slope stability, and to provide a stable shoreline bulkhead. The berm material could be placed either above or below the chemical isolation layer.

The illustration below presents a cross sectional schematic of the individual components of the overall cap thickness design.

CROSS-SECTIONAL LAYOUT OF SEDIMENT CAP COMPONENTS



(Not to Scale)

2.2.6 Capping Without Chemical Isolation Protection

A thinner cap than is described above can be applicable and suitable for portions of OU-2 in areas further from shore where groundwater transport does not significantly impact chemical flux rates and corresponding chemical isolation layer thicknesses. The sealed shoreline bulkhead will cut off groundwater flow entering the river from the soft sediment and fill zones. Water transmission upward from the basal sand aquifer through the 40+ ft of low permeability marine grey silt zone will be extremely small. Groundwater within OU-1 will be contained by a sealed shoreline bulkhead as part of the OU-1 remedy which will shut off any lateral movement of groundwater from OU-1 to the Southern Area of OU-2. As a result, future effects of groundwater from OU-1 on sediment quality within the Southern Area of OU-2 should not be a concern. Therefore, groundwater flow rates through the cap would be significantly less than assumed in the calculations presented earlier in this subsection and, as a result of this and the lower sediment PCB concentrations offshore, the needed cap isolation layer thickness would likely be less than the twelve inches.

The primary purpose of this type of cap would be to provide physical isolation of the benthic community and associated bioturbation (see Section 2.2.1 above) and cap stabilization/erosion protection stability (see Section 2.2.2 above). This thinner cap would prevent direct exposure of impacted sediment to aquatic organisms and to the overlying surface water. At OU-2, the depth of the aerobic top portion of sediment estimated based on visual observations was reported to be one to four inches in AR's Fall 2004 investigation. The aerobic top portion of sediment is where benthic organisms reside. A cap that does not address chemical isolation would need to be at least four inches thick and consist of habitat surface and erosion control material. The erosion control material would need to consist of large enough particles to be resistant to erosion and thereby be able to stay in place over the long term.

2.2.7 Cap Placement

Cap material should be applied slowly and uniformly in a layer over the area to be capped. Equipment and placement rates should be controlled to minimize bearing capacity issues and slope failures as well as to prevent excessive displacement of, or mixing with the underlying sediments. Site characteristics, including water depth, nature of sediments, currents, bathymetry, and vessel traffic also influence cap placement considerations. Experience at other sites shows that sand caps have been successfully placed over fine-grained contaminated material with minimal mixing of the cap with contaminated sediments (Palermo et. al., 1998) and over sediments with low strengths.

A review of other completed capping projects demonstrates that sediments with shear strengths much less than those at Hastings OU-2 were successfully capped without bearing failures when the caps were constructed by incremental placement of thin capping layers to gradually build up the required cap thickness. The OU-2 FS (Earth Tech, 2003) presents the results of laboratory shear strength tests on 4 samples up to 2 ft below the mudline and the shear strengths varied from 82 to 113 pounds per square foot. A 6-inch-thick sand cap was placed at the Ketchikan Pulp Company Site over sediment with shear strengths as low as 12 pounds per square foot (Otten and Hartman, 2002). The sediment that was capped as part of the Ketchikan project had significantly lower undrained shear strength than exists in sediment at OU-2. In addition, the KPC Ward Cove capping project, Los Angeles Corps Aquatic capping pilot project, Matsushima Bay Japan, PPG Barberton, Hiroshima Bay Sediments Japan, and Lake Biwa Japan projects all had lower or comparable strength sediments.

In those limited areas where a cap would be placed directly over soft native sediment located on a slope, some of the sediment could be displaced by the weight of the sand if it were to be applied incorrectly. Therefore, in these areas, the capping material should be applied uniformly in thin layers to avoid the potential of bearing capacity or slope failures. Likewise, the uncontrolled release of a large amount of cap material that would give rise to a localized mound would need to be avoided, regardless of nature of the underlying native sediments.

The backfill and cap material could be placed effectively using either hydraulic or mechanical methods. For hydraulic placement, water would be added to the capping material to form a slurry which could be pumped from shore or from a diffuser barge over the capping area. The diffuser barge would be moved back and forth, allowing the capping material to gently fall through the water column. Thin lifts would be placed with each pass. Hydraulic placement was used on two recent capping projects: Soda Lake capping project in Wyoming (Houck, *et al.*,

2001) and the Hudson Run Reservoir capping project in Barberton, Ohio. For mechanical placement, a clamshell or excavator bucket would be partially opened to provide a slow, controlled release rate and the operator would swing the bucket in order to distribute cap material evenly over the sediment surface. Mechanical placement of thin sand caps was used at the Ketchikan Pulp Company and Bremerton Naval Complex sites and at the Anacostia test site.

In areas where backfilling and cap placement would follow dredging, the in-place sediment would have been consolidated by the weight of the dredged sediment. These areas should not have large accumulations of unconsolidated soft sediments, but instead would provide adequate foundation support for cap material due to the higher shear strengths resulting from the weight of the dredged sediment prior to removal.

Even though there are no standardized methods to predict the extent of sediment resuspension resulting from cap placement, field data provides some insights. USEPA has conducted monitoring of capping-induced resuspension for projects at Eagle Harbor and Boston Harbor (Magar, *et al*., 2002). Capping resuspension was low for both sites and decreased as capping operations continued. Essentially all of the turbidity associated with capping was from the cap material being placed and not from resuspended sediment. Similar results were also found for capping resuspension monitored for a large-scale capping field pilot study at the Palos Verdes site near Los Angeles (Palermo, *et al*., 2001; McDowell, *et al*., 2001), where contaminant concentrations quickly returned to background levels.

The tidal nature of this site does not pose a significant concern with regard to cap placement. Caps have been successfully placed in water with significant tidal currents including Ward Cove in Ketchikan Alaska (Otten and Hartman, 2002).

2.2.8 Cap Monitoring, Maintenance, and Institutional Controls

Cap effectiveness over the long term would be important to the success of capping. Like upland caps, subaqueous caps are typically monitored, maintained, and repaired for many years, as warranted. Cap integrity can be monitored with periodic bathymetric surveys and/or sediment cores to assess whether a cap has been physically disturbed. Cap performance can also be monitored by chemical or biological analysis of cap material obtained from cores collected within the cap. Chemical analysis may be performed in a variety of ways to confirm that the cap is effectively isolating contaminants. Biological tests on surface cap samples can be used to document the repopulation of the benthic community over time.

In most cases, cap maintenance would be expected to require no more than small repairs of the cap erosion protection layers. One question to consider is whether a cap could be physically damaged by an extreme episodic event, such as a high storm or flow event or a large extent of shoreline abrasion resulting from ice abrasion, exceeding the magnitude of the design events for which the cap erosion protection layer is designed. However, catastrophic failure of large areas of the cap would not occur during either a large storm or flow event or a large ice abrasion event. In the case of a wind event, the exposure of the cap to an extreme event is of limited duration. Some erosion protection material may be moved by the extreme wave energy, but the erosion protection material would not "disappear," and energy would be attenuated by the resulting windrows formed by the erosion protection material. In the case of an ice abrasion event, any damage would be limited to areas impacted at the immediate nearshore boundary of the capped area.

An institutional control is a restriction on the future use of a resource. Use of such controls was authorized in 2003 in the New York State inactive hazardous waste program for the remediation of hazardous waste sites (NYS Environmental Conservation Law (ECL), Article 27-1318). Institutional controls available for a cap include a legally-binding environmental easement that prohibits land uses that damage or are inconsistent with a cap, and notifications to agencies and to the public about the existence and protection of a cap. The basis for an environmental easement is Article 71, Title 36 of the ECL. An environmental easement must be duly recorded and indexed in the county recording office where the land is situated. The easement runs with the land, is enforceable "in perpetuity," and can only be extinguished or amended by a release or amendment filed in the county recording office. The property deed and all subsequent instruments of conveyance for property subject to such easements must contain specific language for the life of the easement and contain reference to the proper book and page number in which the easement is recorded. Environmental easements are enforceable in law or in equity by the grantor, the state, or any affected local government.

AR's affiliate, AERL, holds title to submerged lands that extend as far as 100 to 150 ft from the plant shoreline, and a submerged berm already exists in these areas to support the plant shoreline. AERL would provide the State of New York with an environmental easement to the State of New York for this portion of the near shore remedy within OU-2, as needed. Such an environmental easement could include requirements for cap maintenance, boat anchoring restrictions, and use of floating docks if necessary or desired. Since the State of New York holds title to rest of the river bed within OU-2 (except the Old Marina), the state should be able to place an environmental easement on state-owned river property where needed. An easement like this was used in Appendix C to the consent decree for the General Electric Hudson River PCB remediation project (USEPA, 2005d), and could also be used at other sites to grant a permanent easement and covenant to impose use restrictions on property that runs with land for the purpose of protecting human health and the environment. Pursuant to New York State law, enforcement of easement requirements would be at the discretion of NYSDEC.

TABLE 2.1

RESIDUAL PCB CONCENTRATIONS FOLLOWING DREDGING

Site	Grain Size	Number of Dredge Passes	Post Dredge Average Sediment PCB Concentration (ppm)
Reynolds Massena	Clay, gravel, and sand	Up to 10	0.5 to 1.4
GM Massena	Clay, silt, and sand	2 to 32	9
New Bedford	Clay	1	29 (top foot)
Cumberland Bay	Sand	Multiple	6
Fox Deposit N	Sand, silt, and clay	Not determined	14
Manistique	Sand	Multiple	17
Ford Outfall	Not specified	Not specified	10
Sheboygan	Not specified	Not specified	39
Outboard Marine	Silt	Not specified	3 to 9

FIGURE 2.1

HARBOR AT HASTINGS OU-2

HASTINGS-on-HUDSON, NEW YORK

Example Photos Showing Nearshore River Riprap, Debris and Obstructions

PARSONS

290 ELWOOD DAVIS RD, SUITE 312, LIVERPOOL, NY 13088 PHONE: (315) 451-9560

Figure 2.2
Global Stability for Shoreline Bulkhead

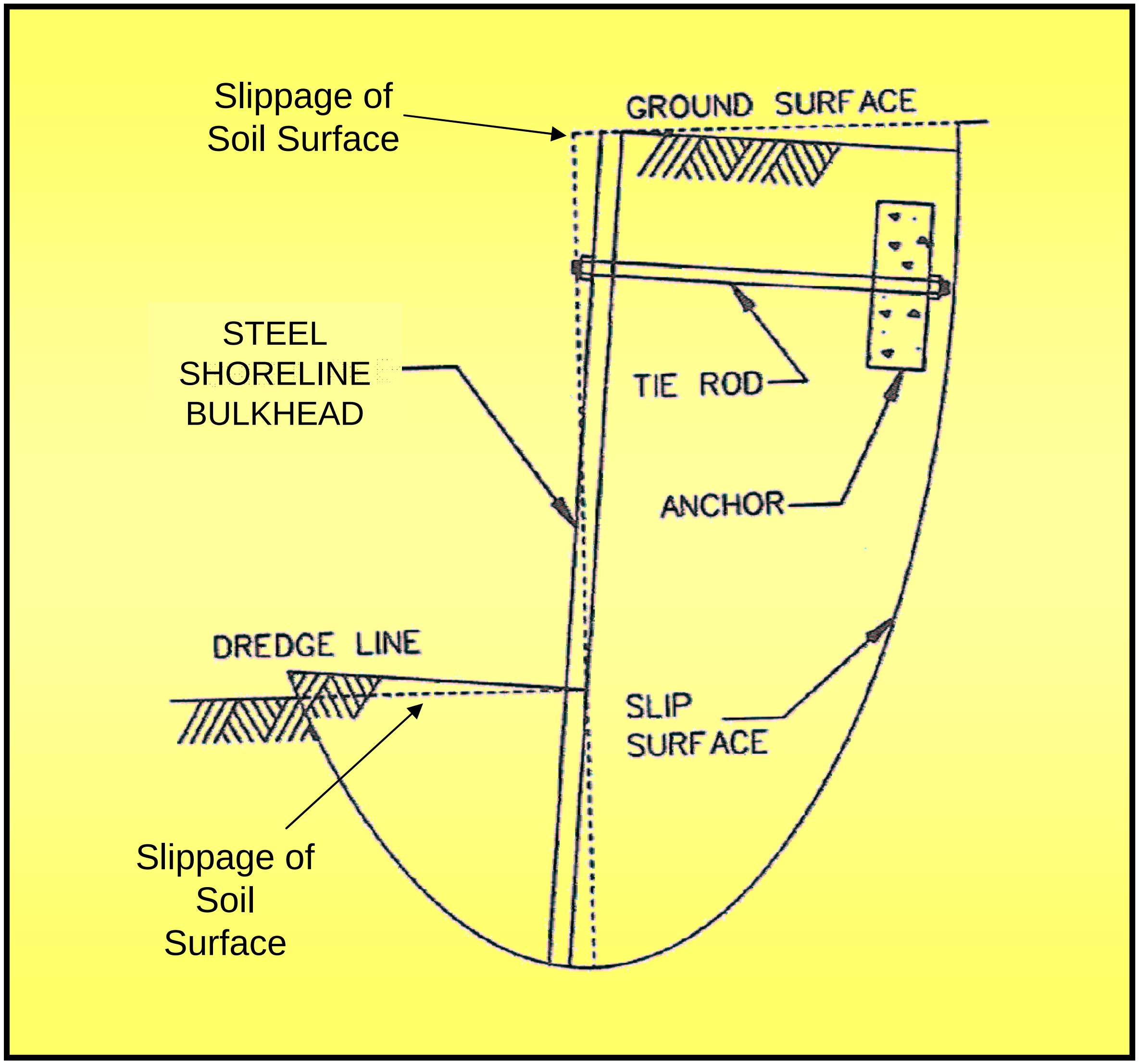


FIGURE 2.3

HARBOR AT HASTINGS OU-2

HASTINGS-on-HUDSON, NEW YORK

Mechanical Dredge Resuspension from Sediment Containing Debris

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FIGURE 2.4

HARBOR AT HASTINGS OU-2

HASTINGS-on-HUDSON, NEW YORK

Typical Silt Curtain Deployment

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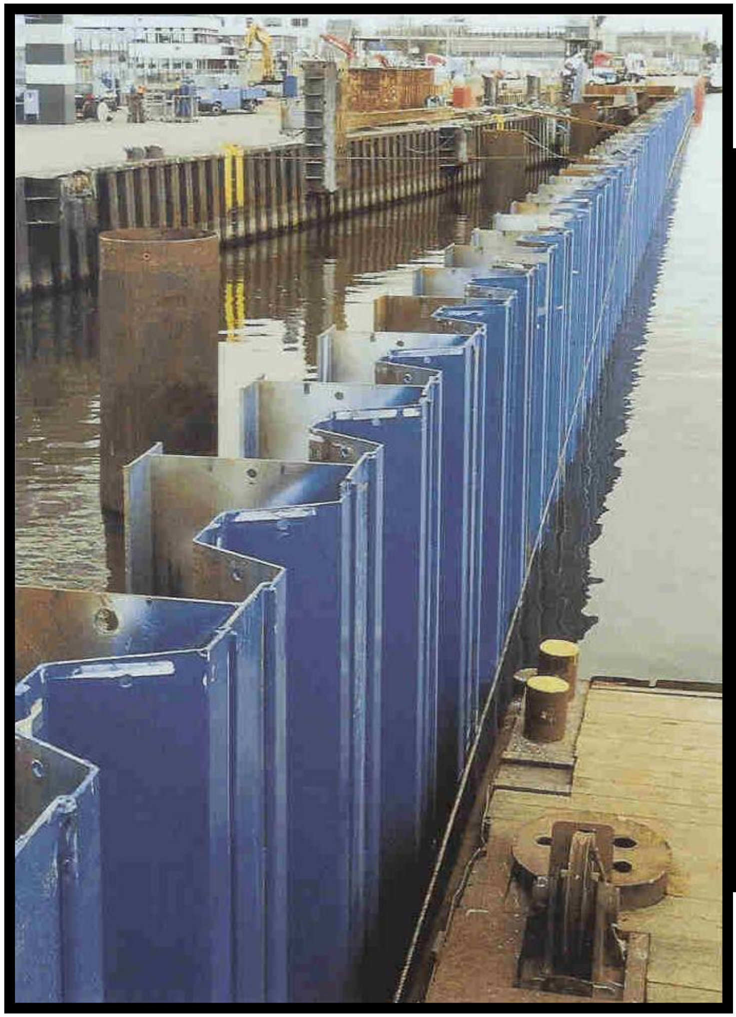

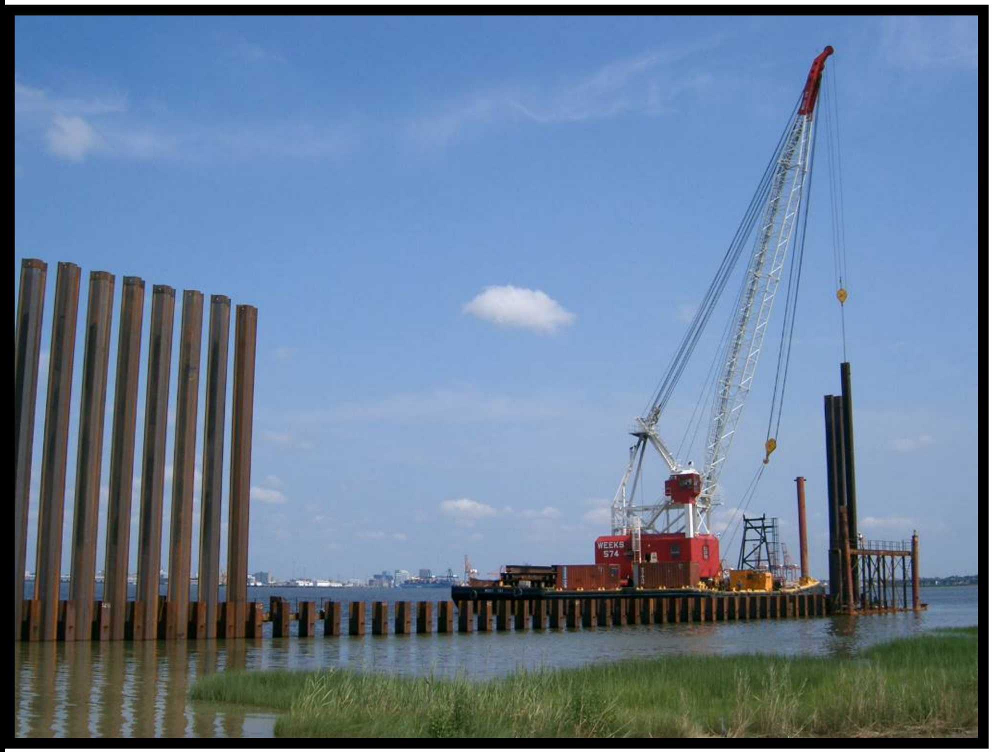

Source: Skyline Steel, 2005

FIGURE 2.5

HARBOR AT HASTINGS OU-2

HASTINGS-on-HUDSON, NEW YORK

Example Temporary Rigid Containment Barrier Installation

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SECTION 3

REMEDIAL ACTION ALTERNATIVES FOR THE NORTHWEST CORNER AREA

The Northwest Corner Area is the area within OU-2 between the North Boat Slip to the south and the Old Marina Area to the north. Remediation within the Northwest Corner Area of OU-2 would be contained by the proposed temporary rigid containment barrier and by the shoreline bulkhead. The shoreline bulkhead is being designed as part of the remedy for OU-1 (Figure 1.2). The Northwest Corner Area evaluated herein is identical to that represented in Figure 4.4 of the October 2003 FS.

Nearly all of the PCBs in OU-2 sediment lie within the Northwest Corner Area. The estimated total amount of PCBs in the Northwest Corner Area sediment is 99 percent by weight of the total PCBs present in OU-2 sediment based on AR's contaminant distribution modeling results. The remaining two percent of PCBs mass in OU-2 is divided amongst the Southern Area, the two boat slips, the Old Marina Area, and the Offshore Area. Over 50 percent of the mass of PCBs in sediment from the Northwest Corner Area is within a 4 to 6-ft thick vertical interval of sediment within 40 ft of the shoreline in the middle third of the Northwest Corner Area from south to north. This interval of sediment is typically 2 to 8 ft below the mudline.

The four remedial action alternatives evaluated for the Northwest Corner consist of varying amounts of dredging followed by capping.

The Northwest Corner Area includes a river surface area of approximately 2.9 acres. As shown in Figure 1.3, most of the area of sediment within the Northwest Corner Area contains PCBs greater than 1 ppm at some depth. The area-weighted average sediment PCB concentration in the Northwest Corner Area is highest in the top 8 ft of sediment and much lower below the top 8 ft (see Table 1.1). The PCBs are dominantly present in the fill and the soft sediment that lay over the marine silt. Through sampling and AR's contaminant distribution modeling, PCBs have been established to extend downward to an elevation of -39 ft. along the northeastern portion of the Northwest Corner Area within OU-2. The thickness of PCB-impacted sediments progressively thins from east to west across the Northwest Corner Area.

The higher levels of copper concentrations in Northwest Corner Area sediment are confined to the area within 50 to 60 ft of the shoreline particularly in the northern half of the Northwest Corner Area (see Figure 1.4). However, only one OU-2 data point (SD04 at 0 to 0.5 ft) of the approximately 20 sediment data points for copper available from the Northwest Corner Area exceeds the proposed sediment copper PRG of 982 ppm. This SD04 data point also exceeds 1 ppm PCBs. From AR's contaminant distribution modeling results, any sediment remediation volume in the Northwest Corner Area to address PCBs would also address copper exceeding the proposed sediment PRG for copper of 982 ppm.

Four remedial action alternatives have been developed and evaluated in this Supplemental FS for the Northwest Corner Area. Table 3.1 provides a summary of the four Northwest Corner

Area (NW) alternatives, NW-1 through NW-4, which are based on various extents of debris-obstruction removal, dredging and capping. Each of these alternatives includes construction of a temporary rigid containment barrier (see Section 2.1.3.2) and construction of an anchored, sealable, shoreline bulkhead (see Section 2.1.4). Each alternative also includes removal of debris and obstructions as needed and dredging between the shoreline and the temporary rigid containment barrier. Following dredging, a berm with a protective cap incorporated would be placed over impacted residual river sediments. This berm-cap would be placed to stabilize the shoreline at the final OU-1 grade, meet PRGs proposed for OU-2 sediment, and provide a habitat layer to facilitate the recolonization the cap. Specific information about remedial action alternatives is presented in this Supplemental FS only for the purpose of evaluating each alternative. Any elevations or other specific information presented herein about any alternative is preliminary, approximate, and subject to change during remedial design.

The No Action Alternative for the Northwest Corner Area was removed from consideration in the 2003 OU-2 FS Report based on sediment PCB concentrations significantly above the 1 ppm PRG. Each of the alternatives retained for evaluation for the Northwest Corner Area includes substantial remedial actions.

The Northwest Corner Area alternatives would accommodate and/or incorporate the site's geotechnical considerations summarized below and described in Appendix B:

- Global stability (also called slope stability) controls the dredge depth allowable for all four of the Northwest Corner Area alternatives. There are geotechnical limits on the depths of sediment that can be dredged immediately adjacent to a new shoreline bulkhead without risk of causing a slope failure where the bulkhead and contaminated upland soil would collapse into the river (see Appendix B). These limits are primarily due to OU-2 topography and low soil shear strength in the marine silt layer which supports the toe of shoreline bulkhead. Because of global stability limitations, all of the remedial alternatives must include substantial berms river-ward of the bulkhead.
- The allowable dredge depth can be increased somewhat by unloading the upland area (OU-1) by backfilling a portion of OU-1 with lightweight fill, and by supporting the proposed shoreline bulkhead with a deadman anchor system. Use of lightweight fill within 100 to 120 ft of the shoreline would lessen but not eliminate the extent of a berm to be placed in the river to provide needed stability for the shoreline bulkhead (see Appendix B). A deadman anchor system could be comprised of steel anchor rods or tendons spaced at regular intervals along the length of the shoreline bulkhead. Each anchor rod would extend approximately 100 to 150 ft eastward into OU-1 perpendicular and away from the shoreline bulkhead to a concrete block buried in the fill.
- Unloading of the upland shoreline area and placement of a deadman anchoring system would require careful coordination with the OU-1 remedial construction as part of Alternatives NW-2, NW-3, and NW-4. The details for this coordination differ among the several remedial alternatives. While coordination approaches were developed and presented in this Supplemental FS to ensuring constructability and feasibility, these approaches cannot be finalized prior to the Remedial Design stage.

- Each Northwest Corner alternative includes placing a berm and a protective cap. As discussed in Section 2, dredging alone has not been able to achieve a 1 ppm PCB PRG at other sediment remediation sites with similar conditions. Additionally, none of the Northwest Corner alternatives would permit dredging to the full depth of PCB impacted sediment at the current shoreline. As a result, a cap would need to be placed following any extent of dredging as an essential component of each alternative. A support berm would likely also be needed in association with this cap to help ensure long-term stability of the shoreline bulkhead. Size requirements of a berm within the river vary amongst the Northwest Corner Area alternatives due to the variation in subsurface conditions observed at this site. None of the Northwest Corner Area alternatives besides NW-3 would include significant net filling in shallow water near the shoreline having a low tide water depth of less than 6 ft (see the profile views presented in Appendix B).

One additional element that has been incorporated into this Supplemental FS is to assume for this Supplemental FS analysis that the final ground surface elevation within OU-1 could be established at an elevation of +4 ft (approximately 2 ft above the maximum daily high tide elevation) at the shoreline with the ground surface sloping up to +9 ft away from shore into OU-1. This would be consistent with the OU-1 ROD, but would require an amendment to the federal consent decree between AR, the Village of Hastings-on-Hudson and the Hudson Riverkeeper to modify the site elevation at the shoreline in a manner that would maximize its usefulness for all parties. A final ground surface elevation of +4 ft at the shoreline (instead of +9 ft) could be established following placement of lightweight fill, following placement of the anchors within OU-1, and prior to dredging. A final ground surface elevation at OU-1 of +4 ft near the shoreline would preserve public access to the shoreline without raising it above the 100-year floodplain. The size of the strip of land remaining in the floodplain would be determined as part of the remedial design for OU-1 and OU-2, and would be suitable for waterfront promenades, parks and other open space uses. To complete the geotechnical calculations in this Supplemental Feasibility Study, this area was estimated to be 100 to 120 feet wide, running perpendicular to the northwest corner shoreline. Conversely, a +9 ft final ground surface elevation would result in a cliff-like land surface configuration at the shoreline 11 ft above the mean minimum daily low tide elevation. Depending on the redevelopment approaches chosen, such a configuration may be less safe and less aesthetically pleasing than a +4 ft ground surface elevation at the shoreline. A final ground surface elevation of +9 ft at the shoreline would also require a berm within the river which would be substantially higher than the existing river berm and mudline. It is likely that AR would need to obtain a Clean Water Act Section 404 fill permit to build that berm, and any significant loss of aquatic habitat from the taller berm would need to be offset by the creation of additional water area and/or water depth elsewhere, possibly in the Old Marina Area, or in Kinally Cove, to satisfy federal and state law and policy.

The results of geotechnical analyses for the shoreline bulkhead and the temporary rigid containment barrier for each of the four Northwest Corner Area alternatives are presented in Table 3.2. Details on the structural and geotechnical assumptions and analysis for each alternative are provided in Appendix B. Assumptions and analyses presented for the Northwest Corner Area and for other areas within OU-2 are based on existing information for purposes of conducting this feasibility study and may be revised during remedial design as warranted. A description of remedy elements common to all of the NW alternatives is provided below.

Temporary Rigid Containment Barrier

For each of the NW alternatives, dredging would be completed inside a temporary rigid containment barrier. Characteristics of the temporary barrier are discussed in Section 2.1.3. The purpose of the temporary barrier would be to contain resuspended river sediments and thereby minimize their release from OU-2.

For three of the four NW alternatives (NW-2, NW-3, & NW-4), the temporary rigid containment barrier would have the same alignment as the temporary rigid containment barrier presented in the 2003 OU-2 FS Report and in NYSDEC's October 2003 PRAP. Under Alternative NW-1, the barrier would be placed closer to the shoreline than for the other NW alternatives, and it would be converted to a submerged bulkhead following dredging and capping. The temporary barrier would most likely consist of a steel sheet pile (Alternative NW-1) or a king pile wall (Alternatives NW-2 through NW-4). A king pile wall is comprised of a combination of interlocking H-piles and sheet piles. The total length of the temporary barrier along the water surface would be approximately 900 ft under Alternative NW-1 and approximately 1,200 ft under Alternatives NW-2 through NW-4.

The temporary rigid containment barrier evaluated herein would need to penetrate into the basal sand beneath the marine silt along its western (and deepest) side approximately 140 ft from shore in order to be able to withstand the forces affecting the barrier over one to two construction seasons. Where the temporary barrier is close to shore, it would only penetrate into the marine silt overlying the basal sand.

Removal of Debris and Obstructions and Dredging

Site investigation work completed by AR since the OU-2 FS Report was issued in 2003 include sediment borings in the Northwest Corner to better define lateral and vertical extent of PCBs in sediment as well as observations of underwater debris and other obstructions that would affect dredging efficiency. Sediment sampling results were incorporated into their AR's contaminant distribution modeling effort of assessing dredge volumes and PCB quantities in sediment.

Existing timber piles would need to be cut and debris would need to be removed in the OU-2 dredge area prior to dredging and/or concurrent with dredging operations. Timber piles within the river along the portion of the Northwest Corner Area to be dredged would be cut at the post-dredging mudline. One or more effective methods for cutting the timber piles at an appropriate depth would be determined during remedial design. Larger debris would also need to be removed before an area is dredged, and multiple dredge removal steps would likely be required for the deeper nearshore cuts in portions of OU-2. Geophysical investigations and sampling efforts conducted in 2004 and 2005 as well as historical investigations at the site have shown a significant amount of debris and obstructions in the Northwest Corner Area of the site. There are, in particular, two distinct areas of obstructions in the Northwest Corner Area, which when combined, span nearly the entire Northwest Corner Area (see Figure 3.1). The first obstruction area is located approximately 200 ft north of the water tower and 300 ft south of the Old Marina Area. This obstruction area extends 150 to 200 ft from the shore line and is characterized by fallen pilings, tires, sub-surficial magnetic debris, and other man-made objects. Historical photographs show that dock/pier structures once extended out into the river in this area in the same location where these obstructions are now located. The second major obstruction area within the Northwest Corner starts at the Old Marina Area and runs approximately 350 ft south along the shoreline out to a maximum of approximately 140 ft from shore. This second obstruction area is distinguished by large stones, rubble, concrete blocks, and other man-made debris prevalent along the slope as well as at the toe of the slope in this area (Parsons, 2005a and 2005b).

Mechanical dredging offers the only feasible method for removing sediment for each of the Northwest Corner Area alternatives due largely to the many obstructions present within OU-2 (see Figure 3.1). Dredging would be completed to a prescribed elevation prior to placing a berm-cap based on alternative-specific contaminant distribution modeling and geotechnical analyses completed as part of this Supplemental FS (see Appendix A and Appendix B) Table 3.3 presents a summary of the quantities of dredged material, backfill materials, and cap materials for each of the four NW alternatives. Table 3.3 also presents a summary of the estimated mass of PCBs and copper that would be dredged from the river for each of the alternatives based on output from AR's contaminant distribution model for OU-2 (see Section 1.3.1 and Appendix A).

Dredged sediment and debris would be moved by barge to an on-shore processing area at OU-1. Here, the sediments would be drained and dewatered as needed to a consistency allowing for transport offsite (by rail, truck or barge). To support sediment remediation at OU-2, temporary barge mooring, barge unloading facilities, stockpile areas, a dewatering area, and water treatment facilities would be constructed onshore to be operational prior to dredging.

Dredging using onshore equipment may not be feasible in the Northwest Corner Area because the OU-1 area within approximately 100 to 120 ft of the shoreline would be a restricted area with limited allowable soil loadings. In addition, the shoreline bulkhead would need to be protected from wind-wave scour which would further limit shoreline-based dredging operations. As a result, for the purpose of evaluating these alternatives, dredging at the Northwest Corner Area is assumed to take place by barge.

Debris and dredged sediment would need to be offloaded onshore at some location outside the Northwest Corner dredging area in order to avoid forces associated with increased upland loads pushing against the shoreline bulkhead. Consequently, the temporary rigid containment barrier may include one or more openings (or gates) to provide access for the dredged material barges, crew boats, and fuel and other supply boats needed during the dredging operation. The design and operational details of the entry gate is a remedial design element that is not believed to significantly affect the feasibility of any of these alternatives, although it would have an impact on the amount of resuspended PCBs that would escape from inside the temporary rigid containment barrier. Following dredging, the temporary rigid containment barrier would be cut at the mudline or removed. Under Alternative NW-1, the temporary barrier would be converted to a submerged bulkhead following dredging.

Dredged Material Management Following Removal

Barges loaded with dredged material would have to be moved to a temporary wharf for offloading. The dredged material from OU-2 would be consolidated at OU-1 for processing and testing. One of the first tasks of the OU-2 remediation would be to construct barge mooring and unloading facilities, stockpile areas, and water treatment facilities for water removed from contaminated sediment.

It would not be practical to unload barges along the Northwest Corner shoreline for many reasons including the following: (a) the water is too shallow for loaded barges; (b) the new shoreline bulkhead would not have fender piles and energy adsorbing features to protect it from damage by the barges; (c) weight of equipment and dredged material would decrease bulkhead stability; (d) limited space would be available inside the temporary barrier for barges to maneuver; and (e) under some alternatives, the upland area along the bulkhead would need to be excavated simultaneously with dredging in the river, in order to reduce weight on both sides of the bulkhead.

Prior to dredging, temporary shoreline facilities could be constructed to berth at least two barges. Mooring structures for barges could consist of temporary floating docks or pile-supported docks. No heavy vehicles or equipment over a certain weight would be allowed to operate within 100 to 120 ft of the shoreline (no-load zone) unless fully supported by roads or floor slabs that do not transfer any load to the existing bulkhead. The roads and floor slabs could be supported by either existing pilings or by new pilings that would terminate vertically within the marine silt.

The specific location for the unloading area would be coordinated with the OU-1 remediation work. Two possible areas for unloading dredged sediment are in the South Boat Slip and along the shoreline in the former Building 15 area (between the South and North Boat Slips). The South Boat Slip is about 150 ft long in the east-west direction by 100 ft wide, but its current water depth is too shallow for loaded barges, and the area would need to be dredged to allow barge navigation. Alternatively, sufficient space exists for two barges parallel to the river in the former Building 15 area, where water at low tide is deep enough for loaded barges about 30 ft west of the existing shoreline, but additional facilities would need to be installed to connect that dock to the south shoreline, and/or an additional area would have to be dredged in a debris filled location to allow barges to dock closer to shore. A third location, the North Boat Slip, is available, but is problematic because it is too narrow for barges to be placed at right angles to the shoreline and too short to hold two barges end-to-end. It is likely that only one barge at a time could dock at this location. A fourth alternative would be to create a barge unloading area on the north side of the site in the old marina area, if the marina owner would provide site access and allow dredging for that purpose, possibly in conjunction with remediation in the marina. For the purposes of evaluating feasibility, it is assumed that, during remedial design, one or more of these barge unloading options would be adapted for implementation

A typical barge would likely be 150 ft long, 35 to 40 ft wide and 12 ft high (empty) with a capacity of 1,000 to 1,500 tons (sediment and water). The barges would have a water depth draft requirement of 2 to 4 ft when empty, but would require a draft of approximately 10 ft when loaded. Mechanical dredging adds water to the dredged material volume because each bucket contains a mixture of sediment and water. The volume of water is typically 10 to 50 percent of the in-place sediment volume based on experience at other sites. For planning purposes, it is assumed that the material in the barge would consist of 75 percent sediment and 25 percent water by volume. Therefore, 1,000 tons (900 cubic yards of sediment-water mixture) in a barge would provide capacity for approximately 600 to 750 in-place cubic yards of sediment, depending on the sediment density.

A 600-cy volume of sediment has dimensions of 60 ft by 60 ft by 4.5 ft high. Since the dredged material would be very soft and have low shear strength, stockpile areas would need to contain wet dredged material.

The dredged material would be drained and dewatered as needed prior to stockpiling. Water generated from processing dredged sediment would either be treated and released to the river in compliance with NYSDEC discharge limits or routed to a Westchester County municipal wastewater treatment plant. Solid debris would be washed and placed on site or moved offsite.

Water would need to be drained or otherwise removed from the dredged sediment prior to transporting the sediment away from the site. Sediment water could be removed by adding a solidification material like cement or lime, although that would result in a higher volume and weight of any sediment that requires off-site disposal. Sediment water also could be removed by mechanically dewatering the sediment. Water generated from mechanical dewatering would be treated in accordance with state discharge requirements before being returned to the Hudson River.

Sediment containing 10 ppm PCBs or less may be able to be reused as fill at OU-1 or placed as fill in New Jersey or in Pennsylvania as is taking place with sediment from New York – New Jersey Harbor. Sediment containing over 10 ppm PCBs would need to be transported offsite either to a facility that can receive sediment containing PCBs less than 50 ppm or to a facility permitted under the Toxic Substances Control Act (TSCA) that can receive sediment containing over 50 ppm PCBs. Dredged sediment would be tested to confirm metals concentrations are not hazardous.

Berm and Cap

As discussed in Section 2, dredging alone is not likely to achieve a 1 ppm PCB PRG based on sediment contaminant distribution, the fine-grained nature of site sediment, and results from other sediment remediation sites with similar conditions. Therefore, a protective cap placed following dredging is a component included in each alternative. A protective cap would effectively contain residual sediment with PCB and/or metal concentrations above PRGs. The erosion protection layer of the cap would be part of the berm, and it would also be designed and installed to withstand ongoing and intermittent natural forces, such as storm events and annual early spring ice sheets moving within the river. The habitat surface layer of the cap would be designed and installed to facilitate recolonization of the benthic community. Once placed, the berm and cap would be monitored and repaired over the long term (see Section 2.2).

With each of the Northwest Corner alternatives, granular fill material (likely crushed stone) would need to be placed in the river adjacent to the shoreline bulkhead to form a berm to provide long-term shoreline stability. The berm would be placed after dredging is complete and prior to sealing the wall and allowing surcharge loading within 100 to 120 ft of the bulkhead. For some alternatives, the berm may need to include wick drains or other consolidation enhancement measures to be evaluated during remedial design as needed to accelerate marine silt consolidation following placement. The protective cap placed following dredging would be incorporated into the design of the berm resulting in a berm and protective cap that would consist of the following elements as explained in Section 2.2:

- Chemical isolation layer, which would typically be sand with some fines and organic matter;
- Granular fill for the berm, which may be crushed rock or gravel with some sand;
- Erosion protection layer, which would be designed to resist erosion and installed in areas with no granular berm or where the isolation layer is placed on top of the cap; and
- Habitat surface layer, which would promote recolonization of aquatic organisms.

3.1 ALTERNATIVE NW-1: DREDGE FOR CAP STABILITY

Alternative NW-1 involves dredging to an elevation of -7 ft along the face of the proposed shoreline bulkhead and out into the river to where the mudline elevation is -7 ft (where the dredge cut would meet the existing surface of the river bottom). Previous consideration was given to a dredge cut that sloped downward away from shore, but the same purpose and effectiveness can be achieved with a horizontal dredge cut. The dredge area would be contained within a temporary rigid containment barrier located approximately 50 ft from shore. After dredging is completed, a protective cap would be placed in the area between the shoreline bulkhead and the temporary rigid barrier. The temporary rigid containment barrier would then be cut off near the top of cap elevation to form a submerged bulkhead. Figures 3.2 and 3.3 show proposed Alternative NW-1 in plan and section views. Details of the structural and geotechnical aspects of Alternative NW-1 are provided in Appendix B.

Figure 3.2 presents a plan view of the Northwest Corner Area during dredging under Alternative NW-1. The alignments of the proposed shoreline bulkhead and submerged bulkhead (the temporary rigid containment barrier at the time of dredging) are shown. A horizontal dredge cut at elevation -7 ft adjacent to the shoreline bulkhead is shown in Figure 3.2. Figure 3.2 also shows an offshore berm to support the increase in upland grade. Figure 3.2 also shows placement of lightweight fill onshore to address surcharge restriction limits within OU-1 while dredging is ongoing within OU-2.

Figure 3.3 shows a schematic cross-sectional view of Alternative NW-1 during proposed NW-1 dredging. The upland is assumed to be at elevation +4 ft immediately adjacent to the shoreline (sloping up to elevation +9 ft at a distance of 100 to 120 ft inland) during dredging, and the upland area is assumed to be backfilled with lightweight fill within 100 to 120 ft of the shoreline bulkhead. Also shown on this figure (as a dashed line) is a proposed final berm-cap between the shoreline bulkhead and the submerged bulkhead.

Construction of most of the OU-1 (onshore) remedy that NYSDEC selected in its March 2004 Record of Decision (NYSDEC, 2004) could be completed prior to implementing Alternative NW-1. The OU-1 remedy includes construction of a shoreline bulkhead into the marine silt, excavation of contaminated material in the Northwest Corner Area (to 9 ft below the current ground surface along the shoreline), installation of the bulkhead wall anchorage system concurrent with backfilling with lightweight fill within 100 to 120 ft of the shoreline, and construction of the specified onshore cap and containment system.

NW-1 Temporary Rigid Containment Barrier / Submerged Bulkhead

Under Alternative NW-1, a temporary rigid containment barrier would be installed approximately 50 ft from the shoreline in relatively shallow water as shown in Figure 3.2. This temporary barrier would be approximately 980 ft long with the top of the barrier temporarily at elevation +5 ft and the toe approximately at elevation –61 ft, which is approximately 14 ft above the top of the basal sand. The temporary barrier would not be watertight, however, and water levels on opposite sides would be allowed to equilibrate during tide cycles.

Following dredging, the temporary barrier would be cut below the water line to form a submerged bulkhead. Characteristics of the temporary rigid containment barrier - submerged bulkhead are discussed in Section 2.1.3. The purpose of converting the temporary rigid containment barrier to a submerged bulkhead under Alternative NW-1 would be to help restore aquatic habitat by providing a length of sediment along the Northwest Corner Area with varying water depths which would further promote aquatic habitat restoration and nearshore erosion protection.

NW-1 Dredging

Once the temporary rigid containment barrier is in place, timber piles and debris would be cut as needed, and sediment in the river inside the temporary barrier would be dredged to an elevation of -7 ft. Under Alternative NW-1, approximately 5,900 cubic yards of sediment would be removed, which is estimated to include 61 percent of the PCB mass in OU-2 and 18 percent of the elevated copper mass based on AR's contaminant distribution modeling results (see Table 3.2).

Timber pile cutting, removing debris and obstructions, and dredging under Alternative NW-1 and under any of the other NW alternatives would most likely be done from a barge. At least one opening in the temporary containment provided by the submerged bulkhead would be needed to allow barges and support boats to enter and leave the containment area.

NW-1 Berm and Cap

A protective cap would be placed both inside and outside the containment area as needed after dredging assuming the PRGs are not met in surface sediment following dredging. An extension to the existing berm would also be constructed in the containment area following dredging as shown in Figure 3.3. The protective cap would be placed in conjunction with the berm over approximately three acres in the river up to a distance corresponding to the lateral extent of the Northwest Corner Area.

Following dredging and placement of berm and cap material, the temporary rigid containment barrier would be cut near the new mudline and converted to a submerged bulkhead. The berm and cap would be the same elevation on both sides of the submerged bulkhead, so there would not be any long-term lateral load on the bulkhead.

NW-1 Sediment Management

Following removal from the river, dredged sediment and debris would be moved by barge to an on-shore processing area at OU-1. Here, the sediments would be processed as needed to a consistency allowing for transport offsite (by rail, truck or barge). Sediment dredged under this alternative would likely contain PCBs at concentrations greater than and less than 50 ppm, so at least a portion of the dredged sediment would need to be managed at a TSCA-permitted facility. The nearest TSCA-permitted facility with rail access is in Belleville, Michigan near Detroit.

NW-1 Remediation Timeframe

Alternative NW-1 could be completed within approximately five months after the OU-1 shoreline bulkhead is in place and once support facilities are available at OU-1 to unload barges and process dredged sediment and debris. The NW-1 temporary rigid containment barrier would take approximately two to three months to install based on recent input from experienced pile installers. Dredging and capping (including berm placement) would likely be completed during a two to three-month construction period, and less than one month should be needed to safely cut off the submerged bulkhead at the new mudline elevation following dredging and capping.

3.2 ALTERNATIVE NW-2: DREDGING TO LIMITS OF BULKHEAD STABILITY

Northwest Corner Area Alternative NW-2 involves dredging to elevation -9 ft to -14 ft along the shoreline bulkhead, and deeper away the shore, removing approximately 75 to 82 percent of the site wide PCB mass, and approximately 22 percent of the site wide elevated copper mass from the river (all of the copper above 982 ppm in the Northwest Corner Area). The proposed dredge depth is the maximum depth consistent with maintaining a suitable factor of safety for the bulkhead and PCB containment remedy on shore (OU-1). Deeper dredging cuts at the shoreline would require a deeper bulkhead, along with a change in the OU-1 ROD and an amendment to the OU-1 consent agreement between AR and NYSDEC pertaining to the depth of the shoreline bulkhead. Deeper dredging is evaluated in Alternative NW-4.

The upland area in OU-1 adjacent to the shoreline would be unloaded as much as practical prior to dredging. Two options are evaluated under Alternative NW-2:

- Under Alternative NW-2, Option A, dredging in OU-2 would extend to elevation -9 ft at the shoreline bulkhead and slope downward away from shore as practical based on geotechnical constraints and as needed to dredge sediment exceeding PRGs; and

- Under Alternative NW-2, Option B, dredging in OU-2 would extend to elevation -14 ft at the shoreline bulkhead and slope downward away from shore as practical based on geotechnical constraints and needed to dredge sediment exceeding PRGs. For example, OU-1 may not be able to be filled to the +4 ft elevation prior to dredging in order to be able to dredge to elevation -14 ft at the shoreline.

Both options are based on dredging to their respective target elevations with the OU-1 ground surface at an elevation of +4 ft which is at or above the daily maximum high tide water level. Under Option A, the dredge cut would be to elevation -9 ft at the shoreline and slope downward away from shore to a specified maximum depth. Under Option B, to achieve a dredge cut to elevation -14 ft at the shoreline where the upland fill/marine silt interface is between elevation -14 ft and elevation -24 ft, it would be necessary to dredge horizontally approximately 25 ft at an elevation of -14 ft prior to sloping the dredge cut downward (see Appendix B). Where the interface between the upland fill and the marine silt is at elevation -25 ft or lower, the dredge cut under Option B could slope downward away from the shoreline without a horizontal bench cut.

Under both options, the dredge area would be contained by the temporary rigid containment barrier installed along the same alignment as the temporary barrier presented in Figure 4.4 of the 2003 OU-2 FS Report. At the completion of dredging, a berm and protective cap would be placed in the area between the shoreline bulkhead and the temporary rigid containment barrier. .

As part of Alternative NW-2, Option A, the OU-1 upland is assessed at elevation +4 for 100 to 120 ft inboard of the shoreline bulkhead prior to sloping up to elevation +9 ft further into OU-1. The locations of both the proposed shoreline bulkhead and the temporary rigid containment barrier are indicated on Figure 3.4. The dredge cut under this option would be to elevation -9 ft at the shoreline bulkhead and sloping away from shoreline bulkhead. Lightweight fill would be used in the OU-1 area as shown in Figure 3.5. Surcharge loads would be restricted within 100 to 120 ft of the bulkhead head at the time of dredging. The shoreline bulkhead would be sealed most likely following dredging and berm-cap placement. Alternative NW-2, Option B differs from Option A in that the dredging at the shoreline bulkhead wall would be to elevation -14 ft after OU-1 is backfilled at the shoreline to an elevation of +3 to +4 ft.

Under Alternative NW-2, portions of the required OU-1 remedy would need to be completed to stabilize the shoreline before OU-2 could be remediated. OU-1 work includes the construction of a shoreline bulkhead into the relatively impermeable marine silt but not into the basal sand below the marine silt as shown on the figures for this alternative. The shoreline bulkhead would be installed with a deadman anchor system. OU-1 would be excavated and backfilled with lightweight fill to an elevation of +3 ft to +4 ft within 100 to 120 ft of the shoreline prior to dredging in the river. Backfilling the upland to elevation +3 ft to +4 ft would avoid flooding of OU-1 at high tide.

Final OU-1 backfilling away from shore would be delayed until the end of OU-2 dredging and capping operations in order to reduce the weight of material in the upland area and maintain a sufficient global stability factor of safety. This delay in the final backfilling of OU-1 and delaying the sealing of the shoreline bulkhead, in addition to restricting the upland surcharge during dredging and using lightweight fill, would be needed to allow dredging to the depths included in this alternative. Without these measures, it would not be possible to safely dredge to the depths included as part of this alternative.

NW-2 Temporary Rigid Containment Barrier

The temporary rigid containment barrier that is part of Alternatives NW-2 through NW-4 would be approximately 1,200 ft long and consist of king pile wall (a combination of H-piles and sheet piles). The top of the wall would be at elevation +10 ft and the total vertical length of the piles along its western side would be approximately 110 ft. The temporary barrier would be installed in the river approximately 140 ft from shore along the outer edge of the Northwest Corner Area.

Because the removed obstructions and dredged sediment would need to be offloaded onshore at some location outside the Northwest Corner Area, the temporary barrier would likely have at least one opening (or gate) to provide access for the dredged material barges, crew boats, and fuel and supply boats during the dredging operation. Any opening may be covered with a silt curtain during periods of active dredging. The northern end of the temporary barrier would extend off the northern edge of OU-1, and the southern portion may extend on an angle from the North Boat Slip to a position approximately 140 ft from the shoreline running parallel to the Northwest Corner Area (for example, see Figure 1.3).

NW-2 Dredging

Once OU-1 is excavated and filled to an elevation of +4 ft (for Option A) or to +3 to +4 ft (for Option B) and once the temporary rigid containment barrier is in place, timber piles and debris would be cut as needed prior to dredging. The sediments within the containment area exceeding the PCB PRG and the proposed copper PRG would subsequently be dredged to elevation -9 ft (Option A) or -14 ft (Option B) adjacent to the shoreline. The dredge cut would achieve the targeted depth near the shoreline and extend deeper from the shore at a maximum cut slope that would be determined during remedial design. A bench cut into the river at elevation -14 ft may be needed for some shoreline areas under Option B for shoreline stability support.

Alternative NW-2 targets maximizing dredge depth, with the limiting factor being the global stability of the shoreline bulkhead. Alternatives NW-2, Options A and B represent the practical limit of dredging. Dredging deeper than elevation -9 ft or -14 ft (depending on location) adjacent to the NW-2 shoreline bulkhead is technically impracticable. At the time of dredging, it is assumed that OU-1 within 100 to 120 ft of the shoreline bulkhead would have been excavated previously to approximately elevation -6 ft in accordance with the OU-1 Record of Decision and backfilled to an elevation of +3 ft to +4 ft with lightweight fill. Option A is evaluated as a likely maximum practicable dredge cut depth at the shoreline with a shoreline bulkhead extended into the marine silt based on the geotechnical constraints described in Appendix B. Option B is considered an absolute maximum possible dredge cut at the shoreline with a shoreline bulkhead extended into the marine silt assuming results from the geotechnical analysis that would be completed during remedial design would be less restrictive than under Option A. To achieve a dredge depth deeper than elevation -9 to -14 ft, the complexity and risk would increase significantly and become impracticable as outlined below. Each of these factors also make Option B (dredging in the river to elevation -14 ft along the shoreline) more difficult to implement than Option A (dredging in the river to elevation -9 ft along the shoreline).

- To dredge deeper, the OU-1 area would have to be unloaded to a greater extent than can be achieved by excavating OU-1 to elevation -6 ft, dewatering while the excavation is open, and backfilling with lightweight fill to a minimum elevation of + 4 ft with the shoreline bulkhead not yet sealed to minimize loads on the bulkhead. The practical limits of dredging are exceeded when the excavation remains open for any length of time below elevation +4 ft based on site management constraints including tidal and groundwater elimination problems.

- Both bulkhead wall anchorage and internal bracing would need to be installed. The deadman anchorage and bracing, installed at approximately elevation 0 ft would be both inundated and exposed during construction, constraining the OU-1 work area and possibly presenting a health and safety risk to site workers and the public. AR is not aware of construction at any other sites that has been undertaken in this manner.
- Significant existing surface and subsurface structures at OU-1, coupled with the extra excavation support and dewatering considerations required to leave the excavation open, would make construction execution and safe movement of personnel and equipment within OU-1 difficult at best during construction.
- The duration of the OU-2 remedial action coupled with remediation of OU-1 would require the OU-1 excavation to remain open over winter months, particularly under Option B. During winter months, OU-1 groundwater would need to be pumped to maintain the OU-1 water table below the bottom of the excavation and avoid land side ice loading on the shoreline bulkhead. Given this elevation and the tidal conditions, this is impractical.

Under Alternative NW-2, approximately 18,000 cubic yards of sediment would be removed under Option A, which is estimated to include 75 percent of the PCB mass in OU-2 river sediment based on site-specific contaminant distribution modeling results (see Appendix A). Approximately 25,000 cubic yards of sediment would be removed under Option B, which is estimated to include 82 percent of the PCB mass in OU-2 river sediment.

NW-2 Berm and Cap

Once dredging is complete, granular fill would be placed in the river to form a berm needed for shoreline bulkhead stability, and the temporary rigid containment barrier would either be cut in place near the existing mudline or removed. A protective cap would be incorporated into the berm design in those areas where residual sediment concentrations exceed PRGs. The berm and protective cap would be placed over the area to be dredged within the Northwest Corner Area (see Figure 3.5).

The protective cap would be installed to permanently contain in place residual sediment exceeding PRGs. As stated for Alternative NW-1, and as described in Section 2.1, the cap would be designed and installed to restore the existing aquatic habitat and uses, and to withstand ongoing and intermittent natural forces as needed given the berm portion of the berm-cap would also provide erosion protection.

Figures in Appendix B show the anticipated size of the required berm-cap to support the long term loading conditions acting on the shoreline bulkhead under Alternative NW-2, Option B. The required berm would have a maximum thickness of approximately 8 to 9 ft over the existing mudline elevation, but no more than below the current mudline at the bulkhead.

Once the support berm - protective cap is in place, the OU-1 remedy would be completed by installing the onshore cap and containment system, creating a final onshore elevation of approximately +4 ft at the shoreline sloping up to +9 ft at 100 to 120 ft away from the shoreline.

NW-2 Sediment and Debris Management

Following removal from the river, dredged sediment and debris would be moved by barge to an on-shore processing area at OU-1. Here, the sediments would be drained and dewatered as needed to a consistency allowing for transport (by rail, truck or barge) to a suitable permitted facility. Debris would be either washed and retained on site or processed for removal from the site.

NW-2 Remediation Timeframe

Alternative NW-2 would likely require eight to twelve construction months to complete once the OU-1 shoreline bulkhead is in place. Installation of the 1,200-ft long temporary rigid containment barrier would likely require approximately three to four months, which includes downtime due to adverse weather conditions such as winds over 20 to 25 miles per hour which frequently make working conditions in the river unsafe. Once the temporary rigid containment barrier is in place, removal of debris and obstructions and dredging could be completed in approximately four to six months for Options A and B, assuming no significant weather or administrative constraints develop during the remedial action. The estimate of four to six months for removing debris and obstructions and dredging is based on the presence of abundant debris and the problems these materials would present. This time estimate is also subject to considerable uncertainty due to the unknown impacts that may be related to site obstructions. Following dredging, the berm and protective cap could then be placed in approximately one to two months. Marine silt consolidation under the weight of the berm is not required for this alternative. Therefore, the total time for containment barrier installation, dredging, and berm-cap placement would be eight to eleven months for Option A and nine to twelve months for Option B.

3.3 ALTERNATIVE NW-3: REDIVIDE OU-1 AND OU-2

Under Alternative NW-3, the shoreline bulkhead in the Northwest Corner Area (required by the OU-1 remedy) would be relocated into the river along an alignment extending out to 40 to 100 ft west of the current shoreline in its northern extent, as shown in Figures 3.7 and 3.8. As with Alternatives NW-1 and NW-2, the bulkhead along the new shoreline would not penetrate into the basal sand, and a temporary rigid containment barrier would be installed approximately 140 ft from shore to reduce losses of sediment resuspended by dredging.

Alternative NW-3 is unique in that the relocated sealed bulkhead would be aligned to allow the deepest impacted sediments exceeding PRGs on the river side of the new shoreline to be targeted for dredging without exceeding geotechnical constraints. Alternative NW-3 also has the advantage of being the only available remedial alternative that would remove all of the sediments identified to contain PCBs over 1 ppm riverward of the OU-1 sealed shoreline bulkhead to the temporary rigid containment barrier. In addition, the timber piles and significant debris between the existing shoreline and the new shoreline would be permanently contained, resulting in less sediment being resuspended due to removing debris and obstructions and dredging operations in the nearest shore areas that have the greatest abundance of debris.

The NW-3 bulkhead alignment would allow dredging immediately next to the bulkhead to a depth that would target all sediment known to contain PCBs over 1 ppm in the portion of the river between the relocated sealed bulkhead that would separate OU-1 from OU-2 and the temporary rigid containment barrier. Therefore, this bulkhead alignment is dictated by both geotechnical constraints and sediment chemistry depth, and its distance away from the existing shoreline would vary along its length.

The alignment shown in Figure 3.6 was used to assess the feasibility of this remedial alternative. The final alignment would be determined during remedial design. Geotechnical analyses presented in Appendix B show that Alternative NW-3 is constructible and would provide long term effectiveness if constructed. The alignments of the shoreline bulkhead to facilitate OU-1 excavation, the relocated sealed bulkhead, and the temporary rigid containment barrier are shown in Figure 3.6. The toe of the support berm required to fill behind the relocated sealed bulkhead (extending the upland area) is also shown.

Figure 3.7 show a simplified cross-sectional view of the Northwest Corner Area during proposed NW-3 at the end of OU-2 and OU-1 remediation construction. A more specific cross sectional view is presented in Appendix B.

NW-3 Sequence

As with all of the remedial alternatives evaluated, the actual construction sequence will need to be established during Remedial Design. However, the feasibility of NW-3 was evaluated and established based on the following possible construction sequence:

- Install a sheet pile wall along the existing shoreline to control water during OU-1 remedial excavation and to support bracing onshore.
- Excavate the OU-1 upland area (9 ft below existing ground surface) in accordance with the OU-1 remedy. Backfill the OU-1 excavation area with lightweight fill within 100 to 120 ft of the existing shoreline. Backfill from elevation -6 ft to approximately elevation 0 ft within 100 to 120 ft of the shoreline. Install a deadman anchorage system. Then, backfill with lightweight fill to elevation +4 ft. This would result in a net unloading of the OU-1 area.
- Install the new relocated sealed bulkhead along an alignment similar to the one shown in Figure 3.6. Brace and anchor the relocated sealed bulkhead to the existing OU-1 shoreline with steel whalers and deadman anchor rods extending into the OU-1 upland area.
- Install the temporary rigid containment barrier. The temporary barrier would have the same alignment and characteristics as in Alternative NW-2.
- As needed, cut any timber piles, remove obstructions, and dredge sediment in the contained area between the new Relocated sealed bulkhead and the temporary rigid containment barrier, where sediment PRGs for PCBs and/or copper are exceeded.

- Place fill material in the river and new shoreline area to create a berm needed to support the relocated sealed bulkhead. Install wick drains (or other consolidation devices) within the offshore fill area to accelerate consolidation strength gain in the marine silt under the weight of the berm material. Consolidation devices could be installed within the berm and underlying marine silt to speed up consolidation and increase strength of the marine silt, thereby increasing stability at the shoreline (see Appendix B).
- Cut or remove the temporary rigid containment barrier.
- After sufficient consolidation of the marine silt beneath the berm, complete construction of the new shoreline and upland area. After backfilling to El. 0 in the new upland area with conventional fill material, continue backfilling to elevation +4 with lightweight fill. Place the protective cap as needed within the berm. Seal the shoreline bulkhead. The estimated berm staged construction and consolidation time is expected to exceed two years.
- Complete filling within OU-1 to final grades.

The berm in the river would be needed to maintain the stability of the shoreline bulkhead would also provide erosion protection. As in all of the other alternatives, the protective cap would be applied in conjunction with the berm to restore the existing aquatic habitat and to provide chemical isolation as needed.

Under Alternative NW-3, the OU-1 remedy would be completed following dredging and capping, including the new upland creation in the river. The OU-1 area would be expanded slightly to include all of the area east of the relocated sealed bulkhead.

Less than one acre of river area would be filled under this alternative. An equal or greater area of open water river habitat would be created elsewhere, on site or nearby, to mitigate any potential impact of this remedy on the environment. Two potential mitigation areas are the shoreline along the Southern Area and adjacent to the South Boat Slip. As discussed in Section 2.1.4, moving the shoreline bulkhead approximately 30 ft inland from the existing Southern Area shoreline and removing soil (widening the river) is one option that could be evaluated during remedial design. Approximately a half acre of new river space could be opened up in the Southern Area by moving the shoreline approximately 30 ft inland along the former Building 15 footprint as discussed in Section 5. Additional water depth and acreage might be created by dredging to navigational depths in the Old Marina Area, and by dredging in Kinally Cove, restoring these two areas for boating and possibly for other recreational uses. AR would need to obtain site access and permission to implement such work from the property owners.

NW-3 Temporary Rigid Containment Barrier

The Alternative NW-3 temporary rigid containment barrier would have the same purpose and be located along the same alignment as under Alternative NW-2, approximately 140 ft west of the shoreline along the outer edge of the Northwest Corner Area. The location of this barrier is shown in Figure 3.6.

NW-3 Dredging

Once OU-1 is excavated and backfilled near the shoreline and the temporary rigid containment barrier is in place, the contained area of the river would be dredged.

Under Alternative NW-3, nearly 100 percent of the PCB mass would be removed from the river or contained within the new shoreline. Approximately 15,000 cubic yards of sediment would be removed, which is estimated to include 3 percent of the PCB mass in OU-2 river sediment based on AR's site-specific contaminant distribution modeling results. Although the PCB removal mass during dredging would be significantly less than for other alternatives considered, virtually all of the PCBs not dredged would be contained within the environmentally secure OU-1 upland closure.

NW-3 Berm and Cap

Following dredging, backfill would be placed in the river to form the berm required for shoreline bulkhead stability, then the temporary barrier would be cut in place near the existing mudline (or extracted in areas of low contamination) along its entire length. A protective cap would be integrated within the berm and also over other unbermed Northwest Corner Area sediment where residual sediment concentrations exceed 1 ppm PCBs. The proposed copper PRG of 982 ppm copper is not exceeded in the river area offshore of the relocated shoreline bulkhead.

NW-3 Sediment Management

Sediment would be managed in the same manner as described for the other remedial action alternatives. Following removal from the dredged area, dredged sediment and debris would be moved by barge to an on-shore processing area at OU-1. Here, the sediments would be drained and dewatered as needed to a consistency allowing for transport offsite (by rail, truck or barge). Debris would be either washed and retained on site or processed for removal from the site.

NW-3 Remediation Timeframe

Alternative NW-3 would require at least 30 construction months to fully implement. The temporary rigid containment barrier and the NW-3 shoreline bulkhead would likely require four months to install. Dredging and placement of berm and cap materials would likely take an additional three to five months to complete. Construction of the new shoreline (the berm fill area shown on Figure 3.7) would require approximately another seven to nine months followed by approximately one year to install wick drains (or other consolidation devices) and allow for needed consolidation strength gain under the weight of the berm.

3.4 ALTERNATIVE NW-4: PENETRATE SHORELINE BULKHEAD INTO BASAL SAND

Unlike Alternatives NW-1 through NW-3, the shoreline bulkhead under Alternative NW-4 would be driven deeper through the marine silt and into the basal sand, in order to provide more soil support at the base of the wall and to increase global slope stability to allow dredging to greater depths near the shoreline. The shoreline bulkhead would be approximately 90 ft in depth, and it would most likely consist of a king-pile system using a combination of H-piles and sheet piles or equivalent installed with a tie-back system.

NW-4 Shoreline Bulkhead

YU Associates in their analysis for NYSDEC of a shoreline bulkhead into the basal sand provided a dredge cut to elevation -32 ft at the bulkhead and then a dredge slope outboard of the bulkhead away from shore. YU Associates concluded that grade 60 AZ48 sheet piles were suitable for the shoreline bulkhead. A comparable analysis by Haley & Aldrich, based on assumptions believed to be more appropriate to conditions at the site, suggested that the shoreline bulkhead strength would need to exceed the available sheet pile wall sections and that a king pile type wall would be required to support the bulkhead during the dredging to the depths proposed by YU Associates. The primary differences between the analysis by YU Associates and the analysis by Haley & Aldrich are:

- YU Associates assessed conditions based on a higher shear strength factor of 0.24 as opposed to the Haley & Aldrich analysis based on 0.21.
- YU Associates used a shear strength profile on the river side of the wall typical of soil adjacent to the wall but not representative of all of the soil within the zone of influence of the wall. Because of the downward slope, marine silt at greater distance from the wall is less consolidated and therefore significantly weaker.
- YU Associates assessed the top of the marine silt at elevation -25 ft in the OU-1 upland area. The top of the marine silt throughout much of the OU-1 upland area is at approximately elevation -17 ft based on all available data. At the Northwest Corner shoreline, the top of the marine silt layer varies from approximately elevation -14 ft to elevation -35 ft.

A king pile wall is comprised of interlocking sheet pile pairs and H-piles. Because of their size and shape (approximately 3 ft by 1.5 ft) H-piles are more likely to drag obstructions and contaminated soils down into the basal sand layer when driven on site. Soil has a tendency to plug in the corners of H-piles and to travel downward with the piles when the piles are driven. In addition to potential contaminant drag-down, H-piles have the potential to forms voids along its corners during installation. These voids can be enlarged through piping caused by the upward groundwater flow of the basal sands. These enlarged voids would create the potential for downward DNAPL along this enlarged pathway.

NW-4 Temporary Rigid Containment Barrier

The temporary rigid containment barrier under Alternative NW-4 would have the same purpose and be located along the same alignment as under Alternative NW-2 and NW-3, approximately 140 ft west of the shoreline along the outer edge of the Northwest Corner Area.

NW-4 Dredging

Dredging would be completed inside the same temporary rigid containment barrier alignment included in Alternative NW-2 (see Figure 3.8). Sediment exceeding the PCB and proposed copper PRG inside the temporary rigid containment barrier would be dredged to a limited maximum depth based on the following two criteria: (1), the dredging depth next to the shoreline bulkhead would be limited to an elevation of -32 ft based on an analysis completed for NYSDEC (YU Associates, March 2005b); and (2) the dredge cut-line would be sloped downward at a slope of approximately five horizontal to one vertical away from the bulkhead, to increase the removal depth of contaminated sediments above PRGs.

Under Alternative NW-4, approximately 51,000 cubic yards of debris and sediment would be removed, which is estimated to include 99 percent of the PCB mass based on AR's site-specific contaminant distribution modeling.

NW-4 Berm and Cap

Following dredging, a protective cap in conjunction with a berm would be placed over approximately three acres, to a distance of up to the lateral extent of the NW Corner (see Figure 3.9). The protective cap would be incorporated into the berm design or the protective cap would be placed by itself over any dredged area wherever a berm would not be needed but where sediment PRGs are exceeded following dredging. Following placement of the berm - protective cap, the temporary rigid containment barrier would either be cut in place near the existing mudline or removed. The OU-1 remedy would then be completed by installing the onshore cap and containment system.

NW-4 Sediment Management

Sediment would be managed in the same manner as described for the other remedial action alternatives. Following removal from the dredged area, dredged sediment and debris would be moved by barge to an on-shore processing area at OU-1. Here, the sediments would be drained and dewatered as needed to a consistency allowing for transport offsite (by rail, truck or barge). Debris would be either washed and retained on site or processed for removal from the site.

NW-4 Remediation Timeframe

Implementation of Alternative NW-4 would require approximately 12 to 15 months once the OU-1 shoreline bulkhead is in place. The temporary rigid containment barrier could likely be installed in three to four months. Dredging and cap-berm placement would follow placement of the temporary rigid containment barrier and could be completed in an additional nine to 11 months.

TABLE 3.1

REMEDIAL ACTION ALTERNATIVES FOR THE NORTHWEST CORNER (NW)

HARBOR AT HASTINGS OU-2

Alternative	General Description
NW-1: Dredge for Cap Stability	Dredge to elevation -7 ft where sediment PRGs are exceeded inside a temporary rigid containment barrier located approximately 50 ft from shore. Place berm material as needed for shoreline stability. Convert temporary rigid containment barrier into a submerged bulkhead to help support a cap. Place a protective cap over the berm.
NW-2: Dredge to Limits of Bulkhead Stability	Dredge where sediment PRGs are exceeded inside temporary rigid containment barrier (interlocking H piles and sheet piles) located approximately 140 ft from shore. Place berm material as needed for shoreline stability. Place a protective cap as needed integrated with the berm. Cut or remove temporary rigid containment barrier. Option A: Dredge to elevation -9 ft at the face of the bulkhead (sloping down at 5 horizontal to 1 vertical into the river away from shore). Option B: Dredge to elevation -14 ft at the face of the bulkhead (sloping down at 5 horizontal to 1 vertical into the river starting 30 ft away from shore).
NW-3: Redivide OU-1 and OU-2	Place new shoreline bulkhead/NW-3 bulkhead 50 to 100 ft away from shore. Dredge where sediment PRGs are exceeded between new shoreline and temporary rigid containment barrier located approximately 140 ft from shore. Place berm material as needed for shoreline stability. Cut or remove temporary rigid containment barrier. Allow for ground consolidation to complete. Complete berm and integrate protective cap with the berm where needed.
NW-4: Penetrate Shoreline Bulkhead Into Basal Sand	Dredge where sediment PRGs are exceeded inside temporary rigid containment barrier located approximately 140 ft from shore. Dredge as feasible once shoreline bulkhead penetrating into the basal sands is in place. Place berm and protective cap where needed inside barrier. Cut or remove temporary rigid containment barrier when dredging is completed.

Note: 1) Elevations are based on the NAVD88 datum (mean tidal elevation is +0.1 ft).
2) Sediment PRGs are 1 ppm for PCBs and 982 ppm proposed for copper.

TABLE 3.2

CHARACTERIZATION OF BULKHEAD AND CONTAINMENT STRUCTURES FOR THE NORTHWEST CORNER ALTERNATIVES

HARBOR AT HASTINGS OU-2

		NW-2			
	NW-1	**Option A**	**Option B**	**NW-3**	**NW-4**
Shoreline Bulkhead					
Length (ft)	900	900	900	1060	900
Maximum depth (elevation in ft)	-35	-54	-54	-65	-75
Penetrate into basal sand?	No	No	No	No	Yes
Final OU-1 ground elevation at shoreline (ft)	+4	+4	+4	+4	+4
Interim OU-1 ground elevation at shoreline while dredging (ft)	+4	+3 to +4	+3 to +4	+3 to +4	+4
Temporary Rigid Containment Barrier					
Barrier length (ft of sheet piles connected with H-piles)	900	1,200	1,200	1,200	1,200
Maximum distance from shoreline (ft)	50	140	140	140	140
Pile length below mudline (ft)	45	50 to 70	50 to 70	50 to 70	50 to 70
Penetrate into basal sand?	No	Yes	Yes	Yes	Yes
Approximate installation time (months)	3	4	4	4	4

Note: Elevations are based on the NAVD88 datum (mean tidal elevation is +0.1 ft).

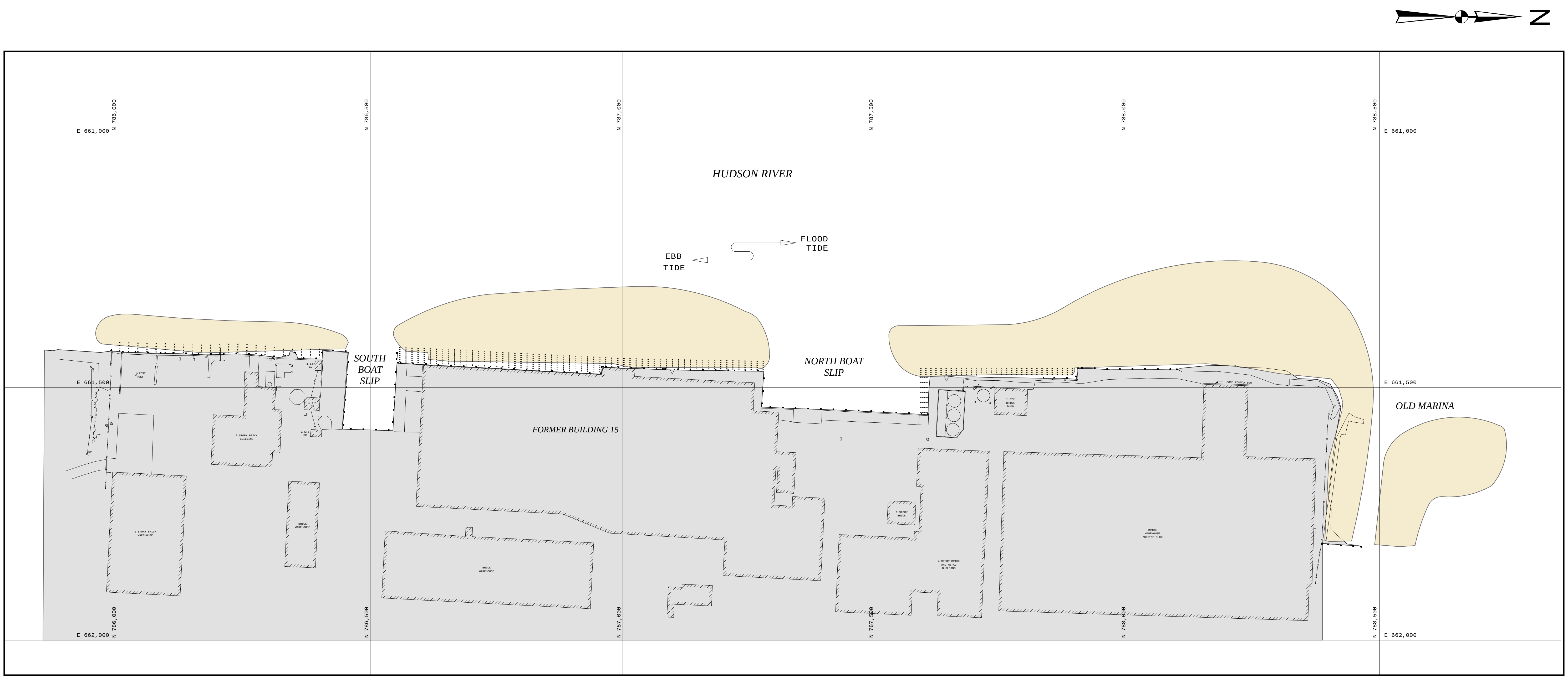
TABLE 3.3

DREDGING AND CAPPING QUANTITIES AND DURATIONS FOR THE NORTHWEST CORNER ALTERNATIVES

HARBOR AT HASTINGS OU-2

		NW-2			
	NW-1	Option A	Option B	NW-3	NW-4
Dredging					
Volume (from ESI model) (cubic yards)	5,900	19,000	27,000	18,000	51,000
Lowest cut elevation at shoreline (ft)	-7	-9	-14	-38	-32
Percent OU-2 PCB mass dredged (from ESI model) (1)	61	75	82	99(2)	99
Approximate debris removal and dredging duration (months)	2	3 to 4	4 to 5	3	7 to 8
Berm – Protective Cap					
Area (acres)	2.3	2.2	2.3	1.2	2.3
Approximate Berm – Cap placement duration (months)	0.5 to 1	1 to 2	1 to 2	1	2 to 3

Note: (1) Percentages of mass are based on 100 percent being the mass within all sediment within OU-2.
(2) Based on new shoreline location offshore from the current shoreline.



Note:
Areas of concentrated debris and obstructions were determined from 2004 and 2005 geophysical and sampling work, and supplemented by historical aerial photographs and debris information presented in the 2003 Feasibility Study.

Legend

OU-1 Area

Area of Concentrated Debris and Obstructions (Based on debris surveys conducted by Atlantic Richfield during 2004 and 2005.)

200 100 0 200 400
Feet

AR and AERL

FIGURE 3.1
DEBRIS SURVEY RESULTS
HASTINGS-ON-HUDSON, NEW YORK

PARSONS

290 ELWOOD DAVIS ROAD, SUITE 312, LIVERPOOL, N.Y. 13088, PHONE: 315-451-9560

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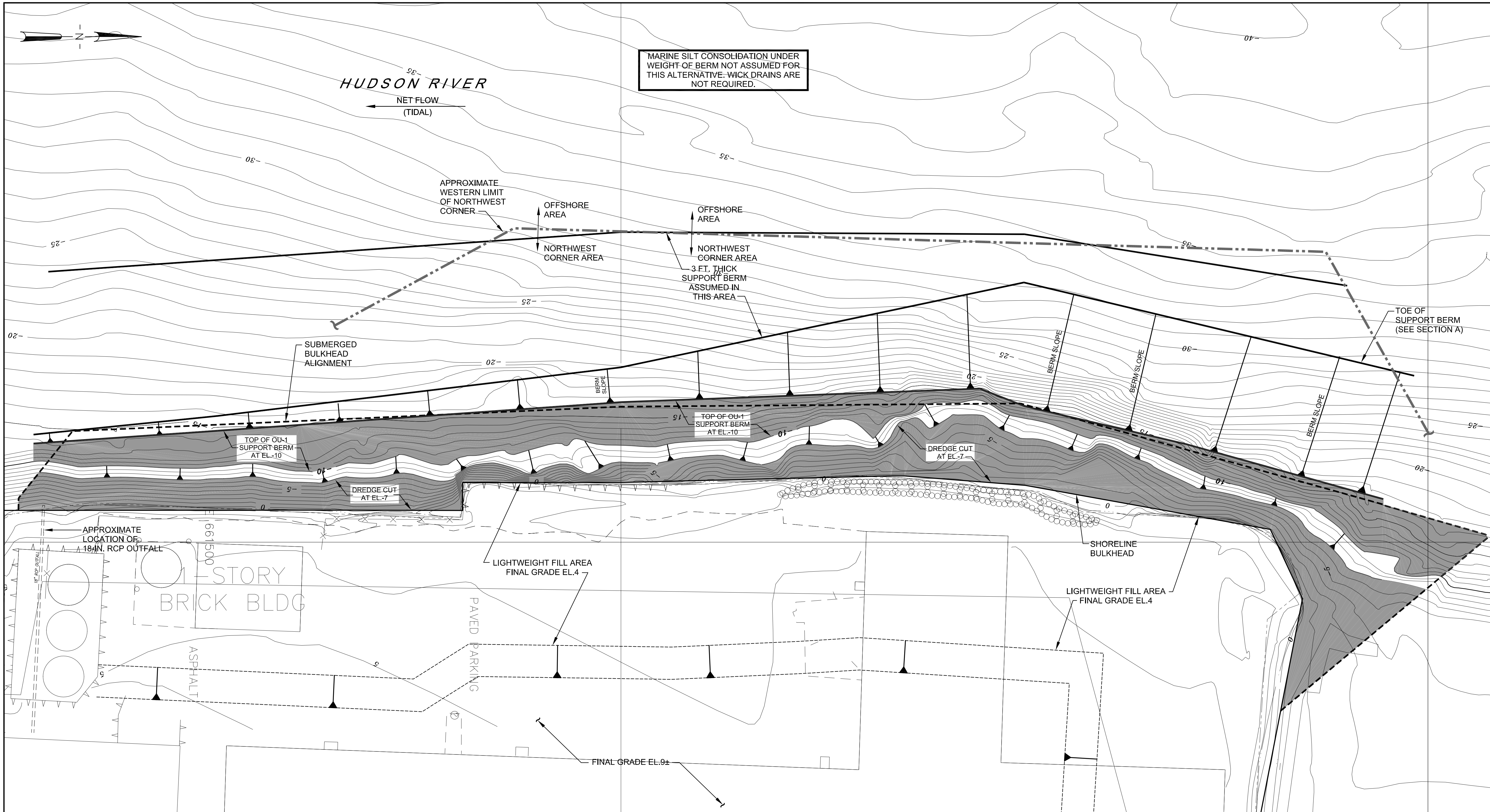

NOTES:

1. DRAWING BASED ON NAVD 88 DATUM. TO CONVERT FROM NAVD88 TO NGVD29 DATUM ADD ONE FOOT TO NAVD88 ELEVATIONS. PLAN BASED ON NEW YORK 1988 STATE PLANE COORDINATE SYSTEM.
2. SOIL PROFILES SHOWN IN SECTION VIEW REFLECT TYPICAL CONDITIONS IN THE VICINITY OF THE SECTION CUT. THE SOIL PROFILES ARE SIMPLIFIED AS NECESSARY FOR USE IN THE ENGINEERING ASSESSMENT OF REMEDIAL ACTION ALTERNATIVES.
3. CALCULATIONS FOR NW-1 WERE PERFORMED ON A LIMITED NUMBER OF DESIGN CROSS SECTIONS AS DISCUSSED IN APPENDIX B. BERM CONDITIONS DEPICTED AT AND BETWEEN SECTIONS SHOWN ON THESE DRAWINGS ARE INFERRED FROM THE DESIGN SECTION CALCULATIONS USING ENGINEERING JUDGMENT AND WILL HAVE TO BE CONFIRMED DURING SUBSEQUENT EVALUATION STEPS.
4. MARINE SILT CONSOLIDATION UNDER WEIGHT OF BERM NOT ASSUMED FOR THIS ALTERNATIVE. WICK DRAINS ARE NOT REQUIRED.
5. ALL ENGINEERING ELEMENTS PROVIDED ON THIS PLAN WERE DEVELOPED BASED ON EXISTING INFORMATION FOR THE PURPOSE OF EVALUATING REMEDIAL ALTERNATIVES AT THE SUBJECT SITE. THE ACTUAL DESIGN ELEVATIONS, DIMENSIONS, AND OTHER ENGINEERING ASPECTS OF THE SELECTED REMEDY WILL BE DEVELOPED DURING REMEDIAL DESIGN.

28612-010 D132

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UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

HARBOR AT HASTINGS SITE
SUPPLEMENTAL FEASIBILITY STUDY FOR OU-2
HASTINGS-ON-HUDSON, NEW YORK

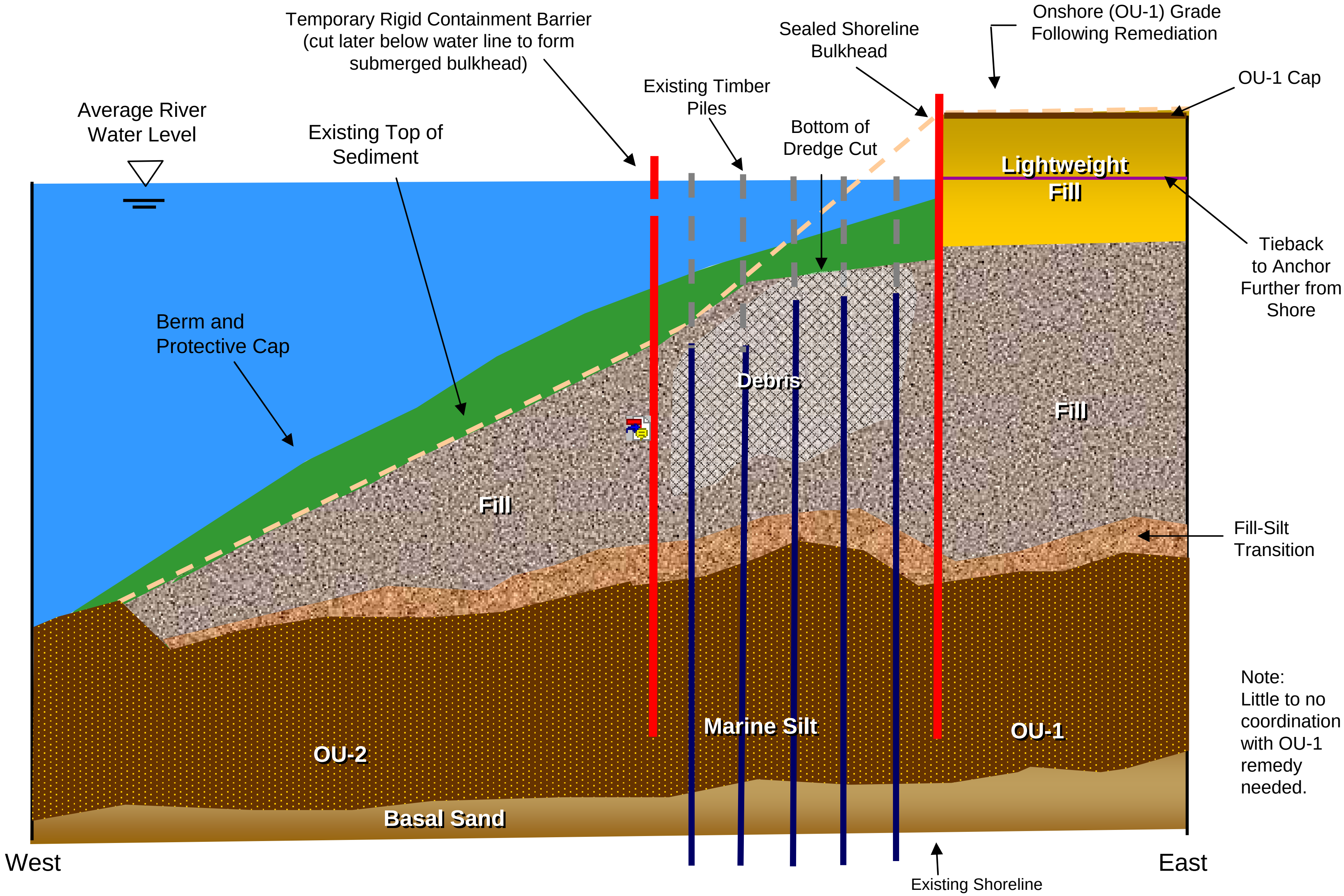
NORTHWEST CORNER ALTERNATIVE NW-1 SHOWING DREDGE CUT AND OU-1 OFFSHORE SUPPORT BERM

SCALE: AS SHOWN

18 APRIL 2006

FIGURE 3.2

Figure 3.3
Harbor at Hastings OU-2
Typical Cross Section for Alternative NW-1: Dredge for Cap Stability



Section View Perpendicular to Shoreline

(not to scale)

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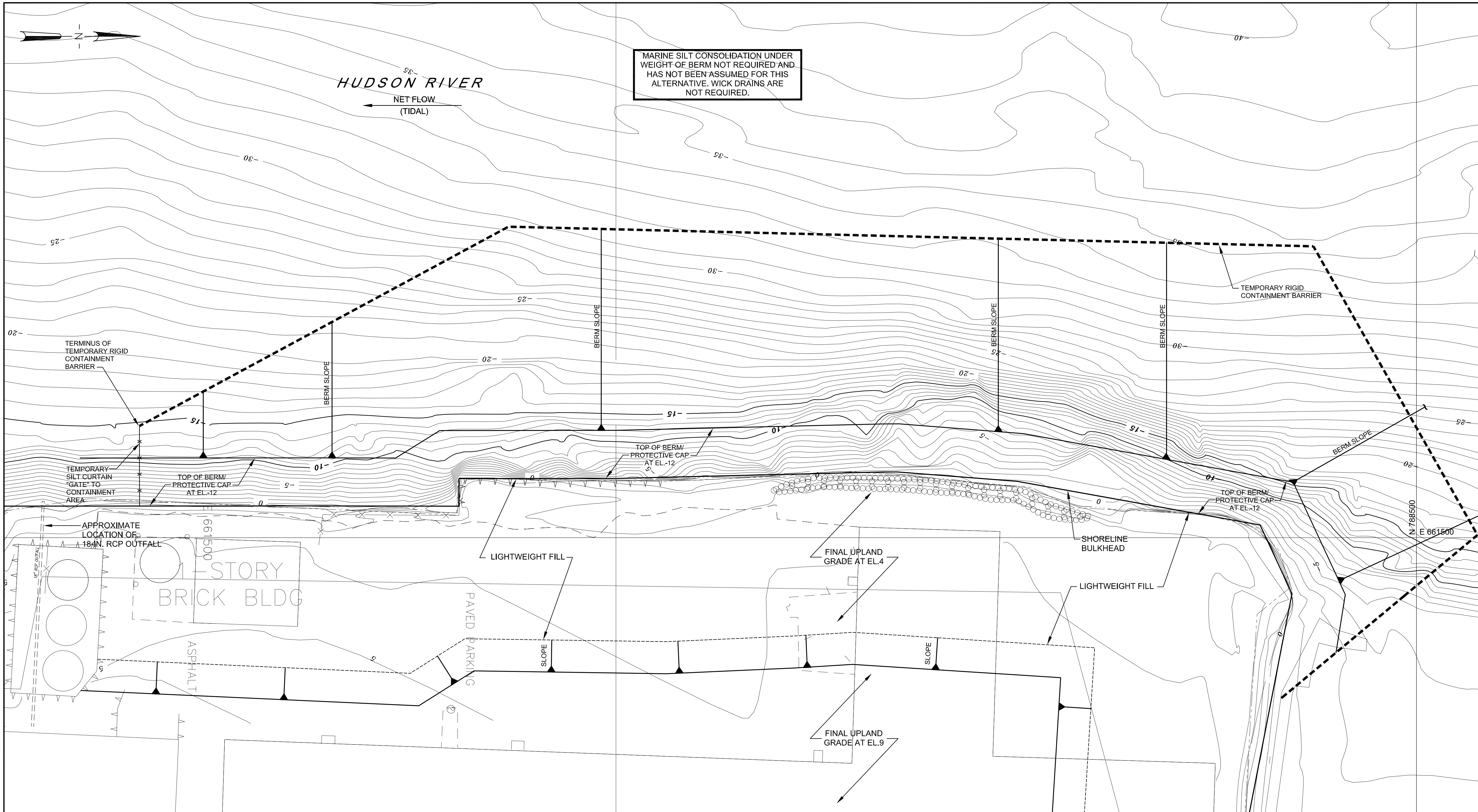
April 2006



NOTES:

1. DRAWING BASED ON NAVD 88 DATUM. TO CONVERT FROM NAVD88 TO NGVD29 DATUM ADD ONE FOOT TO NAVD88 ELEVATIONS. PLAN BASED ON NEW YORK 1988 STATE PLANE COORDINATE SYSTEM.
2. SOIL PROFILES SHOWN IN SECTION VIEW REFLECT TYPICAL CONDITIONS IN THE VICINITY OF THE SECTION CUT. THE SOIL PROFILES ARE SIMPLIFIED AS NECESSARY FOR USE IN THE ENGINEERING ASSESSMENT OF REMEDIAL ACTION ALTERNATIVES.
3. APPROXIMATE FINAL BERM CONFIGURATION FOR THIS ALTERNATIVE IS SHOWN ON THIS FIGURE. THE DREDGE CUT IS NOT SHOWN.
4. CALCULATIONS WERE PERFORMED AT SELECT SECTIONS AND EXTRAPOLATED TO OTHER SECTIONS.
5. MARINE SILT CONSOLIDATION UNDER WEIGHT OF BERM NOT REQUIRED AND HAS NOT BEEN ASSUMED FOR THIS ALTERNATIVE. WICK DRAINS ARE NOT REQUIRED.
6. ALL ENGINEERING ELEMENTS PROVIDED ON THIS PLAN WERE DEVELOPED BASED ON EXISTING INFORMATION FOR THE PURPOSE OF EVALUATING REMEDIAL ALTERNATIVES AT THE SUBJECT SITE. THE ACTUAL DESIGN ELEVATIONS, DIMENSIONS, AND OTHER ENGINEERING ASPECTS OF THE SELECTED REMEDY WILL BE DEVELOPED DURING REMEDIAL DESIGN.

0 30 60 90 120
SCALE IN FEET

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HARBOR AT HASTINGS SITE
SUPPLEMENTAL FEASIBILITY STUDY FOR OU-2
HASTINGS-ON-HUDSON, NEW YORK

NORTHWEST CORNER
ALTERNATIVE NW-2 OPTION B
PLAN VIEW

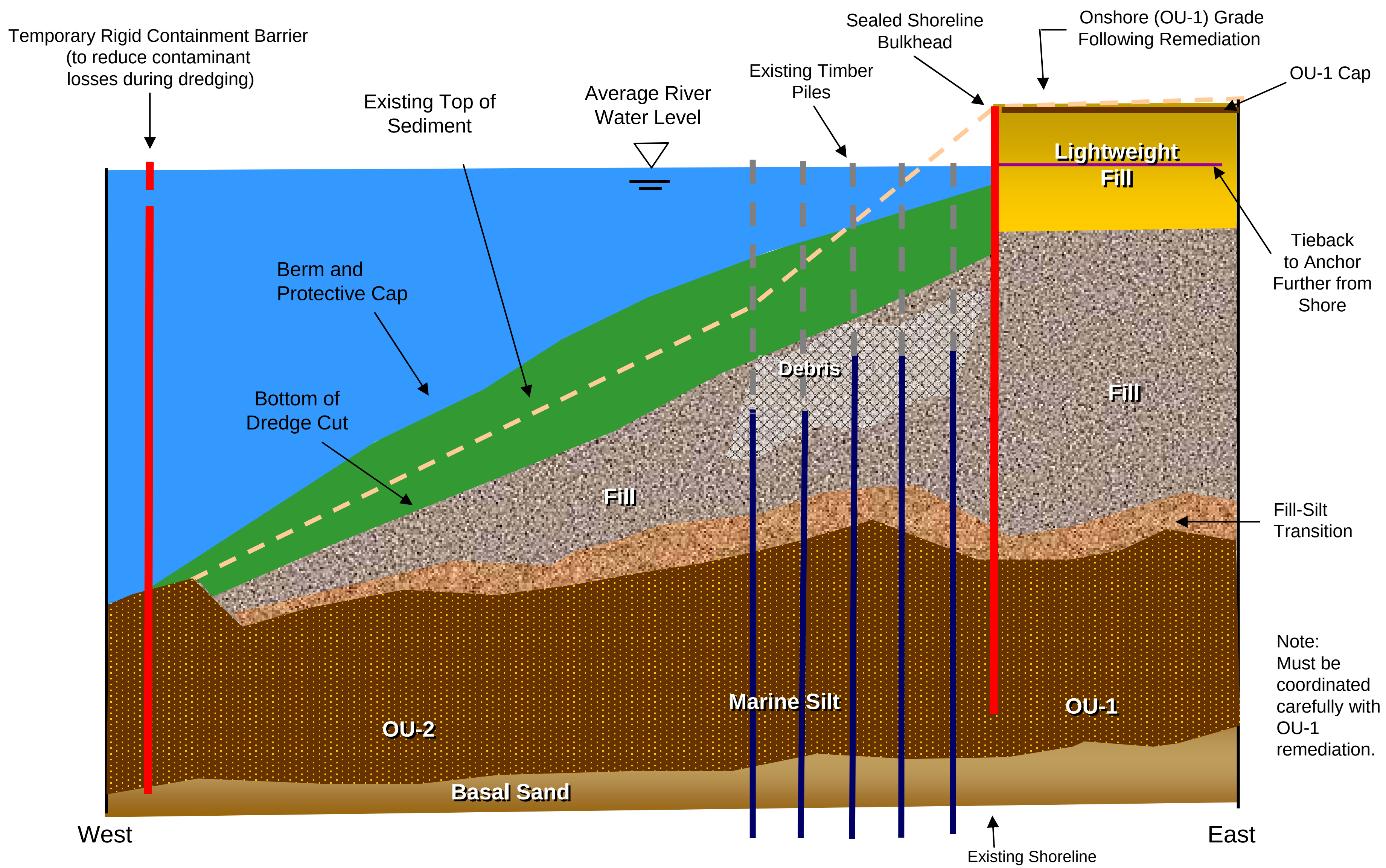
SCALE: AS SHOWN

18 APRIL 2006

28612-010 D133

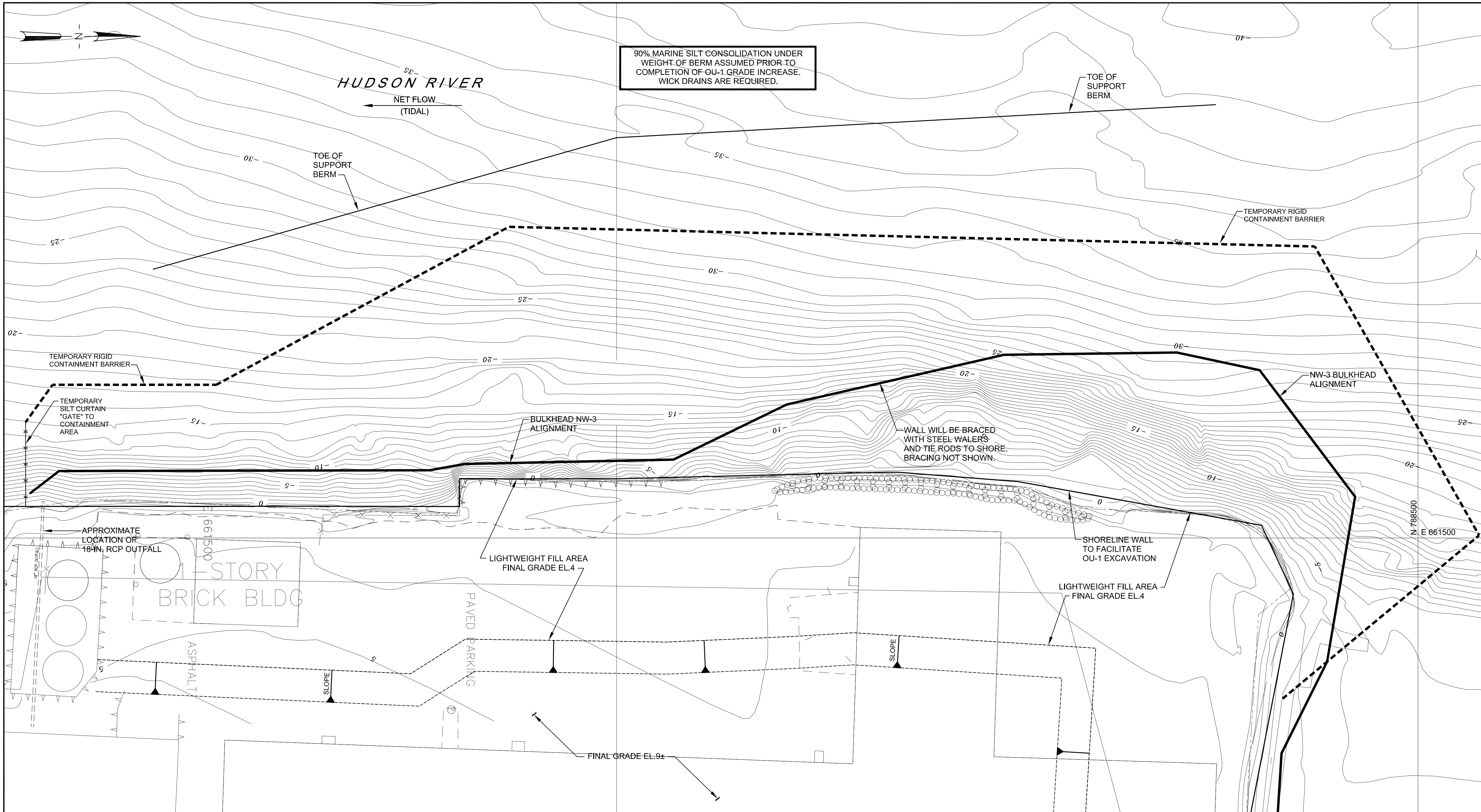
FIGURE 3.4

Figure 3.5
Harbor at Hastings OU-2
Typical Cross Section for Alternative NW-2: Dredge to Limits of Bulkhead Stability



Section View Perpendicular to Shoreline

(not to scale)



NOTES:

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3. CALCULATIONS WERE PERFORMED AT SELECT SECTIONS AND EXTRAPOLATED TO OTHER SECTIONS.
4. 90% MARINE SILT CONSOLIDATION UNDER WEIGHT OF BERM ASSUMED PRIOR TO COMPLETION OF OU-1 GRADE INCREASE. WICK DRAINS ARE REQUIRED.
5. DREDGE CUT ASSUMED FOR GEOTECHNICAL CALCULATIONS IS SHOWN ON BOTH THE PLAN AND SECTION VIEW DRAWINGS FOR THIS ALTERNATIVE. WHERE THE DREDGE CUT BASED ON ENVIRONMENTAL DATA (FIGURES 1.3 AND 1.4) WOULD BE LESS THAN THE DREDGE CUT ASSUMED IN THE GEOTECHNICAL CALCULATIONS, THE ENVIRONMENTAL DREDGE CUT IS ALSO SHOWN ON THE SECTION VIEW DRAWINGS FOR THIS ALTERNATIVE.
6. ALL ENGINEERING ELEMENTS PROVIDED ON THIS PLAN WERE DEVELOPED BASED ON EXISTING INFORMATION FOR THE PURPOSE OF EVALUATING REMEDIAL ALTERNATIVES AT THE SUBJECT SITE. THE ACTUAL DESIGN ELEVATIONS, DIMENSIONS, AND OTHER ENGINEERING ASPECTS OF THE SELECTED REMEDY WILL BE DEVELOPED DURING REMEDIAL DESIGN.

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UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

HARBOR AT HASTINGS SITE
SUPPLEMENTAL FEASIBILITY STUDY FOR OU-2
HASTINGS-ON-HUDSON, NEW YORK

NORTHWEST CORNER AREA
ALTERNATIVE NW-3
ALIGNMENT OF STRUCTURAL WALLS

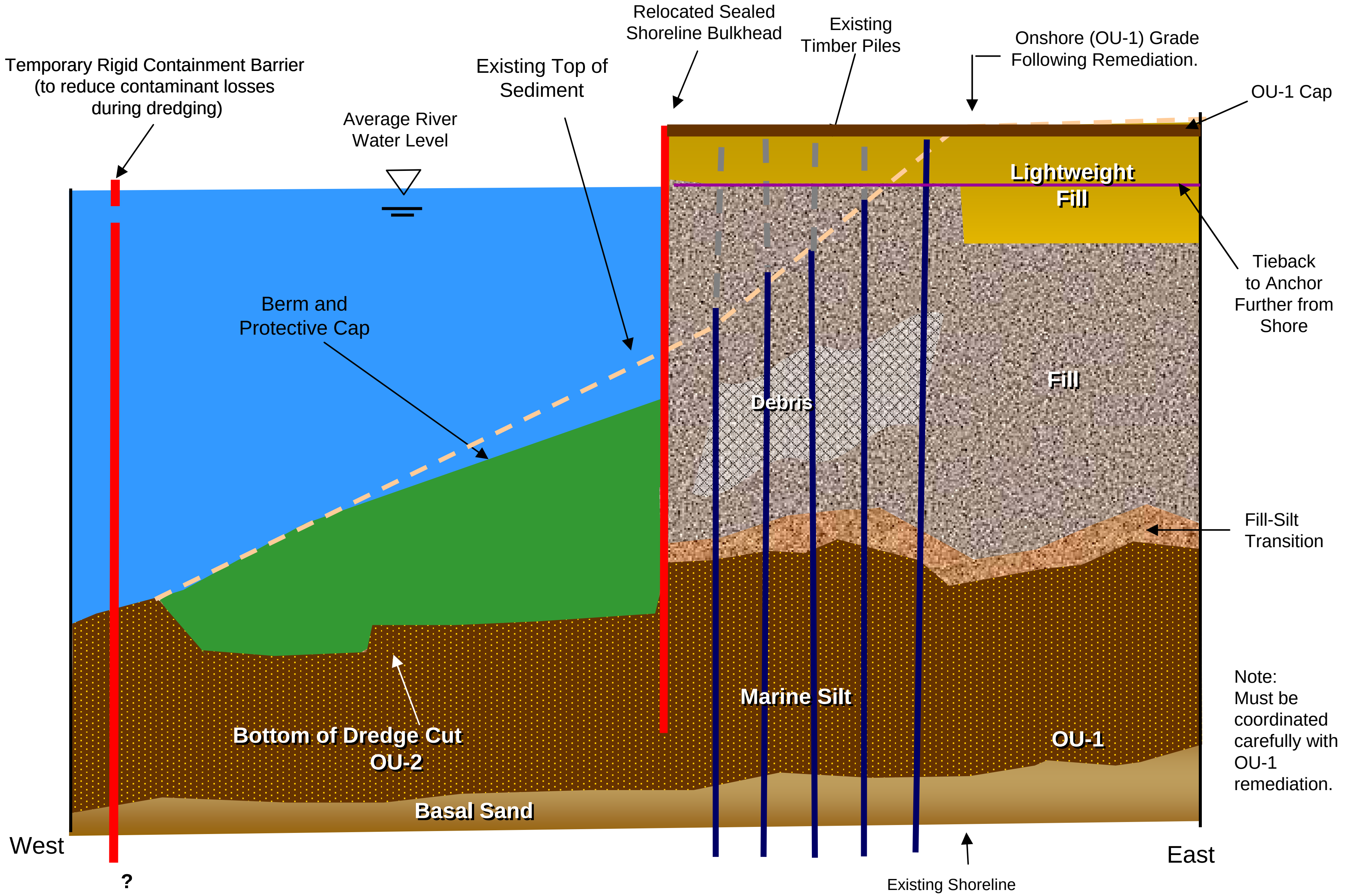
SCALE: AS SHOWN

18 APRIL 2006

28612-010 D134

FIGURE 3.6

Figure 3.7
Harbor at Hastings OU-2
Typical Cross Section for Alternative NW-3: Redivision of OU-1 and OU-2



Section View Perpendicular to Shoreline

(not to scale)

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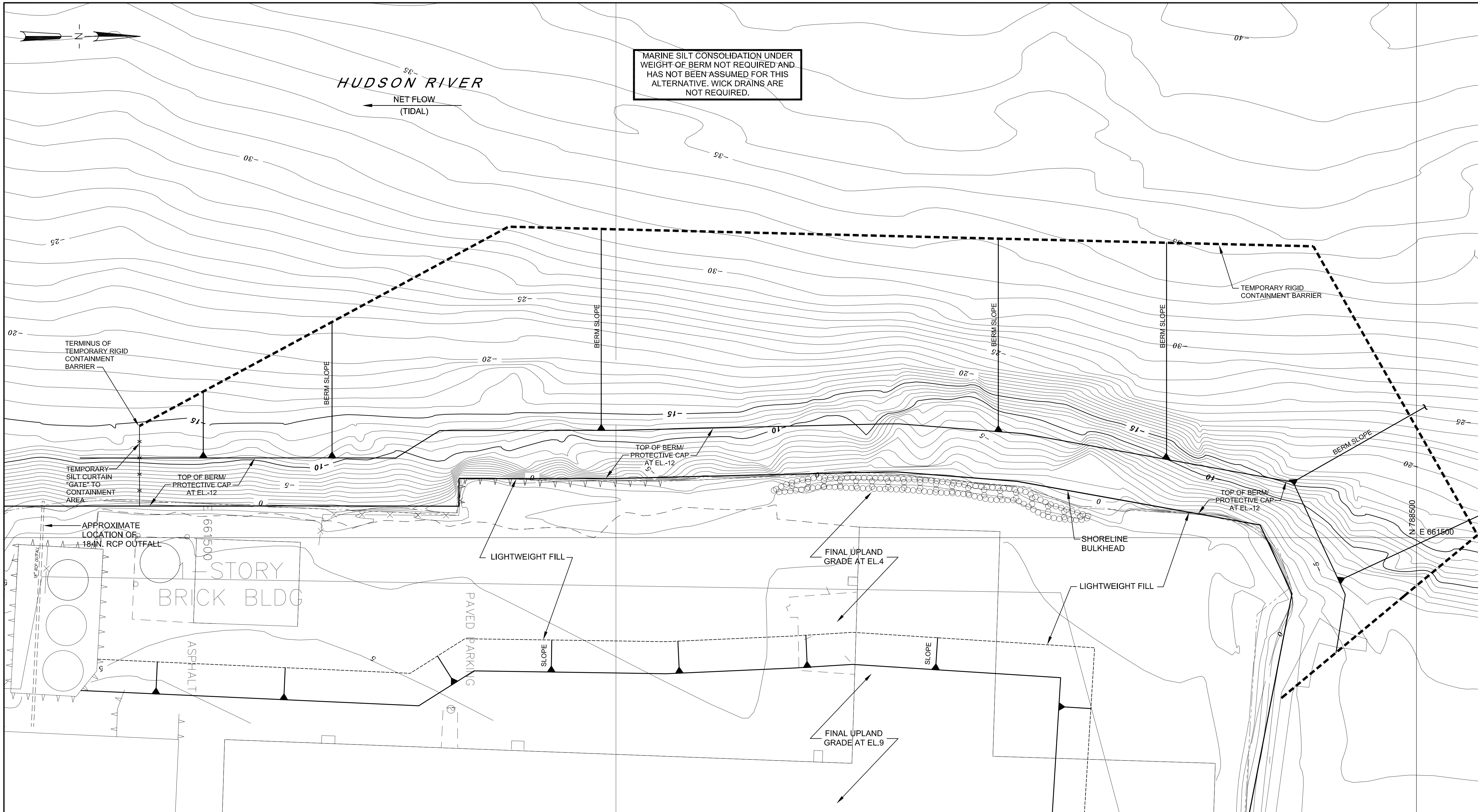


NOTES:

1. DRAWING BASED ON NAVD 88 DATUM. TO CONVERT FROM NAVD88 TO NGVD29 DATUM ADD ONE FOOT TO NAVD88 ELEVATIONS. PLAN BASED ON NEW YORK 1988 STATE PLANE COORDINATE SYSTEM.
2. SOIL PROFILES SHOWN IN SECTION VIEW REFLECT TYPICAL CONDITIONS IN THE VICINITY OF THE SECTION CUT. THE SOIL PROFILES ARE SIMPLIFIED AS NECESSARY FOR USE IN THE ENGINEERING ASSESSMENT OF REMEDIAL ACTION ALTERNATIVES.
3. APPROXIMATE FINAL BERM CONFIGURATION FOR THIS ALTERNATIVE IS SHOWN ON THIS FIGURE. THE DREDGE CUT IS NOT SHOWN.
4. CALCULATIONS WERE PERFORMED AT SELECT SECTIONS AND EXTRAPOLATED TO OTHER SECTIONS.
5. MARINE SILT CONSOLIDATION UNDER WEIGHT OF BERM NOT REQUIRED AND HAS NOT BEEN ASSUMED FOR THIS ALTERNATIVE. WICK DRAINS ARE NOT REQUIRED.
6. ALL ENGINEERING ELEMENTS PROVIDED ON THIS PLAN WERE DEVELOPED BASED ON EXISTING INFORMATION FOR THE PURPOSE OF EVALUATING REMEDIAL ALTERNATIVES AT THE SUBJECT SITE. THE ACTUAL DESIGN ELEVATIONS, DIMENSIONS, AND OTHER ENGINEERING ASPECTS OF THE SELECTED REMEDY WILL BE DEVELOPED DURING REMEDIAL DESIGN.

0 30 60 90 120
SCALE IN FEET

HALEY & ALDRICH
UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

HARBOR AT HASTINGS SITE
SUPPLEMENTAL FEASIBILITY STUDY FOR OU-2
HASTINGS-ON-HUDSON, NEW YORK

NORTHWEST CORNER AREA
ALTERNATIVE NW-4
PLAN VIEW

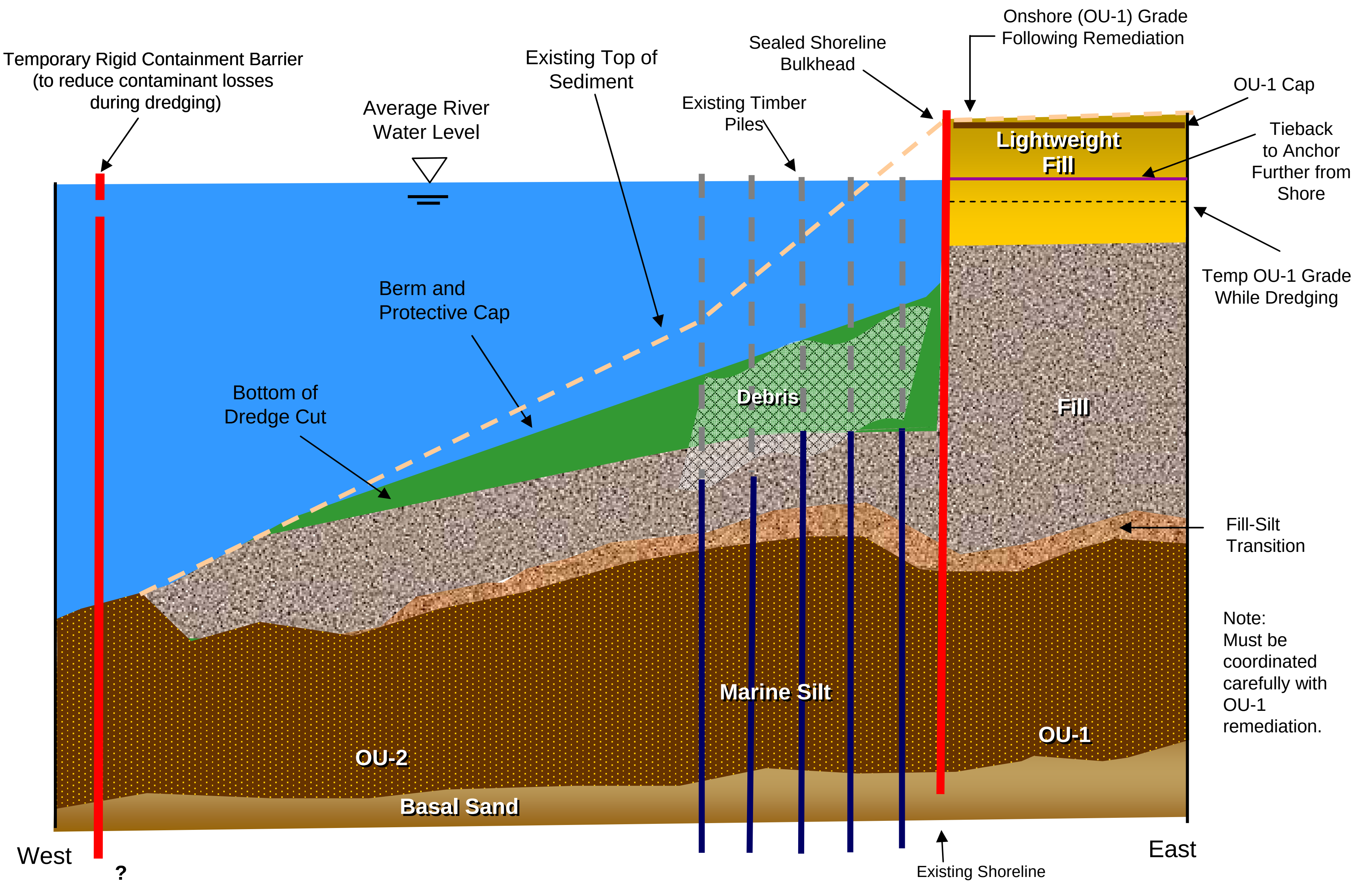
SCALE: AS SHOWN

18 APRIL 2006

28612-010 D135

FIGURE 3.8

Figure 3.9
Harbor at Hastings OU-2
Typical Cross Section for Alternative NW-4: Penetrate Shoreline Bulkhead Into Basal Sand



Section View Perpendicular to Shoreline

(not to scale)

SECTION 4

EVALUATION OF REMEDIAL ACTION ALTERNATIVES FOR THE NORTHWEST CORNER AREA

Remedial action alternatives for the Northwest Corner Area presented in Section 3 are evaluated in this section based on the evaluation criteria presented in Part 375 (Subpart 1) in Title 6 of the New York Code of Rules and Regulations and in the National Contingency Plan (Title 40 of the Code of Federal Regulations Part 300.430). NYSDEC and USEPA have provided direction for evaluating these criteria in Technical and Guidance Memorandum 4030: *Selection of Remedial Actions at Inactive Hazardous Waste Sites* (NYSDEC, 1990) and in *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (USEPA, 1988). These nine evaluation criteria have been segmented by USEPA into three types of criteria as follows:

Threshold Criteria

- Overall protection of human health and the environment
- Compliance with applicable or relevant and appropriate requirements (called standards, criteria, and guidelines in New York State)

Primary Balancing Criteria

- Short-term effectiveness
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, and volume through treatment
- Implementability
- Cost

Modifying Criteria

- State acceptance
- Community acceptance

An alternative must meet the two threshold criteria presented above to be carried through the detailed analysis of alternatives. If the two threshold criteria are met, the primary balancing criteria are evaluated as the basis for selecting the preferred remedy among the alternatives. The two modifying criteria, state acceptance and community acceptance, will be addressed as a follow-up to this Supplemental FS Report. State acceptance will be presented in the upcoming proposed remedial action plan, also called the proposed plan, and in the upcoming Record of Decision for OU-2, both of which will be prepared by NYSDEC. Community acceptance will be assessed in the responsiveness summary portion of the upcoming Record of Decision based on the public's response to the alternatives described in this Supplemental FS report and in the upcoming proposed plan.

In addition, further consideration is given in the National Contingency Plan to "practicable" remediation. For OU-2, remedial action objectives were presented initially in the 2003 FS and incorporated into the 2003 Proposed Plan (see Section 1.7). These objectives (or goals) are to be met to the extent practicable. As the term "practicable" is not specifically defined in the National Contingency Plan, the term must be understood on a site-specific and fact-specific basis. For OU-2, the "practicability" of various remedial alternatives is assessed in these evaluation sections on the basis of short-term and long-term impacts, implementability, cost effectiveness, and the extent of compliance with standards, criteria, and guidelines.

This remedy will also be selected under New York law, which states that the goal of remediation is to restore a site to "pre-disposal conditions, to the extent feasible and authorized by law." 6 NYCRR 375-1.10(b). A "feasible remedy" is defined as one that: (a) is "suitable to site conditions;" (b) can be "successfully carried out with available technology;" and (c) considers "cost-effectiveness." 6 NYCRR 375-1.10(c)(6). All three factors must be considered when setting remedial action goals for the site.

NYSDEC has set a remedial action goal of 1 ppm for PCBs in sediments in the lower Hudson River, and this Supplemental Feasibility Study adopts the same goal. Sediments throughout the region reportedly contain background concentrations of 1 to 1.2 ppm PCBs released from many other sources up and down stream from Hastings OU-2. It would be futile to try to establish and maintain sediment levels below background in a few acres of the lower river, where OU-2 is located, when surrounding sources of contamination in this 300 mile long river system would quickly recontaminate the area.

NYSDEC proposed a remedial action goal of 88.7 ppm for copper in sediments at OU-2, based on reported background levels of copper in lower Hudson River sediments. Copper above that level was found throughout the fill material used to build the plant site that forms OU-1, and the river berm that supports it in OU-2, and substantially higher levels of copper were also found in the fill material used to create the Tappan Terminal next door. Copper appears to be a component of the ash, slag, and/or other materials used as fill from the mid-1800's to early 1900's. To completely remove this level of copper from the fill material with available technology, one would have to remove the fill itself.

Site conditions are not suited to a remedy that completely removes fill material from the river. There is a berm of fill material in the river that supports both the OU-1 and Tappan Terminal land masses, and removal of the deeper fill layers is likely to cause the shoreline to collapse, releasing higher levels of on-shore contamination into the river (see Section 2.1.4.2). Even if the risk of collapse could be controlled, there is no need to remove fill material with low levels of copper in it, as site-specific tests show that copper at the 88.7 ppm level is not bioavailable or harmful (See Appendices C and D).

This Supplemental Feasibility Study proposes an alternative remedial action goal of 982 ppm copper, because higher levels of copper may be bioavailable to, and therefore may have an adverse impact on, aquatic life at this site. Recent guidance from US EPA (2005b) provides a rigorous methodology for assessing the factors that limit the bioavailability and toxicity of metals. This USEPA ESB guidance recognizes the importance of acid volatile sulfides (AVS) and total organic carbon (TOC) in sequestering or binding up metals in sediments, thereby limiting their introduction into porewater, which is the primary route of exposure for benthic organisms. This USEPA guidance also establishes a scientific method for evaluating the bioavailability and toxicity of metals in sediments, including a detailed methodology for quantitatively assessing the metal binding capacity of sediments.

Site-specific AVS, TOC and metal porewater data were gathered after the OU-2 Proposed Plan was issued in 2003. AR conducted supplemental sediment investigations at OU-2 during 2004 and 2005 to fill data gaps and allow the site-specific bioavailability and toxicity of metals to be evaluated based on the methods presented in the USEPA (2005b) ESB guidance. The results of that analysis are summarized in Section 1 and presented in more detail in Appendix C, to show that a copper concentration of 982 ppm is a conservative, site-specific, no observed adverse effects sediment concentration that is a suitable proposed remedial goal (PRG) for OU-2. This proposed PRG for copper, and proposed PRGs for lead, nickel and zinc based on the same ESB methodology, are well below the toxicity threshold identified in the USEPA (2005b) ESB guidance.

The evaluation of remedial action alternatives for the Northwest Corner Area is presented in Table 4.1 where the NYSDEC evaluation criteria are assessed separately for each alternative. This evaluation is summarized below.

4.1 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT (A THRESHOLD CRITERIA)

This criterion addresses whether or not an alternative provides adequate protection against ongoing risks. Current, ongoing potential risks have been identified in the Remedial Investigation Report for OU-2 (Earth Tech, 2000). The remedial action objectives have as their goal the protection of human health and the environment. The PRGs for OU-2 sediment of 1 ppm for PCBs and 982 ppm PRG proposed for copper have been established to meet the remedial action objectives (see Section 1.7 and the introduction to this section). Evaluating the degree to which sediment exceeding PRGs would no longer be in contact with fish and other forms of aquatic life is the primary factor for determining whether an alternative can meet the threshold criteria called protection of human health and the environment and also meet the remedial action objectives for OU-2.

4.1.1 Evaluation of Overall Protection of Human Health and the Environment Common to All Northwest Corner Area Alternatives

All of the remedial action alternatives for the Northwest Corner Area would be protective of human health and the environment in the long term except Alternative NW-4 due to penetration of the shoreline bulkhead into the basal sand. Installation of the shoreline bulkhead into the basal sand would likely provide a preferential pathway for downward PCB migration by creating new openings along the support structure-soil interface. DNAPL layers are typified by extremely heterogeneous distributions and unpredictable transport pathways. A small amount of DNAPL in the subsurface may be virtually impossible to locate and still lead to widespread and long-lasting plumes. Based on DNAPL flow mechanics, the PCB DNAPL at OU-1 is in a state of equilibrium held at its current location because the downward (gravitational) forces of the DNAPL fluid cannot overcome the pore entry pressures of the marine silt. Remobilization of PCB DNAPL is not expected to occur unless this equilibrium is disturbed. As discussed in the OU-1 Feasibility Study (Shaw Environmental and Haley & Aldrich Inc., September, 2002) and in Section 2.1.4.2 herein, two equilibrium disruptors that have the potential to remobilize DNAPL and thereby potentially cause contamination of the basal sand are:

1. A change in the porosity/permeability of the marine silt; and
2. Creation of preferred flow pathways by driving bulkhead sheeting and support piles through the marine silt layer, piercing into the basal sand aquifer below.

All four of the remedial action alternatives for the Northwest Corner Area would require placement of a cap following dredging. Direct exposures of fish and other local aquatic life to Northwest Corner Area sediment that exceeds PRGs for OU-2 would be eliminated over the long term through capping. As a result, long-term impacts to human health from site sediment through fish consumption and sediment contact and long-term impacts to aquatic life would be eliminated.

Capping at the Northwest Corner Area can effectively protect human health and the environment over the long term. A protective cap has been employed successfully at many other sediment sites with the objectives of physical isolation, stability-erosion protection, chemical isolation, and restoration of aquatic habitat temporarily lost due to dredging. As discussed in Section 2.2, in addition to physical isolation, habitat restoration would be provided in the top of a cap consisting of natural media that would support benthic organisms. A protective cap would provide stability and erosion protection against wind-wave scour and boat propeller wash, with a reasonable cap material particle diameter of less than 1 inch in the Northwest Corner Area away from the shoreline (see the analysis summarized in Section 2.2.2). Close to the shoreline, larger diameter cap material, as is currently in use at OU-2, would be placed to protect against potential shoreline impacts from ice. The third layer of a protective cap for chemical isolation would protect against possible PCB movement upward through porewater. Modeling has been completed in association with Professor Danny Reible of the University of Texas at Austin as part of this Supplemental FS to assess whether a cap can provide adequate chemical isolation at OU-2 (see Section 2.2.3). Results from the modeling of chemical isolation show that any soluble PCBs at OU-2 would not be able to migrate upward through a cap designed and installed to control chemical movement. Porewater transport of metals through a cap is not a concern at this site because, none of the porewater analyses completed on samples from OU-2 show metals in porewater above NYS saltwater quality standards for metals. An engineered cap would eliminate long-term exposure of sediment in the Northwest Corner Area to benthic organisms and to aquatic life.

A protective cap can be placed effectively at OU-2 using one of multiple available placement techniques discussed in Section 2.2.7. A protective cap can also be effectively monitored and maintained, and institutional controls can be implemented, such as an environmental easement, to assure the cap remains protective over the long term.

Dredging would remove contaminated sediment from the river, however due to the concentrations of PCBs in the sediment and the inability to remove 100 percent of the affected sediments, dredging would not reduce long-term risks or provide additional long-term protection of human health and the environment beyond the protection provided by capping. Residual contamination would remain in river sediment following dredging, because dredging efficiency is less than 100 percent as discussed in Section 2.1.1 and because fine-grained contaminated sediment present at OU-2 settles slowly following dredging. A typical residual fraction of sediment mass resuspended due to dredging is 4 percent in an area with significant debris to be removed and side slopes, such as the Northwest Corner Area, based on information available from completed environmental dredging projects (SMWG, 2005).

Dredging and capping would disrupt the river bottom and the associated benthic community. However, by placing a top layer of a protective cap as presented in Section 2.2, benthic organisms are expected to recolonize the habitat surface layer of the cap (see Section 2.2) within 2 to 4 months during the biologically productive time of the year (i.e., April through November at this site) (Dernie, 2003). As most of the aquatic biota lives within the top 3 to 6 inches of sediment, the lower erosion protection layer of the cap would prevent the biota from contacting contaminated sediment. Since OU-2 is known to accumulate sediment, the gradual natural deposition of native materials will also support restoration of local aquatic habitat following construction.

4.1.2 Comparative Evaluation of Overall Protection of Human Health and the Environment Among Northwest Corner Area Alternatives

Dredging would result in resuspension of sediment which would adversely impact river water quality in the short term, primarily within the river area inside the rigid temporary containment barrier. As shown in Table 4.2, masses of PCBs resuspended into the river water column inside the temporary rigid containment barrier for each of the four Northwest Corner Area alternatives are estimated to be as follows, based on estimates of total PCB mass from AR's contaminant distribution model results: approximately 700 pounds under Alternative NW-1; 800 pounds for Option A and 900 pounds for Option B under Alternative NW-2; 10 pounds under Alternative NW-3; and 1,100 pounds under Alternative NW-4. Under Alternative NW-3, significant debris-laden sediment near the shoreline would be contained and not dredged, thereby resulting in a lower percentage of dredged sediment (approximately 1 to 2 percent) becoming resuspended compared to approximately 4 percent of the dredged sediment becoming resuspended under the other NW alternatives (see Section 2.1.3). Additionally, Alternative NW-3 would be constructed in a manner that would place the remaining (undredged) PCBs within the sealed OU-1 upland area.

Resuspended sediment would be released to the river beyond the temporary rigid containment barrier in the short term as part of removing debris and obstructions and dredging. Some release to the river beyond the temporary barrier would adversely impact water quality in the short term and is unavoidable due to tidal forces changing the river water level, hydrodynamic forces on the temporary barrier, and the expected slow settling rate for resuspended OU-2 sediment (see Section 2.l). One goal while removing debris and obstructions and dredging would be to control these releases as practicable to meet a far-field point of water quality compliance guideline to be established by NYSDEC. The water quality point of compliance during dredging at other New York State PCB dredging sites has been a PCB water concentration of 2 micrograms per liter (or 2 parts per billion) at a location one mile from dredging operations. Adverse impacts of resuspended sediment on river water quality would be greater if dredging time is longer, PCB concentrations are greater, and/or a greater volume of debris needs to be removed. Impacts from resuspended sediment would be less adverse under Alternative NW-3 than under the other Northwest Corner Area alternatives followed by Alternative NW-1, based on less mass of PCBs being resuspended and a relatively short anticipated dredging duration of approximately 2 months (see Table 4.2). Because sediment dredged as part of Alternative NW-3 is further from shore and less impacted, residual sediment PCB concentrations prior to capping would also be lower under Alternative NW-3 than under the other Northwest Corner Area alternatives. Resuspension would be less under Alternative NW-1 than under Alternative NW-2 or NW-4, because less sediment would be dredged, and less debris would need to be removed over a smaller surface area of the Northwest Corner Area.

The use of wick drains (or other consolidation devices), if needed as part of Alternative NW-3 to consolidate berm material placed in the river, would provide a short-term pathway for soluble PCBs and metals to migrate upward into the water column. However, the excess water would drain eventually, and dredging as part of Alternative NW-3 would be conducted further from shore than for the other Northwest Corner Area alternatives and residual concentrations would be limited to approximately 2 percent of the sediment PCB mass that could not be dredged, so residual sediment PCB concentrations would be lower than closer to shore. In addition, site investigation results show metal concentrations measured in porewater from a wide range of sediment metal concentrations do not exceed water quality standards, criteria or guidelines.

Groundwater quality would in all likelihood be adversely impacted from implementing Alternative NW-4, because PCBs could reach the underlying basal sand aquifer due to driving the shoreline bulkhead into the basal sand. The purpose of driving the shoreline bulkhead into the basal sand under this alternative would be to allow contaminated sediment to be removed from greater depths below in the mudline. However, the state groundwater quality standard for PCBs is 0.09 parts per billion, and only a very small quantity of PCBs would need to reach the basal sand aquifer to exceed the state groundwater quality standard for PCBs.

Similarly, for many years, USEPA and other agencies have advised parties to stop drilling monitoring wells when a low permeability unit like the marine silt is encountered in areas containing DNAPL, to avoid piercing through the confining layer and creating a pathway for PCBs to migrate into deeper units below (e.g., USEPA, 1992 and 1994). Note that this USEPA guidance concerns the impact of drilling a monitoring well, which is less than the impact of installing steel sheeting and piles, because the bulkhead along the Northwest Corner Area will be much longer than the circumference of a monitoring well.

USEPA's guidance "DNAPL Site Evaluation" (USEPA, 1993a) reiterated at greater length the Agency's concerns about not creating vertical pathways through the confining layer via drilling, and provided guidance for remedial actions, including the installation of underground containment walls. "Small fractures or openings will facilitate DNAPL breakthrough. The long-term integrity of engineered subsurface barriers is not well known. Consideration must be given to the compatibility of barrier wall materials with subsurface chemicals, the potential for inducing migration during wall construction, and changes to the hydrogeologic system affected by wall emplacement." Also in 1993, the USEPA reiterated these concerns about preserving the integrity of the confining layer, noting that DNAPLs can penetrate features as narrow as 10 microns. "Evaluation of the Likelihood of DNAPL Presence at NPL Sites" (USEPA, 1993b). This document directed that clay and silt units "should be assumed to permit downward migration of DNAPL through fractures unless otherwise proven in the field". It continues by noting that this can be exceptionally hard to prove otherwise, even with intensive site investigation (USEPA, 1993b).

The proposed sealed shoreline bulkhead would artificially create such a "fracture" along the entire west (downgradient) side of OU-1, if constructed through the marine silt into the underlying basal sand. Recent geotechnical boring data at OU-1 also suggest that a more substantial shoreline bulkhead may be needed under Alternative NW-4, including H-piles, which are even more likely to drag obstructions and contaminated soils down into the basal sand layer when driven on site. Soil has a tendency to plug in the corners of H-piles and to travel downward with the piles when the piles are driven. In addition to potential contaminant drag-down, H-piles have the potential to form voids along pile corners during installation, and these voids can be enlarged through piping caused by the upward flow of groundwater from artesian conditions in the basal sands. These enlarged voids would create the potential for more NAPL migration along this enlarged pathway.

4.2 COMPLIANCE WITH STANDARDS, CRITERIA, AND GUIDELINES (A THRESHOLD CRITERIA)

Water quality standards, performance requirements (such as requirements for managing dredged contaminated sediment), and other substantive environmental protection requirements, criteria, or limitations that specifically address a contaminant, remedial action, or location must be met in order for an alternative to satisfy this threshold evaluation criterion. These standards, criteria and guidelines are based on state or federal environmental laws. The State of New York refers to these requirements as standards, criteria and guidelines in lieu of the federal CERCLA term, applicable or relevant and appropriate requirements, used in the National Contingency Plan. These standards, criteria, and guidelines can be categorized as chemical-specific, action-specific, and location-specific as discussed below.

4.2.1 Evaluation of Compliance with Standards, Criteria and Guidelines Common to All Northwest Corner Area Alternatives

The PRG of 1 ppm for PCBs and the proposed PRG of 982 ppm for copper would be met to the extent practicable for each of the Northwest Corner alternatives as a result of capping. Sediment exceeding 1 ppm PCBs and the proposed copper PRG of 982 ppm would no longer be in contact with aquatic life in the river at OU-2 for each of the Northwest Corner Area alternatives as a result of capping. Sediment less than 1 ppm PCB and 982 ppm copper in contact with aquatic life would also be less than PRGs proposed for other metals in OU-2 sediment. As described in Section 1.7, impacts from other metals in sediment of potential concern at this site (lead, nickel, and zinc) would be addressed at OU-2 by addressing sediment with copper over 982 ppm.

Other chemical-specific requirements associated with each of the remedial action alternatives can be met including discharge limits for water removed from dredged sediment and PCB limits for managing sediment at particular offsite facilities. Water treatment technologies have been used at other PCB-impacted sites to meet anticipated NYSDEC discharge limits for PCBs in water, so such discharge limits are most likely achievable. Dredged sediment stockpiles shown to contain over 50 ppm PCBs would be shipped to a TSCA-approved facility.

Water quality would be monitored while removing debris and obstructions and dredging. Monitoring results would be compared with the short-term, far-field water quality guidelines to be established by NYSDEC. Dredging operations would be adjusted to the extent practicable to control impacts on water quality outside the contained dredging area. Exceedances of short-term guidelines are possible while debris is being removed and while dredging is ongoing. While the mass of PCBs resuspended into the water can be estimated, water quality during removal of debris and obstructions and during dredging operations cannot be predicted at this time given the complex nature of sediment transport and water circulation in the lower Hudson River and given the sediment PCB concentration variations within OU-2. The state water quality guidelines for short-term far-field water quality compliance would be met to the extent practicable.

Action-specific standards, criteria and guidelines include requirements associated with a particular portion of a remediation effort, such as managing dredged sediment in accordance with federal and state dredge and fill requirements and federal and state waste management rules and regulations. The primary action-specific SCGs applicable to remediating OU-2 are Article 15 of the New York State Environmental Conservation Law (Use and Protection of Waters), Section 404 of the Federal Clean Water Act, Section 10 of the Federal Rivers and Harbor Act, and State and Federal Waste Management Regulations under the RCRA and the portion of the TSCA pertaining to PCBs. In addition, NYSDEC can establish short-term water quality guidelines associated with sediment resuspended in the river due to dredging. At other dredge sites, and as discussed in Section 2.1.3.3, the State of New York has established 2 micrograms per liter PCBs as a short-term water quality guideline to be met one mile away from the dredging activity. Other state requirements, such as a water quality certification, a coastal consistency certification, and chemical-specific water discharge limits while processing dredged sediment, would also need to be met as part of implementing the preferred remedial action alternative. Requirements to assess the environmental impacts of dredging and filling at OU-2 are addressed by the combination of the 2003 OU-2 FS Report and this Supplemental FS Report.

The effect of residual contaminated sediment, which is unavoidable following dredging as discussed in Section 2.1, and the need for physically stabilizing the shoreline bulkhead, would both result in the need to place a berm and protective cap as part of all four Northwest Corner Area alternatives. Article 15 of the New York State Environmental Conservation Law (implemented through Title 6 of the New York Code of Rules and Regulations Part 608) and Section 404 of the Federal Clean Water Act together regulate alterations to protected waters such as dredging and filling. For example, any change to water depths in a navigable waterway due to dredging and capping would need to be assessed by NYSDEC and by USACE for compliance with these regulations. From Part 608.5 of Title 6, a permit is required where a party desires to dredge and fill or place a cap over river sediments. NYSDEC would review any permit application and grant, conditionally grant, or deny the permit. A decision whether to grant the permit would be governed by whether: (a) the proposal is reasonable and necessary; (b) the proposal would not endanger the health, safety or welfare of the people of the State of New York; and (c) the proposal would not cause unreasonable, uncontrolled or unnecessary damage to the natural resources of the state. NYSDEC and USACE have demonstrated a reluctance to approve dredge and fill activities that involve losses in water depth if alternatives are available that would eliminate or reduce loss of water depth. Similarly, use guidelines under Title 6 of the New York State Code of Rules and Regulations Part 661 indicate filling of a portion of a tidal body of water where the water depth is less than 6 ft at mean low tide is a "presumptively incompatible use" that should not be undertaken unless suitable mitigation is provided in the form of enhancing or creating new water habitat to replace habitat lost as a result of remediation. The only alternative that would require some filling of the river near the existing shoreline where the mean low-tide water depth is less than 6 ft is Alternative NW-3. All of the other Northwest Corner Area alternatives include sufficient dredging near the shoreline so as to minimize net infilling of the river at low-tide water depths less than 6 ft.

Overall hydraulic effects of dredging and filling both in the river near shore and on land at OU-1 (within the 100-year floodplain) constitute one aspect of the dredge and fill regulations under Article 15 of the State Environmental Conservation Law and Section 404 of the Federal Clean Water Act that would need to be further evaluated during remedial design. However, hydraulic effects would most likely be minor under any of the remedial action alternatives evaluated in this report due to the small area and small mudline or land surface elevation change being considered in comparison to the overall area and volume of the lower Hudson River (see Table 4.3).

Requirements for managing dredged sediment onshore are primarily federal requirements under RCRA and TSCA, state requirements based on RCRA (primarily implemented through Title 6 of the NY Code of Rules and Regulations Parts 360 and 375), and state provisions for beneficially reusing dredged sediment onshore at OU-1 as fill needed to raise the ground surface. RCRA requirements pertain to offsite transport and containment of material such as dredged sediment at a permitted facility. Dredged sediment with over 50 ppm PCBs would need to be contained at a TSCA-permitted facility, and the nearest such facility with rail access is in Michigan. Otherwise, dredged sediment can be effectively contained offsite at a permitted facility approved to receive non-hazardous solids. Copper or other metal concentrations in OU-2 sediment are not hazardous as defined under RCRA and corresponding state regulations.

Superfund requirements include a need to review the status of a remedy every five years if media exceeding PRGs are left in place. All four of the Northwest Corner Area alternatives would leave sediment exceeding PRGs capped in place, so a remedy review would be required every five years following the remedial action.

Location-specific standards, criteria and guidelines include and requirements from Westchester County and requirements contained within the Village Code for Hastings-on-Hudson. The only potentially applicable Westchester County requirements identified are associated with conveying treated water from dredge water treatment operations to the Westchester County sewer system if the treated water could not be discharged from the site. However for this Supplemental FS, one assumption is that dredge water would be treated and returned to the river at the site in accordance with state discharge requirements. With this assumption, the Westchester County sewer system requirements would not be applicable. Section 217 of the Village Code includes limitations on construction noise. For purposes of construction, the Village Code does not appear to limit the extent of construction noise as long as construction is restricted to the normal working times specified in the Village Code (7:30 AM to 8:00 PM each Monday through Saturday and 10:00 AM to 5:00 PM each Sunday). Alternative NW-4 is anticipated to result in more noise than the other Northwest Corner Area alternatives, because the shoreline bulkhead would take longer to install to its deeper depth and over two times more dredging would be conducted.

4.2.2 Comparative Evaluation of Compliance with Standards, Criteria and Guidelines Among Northwest Corner Area Alternatives

For the Northwest Corner Area, Alternatives NW-1, NW-2, and NW-3 would meet the standards, criteria, and guidelines associated with sediment remediation to the extent practicable. The only possible exception to meeting standards, criteria and guidelines would be short-term, far-field water quality guidelines to be established by NYSDEC to monitor effects of sediment resuspension while removing debris and obstructions and dredging. All sediment exceeding PRGs would not be able to be completely removed under any of the Northwest Corner Area alternatives except Alternative NW-3, where dredging would be conducted starting west of the current shoreline. With the exception of Alternative NW-3, additional dredging beyond dredging included as part of Alternative NW-1 would not improve compliance with standards, criteria, and guidelines because, in addition to unavoidable sediment residuals, some sediment exceeding PRGs would not be able to be dredged. As a result, capping following dredging would be needed as part of all four NW alternatives as discussed above in Section 4.1.

Short-term, far-field water quality guidelines to be established by NYSDEC for debris-obstruction removal and dredging operations would be met under all of the alternatives to the extent practicable. Alternatives NW-1 and NW-3 include less removal of debris and obstructions and a smaller dredge area over a shorter dredging time compared to the other Northwest Corner Area alternatives, which would result in less adverse impacts on short-term river water quality. Alternative NW-4 would result in the most removal of debris and obstructions and the most dredging and therefore, the most adverse short-term impact on surface water quality of any of the Northwest Corner Area alternatives.

Alternative NW-3 is unique in that it would allow all of the sediment exceeding PRGs inside the temporary rigid containment barrier to be dredged, because the dredge area would be beyond a new shoreline extended to the west of the existing shoreline. The precise alignment for the new shoreline bulkhead under Alternative NW-3 would be established during remedial design. Alternative NW-3 has been evaluated in this Supplemental FS based on a new shoreline alignment located approximately 40 to 100 ft west of the current shoreline, with the objective that all sediment exceeding PRGs would be targeted for dredging without jeopardizing shoreline stability. However, because the new shoreline bulkhead under Alternative NW-3 would be 40 to 100 ft west of the current shoreline, Alternative NW-3 would also result in losing approximately one acre of river habitat that would need to be replaced locally. Such replacement would need to be approved in advance by NYSDEC and by USACE. Fish and Wildlife Service within the US Department of the Interior could also play a role in approving any replacement site. One possible replacement option is presented in Sections 5 and 6 of this Supplemental FS and consists of moving the Southern Area shoreline along former Building 15 inland approximately 30 ft to minimize the need for a berm in the river to stabilize the shoreline (see Sections 5 and 6). The Southern Area shoreline along former Building 15 and the South Boat Slip is approximately

1,200 ft long, so moving the shoreline inland approximately 30 ft would create an equivalent area of new river habitat.

Alternatives NW-2 and NW-4 would require longer times to implement and would generate the largest quantities of sediment and water to manage as shown in Table 3.2. However, these factors are not anticipated to significantly affect compliance with standards, criteria, and guidelines. Different extents of impacts due to longer implementation time and larger quantities of sediment and water to manage are instead primarily factors under short-term effectiveness.

As described in Section 4.1, there are significant questions and concerns about Alternative NW-4 being able to meet groundwater quality standards for PCBs. Penetrating the shoreline bulkhead into the basal sand means that the marine silt confining layer would be breached by the new shoreline bulkhead. This breaching of the marine silt would provide a pathway for PCBs to migrate vertically downward into the basal sand. Movement of PCBs into the basal sand would most likely exceed the state groundwater quality standard for PCBs given the low concentration of the water quality standard (0.09 parts per billion). Such a breach of a confining layer is not recommended by USEPA regulatory guidance (e.g., USEPA, 1992).

Based on this assessment of the Northwest Corner Area alternatives for overall protection of human health and the environment and for compliance with standards, criteria, and guidelines, Alternatives NW-1, NW-2, and NW-3 are expected to meet these threshold criteria and are therefore carried through the evaluation below for each of the five NYSDEC balancing criteria: short-term effectiveness, long-term effectiveness and permanence, reduction of toxicity-mobility-volume, implementability, and costs. Although Alternative NW-4 is likely to violate state groundwater quality standards, as well as federal guidelines and industry practices that prohibit the creation of pathways for NAPL to migrate through an aquitard to the aquifer below, Alternative NW-4 is also carried through this Supplemental Feasibility Study analysis to evaluate its ability to meet the five balancing criteria.

4.3 SHORT-TERM EFFECTIVENESS (A BALANCING CRITERIA)

Short-term effectiveness refers to the effects of an alternative on human health and the environment during the construction or implementation phase of a remedial action. The following elements are considered while evaluating the short-term effectiveness of each alternative: (a) protection of the community during remedial construction; (b) environmental impacts and impacts to site employees and remediation workers during remedial construction, (c) environmental monitoring to be performed while implementing the remedial alternative; (d) elapsed time until the remedial action objectives would be achieved; and (e) short-term impacts on the existing aquatic ecological community, particularly temporary habitat loss.

4.3.1 Evaluation of Short-Term Effectiveness Common to All Northwest Corner Area Alternatives

As indicated under protection of human health and the environment (Section 4.1), dredging and capping would physically disrupt the existing river bottom in the Northwest Corner Area in the short-term. As also noted in Section 4.1, this impact would be evident during the months while construction is ongoing plus 2 to 4 additional months from April through November for the aquatic habitat to restore itself naturally following capping (Dernie, 2003). However, habitat restoration following capping is part of each alternative to provide habitat similar to what was present prior to dredging (see Section 3.2).

Much of the sediment resuspended from the Northwest Corner Area while removing debris and obstructions and while dredging would be retained inside the rigid temporary containment barrier. However, the temporary barrier would not always be closed, since the temporary barrier would, at times, need to allow barges and support boats to pass through to transport materials, debris, dredged sediment and berm-cap materials to and from shore. Moreover, the water level inside and outside the barrier would need to be kept the same across the barrier by allowing some water to penetrate through the barrier; otherwise the barrier could not withstand the river's hydrodynamic forces. As a result, some contaminated sediment resuspended due to removing debris and obstructions and dredging would be expected to leave the area of the river enclosed by the temporary rigid containment barrier.

Settling tests conducted by AR with OU-2 sediment as described in Section 2.1 and the silty nature of the contaminated sediment both indicate that resuspended sediment would not fully settle to the river bottom between dredge shifts or tidal cycles. As a result, water quality would decline over the short term inside the temporary rigid containment barrier for the duration of a dredging effort. Unavoidable releases to the river outside the temporary rigid containment barrier would occur that would impair water quality as the removal of debris and obstructions and dredging efforts continue over multiple months. Releases outside the temporary barrier are unavoidable because of tidal fluctuations, the need to maintain the same water level inside and outside the temporary barrier, the unavoidable periodic discharges from a Westchester County permitted sanitary sewer overflow located approximately 60 ft south of the water tower into the Northwest Corner containment area, and the slow settling time of OU-2 sediment. Releases outside a contained area have occurred at other dredge sites. If such releases exceed the far-field water quality guidelines, dredging procedures may be able to be modified at OU-2 to reduce the short-term, far-field impact. Results from OU-2 dredge elutriate tests to date show relatively low PCB concentrations up to 0.3 micrograms per liter (or 0.3 parts per billion) in the water column (compared to a likely 2 micrograms per liter far-field water compliance concentration). However, available test results do not allow effects of resuspended sediment on water quality to be fully assessed at this time. Sediment from OU-2 tested by AR using the USACE dredge elutriate test procedure only contained up to 3 ppm PCBs. Furthermore, effects of cumulative sediment remaining in the water column following multiple days of dredging cannot be taken into account using the dredge elutriate test procedure. Additional tests with OU-2 sediment could be undertaken during remedial design if warranted to assess short-term impacts on water quality outside the barrier. PCBs are more of a water quality concern than metals because of lower water quality standards for PCBs and because site metal porewater concentrations and results from metal dredge elutriate tests with OU-2 sediment did not exceed water quality standards for metals.

Short-term impacts to the surrounding village would potentially include impacts of noise and traffic flow directly east of OU-1 along River Street, and possibly dust and odors. Noise impacts would be restricted by adhering to the requirements of Section 217 of the Village Code. Remedial operations beyond these time intervals would be limited to low noise tasks such as, for example, unloading sediments from a barge, processing dredged sediment on shore, treating water from dredged sediment**,** and other activities identified during remedial design. The activities with the most noise would likely be the hammering into place of the shoreline bulkhead and temporary rigid containment barrier early in the implementation phase. If, for example, the shoreline bulkhead and temporary rigid containment barrier are installed using vibratory hammers, the noise would be comparable to the noise from starting up a railroad engine. Use of an impact hammer, if needed, would result in large, intermittent noise bursts while the shoreline bulkhead and the temporary rigid containment barrier are being placed. Noise from this and other possible construction activities would be controlled as required in accordance with the Village Code. Similarly, lights at night can be limited to work areas along the shoreline and within OU-1, as needed to support low noise activities. Transport of dredged sediment and fill from and to OU-2 would take place by truck, rail or by barge, and the impact of transportation on village traffic will be considered when selecting the method of transport. The only traffic anticipated once construction equipment is at the site would be from remediation workers and visitors. Dust can be controlled by wetting the sediment processing area at OU-1, or by placing dry sediments inside containers or a shelter constructed to prevent contaminated dust from migrating off-site. Odors are not anticipated to be a concern away from OU-1 given that neither PCBs nor metals emit an odor that would be spread any significant distance away from its source east of the commuter rail tracks. Odors from sediment void of oxygen are not expected to be evident outside of the site based on experience at previous dredge sites. Other potential odors tend to rapidly subside with distance from their source based on experience at other dredge sites.

4.3.2 Comparative Evaluation of Short-Term Effectiveness Among Northwest Corner Area Alternatives

Alternatives that include less dredging would result in less short-term disruption of the existing river habitat both in area of the river affected and in duration of the impact. Alternatives NW-1 and NW-3, would, in addition to less short-term river habitat disruption, result in less sediment being resuspended into the river water column, a shorter and less adverse impact on river water quality outside the temporary barrier, and less worker risk than would Alternatives NW-2 and NW-4.

Table 4.2 presents a quantitative comparison of the adverse, short-term release of PCBs anticipated to become resuspended as a result of removing debris and obstructions and dredging associated with each of the Northwest Corner Area alternatives. As shown in Table 4.2, and discussed in Section 4.1, resuspension of contaminated sediment into the water column and residual sediment concentrations after dredging (and prior to capping) would be much less adverse under Alternative NW-3 than under the other Northwest Corner Area alternatives.

The short term impact of the remedy includes any injuries that workers may suffer while implementing the remedy. Implementation of the remedial alternatives presents a risk of fatal and non-fatal injury to workers and the community through which sediment and clean fill are transported. Occupational risks can be determined based on national statistics on rates of fatality and non-fatal injury maintained by the U.S. Department of Labor. Transportation risks can be determined based on the accident statistics for heavy trucks and railroads maintained by the U.S. Department of Transportation. The methodology and results of the occupational and transportation risk assessment are presented in Appendix F. There are several ways to express the same estimate of a risk of a fatality or a non-fatal injury. Two alternative risk metrics are presented in this Supplemental FS and are briefly described below. A risk estimate conveys the likelihood or probability of an event. One risk metric, commonly referred to as the "chance" of an event, conveys the number of times an action needs to be repeated before a single event will occur, on average. In terms of occupational risks of at least one fatality associated with implementing a remedial alternative, we could state that there is a 1 in 100 chance of a fatality, for example. This means that, on average, if the remedial alternative was repeated 100 times, one fatality would be expected. A second risk metric can be used to express the likelihood or probability of fatalities associated with a single implementation of the remedial alternative. Because this risk metric is derived from the probability distribution of fatalities (see Appendix F), it conveys information about the probability of at least one fatality. For example, if there is a 1 in 100 chance of a fatality, then the risk of at least one fatality is 1×10^{-2} or 0.01.

In the worker risk assessment presented in Appendix F, occupational risk estimates represent risks of worker fatalities rather than non-fatal injuries. While national statistics on non-fatal injuries are available, the classification scheme is based on a standard for classifying industries rather than occupations. Risk estimates based on these statistics would reflect a combination of industries, none of which can be directly related to workers involved in sediment remediation. Risks of non-fatal injuries associated with transportation of sediment and clean fill are presented as part of the transportation risk estimates.

Less dredging would also result in less risk to construction workers as summarized in Table 4.3. Occupational risks of implementing Alternative NW-1 are approximately one third to one fourth the occupational risk of implementing the other Northwest Corner alternatives.

Based on the rate of injury reported for similar projects and types of work, the estimated risk of an on-site worker fatality range from 1 in 100 for Alternative NW-1, to 1 in 24 to 1 in 33 for Alternative NW-2, 1 in 31 for Alternative NW-3, and 1 in 36 for Alternative NW-4 (see Table 4.3). For Alternative NW-4, this means that if the remedy was performed 36 times, it is likely there would be one fatal accident on site. Put another way, there is a 3 percent risk of at least one fatal on-site accident if Alternative NW-4 is chosen as the remedy for the Northwest Corner Area. The risks of a fatal injury on site range from 1 percent for Alternative NW-1 to 4 percent for Alternative NW-2, Option B. Most of this risk is associated with a high rate of reported injuries at barge dredging projects, where most fatal injuries are suffered by persons working on the barge (see Appendix F). The risk of at least one fatal accident during transportation on or off site is approximately 1 percent.

AR will only undertake remedial action where it can develop a way to perform the work safely, without significant injury or fatalities. Alternative NW-1 involves significantly lower worker risks. AR would seek to control all worker injury risks through health and safety planning and safe work practice. AR’s safety management program would be strictly followed. However, the combined risk of injury from remediation work at all areas of OU-2 should be considered when selecting alternatives, and the risk of a fatal injury rises with the size of the area to be dredged, as well as the depth of dredging. The cumulative short term impact of all dredging alternatives must be considered and weighed against the benefits that dredging might achieve. Worker risks will be evaluated in more detail during remedial design, and remedial alternatives may need to be modified to ensure that the work can be performed safely.

The total time to cut the timber piles, remove debris, and dredge would range from approximately 2 months under Alternative NW-1 to approximately 10 months under Alternative NW-4 (see Section 3 and Table 4.2). The extent of debris has not been able to be well defined so these time estimates could be low depending on the extent of debris that needs to be removed prior to and during dredging operations. Placement of the berm and cap would require 1 to 3 months following dredging depending on the volume of berm and cap material to be placed. Along with 3 to 4 months to place the temporary rigid containment barrier, the total remediation time for the Northwest Corner Area alternatives is estimated to range from 4 to 6 months under Alternative NW-1 to 13 to 15 months (over two construction seasons) under Alternative NW-4. Berm placement and consolidation under Alternative NW-3 would require over two years to provide a stable condition.

Wick drains (or other consolidation devices) would likely need to be installed as part of Alternative NW-3 based on a final shoreline OU-1 elevation of +4 ft. The purpose of sediment consolidation devices would be to expedite consolidation of the marine silt layer beneath the berm and protective cap so as not to excessively delay completion of the OU-1 remedy. Consolidation devices would not be needed under Alternatives NW-1, NW-2, or NW-4 because sediment consolidation would not need to be enhanced as part of those alternatives (see Appendix B). The consolidation time needed under Alternative NW-3 would be less than 1 year.

If rail transportation is used, the number of rail cars entering and leaving OU-1 on a daily basis with material for OU-2 would not differ substantially among the Northwest Corner Area alternatives, but the duration of rail use would be approximately 7 to 8 months under Alternative NW-4 compared to as short as 2 months under Alternative NW-1 (see Section 3 and Table 4.2). Under Alternative NW-1, on average, approximately two rail cars per day would leave OU-1 during dredging full of dredged sediment and approximately four rail cars per day would enter OU-1 with soil for the berm and cap. Under Alternatives NW-2 and NW-3, on average, approximately three to four rails car per day would leave OU-1 during dredging full of dredged sediment and approximately two to three full rail cars per day would enter OU-1 with soil for the berm and cap. Under Alternative NW-4, approximately two to three rail cars per day would leave OU-1 during dredging full of dredged sediment and approximately one to two rail cars per day would enter OU-1 with soil for the berm and cap.

If trucks are used, the number of trucks to haul sediment offsite would range from approximately 300 under Alternative NW-1 to approximately 2,600 under Alternative NW-4. The effort of importing berm-cap material would add approximately 50 percent more trucks entering and leaving the site under Alternatives NW-1 and NW-4.

4.4 LONG-TERM EFFECTIVENESS AND PERMANENCE (A BALANCING CRITERIA)

The long-term effectiveness and permanence of a remedial action alternative is evaluated based on the following: (a) magnitude of the human health and ecological risk remaining following remediation; and (b) adequacy and reliability of controls used to manage capped sediment that would remain at OU-1 or OU-2 following remediation.

4.4.1 Evaluation of Long-Term Effectiveness and Permanence Common to All Northwest Corner Area Alternatives

As discussed in Section 4.1, dredging alone would not be a protective or effective remedy under any of the Northwest Corner Area alternatives, because residual contaminated sediment would remain in the river after dredging, at levels that exceed the 1 ppm PCB remedial goal. Residual contaminated sediment is a byproduct of all dredging operations as discussed in Section 2.1. A protective cap would be needed as part of all Northwest Corner alternatives to cap this residual material, protecting biota from exposure to contaminated sediment, preventing erosion of residual contaminated sediment in the river, and reducing the risk of migration beyond the OU-2 boundaries. The protective cap would be designed, installed, and maintained to provide long-term chemical isolation, prevent erosion from waves and other forces, and restore aquatic habitat as described in Section 2.2. Sediment capping has been employed effectively at many other sediment sites. The berm needed to help stabilize the shoreline would provide erosion protection that would otherwise be provided by a portion of the protective cap.

The protective cap would also be compatible with future land and water use. In combination with a berm to support the shoreline bulkhead, the berm and cap thickness together would not be significant enough to significantly affect the hydraulic carrying capacity of the lower Hudson River (see Table 4.3). For the Northwest Corner Area alternatives, the percent change in river hydraulic capacity along a typical cross section of the river at this site would be less than 1 percent with a +4 ft OU-1 ground surface elevation at the shoreline sloping upward to +9 ft at 100 to 120 ft inland.

As noted in Section 2.2, a final OU-1 ground surface elevation of +4 ft at the shoreline sloped upward to +9 ft 100 to 120 ft inland may be acceptable to all stakeholders. A ground surface elevation of +4 at the shoreline may provide a more suitable ground surface than the +9 ft elevation throughout OU-1 that is currently in the federal consent decree. The area of OU-1 with a ground surface elevation below +9 ft could be used for recreational purposes, and would only become unusable during 100 year or higher flood events. Periodic flooding at ground surface elevations below the 100-year floodline (established based on federal maps as approximately elevation +7 ft) can be accounted for in the OU-1 design and should not have a long-term adverse effect on the shoreline bulkhead. The OU-1 land surface will need to drain over the long term by providing a sloped land surface.

Measures to maintain the protectiveness and effectiveness of a cap over the long term include monitoring, cap repair, and one or more institutional controls to guard against damage. Each of these measures is discussed in Section 2.2, and each would be implemented by AR over the long term at this site. Cap monitoring and repair have been successfully conducted for many years at numerous cap sites. Institutional controls that are most effective include environmental easements within the river for which the regulatory mechanisms to develop are in place in New York State. Environmental easements are currently being developed within the General Electric remedial design for sediment dredging in the Upper Hudson River and NYSDEC's web site contains an example environmental easement framework that could be applied to OU-2 (at www.dec.state.ny.us/website/der/easement.pdf).

USEPA's December 2005 sediment remediation guidance lists site conditions conducive to sediment capping. All of these conditions are met at the Northwest Corner Area: available cap materials, compatible infrastructure, adequate water depth, controllable disturbances of a cap (such as large anchors), long-term risk reduction outweighing short-term habitat disruption, river hydrodynamic conditions can be accommodated, controllable groundwater upflow, sufficient sediment strength to support a cap, low rate of contaminant flux upward into a cap, and a contiguous cap area (USEPA, 2005, page 5-2). A sediment cap at OU-2 would continuously block underlying sediment from impacting aquatic biota and prevent contaminant migration upward through the cap. The potential for remedy failure would be very small given the cap would be monitored and maintained regularly over time and repaired if warranted based on monitoring results. Monitoring efforts would focus on cap disturbances based on bathymetry, contaminant flux based on sediment concentrations, and biota recolonization.

No treatment residuals from the Northwest Corner Area would result in adverse impacts. The protective cap would effectively contain sediment not dredged from OU-2. Sediment dredged from the Northwest Corner Area would be effectively managed. Treated water would be released back to the river. In addition, no adverse long-term effect on river aquatic habitat from dredging and capping is expected given the river's ability to fully restore itself over time following capping. The top layer of the cap would be provided with suitable characteristics for natural and complete restoration as discussed in Section 2.2.

USEPA (2005a) clarifies that in situ sediment caps may provide acceptable levels of both short-term and long-term effectiveness and permanence and that there should not be a presumption that removal of contaminated sediments would necessarily be more effective or permanent than capping. A protective cap can be maintained over the long term in the river as discussed in Section 2.2. In addition, dredging would leave some residual contamination in the river because of physical constraints reaching deep contaminated sediment adjacent to shore and because of residual contamination resulting from any dredging effort as discussed in Section 2.1. The reliability of a protective cap within OU-2 is strong based on its ability to prevent adverse impacts as observed at previously capped sites. Worst-case events, such as Hurricane Floyd, have been factored into the analysis of a protective cap within OU-2 using Hydroqual's hydrodynamic model of the Hudson River Estuary. Therefore, reliability of a properly-designed and properly-installed protective cap in OU-2 is not considered to be significantly different from the reliability of containing dredged sediment at an upland containment facility offsite.

4.4.2 Comparative Evaluation of Long-Term Effectiveness and Permanence Among Northwest Corner Area Alternatives

The extent of berm and cap in the river based on the shoreline OU-1 grade being set at + 4 ft and sloping up to +9 ft at 100 ft inland is presented in Table 4.4. One related NYSDEC requirement for a cap at OU-1 is to provide a minimum slope of 4 percent (4 ft over 100 ft) to promote drainage off the cap. The extent of berm and cap presented in Table 4.4 incorporates measures to reduce berm volume in the river, such as use of tieback anchors and lightweight fill within OU-1 to the extent practicable. Alternatives NW-1 and NW-3 would result in a small amount of filling in the river from the net effects of dredging, placing a berm, and placing a protective cap. The change in river cross section, which is an indication of the effect of placing a berm and cap on the river's capacity to carry flood waters, would only be 0.1 and 0.3 percent under Alternatives NW-1 and NW-3. Under Alternatives NW-2 and NW-4, a net increase in river volume would result from the net of dredging and filling.

Sediment dredged from the river and residual solids generated from water treatment would be permanently removed from OU-2 for classification and either reused or consolidated at a permitted facility. Volumes of sediment to be dredged are presented in Tables 3.2 and 4.5. In addition, water removed from sediment to improve sediment handling would be treated and returned to the river.

Without including resuspension of sediment during dredging, the AR's contaminant distribution modeling results provide estimates of the extent of PCB mass removable from the river as part of each remedial action alternative. From these modeling results, the percentages of PCB mass removed under all of the Northwest Corner Area alternatives is very high: approximately 61 percent for Alternative NW-1, 75 and 82 percent for Alternative NW-2 (Options A and B), 100 percent for Alternative NW-3 by either containing the PCBs or dredging, and 99 percent for Alternative NW-4 (see Table 4.5).

While more PCBs would be removed under Alternatives NW-2 and NW-4, as shown in Table 4.5, the PCB mass removed per cubic yard of sediment dredged would be approximately 3.3 pounds per cubic yard under Alternative NW-1, compared to approximately 1.1 pounds per cubic yard or less for Alternatives NW-2, NW-3 and NW-4. Dredging efficiency is therefore highest for Alternative NW-1. Dredging efficiency in terms of pounds of PCBs removed per cubic yard of sediment would be three times higher for Alternative NW-1 than for Alternative NW-2 and five times higher for Alternative NW-1 than for Alternative NW-4.

For Alternative NW-3, all of the sediment that exceeds PRGs would be dredged between the created shoreline west of the existing shoreline and the temporary rigid containment barrier. Alternative NW-3 is the only alternative for the Northwest Corner Area that provides for dredging all of the sediment in the river that exceeds sediment PRGs inside between the created shoreline and the temporary rigid containment barrier.

For Alternative NW-4, the benefit of being able to dredge deeper by installing the shoreline bulkhead into the basal sand is an increase in sediment from 82 to 99 percent of PCB mass that could be removed from OU-2 compared to Alternative NW-2, Option B. The problems with dredging deeper in particular include creating new pathways for PCBs to migrate into uncontaminated groundwater within the basal sand (see Sections 2.1.4.1 and 4.1), higher amounts of sediment resuspended in the water column during construction (see Section 4.3), and higher costs (see Section 4.8). Furthermore, a cap would still be needed as part of Alternative NW-4 to meet remedial action objectives because not all of the sediment exceeding PRGs could be removed.

The submerged bulkhead under Alternative NW-1 would provide some additional erosion protection and habitat benefits not provided as part of the other remedial action alternatives. The cutoff submerged bulkhead under Alternative NW-1 would provide a linear shelf of clean sediment parallel to the Northwest Corner Area shoreline where sediment and aquatic life forms could accumulate gradually over time.

4.5 REDUCTION OF TOXICITY, MOBILITY, AND VOLUME THROUGH TREATMENT (A BALANCING CRITERIA)

The evaluation of the reduction of toxicity, mobility, and volume involves consideration of the following: (a) extent of expected reduction in toxicity, mobility, and volume; (b) type and degree to which treatment would be irreversible; (c) type and quantity of residuals that would be present following treatment; and (d) USEPA's preference for treatment.

Water from sediment draining and/or dewatering operations would be treated to meet state discharge requirements prior to releasing treated water back to the river.

4.6 IMPLEMENTABILITY (A BALANCING CRITERIA)

Implementability considers the technical and administrative feasibility of implementing an alternative and the availability of the services and materials required during its implementation. The following factors are examined herein as part of implementability to the extent each factor is relevant for each remedial alternative: (a) anticipated remedial construction and/or operation steps; (b) reliability of each technology within the alternative; (c) extent and complexity of monitoring remediation effectiveness following implementation; (d) ease of undertaking additional remedial actions if needed; (e) activities needed to coordinate with other offices and agencies to obtain necessary approvals and permits; (f) availability of adequate on-site or off-site sediment management services; (g) availability of necessary equipment, specialists, skilled operators, and provisions to provide additional resources; and (h) amount of sediment that would be capped or dredged.

4.6.1 Evaluation of Implementability Common to All Northwest Corner Area Alternatives

Dredging is provided as part of each remedial action alternative for the Northwest Corner Area as a practicable measure to remove contaminated sediment, provide water depth in shallow water nearshore for a berm needed to support the shoreline bulkhead, and provide water depth for a protective cap. Without dredging, the berm and protective cap together would result in loss of river area adjacent to the shoreline, which would result in the remedial action alternatives for the Northwest Corner Area being less administratively implementable.

Each of the remedial action steps outlined in Table 4.1 to implement the remedial action alternatives for the Northwest Corner Area would by themselves be able to be constructed. However, the significant extent of debris in the Northwest Corner Area would slow dredging operations, increase the need for onshore support facilities, and also result in more sediment being resuspended into the water column in the short term. As shown in Figure 3.1, large pieces of concrete and/or other debris exist throughout much of the Northwest Corner Area and the vertical extent of large concrete/debris cannot be quantified using available investigation techniques. Geophysical investigations in 2004 and 2005 by AR and prior investigations have shown the entire Northwest Corner Area includes fallen pilings, magnetic debris, concrete rubble, large stones, and other large objects. Removing debris and obstructions would be needed prior to and perhaps continuing throughout the dredging effort depending on the extent of debris vertically below the mudline. Separate barges in the river and a separate processing area at OU-1 would likely be needed to handle the debris.

The temporary rigid containment barrier is believed to be able to be installed as part of any of the Northwest Corner Area alternatives, but not without challenges, given the water depths of 30 to 35 ft offshore, frequent sustained winds, strong tidal currents, and the 4-ft vertical tidal range. In addition, a long lead time of many weeks or months may be needed to fabricate and deliver the steel needed for the temporary barrier. There are no known underwater utilities in the area that would further complicate placing the temporary barrier (or the berm and protective cap following dredging).

An initial assessment indicates sufficient space is available at OU-1 to unload and process debris and sediment dredged from OU-2. Temporary dock facilities could be installed and the sensitivity of the OU-1 shoreline area to additional loads during either the OU-1 or the OU-2 remedial actions would need to be addressed during remedial design. A rail spur may be added at OU-1 for offsite transport of dredged sediment and for incoming fill material that would form the berm and protective cap.

An 18-inch diameter Westchester County permitted sewer overflow discharge to the river is in place in the Northwest Corner Area at a location approximately 50 ft north of the southern end of the Northwest Corner Area. Placement of the shoreline bulkhead and dredging efforts in the southern end of the Northwest Corner Area will need to account for discharges that occasionally pass through this pipe to the river during significant weather events. Handling of this discharge during OU-2 remediation efforts is not believed to be a significant challenge or result in adverse impacts.

A berm-cap is implementable based on success observed placing caps at other sites and based on shear strength available within site sediment. Berms and caps have been successfully placed at other sites (see Section 2.2.7). The maximum allowable final slope for a berm-cap would be determined during remedial design.

Institutional controls for capping would likely focus on the State of New York acquiring one or more environmental easements (see Section 2.2.8). Draft language for such an easement has been prepared by NYSDEC. Items that would further protect the cap, such as boat anchoring restrictions and use of floating docks, can be included in an environmental easement. Pursuant to New York State law, enforcement of easement requirements would be at the discretion of NYSDEC.

4.6.2 Comparative Evaluation of Implementability Among Northwest Corner Area Alternatives

Additional removal of debris and obstructions and additional dredging beyond what is included in Alternative NW-1 would slow the pace of finalizing the ground surface elevation and follow-up redevelopment of OU-1. Because Alternative NW-1 could be largely completed independent of the OU-1 remedial action, and would involve less dredging, OU-1 could be redeveloped 2 to 3 years sooner under Alternative NW-1 than under the other remedial action alternatives for the Northwest Corner Area. Additional time would be needed under the other NW area alternatives to coordinate remediation activities for OU-2 with design and implementation activities currently underway for OU-1. OU-1 also cannot be fully redeveloped until the river berm and onshore soil are sufficiently consolidated.

Alternative NW-3 would be particularly complicated to construct. It would also be very time consuming to implement due to creating new land where the soil would need to be consolidated gradually over time following dredging offshore from the new shoreline. Wick drains (or other consolidation devices) would also likely need to be placed as part of Alternative NW-3 to speed up consolidation of berm material that would be placed in the river. An advantage of Alternative NW-3 is that dredging would be conducted away from the nearshore area where dense debris is known to exist based on AR's investigation results. The primary benefits of Alternative NW-3 are its ability to address all of the PCBs exceeding 1 ppm PCBs in river sediment and the fact that dredging would be avoided in the nearshore area where many obstructions exist and sediment in the most contaminated area of OU-2 would become resuspended while being dredged.

Option B under Alternative NW-2 and Alternative NW-4 would also be more difficult and time consuming to implement due to the larger scope of dredging nearshore and the larger volume of berm material to place within OU-2 (see figures in Appendix B).

Alternative NW-4 is less implementable due to the risk of DNAPL transport associated with it. Further remedial actions would not be easy to undertake if required to address PCBs in the basal sand layer, and the technology to mitigate such a problem is both limited and poorly effective.

4.7 COSTS (A BALANCING CRITERIA)

A cost estimate has been prepared for each remedial action alternative in accordance with *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* (USEPA, 2000a). The cost evaluation assesses estimated capital, annual operation and maintenance (O&M), periodic costs, and total net present value.

Capital costs are those expenditures that are quantifiable and required to construct or implement a remedial action; they consist of present, future, and direct and indirect expenses. Direct capital costs include construction, site development, and sediment management costs necessary to implement the remedial alternative. Indirect capital costs include expenditures for engineering, regulatory approvals, construction oversight, contingency allowances, and any other services that are not part of the actual installation costs.

Operation and maintenance costs are those post-construction costs necessary to ensure or verify the continued effectiveness of a remedial action. These costs are typically estimated on an annual basis and may include, but are not limited to: labor, equipment, and energy associated with activities such as cap monitoring, maintenance, and repair.

The net present value for each remedial alternative has been estimated using a consistent maximum period of analysis following remediation of 30 years and a discount rate of 7.0 percent. This discount rate is based on an economic analysis performed by the US Office of Management and Budget. The approximate accuracy of the cost evaluation is minus 30 percent to plus 50 percent, consistent with feasibility study guidance documents, based on the fact that none of the remedial alternatives have been through a detailed design effort.

In addition to development of an estimated cost, alternatives are evaluated on the basis of cost-effectiveness under the comparative evaluation of alternatives. NYSDEC Part 375 under Title 6 (Subpart 1.1(c) (6)), CERCLA Section 121, and the National Contingency Plan require that the selected remedy must be cost-effective. A remedial alternative is cost-effective if its "costs are proportional to its overall effectiveness" (40 CFR 300.430[f][1][ii][D]). Overall effectiveness of a remedial alternative is determined by evaluating the following three of the five balancing criteria: long-term effectiveness and permanence; reduction in toxicity, mobility, and volume through treatment; and short-term effectiveness. Consistent with that requirement, the National Contingency Plan further provides that costs that are grossly excessive compared to the overall effectiveness of an alternative can be relied upon as a basis for eliminating that alternative from consideration (40 CFR 300.430[e][7][iii]).

State law also requires the decision maker to consider cost effectiveness when determining whether a remedy is "feasible" to implement (6 NYCRR 375-1.10(c)).

Alternative	**Estimated Capital Cost ($)**	**Estimated Annual O&M Cost ($)**	**Estimated Net Present Worth ($)**
NW-1	$21.9 Million	$100,000	$23.0 Million
NW-2, Option A	$51.2 Million	$100,000	$52.3 Million
NW-2, Option B	$58.8 Million	$100,000	$59.9 Million
NW-3	$56.0 Million	$100,000	$57.1 Million
NW-4	$95.1 Million	$100,000	$96.2 Million

Capital costs are comprised of non-fixed costs and fixed costs. Non-fixed costs are costs that vary from one alternative to another, such as costs for providing temporary containment, dredging, material management, and capping. Fixed costs are costs that do not vary from one alternative to another, such as costs for permitting and construction setup. Fixed costs have been apportioned equally amongst the areas of OU-2 since the sequence of construction among the OU-2 areas has not yet been established. Appendix E provides specific basis and compilations for the costs estimates for each remedial action alternative.

PCB mass that could be removed per cubic yard of sediment dredged would be approximately 3.3 pounds per cubic yard under Alternative NW-1, compared to approximately 1.1 pounds per cubic yard or less for Alternatives NW-2, NW-3 and NW-4 (see Table 4.5). The cost for PCB removal is high under all alternatives, and ranges (in dollars spent per pound of PCBs removed) from approximately $1,400 per pound for Alternative NW-1 to approximately $2,200 to $2,700 per pound for Alternative NW-2, $110,000 per pound for Alternative NW-3 and approximately $ 3,600 per pound for Alternative NW-4.

There are several factors which contribute to the significant cost increase under Alternatives NW-2, NW-3, and NW-4 compared to Alternative NW-1. The primary cost difference is the temporary rigid containment barrier associated with each alternative. The alignment under Alternatives NW-2 through NW-4 would be approximately 300 ft longer, and set further out into the river than the alignment under NW-1. These factors add additional wall cost, plus additional installation cost in installing the temporary rigid containment barrier in deeper water. Additional dredging, transportation, and disposal in Alternatives NW-2 through NW-4, as well as tiebacks and other protections for the shoreline bulkhead needed to implement these Northwest Corner alternatives, would also add significant cost.

Figure 4.1 presents PCB removal as a function of cost. The portion of copper mass associated with copper concentrations over 982 ppm in Northwest Corner sediment that would be removed or contained under these alternatives ranges from 18 to 22 percent. Figure 4.1 shows that Alternative NW-1 targets the removal of the highest PCB concentrations of sediment in the Northwest Corner Area. Removing, for example, an additional 14 percent of PCB mass would increase the Northwest Corner Area remediation cost by a factor of 2.5. Removing an additional 14 percent would also more than triple the sediment dredge volume with a corresponding increase in the short-term adverse impact of resuspended sediment on river water quality.

4.8 EVALUATION SUMMARY FOR THE NORTHWEST CORNER AREA

Each of the four remedial action alternatives for the Northwest Corner Area is protective of human health and the environment and in compliance with standards, criteria, and guidelines, over the long term with the exception of groundwater quality under Alternative NW-4. Sediment PRGs and OU-2 remedial action objectives would be met implementing any of the four Northwest Corner Area alternatives. Capping would be protective on the basis of the protective cap presented in Section 2.2 and the evaluation presented in this section. A protective cap would eliminate exposure of fish, other aquatic life, and humans to sediment exceeding PRGs. Dredging would also be provided as a practicable measure to remove contaminated sediment and, at the same time, provide additional depth in shallow water area nearshore for a berm needed to support the shoreline bulkhead as well as for a cap. However, the state groundwater quality standard for PCBs would likely be violated if Alternative NW-4 was implemented, because the shoreline bulkhead would penetrate through DNAPL and create new pathways for PCBs in NAPL to migrate into the clean basal sand aquifer below.

New site information collected and analyzed since the 2003 OU-2 FS Report includes geotechnical borings at OU-1. These new geotechnical borings lead to a need to reassess the shoreline bulkhead and the implementability of dredging along the Northwest Corner shoreline. Because of their size and shape (approximately 3 ft by 1.5 ft) H-piles that would be needed to form the NW-4 shoreline bulkhead would more likely drag obstructions and contaminated soils down into the basal sand layer. Soil has a tendency to plug in the corners of H-piles and to travel downward with the piles when driven into the subsurface. In addition to potential contaminant drag-down, H-piles have the potential to forms voids along its corners during installation. These voids would create the potential for downward DNAPL along this enlarged pathway.

Capping is protective and reliable based on an evaluation of site factors and experience from previously capped sites as presented in Section 2.2 and in this section. December 2005 guidance from USEPA on sediment remediation (2005a) lists site conditions conducive to sediment capping. All of these conditions are met for the Northwest Corner Area: available cap materials, compatible infrastructure requirements, adequate water depth, controllable potential cap disturbances (such as large anchors), long-term risk reduction outweighing short-term habitat disruption, river hydrodynamic conditions can be accommodated, controllable groundwater upflow, sufficient sediment strength to support a cap, low rate of contaminant flux upward into a cap, and a contiguous cap area. A protective cap can provide chemical isolation, erosion protection, and restoration of aquatic habitat through the use of different cap layers as described in Section 2.2.

Dredging along the Northwest Corner Area, however, would present engineering challenges. New site observations of underwater debris and obstructions completed since 2003 when the PRAP was issued show extensive debris and obstructions in the Northwest Corner Area. The extent of debris and the silty, fine-grained nature of OU-2 sediment along with the steep sediment slopes nearshore would result in contaminated sediment becoming suspended in the water both while the debris is being removed and while dredging. The temporary rigid containment barrier would help control the spread of resuspended sediment away from OU-2, but this temporary barrier would not be 100 percent effective. Water quality would decline in the short term during debris-obstruction removal and during dredge operations, because resuspended sediment would not be able to settle completely before the next day of dredging is underway. The water level inside and outside the barrier would need to be kept the same across the barrier by allowing some water to penetrate through the barrier; otherwise the barrier could not withstand the river's forces. In addition, overflows from a permitted Westchester County sewer line would enter the contained area during storm events. The temporary barrier would also at times need to allow barges and support boats to pass through to transport materials, debris, dredged sediment and berm-cap materials to and from shore. As a result, some water with unsettled contaminated solids would escape from inside the temporary barrier. Practicable attempts would be made to meet far-field water quality guidelines away from OU-2, but meeting such guidelines may not be possible. Alternatives that include less dredging, such as Alternatives NW-1 and NW-3, would result in lower quantities of PCBs being suspended into the river thereby resulting in less adverse effects on water quality during construction. Less dredging would also result in lower worker risk and less of an adverse effect of construction noise and other aspects of construction on the Village than would Alternatives NW-2 and NW-4. Less filling of the river under Alternative NW-1 would reduce worker risk and effects of construction on the Village compared to Alternative NW-3. Alternative NW-1 would also have the benefit of allowing OU-1 to be remediated and redeveloped independent of the timeframe for remediating OU-2.

In addition to adverse short-term impacts of dredging on water quality, additional worker risks would be evident under Alternatives NW-2 and NW-4. Worker risks consist of risks to site workers and risks associated with transportation workers and non-workers. Worker risks would vary from 0.010 under Alternative NW-1 to 0.041 under Alternative NW-2, Option B (see Table 4.3).

Each of the alternatives is implementable over the long term. However, the alternatives that include the most sediment to dredge and the most berm material to place could result in a 2 to 3 year delay completing the OU-1 remedy due to the need for Alternatives NW-2, NW-3, and NW-4 to be coordinated with remediation activities for OU-1. Higher dredge and berm depths would also result in more time needed for remaining sediment to consolidate and more time needed before OU-1 could be redeveloped. Wick drains (or other consolidation devices) would likely be needed to speed up sediment consolidation as part of Alternative NW-3. In addition, Alternative NW-3 would include additional engineering steps associated with filling that would require months of extra time and coordination with the OU-1 remedial action.

Alternative NW-1 meets the OU-2 remedial action objectives presented in Section 1.4 and provides the most efficient removal of contaminant mass based on mass removed for every dollar spent to implement the alternative. Alternative NW-1 would target removal of the most concentrated sediment. Dredging additional sediment would result in a disproportionate increase in remediation costs. While more PCBs would be removed under Alternatives NW-2 and NW-4, the PCB mass that could be removed per cubic yard of sediment dredged would be approximately 3.3 pounds per cubic yard under Alternative NW-1, compared to approximately 1.1 pounds per cubic yard or less for Alternatives NW-2, NW-3 and NW-4. Similarly, the dollars spent per pound of PCBs removed would be approximately $1,400 for Alternative NW-1 compared to approximately $2,200 to $2,700 for Alternative NW-2, $110,000 for Alternative NW-3 and $ 3,600 for Alternative NW-4.

Approval of Alternative NW-3 by NYSDEC and USACE would be based on a demonstration of value and/or need for moving the shoreline westward into the river. The primary values of Alternative NW-3 are its ability to address all of the PCBs exceeding 1 ppm PCBs in river sediment and avoiding dredging near the shoreline where the extent of debris in sediment is most significant. However, Alternative NW-3 would also take the most time and be the most complicated of the four Northwest Corner Area alternatives to engineer and construct. Option B under Alternative NW-2 would also be comparatively complicated to implement and require very close coordination and possibly delays in association with the remedial action for OU-1.

Given all of these evaluation factors, Alternative NW-1 is recommended for the Northwest Corner Area. Alternative NW-1 would provide efficient contaminant removal by removing the most contaminated sediment per cubic yard of sediment dredged (see Table 4.5) and target the most contaminated sediment (see Figure 4.1). Alternative NW-1 also would result in the least amounts of sediment becoming resuspended into the water in the short term, the lowest worker risk, and the fewest engineering and construction challenges in a challenging river work environment that includes average water velocities of approximately 2 ft per second, a 4-ft tidal range twice each 24 hours, and fine-grained sediment. Alternative NW-1 would also be the alternative to least likely delay redevelopment of OU-1. These benefits of Alternative NW-1 together overshadow the relatively small additional percentages of contaminant mass that would be removed under Alternatives NW-2 or NW-4 making Alternative NW-1 the preferred alternative to implement for the Northwest Corner Area.

TABLE 4.1

NORTHWEST CORNER SHORELINE ALTERNATIVE EVALUATION SUMMARY HARBOR AT HASTINGS OU-2

	NW-1 Dredge for Cap Stability	NW-2 Dredge to Limits of Bulkhead Stability	NW-3 Redivide OU-1 and OU-2	NW-4 Penetrate Shoreline Bulkhead into Basal Sands
Summary description with possible construction sequence (from Section 3)	▪ Place berm in the river away from the dredge area as needed to stabilize shoreline slope during OU-1 grade increase. Top of berm is at Elevation -10 which is down slope and below the OU-2 dredge area. ▪ Install the OU-1 shoreline bulkhead. ▪ Excavate OU-1 upland (9 ft below existing ground surface) in accordance with the OU-1 remedy and backfill to final grade with lightweight fill. Install bulkhead wall anchorage system during backfill operations. ▪ Install temporary rigid containment barrier approx. 50 ft offshore. ▪ Cut timber piles and remove debris within the dredge area. Dredge sediment inside the temporary barrier to elevation -7 ft adjacent to the shoreline where sediment exceeds PCB and copper PRGs. ▪ Place berm and protective cap over the dredged area as needed. ▪ Cut the temporary barrier to	▪ OU-2 and OU-1 remediation efforts would need to be coordinated. OU-2 remediation must follow partial backfill of OU-1 upland area and must precede final OU-1 backfill. ▪ Install the OU-1 shoreline bulkhead. Sealing of the bulkhead may need to be done after dredging to help stabilize the shoreline during dredging operations. ▪ Excavate OU-1 upland (9 ft below existing ground surface) in accordance with the OU-1 remedy and partially backfill to Elevation +3 ft to +4 ft with lightweight fill. Install a bulkhead wall anchorage system during backfill operations. ▪ Install temporary rigid containment barrier approx. 140 ft from shore. ▪ Cut timber piles, remove debris, and dredge sediment inside the temporary barrier where sediment exceeds PCB and copper PRGs. Dredge to elevation -9 ft (Option A) or to -14 ft (Option B) at the shoreline and deeper away from shore. ▪ Place berm in the river as needed. ▪ Cut or remove temporary barrier. ▪ Place berm and protective cap or	▪ OU-2 and OU-1 remediation efforts need to be coordinated. OU-2 remediation must follow partial backfill of OU-1 upland area and must precede final OU-1 backfill. ▪ Install shoreline bulkhead to minimize water within OU-1 during the OU-1 remedial action. ▪ Excavate OU-1 upland (9 ft below existing ground surface) in accordance with the OU-1 remedy and partially backfill to approx. Elevation +3 ft to +4 ft with lightweight fill. Partially install a bulkhead wall anchorage system during backfill. ▪ Install NW-3 bulkhead approx. 40 to 100 ft west of the existing shoreline. Brace and anchor the wall to the shoreline. Sealing of the bulkhead could be done after dredging if needed to help stabilize the shoreline during dredging operations. ▪ Install temporary rigid containment barrier approx. 140 ft from shore. ▪ Remove debris and dredge sediment between the NW-3 bulkhead and the temporary barrier, where sediment PRGs for PCBs and copper are exceeded. ▪ Place berm in the river and fill in the new shoreline area to create a berm	▪ For an economical bulkhead wall design OU-2 and OU-1 remediation efforts would need to be coordinated. ▪ Install the OU-1 shoreline bulkhead wall with toe of wall penetrating into the basal sand strata. Sealing of the bulkhead could be done after dredging if needed to help stabilize the shoreline during dredging operations. ▪ Excavate OU-1 upland (9 ft below existing ground surface) in accordance with the OU-1 remedy and partially backfill to Elevation +4 ft with lightweight fill. Install the bulkhead wall anchorage system during backfill. ▪ Install temporary rigid containment barrier approx. 140 ft from shore. ▪ Cut timber piles, remove debris, and dredge sediment inside the temporary barrier where PRGs for PCBs and copper are exceeded no deeper than elevation -32 ft at the shoreline sloping away at a maximum cut slope of 5 horizontal to 1 vertical. ▪ Place berm in the river as needed to stabilize shoreline. ▪ Cut or remove temporary barrier.

TABLE 4.1, Continued

NORTHWEST CORNER SHORELINE ALTERNATIVE EVALUATION SUMMARY HARBOR AT HASTINGS OU-2

	NW-1 Dredge for Cap Stability	NW-2 Dredge to Limits of Bulkhead Stability	NW-3 Redivide OU-1 and OU-2	NW-4 Penetrate Shoreline Bulkhead into Basal Sands
	form a new submerged bulkhead. ▪ Drain-dewater dredged sediment on site. Treat water that is generated. ▪ Transport dredged and drained-dewatered sediment offsite and place at permanent containment facility.	cap only as needed. ▪ Complete the OU-1 remedy to the final ground elevation consistent with the intent of the Federal Consent Decree. ▪ Drain-dewater dredged sediment on site. Treat water that is generated. ▪ Transport dredged and drained-dewatered sediment offsite and place at permanent containment facility.	needed to support the NW-3 bulkhead. Install wick drains or equivalent within the offshore berm area to accelerate consolidation. ▪ Cut or remove temporary rigid containment barrier. ▪ After consolidation complete berm and new shoreline and place protective cap within the top of the berm inside the dredge area. ▪ Complete the OU-1 remedy to the final ground elevation consistent with the intent of the Federal Consent Decree. ▪ Drain-dewater dredged sediment on site. Treat water that is generated. ▪ Transport dredged and drained-dewatered sediment offsite and place at permanent containment facility.	▪ Place berm and protective cap or cap only as needed. ▪ Complete the OU-1 remedy to the final ground elevation consistent with the intent of the Federal Consent Decree. ▪ Drain-dewater dredged sediment on site. Treat water that is generated. ▪ Transport dredged and drained-dewatered sediment offsite and place at permanent containment facility.
Protection of Human Health and the Environment (overall protection achieved over time by meeting PRGs thereby controlling site risks)	Alternative NW-1 would be protective. ▪ A berm and protective cap following dredging would: (a) eliminate potential for site-related risk to human consumption of fish and shellfish; (b) eliminate potential human and ecological exposure to site contaminants and replace current aquatic habitat; and (c) control potential impacts related to long-term erosion or	▪ Same as for Alternative NW-1 except short-term resuspension of contaminated sediment would be greater. Approx. 20 percent more PCBs (Option A) or 30 percent more PCBs (Option B) would resuspend compared to Alternative NW-1 resulting from additional debris removal and dredging.)	Same as for Alternative NW-1 except: ▪ Eliminating dredging adjacent to the existing shoreline would result in less adverse short-term impacts on river water quality. ▪ PCB PRG would be met by dredging, at least on a cutline basis. Dredging residuals would be isolated by the berm cap. ▪ Less PCBs would be resuspended because PCB concentrations in sediment are lower further from shore. ▪ PCBs remaining inside the relocated	Same as for Alternative NW-1 except: • Driving shoreline bulkhead into basal sands would result in substantial risk of contaminating the basal sands groundwater. ▪ Most adverse short-term impacts to river water quality compared to other alternatives due to resuspension of sediment during additional months of debris removal and dredging with no improvement in long-term effectiveness. Approx. 60 percent

TABLE 4.1, Continued

NORTHWEST CORNER SHORELINE
ALTERNATIVE EVALUATION SUMMARY
HARBOR AT HASTINGS OU-2

	NW-1 Dredge for Cap Stability	NW-2 Dredge to Limits of Bulkhead Stability	NW-3 Redivide OU-1 and OU-2	NW-4 Penetrate Shoreline Bulkhead into Basal Sands
	resuspension of sediment. ▪ Additional dredging would not substantially reduce risk or provide additional long-term protection of human health or the environment. ▪ Cap-berm structure would ensure stability of OU-1 shoreline bulkhead and allow nearshore aquatic life to be restored. ▪ Adverse, short-term resuspension of contaminated sediment during debris removal and dredging would be less than for Alternative NW-2 or NW-4 and over 1 to 2 fewer months. ▪ Sediment containing significant concentrations of PCBs would resuspend resulting from debris removal and dredging.) ▪ Short-term river habitat disruption should not be significant. Sediment biota would recover within 2 to 4 months from April through November.		shoreline would be sealed in place.	more PCBs would resuspend compared to Alternative NW-1 resulting from debris removal and dredging.)
Compliance with NY State SCGs (standards, criteria and guidelines)	Site remedial action objectives would not be met by dredging alone but they would be met to the extent practicable by placing a berm-cap. A berm would be	Site remedial action objectives would not be met by dredging alone but they would be met to the extent practicable by placing a berm-cap. A berm would be needed anyway to	Site remedial action objectives may not be achievable by dredging alone but geotechnical analyses show a berm-cap would be needed regardless to stabilize the shoreline bulkhead.	Site remedial goals would not be met by dredging alone. A berm would be needed anyway to help stabilize the shoreline bulkhead. In addition, the state groundwater quality standard

TABLE 4.1, Continued

NORTHWEST CORNER SHORELINE ALTERNATIVE EVALUATION SUMMARY HARBOR AT HASTINGS OU-2

	NW-1 Dredge for Cap Stability	NW-2 Dredge to Limits of Bulkhead Stability	NW-3 Redivide OU-1 and OU-2	NW-4 Penetrate Shoreline Bulkhead into Basal Sands
Compliance with NY State SCGs, continued	needed anyway to help stabilize the shoreline bulkhead. • Alternative NW-1 would comply with SCGs in the long-term through the effectiveness of capping. • The PCB PRG would not be achieved by dredging on a cutline basis without a cap. • Short-term, far-field exceedances of surface water SCGs may develop in the river from sediment resuspended during debris removal and dredging. These exceedances are expected to be limited to the time when debris removal and dredging are ongoing. • The top of the berm-cap within the river would range from 0 to approximately 10 ft above the existing mudline with the OU-1 final ground surface elevation ranging from +4 ft at the shoreline to +9 ft 100 to 120 ft inland. At low tide water depths less than 6 ft, the top of the berm-cap would not be significantly higher than the existing mudline. The net change in the river cross-section to the dredge cut and	help stabilize the shoreline bulkhead. • Alternative NW-2 would comply with SCGs in the long term through the effectiveness of capping. • PCB PRG would not be achieved by dredging on cutline basis without cap and berm. • Although more sediment volume with PCBs and copper would be dredged, than in Alternatives NW-1 or NW-3, the added dredging would not have any effect on compliance with SCGs in the long-term. • The additional dredging would result in a longer duration of potential for short term river water quality guideline exceedances than for Alternative NW-1. • The berm and cap within the river would range from 7 ft below to 8 ft above the existing mudline (Option A) or from 10 ft below to 8 ft above the existing mudline (Option B) with the OU-1 final ground surface elevation ranging from +4 ft at the shoreline to +9 ft 100 to 120 ft inland. At low tide water depths less than 6 ft, the top of the berm-cap would	• Alternative NW-3 would comply with SCGs in the long-term through the effectiveness of capping assuming agency approvals and permits could be obtained for extending the upland area (OU-1) westward into the river. • PCB PRG would be met by dredging, at least on a cutline basis. Dredging residuals would be isolated by cap-berm required for long-term geotechnical stability. • Area with river sediment exceeding PRGs beyond the new shoreline inside the temporary barrier would be entirely dredged. • Avoiding debris removal or dredging within 40 to 100 ft of shore would result in less extensive resuspension of sediment and therefore less extensive short-term exceedances of river water quality SCGs than for the other three NW Corner alternatives. The net change in the river cross-section due to the dredge cut and placing a berm-cap associated with this alternative would be approximately -0.3% (see Table 4.4). New open water habitat would be created to compensate for less than 1 acre of lost river habitat in accordance with state and federal	for PCBs would be exceeded in the uncontaminated basal sand. • The remedial work in the river would comply with SCGs in the long term to the extent practicable. • The PCB PRG would not be achieved by dredging along. A berm-cap would be needed. • Alternative NW-4 would not ensure compliance with long-term groundwater quality SCGs due to the creation of a lengthy transmissive pathway from the fill downward into the basal sand. DNAPL and contaminants could migrate downward along the bulkhead and then spread laterally through the basal sands resulting in exceedances of the state groundwater quality standard for PCBs (0.09 ppb). • Greatest potential for short-term exceedances of far-field surface water SCGs over the longest duration of any of the NW Corner alternatives due to more extensive debris removal and dredging. • The net change in the river cross-section due to the dredge cut and placing a berm-cap associated with this alternative would be

NORTHWEST CORNER SHORELINE ALTERNATIVE EVALUATION SUMMARY HARBOR AT HASTINGS OU-2

	NW-1 Dredge for Cap Stability	NW-2 Dredge to Limits of Bulkhead Stability	NW-3 Redivide OU-1 and OU-2	NW-4 Penetrate Shoreline Bulkhead into Basal Sands
Compliance with NY State SCGs, continued	berm-cap fill associated with this alternative would be approximately -0.1% (see Table 4.4). A final OU-1 grade of elevation +9 ft (above the 100-year floodplain) across all of OU-1 would result in significantly more fill being needed in the river to support the shoreline bulkhead than if the final OU-1 grade was set at the proposed alternative elevation. • Dredged sediment managed offsite would be transported and consolidated at a properly permitted offsite location. • Coastal zone management requirements should not affect OU-2 remedial efforts. • Remedy status would be reviewed every five years following the remedial action.	not be significantly higher than the existing mudline. The net change in the river cross-section due to the dredge cut and placing the berm-cap associated with this alternative is greater than zero for both options, meaning an overall increase in the river cross-section (see Table 4.4). However, the most significant increases would be in water deeper than 6 ft at low tide. A final OU-1 grade of elevation +9 ft (above the 100-year floodplain) across all of OU-1 would result in significantly more fill being needed in the river to support the shoreline bulkhead than if the final OU-1 grade was set at the proposed alternative elevation. • Management of dredged sediment, coastal zone requirements, and remedy status reviews every five years would be the same as for Alternative NW-1.	requirements to mitigate filling the open water area that would be contained (in accordance with 6 NYCRR Part 608 requirements, the federal Rivers and Harbors Act, and federal Clean Water Act 404(b) (1) guidelines assoc. with filling within a water body). • Management of dredged sediment, coastal zone requirements, and remedy status reviews every five years would be the same as for Alternative NW-1.	greater than zero, meaning an overall increase in the river cross-section (see Table 4.4). • Management of dredged sediment, coastal zone requirements, and remedy status reviews every five years would be the same as for Alternative NW-1.
Short-term Effectiveness (protection of community and workers, environmental impacts and time	▪ Adverse, short-term release of contaminants during dredging would be less than for Alternatives NW-2 or NW-4, because less debris and less sediment would be removed. The 4-foot tidal range, high	• NW-2 would result in more contaminated sediment being resuspended and released from the contained area compared to Alternative NW-1 or NW-3 but less than for Alternative NW-4.	▪ NW-3 would result in less than 10 percent of contaminated sediment mass being resuspended inside the contained area compared to the other Northwest Corner alternatives due to less debris and lower PCB concentrations in sediment offshore	▪ Alternative NW-4 would have the most significant adverse short-term impact from sediment resuspension and release due to more debris being removed, more sediment being dredged, and a longer duration river work effort.

TABLE 4.1, Continued

NORTHWEST CORNER SHORELINE ALTERNATIVE EVALUATION SUMMARY HARBOR AT HASTINGS OU-2

	NW-1 Dredge for Cap Stability	NW-2 Dredge to Limits of Bulkhead Stability	NW-3 Redivide OU-1 and OU-2	NW-4 Penetrate Shoreline Bulkhead into Basal Sands
to achieve protection) Short-Term Effectiveness, continued	river currents, steep sediment slope near shore, the presence of fine (silty) sediment, and existing permitted public discharges increase the extent of resuspension losses. However, PCBs exist in background river water at concentrations above state water quality standards. ▪ The temporary barrier (enclosure) would reduce resuspension impacts, but some sediment would escape due to normal operations, tides, and public discharges. Best practical attempts would be made to meet far-field river water quality goals. ▪ Worker occupation risk is estimated to be 0.01 or a chance of a fatality of 1 in 100 projects (see Appendix F). ▪ Intermittent noise in particular could be noticeable while hammers are used to place the shoreline bulkhead and the temporary barrier. The Village Code would be followed so significant noise would not be evident outside allowable work hours. ▪ Odors from sediment should	• Resuspended sediment would accumulate over multiple days throughout the water column inside any enclosure, because settling time needed (45 hours from column settling tests) would exceed the settling time available between daily dredge shifts. PCB and metal concentrations resuspended in the water column after multiple consecutive days of dredging are affected by many variables and can not be predicted with any certainty. The temporary barrier (enclosure) would reduce resuspension impacts, but some sediment would escape due to normal operations, tides, and public discharges. Best practical attempts would be made to meet far-field river water quality goals. • Shoreline stability is more of a concern than for Alternative NW-1, because during remediation more sediment would be dredged making winter interim shutdown a possibility. • Worker risk would be 3 and 4 times higher for Option A and B, respectively, compared to Alternative NW-1 (see Table 4.3).	from the NW-3 bulkhead. The average sediment PCB concentration that would be dredged (and resuspended) is 25 ppm compared, for example, to 1400 ppm for Alternative NW-1 (see Table 4.2). ▪ Worker protection, shoreline stability, and noise would be similar to Alternative NW-2 with additional river work needed to fill in the area between the NW-3 bulkhead and the current shoreline. • Worker risk would be 3 times higher compared to Alternative NW-1 (see Table 4.3). ▪ Remediation would require parts of a second construction year due to extra steps to install the NW-3 bulkhead and gradual consolidation needed in the area currently occupied by the river. ▪ Fill and berm placement and consolidation would likely require over two years. ▪ Benthic habitat would be restored to preconstruction conditions. ▪ The equivalent of up to 180 full rail cars or 900 fully-loaded trucks (18,000 cubic yards) would leave the site with dredged sediment over the dredge period if all of the sediment would be managed offsite. ▪ Water treatment to meet state	• Worker risk would be 3 times higher compared to Alternative NW-1 (see Table 4.3). ▪ Safety of dredging to workers and risk of shoreline instability adjacent to the shoreline bulkhead would be more problematic than for other NW alternatives due to a greater depth and duration of dredging. ▪ Due to the extent of debris removal and dredging, river work (and resuspension of sediment) would extend beyond one construction year. ▪ Benthic habitat would be restored to preconstruction conditions. ▪ The equivalent of up to 510 full rail cars or 2,600 fully-loaded trucks (51,000 cubic yards) would leave the site with dredged sediment over the estimated 7 to 8 month dredge period. More barge traffic to and from the site would also be needed. ▪ Water treatment to meet state discharge requirements and soil management needed to allow soil to be transported off-site can be effectively completed based on a preliminary analysis of projects at other sites. ▪ Breaching the marine silt layer

NORTHWEST CORNER SHORELINE ALTERNATIVE EVALUATION SUMMARY HARBOR AT HASTINGS OU-2

	NW-1 Dredge for Cap Stability	NW-2 Dredge to Limits of Bulkhead Stability	NW-3 Redivide OU-1 and OU-2	NW-4 Penetrate Shoreline Bulkhead into Basal Sands
Short-Term Effectiveness, continued	not be noticeable off site based on experience at other dredging sites. ▪ River work would last approximately 5 months. ▪ Benthic habitat would be restored to preconstruction conditions. ▪ Approximately 59 full rail cars or 300 fully-loaded trucks (5,900 cubic yards) would leave the site with dredged sediment over the estimated 2 month dredging period. ▪ Water treatment to meet state discharge requirements and soil management needed to allow soil to be transported off-site can be effectively completed based on results from other sites.	• Intermittent noise from placing piles at the shoreline and in the river would last a few weeks longer than for Alternative NW-1 because the temporary barrier would be 1,200 ft long instead of 900 ft long, but the piles could be placed during daytime hours in compliance with Village code requirements. • River work would require approximately 8 to 12 months of effort. • Benthic habitat would be restored to preconstruction conditions. • The equivalent of 190 full rail cars or 950 fully-loaded trucks (under Option A) or 270 full rail cars or 1,350 fully-loaded trucks (under Option B) would leave the site with dredged sediment over the estimated 3 to 5-month dredging period. ▪ Water treatment to meet state discharge requirements and soil management needed to allow soil to be transported off-site can be effectively completed based on a preliminary analysis of projects at other sites.	discharge requirements and soil management needed to allow soil to be transported off-site can be effectively completed based on successes at other sites. ▪ Wick drains (or other consolidation devices) would need to be installed into the marine silt to accelerate consolidation of berm-cap thereby accelerating completion of OU-1 remedy.	would not be protective of the basal sand groundwater either in the short term or over the long term.
Long-term effectiveness and	Dredging alone would not achieve the sediment PRGs due	Dredging alone would not achieve the sediment PRGs due to undredged	PCBs PRGs expected to be achieved in river on at least a cutline basis.	Dredging alone would not achieve the sediment PRGs due to undredged

TABLE 4.1, Continued

NORTHWEST CORNER SHORELINE
ALTERNATIVE EVALUATION SUMMARY
HARBOR AT HASTINGS OU-2

	NW-1 Dredge for Cap Stability	NW-2 Dredge to Limits of Bulkhead Stability	NW-3 Redivide OU-1 and OU-2	NW-4 Penetrate Shoreline Bulkhead into Basal Sands
permanence (magnitude of risk remaining after remediation, reliability of long-term controls) Long-Term Effectiveness and Permanence, continued	to undredged sediments and residuals (see Section 2.1.1). Coupled with well designed cap and berm, NW-1 would provide long-term effectiveness and permanence as long as the site's geotechnical constraints are properly addressed. ▪ Neglecting resuspension, removes 61 percent of OU-2 PCBs from river setting. ▪ Covering undredged affected sediments with a berm-cap would provide reliable long-term protection against erosion from wind-waves (see Section 2.2). Protectiveness would be ensured with berm–cap maintenance proven at other sites. ▪ Institutional controls such as an environmental easement have precedents and should be effective. ▪ Dredging and capping would be consistent with future site land use. Hydraulic carrying capacity of the river would not be significantly affected by the berm and cap.	sediments and residuals (see Section 2.1.1). Coupled with well designed cap and berm, NW-2 would provide long-term effectiveness and permanence as long as the site's geotechnical constraints are properly addressed. No significant additional long-term effectiveness would be provided compared to Alternative NW-1 or NW-4. Undredged affected sediments exposed to the local environment would be covered by a berm-cap as under Alternative NW-1. ▪ 19,000 (or 27,000) additional cubic yards of contaminated sediment would be removed from the river under Option A or Option B respectively, but a berm-cap would be as effective and protective under either option as for Alternative NW-1. ▪ Institutional controls such as an environmental easement have precedents and should be effective. ▪ Dredging and capping would be consistent with future site land use. Hydraulic carrying capacity of the river would not be	Coupled with well designed cap and berm, NW-3 would provide long-term effectiveness and permanence as long as the site's geotechnical constraints are properly addressed. Post dredging residuals exposed to the local environment would be the same as under Alternative NW-1. Other factors associated with long-term effectiveness would be: • Less than one acre of aquatic habitat could be effectively replaced at a nearby location to be determined. • Sediment with concentrations above the PRGs would all be dredged between the new shoreline bulkhead and the temporary barrier. • Institutional controls such as an environmental easement have precedents and should be effective. • Dredging and capping would be consistent with future site land use. Hydraulic carrying capacity of the river would not be significantly affected by the berm and cap.	sediments and residuals (see Section 2.1.1). Coupled with well designed cap and berm, NW-4 would achieve sediment PRGs. However, its lengthy unsealable penetration of a confining layer near known DNAPL would make this alternative not effective over the long term. Residuals exposed to the local environment would be the same as under Alternatives NW-1 and NW-2. ▪ Contamination migrating downward along the shoreline bulkhead to the basal sands would be a source of contamination and potential residual risk to human health and the environment through local groundwater. Long-term effectiveness is questionable if result is newly contaminated basal sand groundwater. ▪ Institutional controls such as an environmental easement have precedents and should be effective. ▪ Dredging and capping would be consistent with future site land use. Hydraulic carrying capacity of the river would not be significantly affected by the berm and cap.

TABLE 4.1, Continued

NORTHWEST CORNER SHORELINE
ALTERNATIVE EVALUATION SUMMARY
HARBOR AT HASTINGS OU-2

	NW-1 Dredge for Cap Stability	NW-2 Dredge to Limits of Bulkhead Stability	NW-3 Redivide OU-1 and OU-2	NW-4 Penetrate Shoreline Bulkhead into Basal Sands
		significantly affected by the berm and cap.		
Reduction of toxicity, mobility and volume through treatment	▪ Water separated from dredged sediment would be permanently treated and thereby reduce mass of PCBs and metals in the return water.	▪ Water separated from dredged sediment would be permanently treated and thereby reduce mass of PCBs and metals in the return water	▪ Water separated from dredged sediment would be permanently treated and thereby reduce mass of PCBs and metals in the return water	▪ Water separated from dredged sediment would be permanently treated and thereby reduce mass of PCBs and metals in the return water
Implementability (technical feasibility, administrative feasibility and availability of resources)	▪ More implementable and technically feasible than NW-2, NW-3, or NW-4 due to less work in the river and independence from the OU-1 remedial action. ▪ Needed resources and work space would likely be available. Sediment dredged from clean navigational dredge sites may be useable for the berm and cap. ▪ Installation of the temporary rigid containment barrier would likely be difficult due to deep water and strong currents. Dredging in debris areas would also be difficult. ▪ Allows OU-1 excavation and final capping to be completed before dredging near the shoreline. ▪ Dredging would provide water depth near shore for placing a	Same as Alternative NW-1 except: • Dredging deep would be difficult to implement due to significant debris and obstructions, more resuspension of sediment in the river, and coordination needed with the OU-1 remedial action. Debris such as rubble and concrete block is difficult to handle, slows production and increases costs. ▪ Any delay of the OU-1 remedial action due to coordination with the OU-2 remedial action would delay onshore redevelopment by a minimum of 2 to 3 years.	Same as for Alternative NW-1 except: ▪ Construction of the new shoreline would be complex and require a high level of monitoring and control during construction due to wick drains (or equivalent) needed to promote consolidation, sequential backfilling on both sides of the shoreline bulkhead, and monitoring during consolidation. ▪ Dredging would be less difficult, because it would be done away from the existing shoreline where there are fewer obstructions. ▪ Approvals would be needed from the NYSDEC and from the US Army Corps of Engineers for filling within the river and for mitigation / replacement of aquatic habitat. Reasonableness of filling between the NW-3 bulkhead and the current shoreline would be important to demonstrate to meet regulatory requirements.	▪ Alternative NW-4 would be the most difficult and complex NW alternative to construct due to significant debris and obstructions, more resuspension of sediment in the river, and coordination needed with the OU-1 remedial action. ▪ Debris such as rubble and concrete block is difficult to handle, slows production and increases costs. ▪ Allows OU-1 excavation and filling of OU-1 to approximately elevation +4 ft to be completed before dredging near the shoreline but completion of the OU-1 remedial action could be delayed. Any delay of the OU-1 remedial action due to coordination with the OU-2 remedial action would delay onshore redevelopment by a minimum of 2 to 3 years. ▪ Administrative feasibility problematic due to federal guidance against penetrating

TABLE 4.1, Continued

NORTHWEST CORNER SHORELINE
ALTERNATIVE EVALUATION SUMMARY
HARBOR AT HASTINGS OU-2

	NW-1 Dredge for Cap Stability	NW-2 Dredge to Limits of Bulkhead Stability	NW-3 Redivide OU-1 and OU-2	NW-4 Penetrate Shoreline Bulkhead into Basal Sands
Implementability, continued	protective cap. ▪ Sediment shear strength needed for cap placement is available (see Section 2.2.7) ▪ Administrative feasibility for this alternative is considered to be routine. Establishing environmental easements with New York State are not expected to be complex. ▪ Underwater utilities that would complicate dredging and capping are not present. ▪ A long lead time may be needed for fabrication and delivery of high-capacity steel for the temporary rigid containment barrier. ▪ Final ground surface elevations at OU-1 would be consistent with the Federal Consent Decree.		▪ Any delay of the OU-1 remedial action due to coordination with the OU-2 remedial action would delay onshore redevelopment by a minimum of 2 to 3 years.	existing confining layer(s) if DNAPL presence is suspected. It is not technically feasible to construct NW-4 without creating open pathways from the fill zone (with DNAPL) into the uncontaminated basal sand below.
Costs (capital, annual, and present worth costs. Capital = construction, non-construction, and contingency)	Capital: $ 21.9 million Long-Term Annual: $100,000 Present Worth: $ 23.0 million Alternative NW-1 is at the knee of the curve (see Figure 4.1). Additional dredging beyond Alternative NW-1 is much less effective in cost per pass of PCBs removed.	Capital: $ 51.2 and $58.8 million Long-Term Annual: $100,000 Present Worth: $ 52.3 and $59.9 million	Capital: $ 56.0 million Long-Term Annual: $100,000 Present Worth: $ 57.1 million (Note: The economic benefit of an additional acre of shoreline is not included in the cost analysis.)	Capital: $ 95.1 million Long-Term Annual: $100,000 Present Worth: $ 96.2 million

TABLE 4.2

MASS OF PCBs IN DREDGED SEDIMENT FOR THE NORTHWEST CORNER AREA ALTERNATIVES

Remedial Action Alternative	Estimated Mass of PCBs Resuspended Due to Dredging (pounds) (1)	Estimated Duration for Debris Removal and Dredging (months)	Estimated Average Sediment PCB Concentration In Dredged Sediment (ppm) (2)
NW-1	700	1 to 2	1,400
NW-2, Option A	800	4	540
NW-2, Option B	900	5 to 6	410
NW-3	10(3)	4	25
NW-4	1,100	7 to 8	260

(1) Based on 4 percent of the dredged sediment by weight becoming resuspended due to site conditions, except for Alternative NW-3 where dredging would be conducted further from the existing Northwest Corner Area shoreline so the resuspension rate is estimated to be 2 percent (see Section 2.1).

(2) Based on the volume weighted-average PCB concentration of dredged sediment, the mass of PCBs removed, and a sediment unit weight of 1 ton per cubic yard.

(3) The 99 percent of sediment PCB mass between the existing shoreline and the relocated shoreline would be transferred from OU-2 into the OU-1 sealed containment.

TABLE 4.3

SUMMARY OF SHORT-TERM WORKER RISKS OF FATALITY FOR THE NORTHWEST CORNER AREA ALTERNATIVES

Remedial Action Alternative	Risk of Fatality for Site Workers	Risk of Fatality for Transportation Workers and Non-workers
NW-1	0.010 or 1 in 100 projects	0.0088 or 1 in 114 projects
NW-2, Option A	0.030 or 1 in 33 projects	0.0088
NW-2, Option B	0.041 or 1 in 24 projects	0.0088
NW-3	0.032 or 1 in 31 projects	0.0088
NW-4	0.028 or 1 in 36 projects	0.0088

TABLE 4.4

APPROXIMATE NET RIVER BERM-CAP VOLUME REQUIRED ABOVE EXISTING MUDLINE TO SUPPORT THE NORTHWEST CORNER AREA SHORELINE BULKHEAD

HARBOR AT HASTINGS OU-2

Remedial Action Alternative	Net Sediment Volume Increase (+) or Decrease (-) Following Dredging and Placement of Berm and Cap (cubic yards) (1)	Percent Change in River Cross Section (2)
NW-1	+ 6,000	-0.1(3)
NW-2, Option A	- 4,200	Greater than zero
NW-2, Option B	- 11,700	Greater than zero
NW-3	+ 13,000	- 0.2
NW-4	- 14,200	Greater than zero

(1) Based on an OU-1 final grade elevation of +4 ft with the shoreline sloping upward to +9 ft at 100 to 120 ft inland based on NAVD88 datum (average tidal water level is +0.1 ft). These sediment volume changes do not include the beneficial effect of settlement from berm-cap placement. For example, a berm-cap with a total thickness of 5 ft above existing grade would have a total settlement over time of approximately 1.5 to 2 ft (see Appendix B).

(2) Based on the existing river cross section at Hastings-on-Hudson being approximately 4,000 ft wide with an average water depth of approximately 40 ft. “Greater than zero indicates more hydraulic capacity would be available following remediation.

(3) Example calculation: 5,000 cubic yards over a 140 ft river width and a 900 ft river length corresponds to a 1.1 ft average increase in water depth. 1.1 ft over a 140 ft river width divided by 40 ft over a 4,000 ft wide river (from note 2 above) is 0.1 percent (or one tenth of one percent).

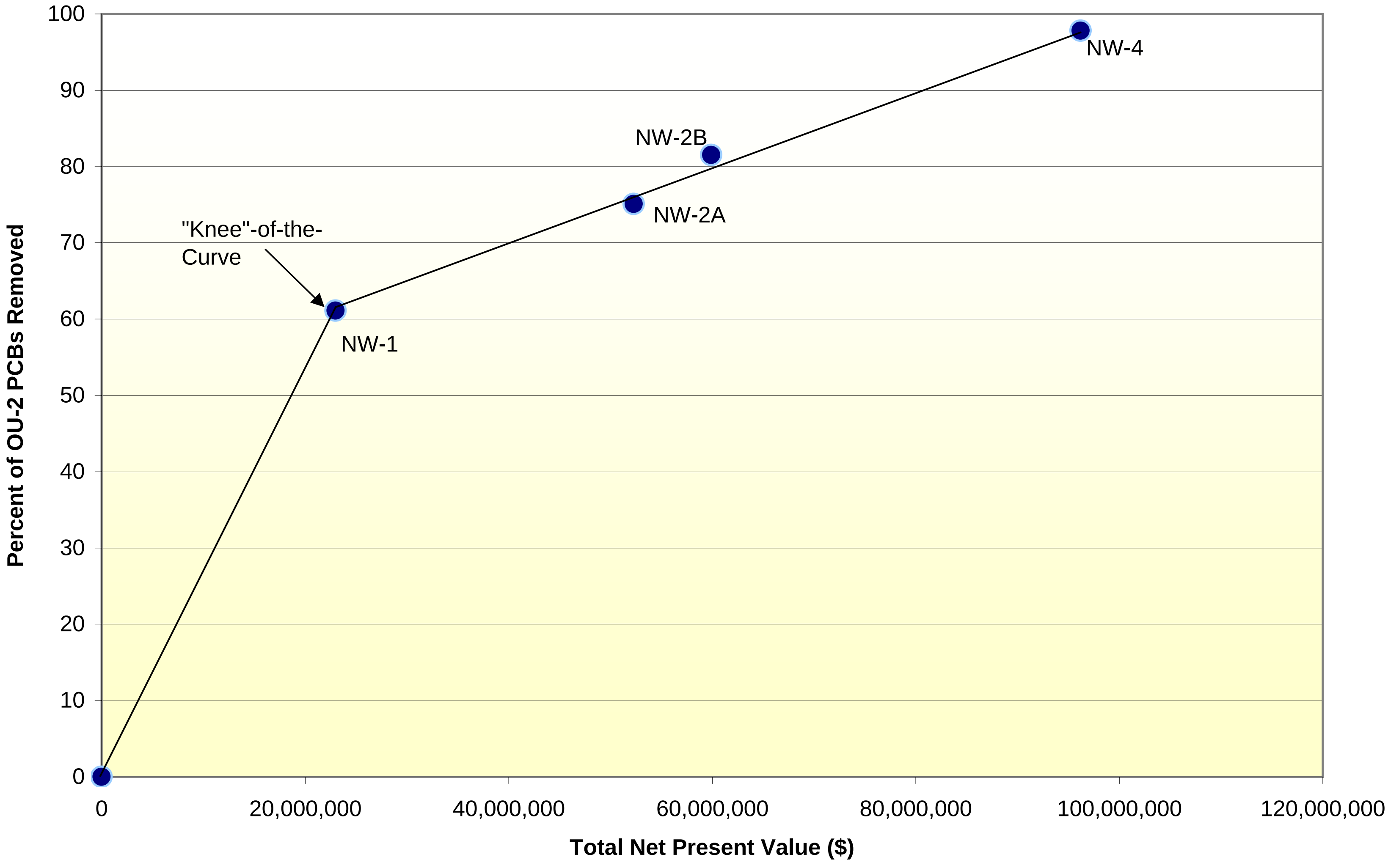
TABLE 4.5

SEDIMENT DREDGE VOLUMES AND CONTAMINANT MASSES FOR THE NORTHWEST CORNER AREA ALTERNATIVES

Alternative	Volume of Sediment to Dredge (cubic yards)	Mass of PCBs Removable (pounds)	Pounds of PCBs Removable per Cubic Yard	Percentage of Removable PCB / Elevated Copper Mass in OU-2 Sediment
NW-1	5,900	17,000	3.3	61 / 18
NW-2, Option A	19,000	20,000	1.1	75 / 22
NW-2, Option B	27,000	22,000	0.8	82 / 22
NW-3	18,000	440 (1)	0.02	99 (1) / 0
NW-4	51,000	26,000	0.5	99 / 22

(1) Under Alternative NW-3, many more pounds of PCBs would be permanently contained behind a new shoreline bulkhead west of the existing shoreline. All of the PCBs in the Northwest Corner Area would be either removed or contained as part of Alternative NW-3.

Figure 4.1
Knee-of-the-Curve Analysis for Northwest Corner Alternatives



P:\441532 (Hastings OU2)\Cost Estimate Support Info\OU-2 Dredge-Mass Volume SummaryNew.xls
5/1/2006

SECTION 5

REMEDIAL ACTION ALTERNATIVES FOR THE SOUTHERN AREA

This section describes remedial action alternatives for the Southern Area (SA) of OU-2. The Southern Area extends for a total length of approximately 1,800 ft from the Northwest Corner Area on the north, to the southern property boundary on the south, encompassing approximately 2.3 acres. The Southern Area extends between the shoreline on the east and the alignment of the silt curtain barrier on the west (see Figure 1.2 and Figure 5.1). Remedial action alternatives for the Southern Area consist of capping only and dredging followed by capping.

Less than 1 percent of the total PCB mass in OU-2 is found in the Southern Area. PCBs above the 1 ppm PRG are found intermittently up to approximately 4 feet below the mudline in the Southern Area (see Figure A.1 and see Figures 2.7c and 2.7d in the 2003 OU-2 FS Report). The quantity of PCBs in Southern Area sediment is less than 30 pounds, compared to approximately 26,000 pounds in Northwest Corner Area sediment. Area weighted average PCB concentrations in Southern Area sediment are lower than the PRG for PCBs of 1 ppm. In addition, the PCBs present in the Southern Area include both site related (Aroclor 1260) and other regional PCBs.

Copper concentrations above the proposed 982 ppm PRG are found in three small areas of sediment shown in Figure 1.4: one localized area off the northern portion of former Building 15 and two localized and two smaller areas midway between the South Boat Slip and the southern boundary of the former plant site. Approximately 45 percent of the site wide copper mass above 982 ppm is concentrated in these areas, in the top 5 to 6 feet of sediment.

Sediments with copper concentrations above the 88.7 ppm background concentration reported in the OU-2 RI are found throughout the Southern Area. These lower levels of copper are likely to be a component of historic fill material (ash and slag) used to create the plant site, the adjacent Tappan Terminal Site, and the river berm that supports them. Fill material is found throughout most of the Southern Area.

The PRGs for metals presented in the 2003 OU-2 FS did not account for site-specific bioavailability or toxicity of metals in sediments at OU-2. Instead, the 2003 OU-2 FS relied upon generic sediment screening criteria from statewide guidance (NYSDEC, 1993) and background concentrations in sediments for the Lower Hudson River as a basis for quantifying PRGs. The OU-2 RI developed, for example, a background concentration for copper of 88.7 ppm. Copper concentrations in Northwest Corner Area sediment generally exceed the background copper concentration of 88.7 ppm to a depth of 8 to 10 ft below the mudline.

However, USEPA in their most recent guidance for contaminated sediment (USEPA, 2005b) indicates on page 2-6 that:

> "Concentrations of bulk (total dry weight basis) metals in sediment alone are typically not good measures of metal toxicity. However, in addition to direct measurement of toxicity, EPA has developed a recommended approach for estimating metal toxicity based on the bioavailable metal fraction, which can be measured in pore water and/or predicted based on the relative sediment concentrations of acid volatile sulfide (AVS), simultaneously extracted metals (SEM), and total organic carbon (TOC). Both AVS and TOC are capable of sequestering and immobilizing a range of metals in sediment."

This USEPA (2005b) guidance provides a rigorous methodology for assessing the factors that limit the bioavailability and toxicity of metals. This guidance recognizes the importance of acid volatile sulfides and organic carbon in sequestering (or binding up) metals in sediments thereby limiting their introduction into porewater, which is the primary route of exposure for benthic organisms. This USEPA guidance also establishes a scientific method for evaluating the bioavailability and toxicity of metals in sediments including a detailed methodology for quantitatively assessing the metal binding capacity of sediments.

As explained in Section 1 and Appendix C of this SFS, bulk concentrations of metals in sediments do not accurately predict whether the sediments have an adverse impact on aquatic life. USEPA's 2005 ESB guidance (USEPA, 2005b) provides a rigorous methodology for assessing the factors that limit the bioavailability and toxicity of metals. This guidance recognizes the importance of acid volatile sulfides and organic carbon in sequestering (or binding up) metals in sediments thereby limiting their introduction into porewater, which is the primary route of exposure for benthic organisms. This USEPA ESB guidance also establishes a scientific method for evaluating the bioavailability and toxicity of metals in sediments, including a detailed methodology for quantitatively assessing the metal binding capacity of sediments.

Site-specific acid volatile sulfides, organic carbon and metal porewater data were collected during supplemental sediment investigations of OU-2 conducted by AR in 2004 and 2005. These data fill previous data gaps and allow the site-specific bioavailability and toxicity of metals to be evaluated based on the methods presented in the USEPA 2005 ESB guidance. The results of this analysis are summarized in Section 1 and presented in more detail in Appendix C to show that a copper concentration of 982 ppm is a conservative, site-specific, no observed adverse effects sediment concentration that is proposed as a PRG for the Southern Area and for the other areas comprising OU-2. Section 1 and Appendix C contain a similar analysis for lead, nickel and zinc. These metals are generally concentrated in the Southern Area in the same locations, and at the same depths, as copper above the proposed PRG (see Figures C.4 through C.7 in Appendix C). Remedies for copper above the proposed PRG also address lead, nickel and zinc above their proposed PRGs.

5.1 REMEDIAL ELEMENTS COMMON TO THE SOUTHERN AREA ALTERNATIVES

Table 5.1 provides a short listing of the elements of each of the SA alternatives. The no action alternative for the Southern Area was removed from consideration during the 2003 OU-2 FS effort. One option consists primarily of a protective cap. The other three alternatives (SA-2, SA-3, and SA-4) include dredging inside a temporary silt curtain.

For each of the Southern Area alternatives, timber piles within the remediation area would be cut at or below the mudline prior to dredging or capping. Significantly large obstructions would be removed prior to dredging.

Dredging as part of Alternatives SA-2, SA-3, and SA-4 would be conducted inside a temporary silt curtain to contain sediment resuspended during remediation and thereby reduce the short-term risks associated with OU-2 contaminants migrating within the river away from the contained area. The silt curtain would encompass the west, south, and north sides of the Southern Area up to the high tide shoreline. If dredging in the Southern Area is conducted while the Northwest Corner Area temporary rigid containment barrier is in place, the temporary silt curtain would encompass the west and south sides only. The most suitable application of a silt curtain, as described in Section 2.1.3.1, is to a mean water depth of 15 ft (*i.e.*, elevation -15 ft), which corresponds to approximately 60 to 80 ft offshore based on the Alpine Ocean Seismic Survey bathymetry measurements reported in Appendix A of the OU-2 RI report (Earth Tech, 2000). This silt curtain alignment would correspond to a maximum water depth where silt curtains have been shown to be relatively effective for containing sediment. A 4-ft tidal range, significant wind waves at OU-2 due to the long upriver wind fetch from the northwest over five miles in length, and typical difficulty holding a silt curtain in tension and keeping it in contact with the mudline most likely would make attempts to effectively use silt curtains in waters deeper than a tidal average of 15 ft counter productive.

The temporary silt curtain could be similar to the silt curtain used effectively during 2004 at the Tarrytown, NY site along the same side of the lower Hudson River approximately 10 miles upstream of Hastings-on-Hudson. The temporary silt curtain would likely consist of an inner impermeable fabric and an outer geotextile anchored every 20 to 30 ft along the curtain length.

As with the Northwest Corner Area alternatives, there are geotechnical limits to the depth of dredging achievable in the Southern Area to keep OU-1 structures and soils in a stable condition. These limits are, as for the Northwest Corner Area, based primarily on soil and sediment shear strength, the depth of fill, and local topography. Results from geotechnical analyses for shoreline bulkhead stability for each of the four Southern Area alternatives are summarized in Table 5.2 and presented in Appendix B. Additionally, the depth of dredging next to the bulkhead can be increased by placing a berm in the river and utilizing lightweight fill at OU-1 within 100 to 120 ft of the shoreline as described in Section 2.1.4 and in Section 3. Surcharge loading has also been assumed restricted within 100 ft inland of the wall and sealing of the walls interlocks has been assumed delayed until after dredging and berm construction.

Alternatives SA-2, SA-3, and SA-4 include use of mechanical dredging due to the debris apparent within the river (see Figure 3.1). A dense field of obstructions was documented offshore of former Building 15 which is situated between the North and South Boats slips, spanning approximately 700 ft of the Southern Area shoreline. These obstructions are characterized by wooden pilings, sections of sheet piling, sub-surficial magnetic debris, tires, and other man-made debris. This debris field extends beyond the Southern Area approximately 150 ft from the shoreline. Geophysical data and sampling results are also indicative of shell beds throughout this area (Parsons, 2005a/b).

Table 5.3 presents a summary of the quantities of dredged material, backfill materials, and cap materials for each of the four SA alternatives. Table 5.3 also presents a summary of the estimated mass of PCBs, copper dredged from the river for each of the alternatives based on AR's contaminant distribution modeling as part of this Supplemental FS (see Section 1.3.1 and Appendix A). Less than 0.1 percent of the PCB mass and 10 to 29 percent of the elevated copper mass are removable under Alternatives SA-2, SA-3, and SA-4.

Removing debris and obstructions and dredging could be done from small barges inside the contained area or possibly from shore-based equipment. It is generally not practical to dredge more than 50 to 60 ft from shore with shore-based equipment due to the large crane size needed onshore close to the shoreline. However, a silt curtain alignment approximately 60 to 80 ft from shore would not leave enough contained area for typically-larger dredge barges and debris barges to operate. Smaller barges would be needed than are envisioned for the Northwest Corner Area. If debris is not removed from land, the debris barge would need to have sufficient capacity to penetrate into and/or remove debris that would otherwise inhibit cap placement or dredging.

Dredged sediment would be processed onshore as described in Section 3 to remove sufficient water to allow sediment to be reused or transported off site. Sediment containing less than 10 ppm PCBs could possibly be reused as fill within OU-1 or reused as fill offsite consistent with how sediment dredged from New York – New Jersey Harbor is being reused. Otherwise, dredged and processed sediment would be transported offsite by truck, by rail or by barge. Water removed from dredged sediment would be treated at OU-1 and released back to the river in accordance with NYSDEC discharge requirements or treated at a Westchester County municipal wastewater treatment plant.

As with the Northwest Corner Area alternatives, granular soil and crushed stone would be placed in the river to form a berm as needed to provide additional stability for a new shoreline bulkhead. The berm would be placed from the face of the bulkhead out from shore into the river. The berm would include wick drains (or other consolidation devices) as needed to accelerate its consolidation following placement.

This Supplemental Feasibility Study identifies the option of moving the south shoreline bulkhead approximately 30 ft inland to create additional water area and depth that might be needed to offset water area and/or depth lost in other remedial alternatives. This option could partially offset water area that may be lost if Alternative NW-3 is selected as a remedy (realignment of OU-1 and OU-2). Approximately a half acre of river habitat could be gained along the Southern Area by moving the shoreline inland, however, since there is limited data regarding the extent of contamination in this portion of OU-1, additional sampling and analysis would be needed during design to assess the potential benefits and cost effectiveness of moving this portion of OU-1 into OU-2.

As needed, a protective cap would be a component of each Southern Area alternative. The protective cap would separate the river from residual contaminated sediment where a berm is not placed and help to restore the existing aquatic habitat. The protective cap, where not placed in conjunction with a berm, would need to withstand ongoing and intermittent natural forces, such as storm events and annual early spring ice sheets moving within the river. The cap would be monitored and repaired as needed over the long term (see Section 2.2).

Specific information about any remedial action alternatives is presented in this Supplemental FS only for the purpose of evaluating each alternative. Any elevations or other specific information presented herein about any alternative is preliminary, approximate, and subject to change during remedial design.

5.2 ALTERNATIVE SA-1: PLACE A PROTECTIVE CAP

Under this alternative, surficial sediment debris would be removed and timber piles would be cut as needed to prepare the sediment surface for installation of a berm and protective cap. The weight of a berm constructed on the riverside of the shoreline bulkhead would enhance bulkhead stability by reducing the load differential on the wall and by gradually increasing the strength of the marine silt foundation soils. The marine silt soils in the Southern Area are less consolidated and weaker at a given depth below the top of the stratum than the marine silt in the Northwest Corner. A protective cap would be placed over portions of the Southern Area where sediment concentrations exceed PRGs for PCBs and copper in the top 1 to 2 ft of sediment. The cap would have the characteristics described in Section 2.2. The cap would be up to 24 inches thick to provide a transition with underlying sediment, chemical isolation (as needed), erosion protection, and aquatic habitat restoration. Close to shore in shallow waters, the cap would include an armoring layer of cobbles and riprap for protection against ice abrasion and prop wash from boats. Away from shore, cap materials would consist of fine gravel with a mixture of sands and silts to restore aquatic habitat.

The cap would encompass approximately 1.8 acres in the Southern Area to address PCBs over 1 ppm and copper over 982 ppm. It would contain approximately 0.1 percent of the PCB mass, and approximately 45 percent of the copper mass above the proposed copper PRG throughout OU-2 based on AR's contaminant distribution modeling results. An additional 30 percent of the site-wide copper mass above the proposed PRG is found outside the southern area boundaries, just beyond the -15 ft mudline elevation at which silt curtains are known to be effective. It may be possible to include some or all of this small area of elevated copper in the area covered by the SA-1 cap, raising the percentage of copper above the proposed PRG contained by this remedial option to approximately 75 percent of the total within OU-2.

Where needed for global stability along the shoreline, a berm would be placed in conjunction with a protective cap. The extent of such a berm will be determined during remedial design. For costing purposes, reasonable berm dimensions are presented in Appendix B based on geotechnical analyses of site information.

Measures could perhaps be included within OU-1 or within OU-2 to reduce the net vertical increase in mudline elevation from placing a berm-cap in the Southern Area. Such measures could, for example, include additional lightweight fill at OU-1 or a deeper shoreline bulkhead.

Under this alternative, surface debris would be removed, and the berm - cap would be placed, without a silt curtain or other forms of temporary containment in the river. Based on cap placements successfully completed at other sites without silt curtains as described in Section 2.2.7, and on the relatively low concentrations of contamination found near the proposed PRGs in the Southern Area, a silt curtain is not needed to contain materials resuspended during debris removal or capping. Following placement, the cap would be monitored long term to assure its continuing protectiveness. Repairs to the cap, if or when necessary, would be made based on long-term monitoring efforts. Institutional controls would be used to help ensure that the cap remains in place and is not damaged by human activities on a long term basis.

Remediation of OU-1 adjacent to the Southern Area could proceed in accordance with the OU-1 ROD independent of river capping work under this alternative. The Southern Area could be capped over a timeframe of approximately 6 to 8 weeks including removal of surface obstructions in order to place the protective cap. This duration may need to be adjusted depending on the extent of berm to place in the river which would be determined during remedial design.

5.3 ALTERNATIVE SA-2: DREDGE UP TO 2 FT AND CAP

The OU-1 remedial action along the shoreline in the Southern Area consists of installing a sealed shoreline bulkhead and raising the site grade to an elevation of +4 ft. Construction of the OU-1 shoreline bulkhead would be completed under this alternative prior to dredging Southern Area sediment. The shoreline bulkhead under Alternative SA-2 would penetrate only into the marine silt. Under this alternative, lightweight fill would be utilized from elevation -4 ft to elevation +4 ft within 100 to 120 ft of the shoreline. The anchor system needed to support the shoreline bulkhead would be installed during the backfilling operation.

Once the temporary silt curtain described earlier in this section is placed, timber piles would be cut and surface debris would be removed prior to dredging. Under Alternative SA-2, the dredge depth would be up to approximately 2 ft below the existing mudline (or deeper adjacent to shore to maintain stability of the sediment closest to shore as described below) in areas where PRGs for PCB and copper are exceeded.

The mudline elevation along the existing Southern Area shoreline varies from 0 ft to -9 ft NAVD88 datum. In areas where the mudline is the highest (i.e., elevation 0 ft to -3 ft), the existing slope near the shoreline is relatively steep to an elevation of -12 ft to -14 ft at a distance approximately 30 ft into the river away from shore. Beyond 30 ft from shore, the slope of the sediment mudline becomes flatter (see river water depths presented in Figure 1.2).

The existing sediment slope near shore has a low factor of safety against sliding, so a slope steeper than three horizontal to one vertical is not expected to be stable after dredging. In these steep-sloped nearshore areas, more than two ft of sediment would likely need to be dredged to provide a safe dredge cut slope on which a cap and berm could be placed (see Figure 5.2 and Appendix B).

A berm could be placed in the river as needed to support the bulkhead with an acceptable factor of safety for long-term shoreline stability. The berm would be the same type as described earlier in this section and in the descriptions of alternatives for the Northwest Corner Area. As described previously in this section, an alternative shoreline bulkhead alignment may be effective in reducing the size of the berm required offshore of former Building 15.

Inside the silt curtain alignment, a protective cap would be installed in conjunction with the berm where PRGs for PCBs and/or copper are exceeded following dredging. As with the

Northwest Corner Area alternatives, the cap would be designed to replace the existing aquatic habitat and to withstand ongoing and intermittent natural forces. The protective cap would also help support and ensure the long-term stability of the shoreline bulkhead.

Under Alternative SA-2, approximately 6,900 cubic yards of sediment would be dredged. From AR's contaminant distribution modeling results, this alternative would remove or contain all of the PCBs and copper found above proposed PRGs within the Southern Area. This is equal to less than 0.1 percent of the PCB mass, and approximately 45 percent of the copper mass, above proposed PRGs within OU-2.

Alternative SA-2 would not result in removal of additional copper contamination beyond the Southern Area boundaries, because that would require dredging beyond the water depth at which silt curtains are known to be effective. Although the silt curtains could be moved to deeper water, they would be less effective at containing material suspended during the dredging process, and that may allow an unacceptable amount of material to escape from the dredge zone.

Alternative SA-2 could be combined with a limited cap for copper outside the Southern Area boundaries by applying the type of cap and capping method proposed under Alternative SA-1. This would raise the percentage of copper addressed by this remedial option to approximately 75 percent of the OU-2 copper mass above the proposed PRG.

Following removal from the dredged area, dredged sediment and debris would be processed at OU-1. Here, the sediments would be drained and dewatered as needed to a consistency allowing for sediment to be either placed within OU-1 (if sediment contains less than 10 ppm PCBs) or transported offsite by rail, truck or barge.

Alternative SA-2 could be completed in four to five months once the shoreline bulkhead is in place. The temporary silt curtain would take approximately three weeks to install. Dredging and capping could then be completed over a timeframe of approximately three to four months (including berm placement). Without wick drains (or other consolidation devices) or without moving the shoreline inland, consolidation of the berm in the river would require another 15 months off former Building 15 and approximately seven years south of the South Boat Slip before the OU-1 remedial action could be completed. Alternatively, incorporating wick drains (or other consolidation devices) into the berm construction could reduce this consolidation time to one to three months off former Building 15 and to less than one year south of the South Boat Slip (see Appendix B). If the shoreline would be moved inland approximately 30 ft, berm consolidation would not be needed. A decision whether to retain the existing IRM bulkhead located along the shoreline would be made as part of the remedial design efforts for OU-1 and for OU-2.

5.4 ALTERNATIVE SA-3: DREDGE TO LIMIT OF BULKHEAD STABILITY

Consistent with Alternative SA-2, placement of the OU-1 shoreline bulkhead under this alternative would be completed prior to dredging, and the bulkhead would extend into the marine silt sediment. The shoreline bulkhead would likely be installed using steel sheet piles with sealed joints and a deadman anchorage system placed within OU-1. The sheet pile interlocks (joints) would most likely be sealed following berm construction to reduce the initial short-term load on the wall.

Under this alternative, lightweight fill would be utilized from elevation -4 ft to elevation +2 to +5 ft within 100 to 120 ft of the shoreline. The anchor system needed to support the shoreline bulkhead would be installed during the backfilling operation.

Once the temporary silt curtain is secured in place in the river, timber piles would be cut, obstructions would be removed, and dredging would be conducted. Dredging would be completed based on existing data where sediment concentrations exceed PRGs, except that the dredge depth would be limited by bulkhead stability near the shoreline. There are two options under this alternative to address different vertical extents of dredging analogous to Alternative NW-2 for the Northwest Corner Area. The options are:

- For Option A, dredge adjacent to shore to an elevation -9 ft at the shoreline bulkhead and slope the dredge cut downward away from shore as practical based on the silt curtain alignment and as needed to remove sediment exceeding PRGs; and
- For Option B, dredge adjacent to shore to elevation -14 ft at the shoreline bulkhead. The dredge cut would need to be horizontal for approximately 20 to 30 ft away from shore after which the dredge cut could slope downward away from shore as practical based on the silt curtain alignment and as needed to remove sediment exceeding PRGs. In addition, OU-1 may not be able to be filled to the +4 ft elevation prior to dredging in order to be able to dredge to elevation -14 ft at the shoreline.

As with the Northwest Corner Area alternatives, the depth of dredging would be limited by global stability, bulkhead design, fill depth, fill and sediment strength, and onshore operations in order to protect the bulkhead and surrounding layers of soil from collapsing into the river. The existing slope has a low factor of safety for sliding and for overall shoreline stability. Option A is evaluated as a likely maximum practicable dredge cut depth at the shoreline with a shoreline bulkhead extended into the marine silt based on the geotechnical constraints described in Appendix B. Option B is considered an absolute maximum possible dredge cut at the shoreline with a shoreline bulkhead extended into the marine silt assuming results from the geotechnical analysis that would be completed during remedial design would be less restrictive than under Option A.

The geotechnical analysis (Appendix B) indicates that the lowest feasible dredge elevation at the shoreline bulkhead is elevation -14 ft with the OU-1 area close to shore backfilled to elevation +4 ft with lightweight fill. The dredge cut would slope downward away from shore. Additionally, a 20 to 30 ft wide bench cut at elevation -14 ft would be needed under Option B to provide additional support. Dredging would be conducted within global stability limits where sediment PRGs for PCBs and/or copper are exceeded. Dredge depth is limited, however, by the alignment of the silt curtain 60 to 80 ft from shore. Approximately 19 percent of the elevated copper mass would be dredged under Option A or Option B.

Following dredging and removal of the temporary silt curtain, a berm - protective would be installed as needed as described earlier for Alternatives SA-1 and SA-2. Dredging quantities under Alternative SA-3 are presented in Table 5.3.

- Under Option A, approximately 8,300 cubic yards of sediment would be dredged; and
- Under Option B, approximately 8,800 cubic yards of sediment would be dredged.

A berm would be needed to support the OU-1 land mass, even if all contamination above proposed PRGs is removed during the dredging process (except dredging residuals).

The berm and protective cap would be placed over approximately 1.8 acres in the river, out to the silt curtain alignment in areas where dredging is completed. The berm would need to extend approximately 20 to 40 ft further west beyond the silt curtain alignment into the offshore area. Following completion of the dredging, berm placement, and capping, OU-1 could be backfilled to its final elevation for redevelopment, and the shoreline bulkhead wall could be sealed.

From AR's contaminant distribution modeling results, this alternative is expected to remove all of the PCBs and copper above the proposed PRGs within the Southern Area boundaries, except for dredging residuals. This is equal to 19 percent of the site wide copper mass, and less than 0.1 percent of the site wide PCB mass.

Alternative SA-3 does not remove or cap additional copper contamination beyond southern area boundaries, because it is located beyond the -15 ft mudline elevation at which silt curtains are known to be effective. It may be possible to move the silt curtains to deeper water to reach the additional area of copper, but the curtains would be less effective as a containment measure at that location, creating potentially unacceptable losses of any material suspended during dredging. It also may be possible to combine SA-3 with the cap proposed under Alternative SA-1 for areas beyond the effective limit of silt curtain technology, raising the percentage of copper contained by this remedial option to approximately 70 percent of the OU-2 site wide total.

Alternative SA-3 could be completed in four to five months once the shoreline bulkhead is in place. The temporary silt curtain should require less than a month to install. Dredging, berm placement, and capping could be completed over a timeframe of approximately three to four months. Consolidation of the berm in the river would require approximately another 15 months before the OU-1 remedial action could be completed. Similar to Alternative SA-2, incorporating wick drains (or other consolidation devices) into the berm construction may reduce this consolidation time to one to three months off former Building 15 and from seven years to less than one year south of the South Boat Slip. If the shoreline would be moved inland, berm consolidation would not be needed offshore of former Building 15 or in the South Boat Slip. A decision whether to retain the existing IRM bulkhead located along the shoreline would be made as part of the remedial design efforts for OU-1 and for OU-2.

5.5 ALTERNATIVE SA-4: PENETRATE SHORELINE BULKHEAD INTO BASAL SAND

Unlike Alternatives SA-2 and SA-3, the new shoreline bulkhead under Alternative SA-4 would be driven deeper through the marine silt and into the basal sand in order to provide more wall strength and to increase global slope stability. The SA-4 dredge depth would be restricted by geometry and the deepest water depth in which the silt curtain in the Southern Area is placed. Based on the silt curtain alignment at a mudline elevation of -15 ft and a steep stable dredge slope in the marine silt, the deepest dredge depth at the face of the shoreline bulkhead would be below the elevation of the deepest sediment exceeding 1 ppm PCBs and/or 982 ppm copper.

The shoreline bulkhead under Alternative SA-4 could consist of heavy sheetpile walls. The shoreline bulkhead would be approximately 80 ft in depth based on a global stability analysis. Following installation of the shoreline bulkhead, the OU-1 excavation area adjacent to the river would then be backfilled with clean lightweight fill within 100 to 120 ft of the shoreline to an elevation of approximately +4 ft to avoid flooding at high tide.

Dredging would be done inside the same type of temporary silt curtain included as part of Alternatives SA-2 and SA-3. Following installation of the temporary silt curtain, timber piles and debris would be cut as needed. Contaminated sediment inside the silt curtain exceeding 1 ppm PCBs and/or 982 ppm copper would then be dredged to a depth that meets the following criteria:

- Because PCBs above the 1 ppm PRG were found 8 feet below the mudline in the South Boat Slip, AR’s contaminant distribution modeling suggests that additional PCBs may be found at similar depths in the former navigation channel that leads into the South Boat Slip. If further sampling confirms the presence of such contamination, this alternative SA-4 would extend as deep as elevation -20 ft along the shoreline to reach sediment with PCBs greater than 1 ppm and/or copper greater than the proposed PRG of 982 ppm in this former navigation channel; and
- The western dredge bottom cut-line could be sloped away from shore, but the cut line elevation would need to be limited near the silt curtain to ensure the temporary silt curtain is not undermined.

Up to approximately 16,000 cubic yards of sediment may be removed under Alternative SA-4. Based on AR’s contaminant distribution model results, this alternative is likely to remove approximately the same mass of PCBs and only 10 percent additional copper above the proposed PRGs as Alternative SA-3, at substantial additional cost.

Following dredging, a berm and protective cap would be placed in the river as needed to support the shoreline bulkhead. The extent of backfill needed for berm construction would be determined during remedial design in conjunction with the design for the OU-1 remedy. Following a consolidation period, the OU-1 remedy would be completed by installing the onshore cap and containment system included in the OU-1 ROD, and creating a final onshore elevation of +4 to +9 ft within 100 to 120 ft of the shoreline within OU-1.

Alternative SA-4 would most likely be able to be completed in five to six months once the shoreline bulkhead is in place. The temporary silt curtain would take less than a month to place prior to removing debris and dredging. Removing debris and obstructions, dredging, and placement of the berm and cap would take approximately four to five months.

TABLE 5.1

REMEDIAL ACTION ALTERNATIVES FOR THE SOUTHERN AREA (SA)

HARBOR AT HASTINGS OU-2

Alternative	General Description
SA-1: Place a Protective Cap	Place a protective cap (and berm as needed) without prior dredging. The cap would be placed where PRGs are exceeded.
SA-2: Dredge 2 ft and Place Protective Cap	Dredge up to 2 ft (or more if needed at spots for shoreline stability), where sediment PRGs are exceeded inside a temporary silt curtain located approximately 60 to 80 ft offshore. Place berm material as needed for shoreline stability. Place a protective cap integrated with the berm where PRGs would not be achieved with dredging.
SA-3: Dredge to Limit of Bulkhead Stability (two options)	Dredge sediment exceeding PRGs inside a temporary silt curtain, located approximately 60 to 80 ft offshore, to a maximum dredge depth at the shoreline of elevation -9 ft (Option A) or -14 ft (Option B). Dredge depths would be based on the shoreline bulkhead not penetrating into the basal sand. Place berm material as needed for shoreline stability. Place protective cap integrated with the berm where PRGs would not be achieved with dredging.
SA-4: Penetrate Shoreline Bulkhead into Basal Sand	Dredge sediment exceeding PRGs inside a temporary silt curtain, located approximately 60 to 80 ft offshore, to a maximum dredge depth at the shoreline needed to meet PRGs. Maximum dredge depth would not be structurally restricted due to the shoreline bulkhead penetrating into the basal sand. Place berm as needed for shoreline stability and protective cap integrated with the berm where PRGs would not be achieved with dredging.

Note: (1) Sediment PRGs are 1 ppm for PCBs and 982 ppm proposed for copper.

TABLE 5.2

CHARACTERIZATION OF BULKHEAD AND CONTAINMENT STRUCTURES FOR THE SOUTHERN AREA ALTERNATIVES

HARBOR AT HASTINGS OU-2

	SA-1	SA-2	SA-3 (2 Options)	SA-4
Shoreline Bulkhead				
Length (ft)	1,100	1,100	1,100	1,100
Maximum depth (elevation in ft)	-47	-47	-47	-75
Penetrate into basal sand?	No	No	No	Yes
Final OU-1 ground elevation at shoreline(ft)	+4	+4	+4	+4
Interim OU-1 ground elevation at shoreline while dredging (ft)	+4	+4	+4	+4
Temporary Silt Curtain				
Curtain length (ft)	0	2,000	2,000	2,000
Maximum distance from shoreline (ft)	NA	70	70	70
Approximate installation time (months)	0	0.7	0.7	0.7

Note: Elevations are based on the NAVD88 datum (mean tidal elevation is +0.1 ft).

TABLE 5.3

DREDGING AND CAPPING QUANTITIES AND DURATIONS FOR THE SOUTHERN AREA ALTERNATIVES

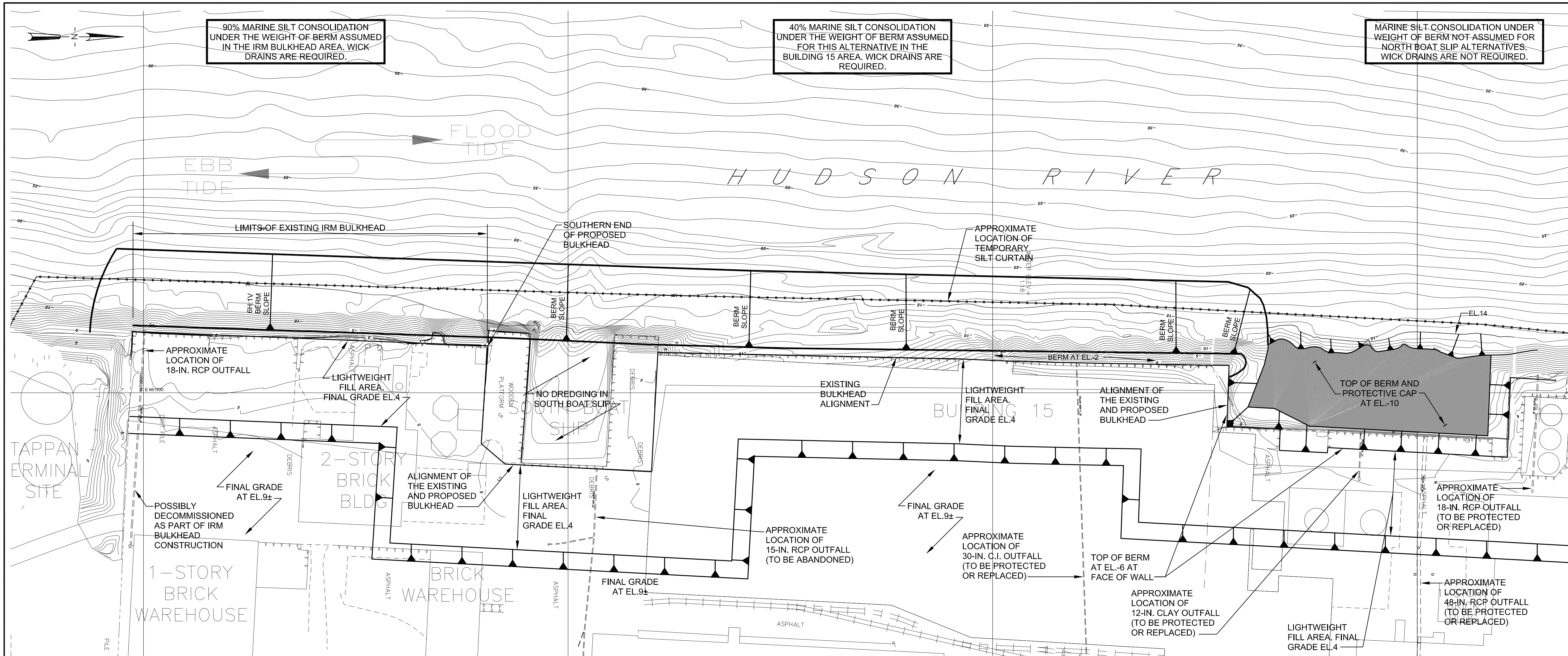
HARBOR AT HASTINGS OU-2

	SA-1	SA-2	SA-3 Option A	SA-3 Option B	SA-4
Dredging					
Volume (cubic yards)	0	6,900	8,300	8,800	16,000
Lowest cut elevation at shoreline (ft)	NA	-9	-9	-14	-23
Percent PCB mass dredged (1)	NA	Less than 0.1	Less than 0.1	Less than 0.1	0.1
Approximate dredging and debris removal duration (months)	2 to 3(2)	3 to 4	4 to 5	4 to 5	5 to 6
Berm – Protective Cap					
Area (acres)	1.8	1.8	1.8	1.8	1.8
Approximate installation time (months)	1	1	1	1	1

Notes:

(1) Percentages of mass are based on 100 percent being the mass within all sediment within OU-2.

(2) Time to cut existing timber piles and remove surface debris in cap area.



SOUTHERN BULKHEAD AND BOAT SLIP AREA NOTES:

1. DRAWING BASED ON NAVD 88 DATUM. TO CONVERT FROM NAVD88 TO NGVD29 DATUM ADD ONE FOOT TO NAVD88 ELEVATIONS. PLAN BASED ON NEW YORK 1988 STATE PLANE COORDINATE SYSTEM.
2. SOIL PROFILES SHOWN IN SECTION VIEW REFLECT TYPICAL CONDITIONS IN THE VICINITY OF THE SECTION CUT. THE SOIL PROFILES ARE SIMPLIFIED AS NECESSARY FOR USE IN THE ENGINEERING ASSESSMENT OF REMEDIAL ACTION ALTERNATIVES.
3. DREDGE CUT ASSUMED FOR GEOTECHNICAL CALCULATIONS IS SHOWN ON BOTH THE PLAN AND SECTION VIEW DRAWINGS FOR THIS ALTERNATIVE. WHERE THE DREDGE CUT BASED ON ENVIRONMENTAL DATA (FIGURES 1.3 AND 1.4) WOULD BE LESS THAN THE DREDGE CUT ASSUMED IN THE GEOTECHNICAL CALCULATIONS, THE ENVIRONMENTAL DREDGE CUT IS ALSO SHOWN ON THE SECTION VIEW DRAWINGS FOR THIS ALTERNATIVE.
4. CALCULATIONS WERE PERFORMED AT THE SECTIONS SHOWN. THE RESULTS OF THESE CALCULATIONS WERE THEN EXTRAPOLATED TO OTHER APPARENTLY SIMILAR AREAS OF THE SITE.
5. ALL ENGINEERING ELEMENTS PROVIDED ON THIS PLAN WERE DEVELOPED BASED ON EXISTING INFORMATION FOR THE PURPOSE OF EVALUATING REMEDIAL ALTERNATIVES AT THE SUBJECT SITE. THE ACTUAL DESIGN ELEVATIONS, DIMENSIONS, AND OTHER ENGINEERING ASPECTS OF THE SELECTED REMEDY WILL BE DEVELOPED DURING REMEDIAL DESIGN.

0 60 120 180 240
SCALE IN FEET

HALEY & ALDRICH
UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

HARBOR AT HASTINGS SITE
SUPPLEMENTAL FEASIBILITY STUDY FOR OU-2
HASTINGS-ON-HUDSON, NEW YORK

SOUTHERN BULKHEAD AND BOAT SLIP AREAS BULKHEAD WALL ALIGNMENT - PLAN VIEW

SCALE: AS SHOWN

18 APRIL 2006

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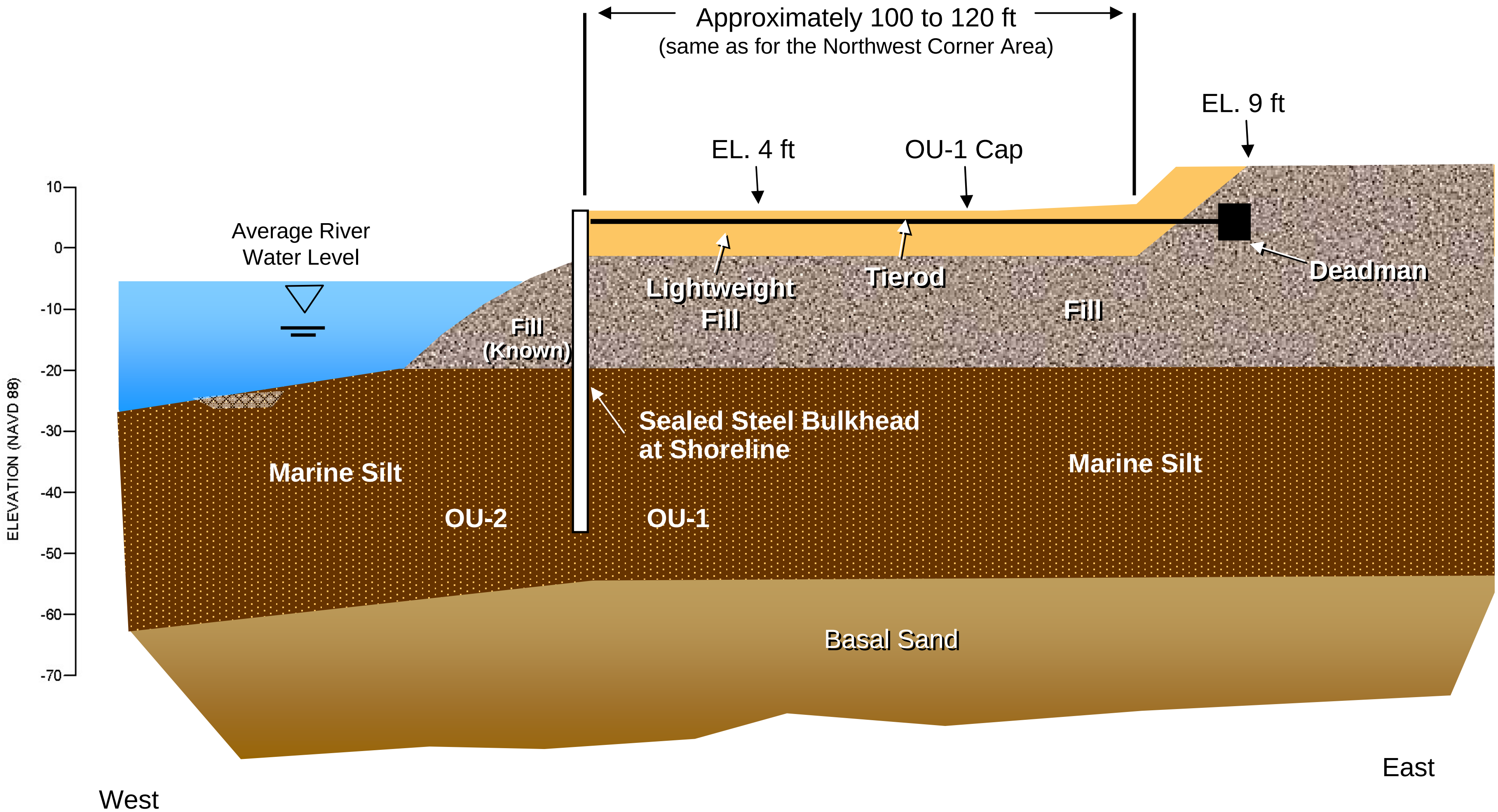
FIGURE 5.1

Figure 5.2
Harbor-at-Hastings OU-2
Typical Cross Section for Southern Area and Boat Slip Alternatives



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April 2006

SECTION 6

EVALUATION OF REMEDIAL ACTION ALTERNATIVES FOR THE SOUTHERN AREA

Remedial action alternatives for the Southern Area of OU-2 presented in Section 5 are evaluated in this section based on the same NYSDEC evaluation criteria used in Section 4 to evaluate remedial action alternatives for the Northwest Corner Area. Each of the remedial action alternatives for the Southern Area includes capping, and three of the four alternatives for the Southern Area also include dredging.

The Southern Area is the portion of OU-2 south of the North Boat Slip along the shoreline and south of the Northwest Corner Area away from shore (see Figure 1.2). The Southern Area extends south along Building 15 to the property boundary at the north end of the Tappan Terminal site. To the west, the Southern Area extends to a practicable average water depth for use of a silt curtain (a top of sediment (mudline) elevation of -15 ft).

Contamination in the Southern Area differs substantially from the Northwest Corner Area, as sediment in the Southern Area contains lower concentrations and a much smaller mass of PCBs. Less than 1 percent of the total PCB mass within OU-2 sediment is in the Southern Area, and the area-weighted average PCB concentration at any sediment depth in the Southern Area is below 1 ppm based on AR's contaminant distribution modeling results (see Table 1.1).

The evaluation of remedial action alternatives for the Southern Area is presented in Table 6.1 where the NYSDEC evaluation criteria are assessed separately for each individual alternative. The evaluation of remedial action alternatives for the Southern Area is summarized below.

6.1 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT (A THRESHOLD CRITERIA)

All of the proposed remedial alternatives would protect human health, aquatic life, and other biota from exposure to OU-2 sediment exceeding proposed PRGs for PCBs and metals in the Southern Area. Eliminating contact with sediment exceeding PRGs is the primary factor for determining whether an alternative can meet the protection of human health and the environment threshold criteria as well as meet the OU-2 remedial action objectives.

6.1.1 Evaluation of Overall Protection of Human Health and the Environment Common to All Southern Area Alternatives

All four of the remedial action alternatives for the Southern Area would protect human health and the environment in the long term, in the same manner as for the Northwest Corner Area alternatives described in Section 4.1.1. All four of the remedial action alternatives for the Southern Area would include a cap that would protect fish and other biota from direct contact with Southern Area sediment that exceeds PRGs. This would eliminate the potential impact of direct exposure of humans and/or aquatic life to contaminated sediments, and indirect exposure of aquatic life to any contaminants from the Southern Area that might otherwise be consumed in the food chain.

Capping can effectively protect human health and the environment in the Southern Area over the long term for the reasons described in Section 2.2 and summarized in Section 4.1.1. A protective cap has been employed successfully at many other sediment sites, because it can provide long-term chemical isolation, erosion control, and habitat replacement. A protective cap could be monitored and maintained over the long term, and institutional controls can be implemented, such as an environmental easement, to assure the cap remains protective.

PCB concentrations in the Southern Area sediment are significantly lower than PCB concentrations in Northwest Corner Area sediment[5], but it may not be possible to remove these concentrations of PCBs through dredging alone. Most other PCB dredging projects have failed to meet a 1 ppm remedial action goal through dredging as discussed in Section 2.2. It may be difficult to meet a 1 ppm PRG in the Southern Area through dredging because a portion of the contaminated sediment is interspersed with fill material and large debris that must be removed with a mechanical dredge technology designed to capture larger objects, not the fine-grained sediments that the contaminants are found in. The berm is steeply sloped in places, and underwater slope failure and slumping is likely resuspend additional fine grained sediments in the river. Column settling tests of sediment from the Northwest Corner Area show that the fine-grained contaminated sediment present at OU-2 settles slowly following dredging. As a result, dredging to or below the known depth of contamination may not succeed in removing all contamination above the PRGs, and an isolation layer portion of a protective cap may be needed to contain those residuals and meet PRGs at the mudline.

The metal levels found in the Southern Area sediment are relatively close to the proposed PRGs, and they are generally found below cleaner sediments (see Figure A.2 for example). Sediments buried below the top few inches are not bioavailable to benthic organisms or aquatic life.

Dredging and/or capping would disrupt the river bottom and the associated benthic community. However, by placing a top layer of a protective cap as presented in Section 2.2, benthic organisms are expected to recolonize the habitat surface layer of the cap (see Section 2.2) within 2 to 4 months during the biologically productive time of the year (i.e., April through November at this site) (Dernie, 2003). As most of the aquatic biota live within the top 3 to 6 inches of sediment, the lower erosion protection layer of the cap would prevent the biota from contacting contaminated sediment. Since OU-2 is known to accumulate sediment, the gradual natural deposition of native materials will also support restoration of local aquatic habitat following construction.

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5 Locations with sediment in the Southern Area exceeding 1 ppm PCBs are intermittent, as shown in Figure 1.3. Sediment in the Southern Area exceeding the proposed 982 ppm PRG for copper is limited to a small portion of the Southern Area adjacent to Building 15 and two very small, isolated spots south of the South Boat Slip (see Figure 1.4).

6.1.2 Comparative Evaluation of Overall Protection of Human Health and the Environment Among Southern Area Alternatives

Dredging would result in resuspension of sediment which would adversely impact river water quality in the short term, primarily within the area contained by the temporary silt curtain but also outside the silt curtain. Short-term impacts from resuspended sediment would be less adverse under Alternatives SA-1 and SA-2 than under the other Southern Area alternatives based on a lower mass of PCBs being resuspended (see Table 6.2). The mass of contaminants resuspended due to dredging would be much less in the Southern Area than in the Northwest Corner Area, because the concentrations and masses of PCBs and metals are much lower in the Southern Area. Based on the lower masses of PCBs in Southern Area sediment compared to the Northwest Corner Area, masses of PCBs that could be resuspended due to dredging in the Southern Area are less than 1 percent of the PCB mass that would likely become resuspended from any of the Northwest Corner Area Alternatives. On the other hand, the fraction of resuspended sediment escaping the contained area would likely be greater in the Southern Area than in the Northwest Corner Area, since silt curtains would be used (see Section 2.1.3.1). Sediment resuspended due to dredging would not settle back into the sediment within a single tidal period based on column settling tests conducted on OU-2 sediment. In addition, water from an existing public stormwater outlet discharge off the northern portion of former Building 15; water released from this outlet during storm events would also tend to keep dredged sediment in suspension.

Dense obstructions off former Building 15 and shell beds throughout the Southern Area would result in more sediment becoming resuspended than if the obstructions and shells did not exist within the Southern Area sediment. Resuspension of PCBs and metals under Alternative SA-1 would be limited, because dredging is not part of that alternative. One goal while removing debris and obstructions and while dredging would be to control sediment releases as practicable to meet a far-field point of water quality compliance guideline to be established by NYSDEC. The water quality point of compliance during dredging at other New York State PCB dredging sites has been a PCB water concentration of 2 micrograms per liter at a location one mile from dredging operations.

No NAPL was detected in the Southern Area of OU-2, or in the portions of OU-2 that are adjacent to it. As a result, if there is any reason to install the deep shoreline bulkhead described in SA-4, it should be possible to penetrate into the basal sand within the Southern Area, without contaminating the basal sand groundwater.

6.2 COMPLIANCE WITH STANDARDS, CRITERIA, AND GUIDELINES (A THRESHOLD CRITERIA)

Water quality standards, performance requirements, Village Code requirements, and other SCGs discussed in Section 4.2 for the Northwest Corner Area also apply to the Southern Area. These various SCGs would be met while remediating sediment in the Southern Area. State far-field water quality guidelines for PCBs while removing debris and obstructions and while dredging would be met to the extent practicable.

6.2.1 Evaluation of Compliance with Standards, Criteria and Guidelines Common to All Southern Area Alternatives

Short-term releases of impacted water outside the temporary silt curtain during dredging operations would be unavoidable in the Southern Area. The likelihood of any short-term, far-field water quality exceedances is less from the Southern Area than from the Northwest Corner Area for various reasons, including much lower sediment PCB concentrations in the Southern Area, even though a silt curtain is less effective at containing resuspended sediment than a temporary rigid containment barrier.

Over the long-term, each of these alternatives would meet the standards, criteria and guidelines to the extent practicable.

Effects of contaminated sediment residuals remaining following dredging and the need to stabilize the bulkhead along the Southern Area shoreline both result in the proposal for a berm and protective cap as part of all four Southern Area remedial action alternatives. The vertical extent of a berm needed to stabilize the shoreline would be determined during remedial design in conjunction with the remedial design ongoing for OU-1. Placement of a berm and protective cap would mean dredge and fill requirements would need to be met based on Article 15 of the New York State Environmental Conservation Law (Use and Protection of Waters), Section 404 of the Federal Clean Water Act, and Section 10 of the Federal Rivers and Harbor Act. Based on these requirements, filling of nearshore aquatic locations would need to be shown to be reasonable and necessary to be approved under Part 661 of Title 6 of the New York Code of Rules and Regulations, particularly where water depths at low tide are less than 6 ft. Any movement of the Southern Area shoreline would also need to be approved by NYSDEC and by USACE.

None of the sediments in the Southern Area are believed to be regulated as hazardous under RCRA. TSCA requirements would not be applicable to sediment dredged from the Southern Area because none of the Southern Area sediment contains over 50 ppm PCBs. Little of this sediment exceeds 10 ppm PCBs, so most of this sediment may also be able to be contained (and reused) at OU-1 without being transported offsite or, alternatively, managed offsite as fill material consistent with how sediment from NY-NJ Harbor is being managed. Subsurface soil can be retained at the site if its PCB concentration is 10 ppm or less based on NYSDEC's Technical and Administrative Guidance Memorandum 4046 (NYSDEC, 1994 and updated in 2001). In fact, fill will be needed at OU-1 to raise the existing ground surface elevation in accordance with the federal consent decree. Site investigation results also show metal concentrations measured in OU-2 sediment containing varying concentrations of metals do not result in porewater concentrations above NYS saltwater quality standards, so impacts of metals from OU-2 sediment that would be contained within OU-1 should also not be a concern.

NYSDEC, as part of its solid waste management regulations under Part 360 in Title 6 of the New York Code of Rules and Regulations, allows for specific beneficial use determinations for material (in this case, sediment) that would otherwise be taken offsite. Such a beneficial use determination could be obtained under the procedures in Section 1.15 of Part 360. Beneficial use of dredged material as fill on land has been granted by NYSDEC at other locations.

6.2.2 Comparative Evaluation of Compliance with Standards, Criteria and Guidelines Among Southern Area Alternatives

For Alternative SA-1, placing a protective cap without prior dredging would reduce water depth. To obtain the regulatory approval needed for this alternative, AR would need to show that the alternative is reasonable, necessary, and would not result in any significant net loss of water depth in the Southern Area. The cap material is expected to consolidate and settle after placement. If any offsetting increase in water depth is needed, it would be in the area close to the shoreline where the water is relatively shallow, and this may be achieved by selecting remedies for other portions of OU-2 that increase water depth in an area of equal or greater size. Where needed to provide stable sediment slope, some sediment could be removed before capping, resulting in an alternative that resembles a combination of SA-1 and SA-2.

The Southern Area alternatives that include dredging would be easier to design to meet dredge and fill requirements. Short-term, far-field water quality guidelines would more likely be met under Alternative SA-2 than under Alternatives SA-3 and SA-4, which would include a larger amount of dredging. Other SCGs, such as sediment management and Village Code requirements, could be met under each of the Southern Area alternatives.

6.3 SHORT-TERM EFFECTIVENESS (A BALANCING CRITERIA)

6.3.1 Evaluation of Short-Term Effectiveness Common to All Southern Area Alternatives

As presented for the Northwest Corner Area, short-term impacts include effects on water quality during dredging operations, short-term effects of remediation activities on local residents and businesses outside OU-1 and OU-2, and worker risks. Short-term effects on water quality outside the area contained by the temporary silt curtain cannot be fully predicted at this time. Some sediment resuspended due to removing debris and obstructions and dredging would migrate around the temporary silt curtain within the river beyond the Southern Area. These short-term effects on water quality would be monitored and controlled to the extent practicable based on the extent of PCBs resuspended and based on the effects measured in the river away from dredging operations. A lower quantity and a lower percentage of PCBs would be resuspended in the Southern Area than at the Northwest Corner Area, due to less debris and shallower dredging. However, as described in Section 2.1, a temporary silt curtain is not as effective as a temporary rigid containment barrier. .

Short-term effects of noise and other short-term impacts of construction on local residents and businesses outside OU-1 would be controlled in accordance to the Village Code requirements summarized in Section 4.3.

Worker risks would be controlled through health and safety planning and safe work practices. AR's safety management program would be strictly followed. Differences in the risk of injury, and measures needed to avoid injury, are shown in Table 6.3 and Section 6.3.2 below.

6.3.2 Comparative Evaluation of Short-Term Effectiveness Among Southern Area Alternatives

Alternatives that include less area to be dredged would result in less short-term disruption of the existing river habitat both in area of the river affected and in duration of the impact. Alternative SA-2 would, in addition to less short-term river habitat disruption, result in less sediment being resuspended into the river water column, less adverse and shorter adverse impacts on river water quality outside the temporary silt curtain, less adverse effects of noise and other construction-related effects on the Village, and less worker risk than would Alternatives SA-3 and SA-4.

Table 6.2 presents a quantitative comparison of the adverse, short-term release of PCBs anticipated to become resuspended as a result of removing debris and obstructions and dredging associated with each of the Southern Area alternatives. As shown in Table 6.2, and discussed in Section 6.1, resuspension of contaminated sediment into the water column and residual sediment concentrations after dredging (and prior to capping) would be less than the PCB PRG of 1 ppm indicating a cap may not be needed in the Southern Area for the purpose of isolating sediment from aquatic life.

Cutting timber piles, removing obstructions, and dredging would extend over approximately 1 to 3 months under Alternative SA-2 and SA-3 and 2 to 3 months under Alternative SA-4 (see Section 5 and Table 6.2). Berm and cap placement would require approximately 1 month following dredging for any of the Southern Area alternatives. Along with 2 to 3 weeks to place the temporary silt curtain, the total remediation time for the Southern Area alternatives is estimated to range from 3 months under Alternative SA-1 to 6 to 9 months under Alternative SA-4.

The time needed to consolidate the marine silt under Alternatives SA-2, SA-3, or SA-4 would be evaluated during remedial design. Options that affect consolidation time include the shoreline aspects of the OU-1 design currently being developed. For example, wick drains (or other consolidation devices) may be needed as part of Alternatives SA-2, SA-3, and SA-4 if the existing shoreline is not moved inland approximately 30 ft as described in Section 4.3.2. Appendix B provides a discussion of various ways to control the time needed to consolidate the marine silt.

Under Alternative SA-1, approximately 75 rail cars or 380 fully-loaded trucks would enter OU-1 with soil for the berm and cap. Under Alternative SA-2, up to approximately 70 rail cars or 350 fully-loaded trucks would leave OU-1 full of dredged sediment if the sediment needs to be hauled offsite. Under Alternatives SA-3, up to approximately 85 to 90 rails cars or 430 to 450 fully-loaded trucks would leave OU-1 with dredged sediment if the sediment needs to be hauled offsite. Under Alternative SA-4, approximately 160 rail cars or 800 fully-loaded trucks would leave OU-1 with dredged sediment if the sediment needs to be hauled offsite. In addition, soil for the berm and cap would need to be brought onsite by rail, by truck, or by barge. Similar estimates for transportation by barge could be completed during remedial design, as part of identifying the most appropriate form of transportation, or mix of transportation options, for the selected remedy.

The short term impact of the remedy includes any injuries that workers may suffer while implementing the remedy. Appendix F describes the methodology used to evaluate the risk of injuries to workers on site, and to workers that transport materials on and off site. Based on the rate of injury reported for similar projects and types of work (not necessarily related to site remediation work), the estimated risk of an on-site worker fatality are 1 in 624 for Alternative SA-1, to 1 in 60 for Alternative SA-2, 1 in 50 to 1 in 53 for Alternative SA-3, and 1 in 33 for Alternative SA-4 (see Table 6.3). For Alternative SA-4, this means that if the remedy was performed 33 times, it is likely there would be one fatal accident on site. Put another way, there is a 3 percent risk of at least one fatal on-site accident if SA-4 is chosen as a remedy. Less dredging would also result in less risk to construction workers as summarized in Table 6.3. Occupational risks of implementing Alternative SA-1, for example, are approximately one tenth the occupational risks of implementing Alternative SA-2. Risks of at least one fatal injury on site under Alternatives SA-2, SA-3, and SA-4 would range from approximately 1.7 percent for Alternative SA-2 to 2 percent for Alternative SA-3. Most of this risk is associated with a high rate of reported injuries at barge dredging projects, where most fatal injuries are suffered by persons working on the barge (see App. F-6).

AR will only undertake remedial action where it can develop a way to perform the work safely, without significant injury or fatalities. The combined risks of on-site and off-site worker injury for Alternatives SA-2 through SA-4 are high in comparison to the risks that the work is designed to prevent (primarily exposure to low level PCBs where the area-weighted average already meets the 1 ppm PRG), indicating that the impact of worker injuries during dredging may exceed the potential long term benefits of dredging. Alternative SA-1 involves significantly lower worker risks.

AR would seek to control all worker injury risks through health and safety planning and safe work practice. AR's safety management program would be strictly followed. However, the combined risk of injury from remediation work at all areas of OU-2 should be considered when selecting alternatives, and the risk of a fatal injury rises with the size of the area to be dredged, as well as the depth of dredging. The cumulative short term impact of all dredging alternatives must be considered and weighed against the benefits that dredging might achieve. Worker risks will be evaluated in more detail during remedial design, and remedial alternatives may need to be modified to ensure that the work can be performed safely.

6.4 LONG-TERM EFFECTIVENESS AND PERMANENCE (A BALANCING CRITERIA)

6.4.1 Evaluation of Long-Term Effectiveness and Permanence Common to All Southern Area Alternatives

Conditions within the Southern Area are as suitable for capping. Capping within the Hudson River would be effective over the long term and also permanent as described in Section 2.2 and in Section 4.4.1. In addition, USEPA indicates in their 2005 guidance about contaminated sediment (USEPA, 2005b) that sediment caps can meet the long-term effectiveness and permanence criteria. Effective measures to maintain cap protectiveness are available as presented in Sections 2.2 and 4.4.1 as well. The various site conditions that allow capping to be effective at the Southern Area and at the Northwest Corner Area are described in Section 4.4.1.

The berm needed to help stabilize the shoreline would provide erosion protection that would otherwise be provided by a portion of the protective cap.

Dredging by itself may not be effective for reasons presented in Section 4.4.1. Residual contaminated sediment would remain in the river following dredging. However, because sediment PCB concentrations are much lower in the Southern Area than in the Northwest Corner Area, residual sediment in the Southern Area following dredging may not contain PCB concentrations over 1 ppm. If residual PCB concentrations are less than 1 ppm, then an isolation layer would not be needed to contain those residuals. However, it is likely that some form of fill material would still be placed in the dredged area to support the OU-1 plant site shoreline, as described in Section 2.1.4.2 and in Appendix B.

Institutional controls would be needed to protect a cap under all alternatives. AR's affiliate owns a portion of the submerged land here, and would provide the State of New York with an environmental easement (see Section 2.2.8). Minor damage to the cap caused by occasional violations of the restrictions (for example, by boats that drop anchor in an unauthorized location) is not likely to result in any significant damage to the environment, as the proposed cap is thick, and the level of contamination below the cap is close to the PRGs, so that minor breaches would not release any significant volume of contaminated sediment into the river environment. Substantial breaches (for example, removal of the entire cap) would require regulatory approval, and the approval process would be used to enforce the institutional controls, and prohibit activities that might release contaminated sediment below the cap.

6.4.2 Comparative Evaluation of Long-Term Effectiveness and Permanence Among Southern Area Alternatives

Without including effects of sediment resuspension during dredging, AR's contaminant distribution modeling results provide estimates of the extent of PCB mass removable from the river as part of each remedial action alternative. Because so little PCB mass is found in the southern area, the mass removed under alternatives SA-2, SA-3 and SA-4 is almost identical, varying by only approximately 10 pounds of PCBs (or less than 0.1 percent of the total PCB mass) in each alternative (see Table 5.5). Removal of copper exceeding the proposed PRG would range from 10 to 29 percent under Alternatives SA-2, SA-3, and SA-4 (see Table 5.5). A berm-cap would likely still be needed as part of any of the Southern Area alternatives to meet remedial action objectives, because dredge residual sediment may exceed PRGs, and because the substantial amounts of fill material removed under SA-4 would need to be replaced with fill material to form the berm needed to support the OU-1 shoreline.

Percentages of OU-2 PCB mass removable from the Southern Area under any of the remedial action alternatives are very low compared to the Northwest Corner Area. PCB removal percentages for the SA Alternatives range from 0 to 0.1 percent, compared to 62 percent removal associated with Alternative NW-1 (see Table 5.5). Given these low percentages, the PCB mass removed per cubic yard of dredged sediment is negligible, compared to 3.2 pounds per cubic yard under Alternative NW-1.

The extent of berm and cap that is estimated to be needed in the river along the Southern Area is presented in Table 6.4 based on the shoreline OU-1 grade being set at + 4 ft and sloping up to +9 ft at 100 to 120 ft inland. The extent of berm and cap presented in Table 6.4 incorporates measures to reduce berm volume in the river, such as use of tieback anchors and lightweight fill within 100 to 120 ft of the shoreline at OU-1 to the extent practicable. The berm required to provide shoreline stability is similar for all four Southern Area alternatives. Various measures to control berm height in the river are discussed in Appendix B and would be evaluated further during remedial design as warranted. These measures include moving the shoreline inland and extending the Southern Area bulkhead into the basal sand.

Sediment dredged from the river and residual solids generated from water treatment would be permanently removed offsite to a permitted facility unless the sediment can be reused at OU-1 or reused offsite as fill material. Volumes of sediment to be dredged are presented in Table 5.2 and in Table 6.5. In addition, water removed from sediment to improve sediment handling would be treated and returned to the river at OU-2.

6.5 REDUCTION OF TOXICITY, MOBILITY, AND VOLUME THROUGH TREATMENT (A BALANCING CRITERIA)

6.5.1 Evaluation of Reduction of Toxicity, Mobility, and Volume Through Treatment Common to All Southern Area Alternatives

As for the Northwest Corner Area sediment, water drained and/or dewatered from sediment would be treated onsite to meet state discharge requirements, prior to releasing the treated water back to the river, or the water would be treated offsite.

6.5.2 Comparative Evaluation of Reduction of Toxicity, Mobility and Volume Through Treatment Among Southern Area Alternatives

The extent that toxicity, mobility and volume would be reduced through treatment does not differ significantly from one alternative to another. More water would be treated as part of alternatives that include higher volumes of sediment to dredge, however the mass of PCBs and metals that would be treated in water would be a small portion of an already low percentage of OU-2 PCBs and metals that are present within Southern Area sediment.

6.6 IMPLEMENTABILITY (A BALANCING CRITERIA)

6.6.1 Evaluation of Implementability Common to All Southern Area Alternatives

Each of the remedial action steps outlined in Table 6.1 to implement the remedial action alternatives for the Southern Area would by themselves be able to be effectively completed. However, significant amount of shells within sediment would slow dredging operations, increase the need for onshore support facilities, and also result in more sediment being resuspended into the water column in the short term. As shown in Figure 3.1, large pieces of concrete and/or other obstructions have been documented offshore of former Building 15 spanning approximately 700 ft of the Southern Area shoreline. This debris is characterized by wooden pilings, sections of sheet piling, sub-surficial magnetic debris, tires, and other man-made obstructions. Field observations also indicate shell beds are present in the Southern Area.

A temporary silt curtain as part of Alternatives SA-2, SA-3, and SA-4 would be implementable; however keeping the silt curtain securely in place during storm events may be difficult. Silt curtains were recently successfully used at a site along the lower Hudson River at Tarrytown, NY approximately 8 miles north of Hastings-on-Hudson. Small barges would need to be used to be able to maneuver inside the dredging area between the silt curtain and the shoreline. As indicated for the Northwest Corner Area alternatives, an initial assessment indicates sufficient space is available at OU-1 to unload and process debris and sediment dredged from OU-2. Debris and sediment could be stockpiled and processed at OU-1 away from the shoreline.

An 18-inch diameter stormwater outlet to the river is in place in the Southern Area at a location approximately 160 ft south of the North Boat Slip along former Building 15. Placement of the shoreline bulkhead and dredging efforts in the Southern Area along former Building 15 will need to account for discharges that occasionally pass through this pipe to the river during significant weather events. Handling of discharges from this outlet pipe during OU-2 remediation efforts is not believed to be a significant challenge or result in adverse impacts.

A berm-cap is implementable based on success observed placing caps at other sites and based on shear strength available within site sediment. Berms and caps have been successfully placed at other sites (see Section 2.2.7). The maximum allowable final slope for a berm-cap would be determined during remedial design.

Institutional controls would be needed to protect the cap under all alternatives. AR's affiliate owns a portion of the submerged land here, and would provide the State of New York with an environmental easement (see Section 2.2.8 and Section 6.4.2) that may include requirements for cap maintenance, boat anchoring restrictions, and use of floating docks in areas where they are needed.

6.6.2 Comparative Evaluation of Implementability Among Southern Area Alternatives

Additional removal of debris and obstructions and dredging substantially beyond the dredging included in Alternative SA-2 to place a berm and protective cap would slow the pace for redeveloping OU-1 following remediation. The facts that Alternative SA-2 could be largely completed independent of the OU-1 remedial action, and that Alternative SA-2 would involve less dredging than Alternative SA-3 or SA-4, would likely result in OU-1 being able to be redeveloped 2 to 3 years sooner under Alternative SA-2 than under Alternatives SA-3 and SA-4. The additional 2 to 3 years needed to implement Alternatives SA-3 and SA-4 would be needed so remediation activities for OU-2 could catch up and be coordinated with design and implementation activities currently underway for OU-1.

OU-1 also cannot be fully redeveloped until the river berm and onshore soil are sufficiently consolidated. A berm would be needed in the river to help stabilize the shoreline and to improve the strength of the underlying soils. With time, the strength of the marine silt below the berm would increase as consolidation occurs which would increase shoreline stability. In addition, wick drains (or other consolidation devices) could be placed as part of Alternatives SA-2, SA-3 or SA-4 to speed up berm consolidation unless other measures are employed to accelerate consolidation. For example, if parts of the shoreline could be moved inland 30 ft near former

Building 15 or at another portion of the Southern Area, then consolidation devices would likely not be needed in those areas (see Appendix B).

If the existing IRM bulkhead is to be retained along the existing shoreline south of the South Boat Slip, consolidation devices would be needed in that area to reduce the time for consolidation of river sediment. Consolidation devices could be placed following placement of the berm but prior to placing the habitat surface layer of the protective cap. In that manner, consolidation devices would be covered by the cap and would not affect use of the river once the drains no longer serve any purpose.

Administratively, each of the four Southern Area alternatives is implementable as long as the vertical extent of a berm-cap in the river can be sufficiently controlled. Measures to control the vertical extent of a berm-cap would be evaluated during remedial design. Moving the shoreline inland 30 ft along former Building 15 is one way to control the vertical extent of a berm-cap (see Appendix B). Moving the Southern Area shoreline inland 30 ft would also result in a transfer of approximately a half acre from OU-1 to OU-2.

6.7 COSTS (A BALANCING CRITERIA)

A cost estimate has been prepared for each remedial action alternative for the Southern Area consistent with the cost estimates presented in Section 4 for the Northwest Corner Area and in accordance with USEPA guidance (USEPA, 2000a). The cost evaluation assesses estimated capital, annual operation and maintenance (O&M), periodic costs, and total net present value.

In addition to development of an estimated cost, alternatives are evaluated on the basis of cost-effectiveness under the comparative evaluation of alternatives. Part 375 (Subpart 1.10(c) (6) within Title 6 of the New York Code of Rules and Regulations, CERCLA Section 121, and the National Contingency Plan require that the selected remedy must be cost-effective. EPA defines a remedy as cost effective if its “costs are proportional to its overall effectiveness.” 40 CFR 300.430(f)(1)(ii)(D). Overall effectiveness of a remedial alternative is determined by evaluating the following three of the five balancing criteria: long-term effectiveness and permanence; reduction in toxicity, mobility, and volume through treatment; and short-term effectiveness. Overall effectiveness is then compared to cost to determine whether the remedy is cost effective. In cases where several remedies offer the same degree of protection to human health and the environment, cost effectiveness principles would require the decision-maker to choose the least expensive of the remedial options.

Alternative	Estimated Capital Cost ($)	Estimated Annual O&M Cost ($)	Estimated Net Present Worth ($)
SA-1	$4.0 Million	$100,000	$5.1 Million
SA-2	$17.9 Million	$100,000	$19.0 Million
SA-3, Option A	$19.7 Million	$100,000	$20.8 Million

SA-3, Option B	$20.2 Million	$100,000	$21.3 Million
SA-4	$33.8 Million	$100,000	$34.9 Million

The above table shows capital costs that are comprised of variable (also called non-fixed) costs and fixed costs. Variable costs are costs that vary from one alternative to another, such as costs for providing temporary containment, dredging, material management, and capping. Fixed costs are costs that do not vary from one alternative to another, such as costs for permitting and construction setup. Fixed costs have been apportioned equally amongst the areas of OU-2 since the sequence of construction among the OU-2 areas has not yet been established. Appendix E provides specific basis and compilations for the costs estimates for each remedial action alternative.

AR's contaminant distribution modeling results provide estimates of the PCB mass removable from the river as part of each remedial alternative. Because so little PCB mass is found in the Southern Area, the amount of mass removed under alternatives SA-2, SA-3 and SA-4 is almost identical, varying by only approximately 10 pounds in each alternative, and the cost of removal is extraordinarily high, ranging from $1.7 million to $2.3 million for each pound of PCBs removed from the Southern Area in SA-2 to SA-4[6]. When compared to the $1,400 per pound cost of removing PCBs in the Northwest Corner (Alternative NW-1), none of the Southern Area dredging alternatives are a cost effective remedy for PCBs.

The dredging remedies also remove copper and other metals above the PRGs proposed in this SFS. As discussed in Section 6.1, the metals levels found in Southern Area sediments are relatively close to the PRGs, and they are generally found below cleaner sediments, where they are not bioavailable to benthic organisms or aquatic life. Alternatives SA-1 and SA-2 would cap this material, while Alternatives SA-3 and SA-4 would remove it. There is no significant difference in the degree of environmental protection achieved in these options, as all would prevent exposure to elevated metals. On the other hand, the cost of alternatives SA-2 through SA-4 is substantially higher than the cost of SA-1. Based on these site conditions and options, containment under alternative SA-1 is the only cost-effective option for the Southern Area. [7].

6.8 EVALUATION SUMMARY FOR THE SOUTHERN AREA

Each of the four remedial action alternatives for the Southern Area is protective of human health and the environment and in compliance with standards, criteria, and guidelines over the long term, with the possible exception of Alternative SA-1 near the shoreline where, without dredging, there could be loss of river habitat. Capping would meets the OU-2 remedial action

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6 There are several factors which contribute to the significant difference in cost between the containment option in Alternative SA-1 and the other alternatives. The primary factors leading to the cost differences of these alternatives are the temporary silt curtain containment barrier associated with each of the removal alternatives (SA-2, SA-3, and SA-4), dredging, transportation and disposal costs associated with dredging, and costs associated with the sealed shoreline bulkhead. The sealed shoreline bulkhead associated with SA-4 adds significant cost, due to the necessity of that wall to penetrate the basal sands

7 This Supplemental FS Report does not include an alternative that targets the removal of copper or other metals above the proposed PRGs, while leaving PCBs in place beneath a cap. Cost estimates for a more targeted copper dredging remedy could be developed to evaluate this option.

objectives presented in Section 1.4 and be protective on the basis of the protective cap assessment presented in Section 2.2 and the evaluation of capping presented in Section 4 and in this section. Dredging could also be provided as a practicable measure to provide some small amount of contaminant removal and provide depth in shallow water area nearshore for a berm needed to support the shoreline bulkhead as well as for a protective cap.

Dredging along the Southern Area, however, has its drawbacks as it does for the Northwest Corner Area. The extent of debris and the silty, fine-grained nature of OU-2 sediment would result in contaminated sediment becoming suspended in the water both while the debris is being removed and while dredging. The temporary silt curtain would help control the spread of resuspended sediment away from OU-2, but this temporary silt curtain would not be 100 percent effective. Water quality would decline in the short term while removing debris and obstructions and during dredge operations, because resuspended sediment would not be able to settle completely before the next day of dredging is underway. Practicable attempts could be made to meet far-field water quality guidelines away from OU-2, but meeting such guidelines may not be possible. In addition, costs for any dredging in the Southern Area would be very high with low quantities of contaminants removed.

Alternatives SA-1 and SA-2 would result in lower quantities of PCBs becoming suspended from sediment into the river and, in turn, less of an adverse effect on water quality during construction. Less dredging would also result in lower worker risk and less of an adverse effect of construction noise and other aspects of construction on the Village than would Alternatives SA-3 and SA-4. These benefits of Alternatives SA-1 and SA-2 are together more significant than the additional small percentages of PCBs and copper that would be removed under Alternatives SA-3 and SA-4 (see Table 6.5).

Remediation based on a sediment copper background concentration of 88.7 ppm would result in much larger volumes and areas of sediment to address than would remediation based on PCBs greater than 1 ppm and copper greater than 982 ppm. For example, dredging under Alternative SA-3, Option B, would include approximately 25,000 cubic yards of sediment based on PCBs and a copper concentration of 88.7 ppm compared to 8,800 cubic yards based on PCBs and 982 ppm of copper. Site data collected and analyzed since 2003 shows no sediment toxicity due to copper at concentrations less than 982 to 1,240 ppm (see Appendix C). A lack of metals toxicity means no additional protection of human health and the environment would be provided as a result of additional remediation based on a lower sediment copper concentration. At the same time, additional adverse short term water quality impacts from resuspending additional sediment, risks from additional worker efforts, and additional berm depth would be needed in the river to stabilize the shoreline bulkhead. These water quality, worker risk and shoreline stability factors would all make additional remediation much less effective resulting in higher costs for no incremental benefit. The result instead would be additional adverse impacts. PCB mass that could be removed per cubic yard of sediment dredged would be less than 0.002 pounds per cubic yard for any of the Southern Area alternatives compared to approximately 3.3 pounds per cubic yard under Alternative NW-1. Similarly, the dollars spent per pound of PCBs removed would be approximately $1.7 million to $2.3 million per pound of PCBs removed in the Southern Area compared to $1,400 for Alternative NW-1. Efficiency of PCB removal in dollars spent per pound of PCBs would therefore be 1,200 to 1,600 times higher for Alternative NW-1 than for any of the Southern Area alternatives.

Under any of the Southern Area alternatives, remediation and redevelopment of OU-1 would be able to continue relatively independent of efforts to remediate OU-2 except that surcharge load would be restricted within 100 to 120 ft of the bulkhead and sealing of the bulkhead sheeting interlocks may not be recommended until the OU-2 remedy is completed.

Moving the shoreline inland would significantly reduce the volume of berm material needed in the river to stabilize the shoreline bulkhead. As a result, the time needed to consolidate the marine silt prior to fully redeveloping OU-1 would be reduced, and measures to expedite sediment consolidation would not be needed in the river. The option of moving the Southern Area shoreline inland could be further evaluated as part of the effort to design the selected remedy.

If the existing IRM bulkhead is to be retained along the existing shoreline south of the South Boat Slip, consolidation devices would be needed in that area to reduce the time for consolidation of river sediment to less than 1 year. Consolidation devices could be placed following placement of the berm but prior to placing the habitat surface layer of the protective cap. In that manner, consolidation devices would be covered by the cap and would not affect use of the river once the drains no longer serve any purpose.

Given all of these evaluation factors, Alternative SA-1 is recommended for the Southern Area. Alternative SA-1 would be protective of human health and the environment and meet the OU-2 remedial action objectives by providing a protective cap to eliminate exposure of fish, other aquatic life, and humans to sediment exceeding PRGs. Dredging as evaluated under Alternatives SA-2, SA-3 and SA-4 would not be cost effective, because it would not provide significant additional benefits. The mass of PCBs in Southern Area sediment is less than one percent of the mass of PCBs in all of the OU-2 sediment. The mass of elevated metals in the Southern Area sediment is less than 30 percent of the elevated metals in all of the OU-2 sediment and is only found in a small portion of the Southern Area. Alternative SA-1 would result in less contaminated sediment becoming resuspended into the water in the short term, lower worker risk, and fewer engineering and construction challenges in a challenging river work environment that includes average water velocities of approximately 2 ft per second, a 4-ft tidal range twice each 24 hours, and fine-grained sediment. These benefits of Alternative SA-1 together overshadow the small additional percentages of OU-2 contaminant mass that would be removed under any of the dredging alternatives.

TABLE 6.1

REMEDIAL ACTION ALTERNATIVES FOR THE SOUTHERN AREA (SA)
HARBOR AT HASTINGS OU-2

	Alternative SA-1 **Place a Protective Cap**	**Alternative SA-2** **Dredge Up to 2 ft and Place Protective Cap**	**Alternative SA-3** **Dredge to Limit of Bulkhead Stability**	**Alternative SA-4** **Penetrate Shoreline Bulkhead into Basal Sands**
Summary description (and possible construction sequence)	▪ Install OU-1 sealed shoreline bulkhead (south of the North Boat Slip) to support raising the OU-1 ground surface in accordance with the Federal Consent Decree and create an impermeable barrier along the shoreline. ▪ If needed, excavate OU-1 soil and backfill with lightweight fill to reduce upland load. Install anchor system to support the shoreline bulkhead during backfilling operations. ▪ Complete other elements of the OU-1 remedial action and redevelop OU-1 independent of the OU-2 remedial action. ▪ Cut timber piles and remove large debris as needed to place a berm-cap. ▪ Place integrated berm-cap in the river as needed to stabilize shoreline and as a protective layer as needed. ▪ Complete the OU-1 remedy to the final ground elevation based on the Federal Consent Decree.	▪ Install OU-1 sealed shoreline bulkhead (south of the North Boat Slip). ▪ If needed, excavate OU-1 soil and backfill with lightweight fill to reduce upland load. Install anchor system to support the shoreline bulkhead during backfilling operations. ▪ Complete as many of the other elements of the OU-1 remedial action as feasible prior to redeveloping OU-1 ▪ Install temporary silt curtain parallel to the shoreline approximately 60 to 80 ft offshore where average water depth is 15 ft. ▪ Cut timber piles, remove large debris, and dredge sediment inside the temporary silt curtain where sediment exceeds PRGs of 1 ppm PCBs and/or 982 ppm copper. ▪ Dredge up to an average of 2 ft at a maximum cut slope for shoreline stability. ▪ Remove the temporary silt curtain. ▪ Place integrated berm-cap in the river as needed to stabilize shoreline and as a protective cap as needed. ▪ Complete the OU-1 remedy to the final ground elevation based on the Federal Consent Decree. ▪ Drain-dewater dredged sediment on	▪ OU-2 and OU-1 remediation efforts would need to be coordinated. OU-2 remediation must follow partial backfill of the OU-1 upland area and must precede final OU-1 backfill. ▪ If needed, excavate OU-1 and partially backfill with lightweight fill to unload the upland area. Install bulkhead wall anchorage as upland is backfilled. ▪ A sequence for OU-2 is as follows once the anchored shoreline bulkhead is in place (south of the North Boat Slip) and OU-1 is filled to an interim elevation of +2 to +5 ft. The bulkhead could be sealed following dredging if needed to help stabilize the shoreline during dredging operations. ▪ Install temporary silt curtain as described for Alternative SA-2. ▪ Cut or remove timber piles and remove large debris in dredge area. ▪ Dredge sediment inside the temporary barrier where sediment exceeds PRGs. Dredge to elevation -9 ft (Option A) or to elevation -14 ft (Option B) at the shoreline and deeper away from shore. ▪ Remove the temporary silt curtain. ▪ Place integrated berm-cap to stabilize shoreline and as a protective cap as needed.	▪ Requires shoreline bulkhead (south of the North Boat Slip) to be driven into the basal sand to allow for deeper dredging but at the risk of impacting the basal sand aquifer. ▪ OU-2 and OU-1 remediation efforts would be more practicable if coordinated as for Alternative SA-2. Dredging in OU-2 would be completed before the OU-1 site grade for redevelopment can be established. ▪ Install shoreline bulkhead to basal sands with anchor system onshore. The bulkhead could be sealed following dredging if needed to help stabilize the shoreline during dredging operations. ▪ If needed, excavate at OU-1 and partially backfill with lightweight fill (or economically advantageous) to unload the upland area. Install bulkhead wall anchorage as upland is backfilled. ▪ Install temporary silt curtain as described for Alternative SA-2. ▪ Cut or remove timber piles, remove large debris, and dredge sediment inside the temporary barrier where 1 ppm PCBs and/or 982 ppm copper. PRGs. ▪ Dredge deeper away from shore as needed and as possible based on silt curtain alignment. ▪ Remove temporary silt curtain.

TABLE 6.1, Continued

REMEDIAL ACTION ALTERNATIVES FOR THE SOUTHERN AREA (SA)
HARBOR AT HASTINGS OU-2

	Alternative SA-1 Place a Protective Cap	Alternative SA-2 Dredge Up to 2 ft and Place Protective Cap	Alternative SA-3 Dredge to Limit of Bulkhead Stability	Alternative SA-4 Penetrate Shoreline Bulkhead into Basal Sands
		site. Treat water that is generated. ▪ Reuse sediment for fill at OU-1 or transport dredged and drained-dewatered sediment offsite and place at permanent containment facility.	▪ Complete the OU-1 remedy to the final ground elevation based on the Federal Consent Decree. ▪ Drain-dewater dredged sediment on site. Treat water that is generated. ▪ Reuse sediment for fill at OU-1 or yransport dredged and drained-dewatered sediment offsite and place at permanent containment facility.	▪ Place integrated berm-cap to stabilize shoreline and as a protective cap as needed. ▪ Complete the OU-1 remedy to the final ground elevation based on the Federal Consent Decree. ▪ Drain-dewater dredged sediment on site. Treat water that is generated. ▪ Reuse sediment for fill at OU-1 or transport dredged and drained-dewatered sediment offsite and place at permanent containment facility.
Protection of Human Health and the Environment (overall protection achieved over time by meeting PRGs thereby controlling site risks)	Alternative SA-1 would be protective. A protective cap after dredging would: (a) eliminate risk related to human consumption of fish and shellfish; (b) eliminate potential human and ecological exposure to site contaminants and replace current aquatic habitat; and (c) control impacts of long-term erosion or resuspension of sediment. • Short-term river habitat disruption would not be significant. Sediment biota would recover within 2 to 4 months from April through November.	Same as Alternative SA-1 plus the following: ▪ Dredging would not reduce long-term risk or provide additional long-term protection of human health or the environment. ▪ Adverse, short-term resuspension of contaminated sediment during additional debris removal and dredging that would take place. ▪ Resuspended mass of PCBs would be less than 1 percent of the PCB mass estimated to be removed under Alternative NW-1, so a protective cap may not be needed to address chemical isolation.	Same as Alternative SA-2 except: • Greater adverse short-term impacts to water quality due to resuspension of sediment during additional debris removal and dredging with no improvement in long-term effectiveness.	Same as Alternative SA-2 except: • Most significant adverse short-term impacts to water quality due to resuspension of sediment during additional months of debris removal and dredging with no improvement in long-term effectiveness.
Compliance with NY State SCGs (standards, criteria	• Alternative SA-1 would comply with site remedial goals and with SCGs in the	• Alternative SA-2 would comply with site remedial goals and with SCGs in the long-term.	Compliance with SCGs would be the same as for Alternative SA-2 except: • More PCB and metals mass	Compliance with SCGs would be the same as for Alternative SA-2 except: • Short-term exceedances of far-field

TABLE 6.1, Continued

REMEDIAL ACTION ALTERNATIVES FOR THE SOUTHERN AREA (SA)
HARBOR AT HASTINGS OU-2

	Alternative SA-1 **Place a Protective Cap**	**Alternative SA-2** **Dredge Up to 2 ft and Place Protective Cap**	**Alternative SA-3** **Dredge to Limit of Bulkhead Stability**	**Alternative SA-4** **Penetrate Shoreline Bulkhead into Basal Sands**
and guidelines) Compliance with NY State SCGs, continued	long-term due to the effectiveness of capping. • River water depths at low tide predominantly exceed berm-cap thickness at the shoreline. Loss of deeper water habitat would be minimized by minimizing the extent the mudline is raised. • 6 NYCRR Part 608 requirements, federal Rivers and Harbors Act, and federal Clean Water Act 404(b) (1) guidelines associated with filling within a water body would need to be met.	• Dredging would not have any effect on compliance with SCGs other than the effect of sediment resuspended in the river during short-term dredging operations. Compliance with SCGs would be the same as for Alternative SA-1 except: • During remedy implementation, there may be short-term, far-field exceedances of surface water SCGs in the river due to sediment resuspended during debris removal and dredging. These exceedances are expected to be limited in duration to the period approximately 2 months during debris removal and dredging. Resuspension would be reduced and limited by the temporary silt curtain while debris removal and dredging are ongoing.	would be dredged, and short term exceedances of river water quality SCGs would be likely for a longer duration due to more extensive resuspension of sediment from debris removal and dredging compared to Alternative SA-2.	surface water SCGs during dredging would be the most likely of any of the SA alternatives and have the longest duration due to more extensive debris removal and dredging.

TABLE 6.1, Continued

REMEDIAL ACTION ALTERNATIVES FOR THE SOUTHERN AREA (SA) HARBOR AT HASTINGS OU-2

	Alternative SA-1 Place a Protective Cap	Alternative SA-2 Dredge Up to 2 ft and Place Protective Cap	Alternative SA-3 Dredge to Limit of Bulkhead Stability	Alternative SA-4 Penetrate Shoreline Bulkhead into Basal Sands
Short-term Effectiveness (protection of community and workers, environmental impacts and time to achieve protection)	• Less short-term adverse effects than for the other SA alternatives. • Worker risk would be 0.0016 or a chance of a fatality of 1 in 625 projects. See Table 6.3 and Appendix F. ▪ Intermittent noise could be noticeable while hammers are used to place the shoreline bulkhead. The Village Code would be followed so noise would not be evident outside of work hours allowed in the ordinance. ▪ Cap placement effects are expected to be minor, so a temporary silt curtain would not be installed. ▪ River work would last approximately 2 to 3 months. ▪ Noise would not be evident outside allowable work hours	▪ Resuspended sediment would accumulate over multiple days throughout the water column inside the silt curtain (with some tidal exchange), because needed settling time (45 hours from column settling tests) would exceed the settling time available between daily dredge shifts. PCB and metal concentrations resuspended in the water column after multiple consecutive days of dredging are affected by many variables and can not be predicted with any certainty. The silt curtain would reduce resuspension impacts outside OU-2, but some sediment would escape due to tides and normal operations. Best practical attempts would be made to meet far-field river water quality goals. ▪ Worker risk would be 10 times higher compared to Alternative SA-1 (see Table 6.3). ▪ Intermittent noise could be noticeable while hammers are used to place the shoreline bulkhead. The Village Code would be followed so excessive noise would not be evident outside of work hours included in the ordinance.	Same as for Alternative SA-2 except: • Alternative SA-3 would result in more contaminated sediment being resuspended and released from the contained area compared to Alternative SA-2 but less compared to Alternative SA-4. • Worker protection and shoreline stability would be more of a concern than for Alternative SA-2, particularly for Option B, because during remediation winter interim shutdown may be needed. • Worker risk would be 12 times higher compared to Alternative SA-1 (see Table 6.3). • River debris removal and dredging work (and resuspension of sediment) would take approximately 3 to 4 months to complete. ▪ If dredged sediment could not be reused at OU-1, the equivalent of 83 full rail cars or 420 fully-loaded trucks (Option A) or 88 full rail cars or 440 fully-loaded trucks (Option B) would leave the site with dredged sediment.	Same as for Alternative SA-2 except: ▪ Alternative SA-4 would have the greatest short-term impact from sediment resuspension and release due to more debris being removed, more sediment being dredged, and a longer river work effort. • Worker risk would be 19 times higher compared to Alternative SA-1 (see Table 6.3). ▪ Safety of dredging and risk of shoreline instability adjacent to the shoreline bulkhead during construction would be more problematic than for the other SA alternatives due to a greater depth and duration of dredging. ▪ Due to complex interaction with OU-1 and the extent of dredging, river debris removal and dredging work (and resuspension of sediment) would extend to 5 to 6 months. ▪ If dredged sediment could not be reused at OU-1, approximately 170 full rail cars or 850 fully-loaded trucks would leave the site with dredged sediment. More barge traffic to and from the site would also be required.

TABLE 6.1, Continued

REMEDIAL ACTION ALTERNATIVES FOR THE SOUTHERN AREA (SA)
HARBOR AT HASTINGS OU-2

	Alternative SA-1 Place a Protective Cap	Alternative SA-2 Dredge Up to 2 ft and Place Protective Cap	Alternative SA-3 Dredge to Limit of Bulkhead Stability	Alternative SA-4 Penetrate Shoreline Bulkhead into Basal Sands
Short-term Effectiveness, continued		▪ Odors from sediment should not be noticeable off site based on experience at other dredging sites. ▪ River debris removal and dredging work (and resuspension of sediment) would last approximately 3 to 4 months. ▪ The equivalent of 69 full rail cars or 350 fully-loaded trucks would leave the site with dredged sediment.	▪ Village Code requirements would limit noise from significant construction work to day time hours.	▪ Village Code requirements would limit noise from significant construction work to day time hours.
Long-term effectiveness and permanence (quantity and characteristics of residuals remaining after remediation, reliability of long-term controls)	▪ Covering residual contamination with a berm-cap would provide effective long-term isolation including protection against erosion see Section 2.2). Protectiveness would be ensured with cap monitoring and maintenance. ▪ Ice scour would not affect cap characteristics since the only potential contact point (the shoreline) would be conservatively armored. ▪ Long-term monitoring of capping is proven from work at other sites. ▪ Institutional controls such as environmental easements have some precedence and should be effective. ▪ Hydraulic carrying capacity of the river would not be	Same as Alternative SA-1 plus: ▪ Dredging alone would most likely not achieve sediment PRGs due to post-dredging residual contamination (see Section 2.1.1). ▪ 8 pounds of PCBs would be removed from the river within 6,900 cubic yards of dredged sediment, but a cap would be needed that would be as effective as the cap under Alternative SA-1. ▪ Dredging and capping would be designed to be consistent with future site land and water use. ▪ Ice scour would not affect cap characteristics since the only potential contact point (the shoreline) would be conservatively armored. ▪ Removes 0 percent of PCBs and 10 percent of the copper above 982 ppm from OU-2 sediment. ▪ The temporary silt curtain would be	▪ No significant additional long-term effectiveness would be provided compared to Alternative SA-2. Residuals exposed to the local environment would be the same as under Alternative SA-2. ▪ Removes 0 percent of PCBs and 19 percent of the copper above 982 ppm from OU-2 sediment by either transferring to OU-1 or by removal offsite. ▪ 1,400 to 1,900 additional cubic yards of sediment and only 2 to 3 more pounds of PCBs and 9 percent more copper greater than 982 ppm would be removed from the river compared to Alternative SA-2. ▪ The temporary silt curtain would be effective and implementable as presented, but also limited by the small silty size of sediment particulates, river currents, tides,	Same as Alternative SA-2 except: ▪ Removes 0.1 percent of OU-2 PCBs from OU-2 sediment. ▪ Approximately 10,000 additional cubic yards, only 16 more pounds of PCBs, and 19 percent more copper greater than 982 ppm would be removed compared to Alternative SA-2. ▪ Ice scour would not affect cap characteristics since the only potential contact point (the shoreline) would be conservatively armored.

REMEDIAL ACTION ALTERNATIVES FOR THE SOUTHERN AREA (SA)
HARBOR AT HASTINGS OU-2

	Alternative SA-1 Place a Protective Cap	Alternative SA-2 Dredge Up to 2 ft and Place Protective Cap	Alternative SA-3 Dredge to Limit of Bulkhead Stability	Alternative SA-4 Penetrate Shoreline Bulkhead into Basal Sands
	significantly affected.	effective and implementable as presented, but also limited by the small silty size of sediment particulates, river currents, tides, and effluent from public discharges (see Section 2.1.3.1). Dredging in debris areas would also be difficult.	and effluent from public discharges (see Section 2.1.3.1). Dredging in debris areas would also be difficult. ▪ Ice scour would not affect cap characteristics since the only potential contact point (the shoreline) would be conservatively armored.	
Reduction of toxicity, mobility and volume through treatment (treatment technologies used, degree or reduction of toxicity, mobility and volume, permanence of treatment, residuals remaining on site)	▪ No treatment would be provided.	▪ Water separated from dredged sediment would be permanently treated and thereby reduce mass of PCBs and metals in the return water.	▪ Water separated from dredged sediment would be permanently treated and thereby reduce mass of PCBs and metals in the return water.	▪ Water separated from dredged sediment would be permanently treated and thereby reduce mass of PCBs and metals in the return water.
Implementability (technical feasibility, administrative feasibility and availability of resources)	▪ Needed resources and work space would likely be available. Sediment dredged from clean navigational dredge sites may be useable for the berm and cap. ▪ Sediment shear strength needed for cap placement is available (see Section 2.2.7). ▪ Successful cap placement has been observed at other	▪ Dredging would not be as difficult as for Alternative SA-3 or SA-4 due to shallower dredge cuts and smaller volumes of sediment to dredge in the river. ▪ Needed resources and work space would likely be available as for Alternative SA-1. ▪ Administrative feasibility for this alternative is considered to be routine as long as the long-term	Same as Alternative SA-2 except: ▪ Dredging would be more difficult than Alternative SA-2 due to deeper dredge cuts in the river. ▪ Any delay of the OU-1 remedial action due to coordination with the OU-2 remedial action would delay onshore redevelopment by a minimum of 2 to 3 years. ▪ Approvals would be needed from the NYSDEC and from the US	Same as for Alternative SA-2 except: ▪ Alternative SA-4 would be the most technically difficult and complex of the SA alternatives due to large dredging depths and volumes combined with obstructions and additional time in the river where conditions are regularly difficult due to winds and currents. ▪ Allows OU-1 excavation and filling of OU-1 approximately elevation +4

TABLE 6.1, Continued

REMEDIAL ACTION ALTERNATIVES FOR THE SOUTHERN AREA (SA) HARBOR AT HASTINGS OU-2

	Alternative SA-1 Place a Protective Cap	Alternative SA-2 Dredge Up to 2 ft and Place Protective Cap	Alternative SA-3 Dredge to Limit of Bulkhead Stability	Alternative SA-4 Penetrate Shoreline Bulkhead into Basal Sands
	sites. ▪ Approvals would be needed from the NYSDEC and from the US Army Corps of Engineers for filling within the river. ▪ Establishing environmental easements with the State are not expected to be complex.	mudline elevation in the river would not change significantly. ▪ Dredged sediment would likely be able to be reused at OU-1. ▪ Establishing environmental easements with the State are not expected to be complex	Army Corps of Engineers if a net filling within the river would result. ▪ Establishing environmental easements with the State are not expected to be complex	ft to be completed before dredging near the shoreline, but completion of the OU-1 remedial action could be delayed. Any delay of the OU-1 remedial action due to coordination with the OU-2 remedial action would delay onshore redevelopment by a minimum of 2 to 3 years.
Costs (capital, annual, and present worth costs. Capital = construction, non-construction, and contingency)	Capital: $ 4.0 million Long-Term Annual: $100,000 Present Worth: $ 5.1 million	Capital: $ 17.9 million Long-Term Annual: $100,000 Present Worth: $ 19.0 million	Capital: $ 19.7 to $20.2 million Long-Term Annual: $100,000 Present Worth: $20.8 to $21.3 million	Capital: $ 33.8 million Long-Term Annual: $100,000 Present Worth: $ 34.9 million

TABLE 6.2

MASS OF PCBs IN DREDGED SEDIMENT FOR THE SOUTHERN AREA ALTERNATIVES

Alternative	Mass of PCBs Resuspended (total pounds) (1)	Estimated Duration for Debris Removal and Dredging (months)	Estimated Average Sediment PCB Concentration In Dredged Sediment (ppm) (2)
SA-1	0	0	No dredging included
SA-2	Less than 0.1	2 to 3	0.6
SA-3, Option A	Less than 0.1	3 to 4	0.6
SA-3, Option B	Less than 0.1	3 to 4	0.6
SA-4	Less than 0.1	5 to 6	0.6

(1) Based on 2 percent of the dredged sediment by weight becoming resuspended due to site conditions (see Section 2.1).

(2) Based on the volume weighted-average PCB concentration of dredged sediment, the mass of PCBs removed, and a sediment unit weight of 1 ton per cubic yard.

TABLE 6.3

SUMMARY OF SHORT-TERM WORKER RISK OF FATALITY FOR THE SOUTHERN AREA ALTERNATIVES

Remedial Action Alternative	Risk of Fatality for Site Workers	Risk of Fatality for Transportation Workers and Non-workers
SA-1	0.0016 or 1 in 624 projects	0.0088 or 1 in 114 projects
SA-2	0.017 or 1 in 60 projects	0.0088
SA-3, Option A	0.019 or 1 in 53 projects	0.0088
SA-3, Option B	0.020 or 1 in 50 projects	0.0088
SA-4	0.030 or 1 in 33 projects	0.0088

TABLE 6.4

APPROXIMATE NET RIVER BERM-CAP VOLUME REQUIRED ABOVE THE EXISTING MUDLINE TO SUPPORT THE SOUTHERN AREA SHORELINE BULKHEAD

HARBOR AT HASTINGS OU-2

Alternative	Net Sediment Volume Increase (+) or Decrease (-) Following Dredging and Placement of Berm and Cap (cubic yards) (1)	Percent Change in River Cross Section (2)
SA-1	+7,300	-0.1 (3)
SA-2	+24,000	-0.3
SA-3, Option A	+23,000	-0.3
SA-3, Option B	+24,000	-0.3
SA-4	+18,000	-0.2

(1) Based on an OU-1 final grade elevation of +4 ft with the shoreline sloping upward to +9 ft at 100 to 120 ft inland based on NAVD88 datum (average tidal water level is +0.1 ft). These sediment volume changes do not include the beneficial effect of settlement from berm-cap placement. For example, a berm-cap with a total thickness of 5 ft above existing grade would have a total settlement over time of approximately 1.5 to 2 ft (see Appendix B).

(2) Based on the existing river cross section at Hastings-on-Hudson being approximately 4,000 ft wide with an average water depth of approximately 40 ft.

(3) Example calculation: 5,000 cubic yards over a 140 ft river width and a 900 ft river length corresponds to a 1.1 ft average increase in water depth. 1.1 ft over a 140 ft river width divided by 40 ft over a 4,000 ft wide river (from note 2 above) is 0.1 percent (or one tenth of one percent).

TABLE 6.5

SEDIMENT DREDGE VOLUMES AND CONTAMINANT MASSES FOR THE SOUTHERN AREA ALTERNATIVES

Alternative	Volume of Sediment to Dredge (cubic yards)	Mass of PCBs Removable (pounds)	Pounds of PCBs Removable per Cubic Yard	Percentage of Removable PCBs / Copper in OU-2 Sediment
SA-1	0	0	0	0
SA-2	6,900	8	Less than 0.002	Less than 0.1 / 10
SA-3, Option A	8,300	10	Less than 0.002	Less than 0.1 / 19
SA-3, Option B	8,800	11	Less than 0.002	Less than 0.1 / 19
SA-4	16,000	24	Less than 0.002	Less than 0.1 / 29

SECTION 7

REMEDIAL ACTION ALTERNATIVES FOR THE NORTH AND SOUTH BOAT SLIPS AND FOR THE OLD MARINA AREA

This section describes alternatives for the North and South Boat Slips and for the Old Marina Area. Additional investigation work completed by AR since the 2003 OU-2 FS Report was issued includes extensive sediment sampling during 2005 particularly in the Old Marina to provide estimates of sediment volumes comparable to the estimates available for the other areas within OU-2.

The locations of the boat slips and the Old Marina Area are shown in Figure 1.2. Boat slip boundaries consist of the OU-1 shoreline on three sides and the river along the west side. The existing open water area of the North Boat Slip is approximately 0.8 acres (330 ft long parallel to the shoreline by 100 ft wide perpendicular to the shoreline). The existing open water area of the South Boat Slip is approximately 0.6 acres (200 ft long parallel to the shoreline by 130 ft wide perpendicular to the shoreline). The Old Marina Area is approximately 2.3 acres in area, and it extends south to north for a distance of approximately 340 ft parallel to the river. The Old Marina Area extends from the northern boundary of the Northwest Corner Area to the northern boundary of the Hudson Valley Health & Tennis Club (see Figure 1.2). The eastern boundary of the Old Marina Area is the existing shoreline at the health and tennis club. The boundary of the Old Marina Area is outside of the temporary rigid containment barrier being evaluated for the Northwest Corner Area. The western boundary of the Old Marina Area is defined by the elevation -15 ft mudline for the same reasons the western boundary of the Southern Area is likewise defined. Sediment samples beyond the elevation -15 ft mudline in the vicinity of the Old Marina Area include cores CS-02, CS-03, and RB-15 that show no PCB concentrations above 1 ppm. Core SD-39, which shows PCBs in sediment over 1 ppm at 2 to 8 ft below the mudline, is west of the Old Marina Area and is being addressed as part of the Offshore Area (see Sections 9 and 10).

The two boat slips and the Old Marina Area share several common characteristics. All three areas have low levels of PCBs. PCB concentrations above 1 ppm in sediment from the two boat slips and in Old Marina Area sediment are limited in extent and concentrations. A review of Table 1.1 shows that the South Boat Slip PCB area weighted averages are 50 percent or less of the PCB PRG (0.5 ppm or less at all sediment depths), and the location in the South Boat Slip with the highest PCB concentration (6 ppm) is below eight feet of sediment that contains less than the PRG of 1 ppm PCBs of which the top four feet did not show any detectable PCBs. The PCB area weighted average concentrations in the North Boat Slip are less than 10 ppm at all depths. However, Table 1.1 also shows that the PRG of 1 ppm is exceeded in the majority of the top 16 feet of sediments from the North Boat Slip. In the Old Marina, PCB concentrations range from below the 1 ppm PRG, up to approximately 10 ppm. The PCB area weighted average concentrations are less than 0.9 ppm at all depths. In the South Boat Slip, the PCB area weighted average concentrations are 0.5 ppm or less at all depths.

The mass of PCBs in North Boat Slip and Old Marina Area sediment are also low particularly when compared to the mass of PCBs in Northwest Corner Area sediment. While thousands of pounds of PCBs are present in Northwest Corner Area sediment, only approximately 50 pounds are contained in North Boat Slip sediment and approximately 500 pounds are contained in Old Marina Area sediment.

In 2001, NYSDEC collected and analyzed five surface sediment samples from the cove north of the Old Marina Area. Four of these five sediment samples showed less than 0.5 ppm PCBs, and the fifth sample showed 1.5 ppm PCBs (NYSDEC, 2001). From these results, it appears sediment within the cove north of the Old Marina Area is not significantly impacted with PCBs. In the South Boat Slip, only one sediment core showed PCBs above 1 ppm in sediment. Even though Figure 1.3 shows PCBs in the South Boat Slip above 1 ppm, sediment exceeding 1 ppm is 8 ft or more below the mudline and therefore inaccessible to aquatic life.

Copper concentrations in boat slip and Old Marina Area sediments are all below the 982 ppm PRG proposed for copper. Sediment copper concentrations generally exceed the background PRG of 88.7 ppm throughout the two boat slips and Old Marina Area sediment below the top 6 inches of sediment. Typical copper concentrations in these sediments are 100 to 300 ppm except at two sample locations: (1) SD-48 in the North Boat Slip at depths 10 to 18 ft below the mudline, where copper concentrations are 400 to 600 ppm; and (2) at SD-49 in the South Boat Slip at a depth 18 to 20 ft below the mudline, where 577 ppm of copper was measured.

USEPA’s 2005 ESB guidance explains that the concentration of metals in bulk sediments does not accurately predict whether those sediments will be harmful. USEPA’s ESB guidance provides a rigorous methodology for assessing the factors that limit the bioavailability and toxicity of metals. This guidance recognizes the importance of acid volatile sulfides and organic carbon in sequestering (or binding up) metals in sediments thereby limiting their introduction into porewater, which is the primary route of exposure for benthic organisms. This USEPA guidance also establishes a scientific method for evaluating the bioavailability and toxicity of metals in sediments, and provides detailed methodology for quantitatively assessing the metal binding capacity of sediments.

Site-specific acid volatile sulfides, organic carbon and metal porewater data have since been obtained during supplemental sediment investigations of OU-2 conducted in 2004 and 2005. These data fill previous data gaps and allow the site-specific bioavailability and toxicity of metals to be evaluated based on the methods presented in the USEPA (2005a) ESB guidance. The results of this analysis are summarized in Section 1 and presented in more detail in Appendix C to show that a copper concentration of 982 ppm is a conservative, site-specific, no observed adverse effects sediment concentration that is a proposed as a PRG for the two boat slips, the Old Marina Area and for the other areas comprising OU-2.

Dredging sediment in both boat slips and the Old Marina Area to remove all copper above NYSDEC proposed 88.7 ppm background level would result in much higher sediment dredge volumes than would dredging sediment based on 1 ppm PCBs and 982 ppm copper, and the additional dredging would not protect human health or aquatic life from adverse impacts.

Remedial action alternatives for the North Boat Slip (Slip alternatives) and for the Old Marina Area (OM alternatives) consist of a combination of dredging and capping. Table 7.1 provides a listing of the elements of the remedial action alternatives for the boat slips and for the Old Marina Area. Remedial action alternatives for the North Boat Slip and for the Old Marina Area have been developed based on the same analysis applied to the Northwest Corner Area. Geotechnical conditions along the shoreline are approximately the same as for the Northwest Corner Area as shown in Table 7.2.

The remedial action alternatives are developed or evaluated for the South Boat Slip in this Supplemental Feasibility Study is monitored natural recovery. The South Boat Slip as well as the North Boat Slip and the Old Marina Area are gradually infilling with settling sediment based on observed losses of water depth over time and based on radioisotope results from the OU-2 RI and also from Fall 2004 investigation efforts. Typical sedimentation rates are approximately 1 to 2 inches per year (Earth Tech, 2000) and such infilling is expected to continue over the long term. Concentrations of PCBs and metals of sediment infilling the South Boat Slip are lower than the PRGs based on results from sediment samples analyzed from four locations (see Figures 1.3 and 1.4).

The only sediment sample in the South Boat Slip with PCBs over 1 ppm is at least 8 ft below the existing mudline well below any sediment that river biota could contact. Similarly, copper concentrations measured in South Boat Slip sediment do not exceed the proposed PRG of 982 ppm at any depth. On this basis, monitored natural recovery is assessed for the South Boat Slip. Monitored natural recovery would consist of monitoring natural infilling that is ongoing and implementing institutional controls needed for other areas within OU-2

Monitoring of natural recovery has been removed from consideration for the North Boat Slip and for the Old Marina Area based on PCB concentrations in sediment above 1 ppm, even though many of the sediment samples contain less than 10 ppm PCBs. The only North Boat Slip sediment samples with PCBs above 10 ppm are from depths 10 to 16 ft below the mudline at location SD-48. Sediment in the two boat slips and in the Old Marina Area, like in the Southern Area, is not nearly as impacted with PCBs as is sediment from the Northwest Corner Area.

To summarize, the following alternatives are being evaluated for the two boat slips and for the Old Marina Area:

<u>North Boat Slip</u>: NSlip-1 Dredge up to 2 ft and Cap
NSlip-2 Dredge to Limits of Global Stability and Cap

<u>South Boat Slip</u>: SSlip-1 Monitored Natural Recovery

<u>Old Marina</u>: OM-1 Dredge up to 2 ft and Cap
OM-2 Dredge to Limits of Global Stability and Cap

A third alternative for the Old Marina may be developed after further discussion with the marina owner, to ensure that the remedy is compatible with proposed future site uses. This alternative is likely to consist of some combination of OM-1 and OM-2.

Specific information about any remedial action alternatives is presented in this Supplemental FS only for the purpose of evaluating each alternative. Any elevations or other specific information presented herein about any alternative is preliminary, approximate, and subject to change during remedial design.

7.1 REMEDIAL ELEMENTS COMMON TO BOAT SLIP AND OLD MARINA AREA ALTERNATIVES

A temporary silt curtain would be installed prior to removing any debris and prior to dredging within the North Boat Slip or within the Old Marina Area. This temporary curtain would likely consist of materials and anchoring similar to the curtain included as part of Alternatives SA-2, SA-3, and SA-4 for the Southern Area (see Section 5). The temporary curtain along the North Boat Slip would extend north-south along its river side. The temporary curtain around the Old Marina Area would have two sections. One section would extend north from the Northwest Corner Area shoreline (or from the temporary rigid containment barrier encircling the Northwest Corner Area) to the northern end of the Old Marina Area along a western alignment where the mudline is at -15 ft. The second section of the temporary curtain around the Old Marina Area would extend from shoreline at the eastern end of the health and tennis club north to connect with the western section of the temporary curtain. If dredging in the Old Marina Area is conducted before or after the Northwest Corner Area is remediated, the temporary silt curtain around the Old Marina Area would extend to the Northwest Corner Area shoreline. Otherwise, the temporary curtain could tie into the temporary rigid containment barrier as shown in Figure 7.1.

Deteriorated timber structures that exist along the North Boat Slip would be removed as part of the remedial effort and prior to dredging. Similar deteriorated timber dock and wharf structures that exist along the north and east sides of the Old Marina Area would also be removed as part of the remedial work prior to dredging. Geophysical investigations conducted by AR during 2004 and 2005 did not show the obstructions to be as numerous in the boat slips as they are in the Southern and Northwest Corner Areas, although approximately six subsurface magnetic anomalies were identified on the outskirts of the North Boat Slip. Visible debris and visible piling fields and dock structures exist in the Old Marina Area. During the 2004 and 2005 geophysical investigations conducted by AR, sunken barges and associated debris were observed in the Old Marina Area as well as cables, tires, subsurface magnetic anomalies and other man-made objects (Parsons, 2005a/b).

Removal of debris and obstructions and dredging would most likely be performed using mechanical means working from barges. It is not believed to be practical to dredge within OU-2 using shore-based equipment due to the need to minimize loads on soil within 100 to 120 ft of the shoreline as discussed in Appendix B.

Each of the North Boat Slip and Old Marina Area alternatives includes dredging based on PCBs in sediment exceeding 1 ppm. Copper is not present in the boat slip or in Old Marina Area sediment above the proposed sediment PRG of 982 ppm for copper (see Figure 1.4).

Dredging in the North Boat Slip could be done concurrently with remediation of the Southern Area as long as construction of the OU-1 shoreline bulkhead around the south, east and north side of the North Boat Slip is completed prior to dredging. The dredged sediment would be moved onto OU-1 for processing to be located more than 100 to 120 ft from shore for stability reasons. Processed sediment could then possibly be reused at OU-1 or transported offsite.

Dredge depths within the Old Marina Area adjacent to OU-1 and adjacent to the Hudson Valley Health and Tennis Club would be limited by shoreline stability considerations (see Appendix B).

In order to dredge and raise the OU-1 ground surface consistent with the intent of the federal consent decree, a shoreline bulkhead would be installed along the North and South Boat Slips and along the southern side of the Old Marina Area with the piles extending to within approximately 15 ft of the basal sand. The shoreline bulkhead would consist of steel sheet piles with joints that would be sealed to minimize flow of water laterally through the bulkhead. The same type of deadman anchorage system would be used to help stabilize the shoreline bulkhead as is shown in Sections 3 for stabilizing the shoreline bulkhead along the Northwest Corner Area.

Following dredging in the North Boat Slip a granular berm-protective cap would be placed as needed for shoreline stability purposes and to achieve PRGs (see Figure 7.2). The berm-cap would be comparable to the berm-cap that is part of alternatives for the Northwest Corner Area and for the Southern Area. Marine silt consolidation would not be needed for this area.

Because PCB and metals concentrations are relatively low in Old Marina Area sediment, dredging and berm placement are not included within 20 to 30 ft of shore along the southern side of the Old Marina Area except to dredge up to 2 ft and place a protective cap as part of Alternative OM-1. Deep dredging would be avoided, because a berm would need to be placed over the entire south side of the Old Marina Area following any remedial action. Elsewhere in the Old Marina Area beyond the southern shoreline, as in the Northwest Corner Area and the Southern Area, dredging would be performed where the PRGs are exceeded and a protective cap would be placed following dredging if a cap is needed to meet PRGs. The protective cap would be consistent with the cap described for the Northwest Corner and Southern Areas. The protective cap would be monitored and repaired over the long term following placement (see Section 2.2).

Debris and dredged sediment would be moved by barge and processed onshore at OU-1 as described in Section 3. The purpose of processing would be to prepare the debris and sediment for reuse at OU-1 or for transport off site. As for the Southern Area, sediment containing less than 10 ppm PCBs could possibly be reused as fill within OU-1 or transported offsite. Water removed from dredged sediment would most likely be treated at OU-1 in accordance with NYSDEC discharge requirements or the water would be treated at a Westchester County municipal wastewater treatment plant and released back to the river.

7.2 ALTERNATIVES NSLIP-1 AND OM-1: DREDGE UP TO 2 FT AND CAP

Under Alternative Slip-1 and OM-1, the dredge depth in both the North Boat Slip and Old Marina Area would be up to 2 ft below the existing mudline where feasible, in areas where the sediment exceeds the PRGs. Similar to Alternative SA-2 in the Southern Area, and assuming the existing sediment slope is steeper than five horizontal to one vertical, deeper dredging would be needed directly adjacent to the shoreline in order to dredge up to 2 ft further from shore and maintain sediment stability. The mudline elevation along the sides of the North Boat Slip is between elevation -3 and -4 ft, and the mudline slopes downward away from shore (see Figure 5.2). A sufficient factor of safety could be maintained while dredging 2 ft along the North Boat Slip shoreline after installing the new shoreline bulkhead.

The existing mudline elevation at the border between the Old Marina Area and the Northwest Corner Area is in the range of -2 ft to -3 ft, and this mudline is approximately level from the southern extent to the northern extent of the Old Marina Area based on measurements from five core locations in the Old Marina Area adjacent to the southern and eastern shorelines (at SD-35, -36, -37, -38 and SD-40). Water depths increase away from shore along the west side of the Old Marina Area.

Sediment volumes and chemical masses for each of the NSlip and OM alternatives are summarized in Table 7.3. Under this alternative, approximately 2,100 cubic yards of sediment would be removed from the North Boat Slip and approximately 6,800 cubic yards of would be removed from the Old Marina Area. Percentages of PCB mass in OU-2 sediment that would be removed from either the North Boat Slip or from the Old Marina Area would be one fifth of one percent or less of the total OU-2 sediment PCB mass based on AR's contaminant distribution modeling results. No copper above the proposed PRG of 982 ppm has been measured in any sediment sample analyzed from the boat slips or from the Old Marina.

Once dredging is complete, a berm-cap would be installed as needed nearshore in the North Boat Slip. In the Old Marina, a protective cap would be placed over the dredge cut as needed to meet PRGs and restore aquatic habitat. Long-term monitoring and maintenance of the protective cap in the North Boat Slip and in the Old Marina Area are included under this alternative.

Alternatives NSlip-1 and OM-1 could be completed at the North Boat Slip or at the Old Marina Area in one construction season once the shoreline bulkhead is in place. Removing debris and obstructions, dredging, berm placement, and capping could be completed over a timeframe of approximately three to four months assuming the North Boat Slip and the Old Marina Area are remediated in sequence and not concurrently.

7.3 ALTERNATIVES NSLIP-2 AND OM-2: DREDGE TO LIMIT OF BULKHEAD STABILITY

Under Alternative Slip-2 and OM-2, the dredge depth would be as deep as needed to remove sediment exceeding PRGs within the geotechnical limits of shoreline stability Removal debris and obstructions and dredging would most likely be done from barges.

Following installation of the shoreline bulkhead, timber piles and large debris would be cut as needed, and the sediment from the North Boat Slip would be dredged. Dredging would be completed to an elevation of -9 ft at the shoreline bulkhead, sloping down to a maximum dredge depth of -14 ft (see Appendix B). Following dredging, a berm-cap would be installed along the North Boat Slip shoreline to help stabilize the shoreline and to meet PRGs and restore aquatic habitat as needed. Adjacent to the shoreline bulkhead, the final elevation would be at approximately elevation -6 ft, sloping downward away from the shoreline (as explained in

Appendix B) which would allow for water access of least 8 ft deep at approximately 25 ft from the shoreline bulkhead. Dredging to this depth would be performed as close to the shoreline bulkhead as reasonably possible while maintaining bulkhead stability. Dredging in the Old Marina Area could be completed to a maximum depth corresponding to an elevation of -14 ft, although such a dredge depth is not shown in any of the sections in Appendix B. The dredge cut adjacent to the shoreline bulkhead would begin at the current mudline elevation and slope away from the bulkhead to the maximum depth, which would leave a berm of fill material and sediment in place to provide needed stability.

The depth of PCBs observed in Old Marina Area sediment is 6 to 8 ft below the mudline. Adjacent to the Northwest Corner Area, dredge depths would be limited by bulkhead stability. In the other portions of the Old Marina Area, dredging to depths of 6 to 8 ft below the mudline to remove sediment with PCBs over 1 ppm would not be limited by stability considerations.

Sediment samples from cores SD-3, CS-25, CS-26 and BS-4 in the North Boat Slip were collected at depths up to 4.7 ft below the mudline and all samples had PCB concentrations less than 10 ppm. Sediment samples from core SD-48 in the North Boat Slip contain PCB concentrations less than 10 ppm up to a depth of 8 ft below the mudline. The only samples in the North Boat Slip with PCBs above 10 ppm were from depths of over 10 to 16 ft below the mudline in core SD-48. Dredged material with PCB concentrations less than 10 ppm would be below the soil cleanup level established for OU-1 soils, so this dredged material should be considered for use within OU-1 as fill.

Under this alternative, approximately 8,400 cubic yards of sediment would be removed from the North Boat Slip, and approximately 15,000 cubic yards of sediment would be removed from the Old Marina Area. Percentages of PCB mass in OU-2 sediment that would be removed from either the North Boat Slip or from the Old Marina Area would total two tenths of one percent in the North Boat Slip and two tenths of one percent in the Old Marina Area based on AR's contaminant distribution modeling results. No copper above the proposed PRG of 982 ppm has been measured in any sediment sample analyzed from the boat slips or from the Old Marina. Once dredging is complete, a berm-cap would be installed as needed nearshore within the North Boat Slip to stabilize the OU-1 shoreline and to meet PRGs and restore aquatic habitat. In the Old Marina Area, a protective cap would be placed as needed for the same purposes. Long-term monitoring and maintenance of the protective cap in the North Boat Slip and in the Old Marina Area and long-term monitoring of South Boat Slip sediment are included under this alternative.

Alternative Slip-2 and OM-2 could be completed in one construction season once the shoreline bulkhead is in place.

7.4 ALTERNATIVE SSLIP-1: MONITORED NATURAL RECOVERY

Sediment deposition occurs within an estuarine system such as the lower Hudson River particularly in nearshore areas like OU-2. Deposition takes place as sediment originating from erosive areas with high water velocities settles through the water column at downstream areas where water velocities are lower. The lower water velocities near the mouth of a river are due to flatter slopes longitudinally along the river's direction of water flow and lower water velocities nearshore away from the main channel. In addition, tidal forces moving upstream from the ocean increase the residence time for water in lower portions of rivers further encouraging sediment settling.

Radioisotope analyses were performed at four OU-2 locations as part of the Fall 2004 Supplemental OU-2 Investigation (Parsons, 2005a/b). These analyses confirmed that deposition is occurring at an average rate of approximately 1 inch per year. In addition, OU-2 RI results show sediment deposition is ongoing within the North Boat Slip at a comparable rate of 1 to 2 inches per year (Earth Tech, 2000). Sediment deposition monitoring has not been conducted in the South Boat Slip, but there is no reason to believe such deposition is not occurring based on results from the river and from the North Boat Slip.

Given that sediment deposition is taking place and given the relatively low concentrations of PCBs and metals in South Boat Slip sediment (see the data sets in the Appendix A figures), monitored natural recovery of South Boat Slip sediment due to ongoing natural infilling is the only remedial action alternative for the South Boat Slip evaluated in this Supplemental FS.

Monitored natural recovery is an alternative that can be protective and effective in the long term as presented in USEPA's most recent guidance on contaminated sediment (USEPA, 2005b).

TABLE 7.1

REMEDIAL ACTION ALTERNATIVES FOR THE NORTH & SOUTH BOAT SLIPS AND OLD MARINA

HARBOR AT HASTINGS OU-2

Alternative	General Description
NSlip-1/OM-1: Dredge 2 ft and Place Protective Cap	Dredge up to 2 ft from the North Boat Slip and Old Marina Area (or more if needed for shoreline stability) where sediment exceeds PRGs. Dredge inside a temporary silt curtain. Place berm material as needed for shoreline stability. Place a protective cap where sediment exceeding PRGs for PCBs and copper remain after dredging.
NSlip-2/OM-2: Dredge to Limit of Bulkhead Stability	Dredge the North Boat Slip and Old Marina where sediment exceeds PRGs to the maximum depth needed to meet PRGs. Dredge inside a temporary silt curtain. Install the shoreline bulkhead along the boat slips prior to dredging without penetrating into the basal sand. Place berm material as needed for shoreline stability. Place protective cap where full removal of sediment exceeding PRGs is not feasible.
SSlip-1 Monitor Natural Recovery	Monitor ongoing natural recovery based on long-term sediment deposition to assure sediment concentrations of PCBs continue to be protective of human health and the environment over the long term.

Note: (1) Sediment PRGs are 1 ppm for PCBs and 982 ppm proposed for copper.

TABLE 7.2

SHORELINE BULKHEAD CHARACTERIZATION FOR THE NORTH BOAT SLIP AND FOR THE OLD MARINA ALTERNATIVES

HARBOR AT HASTINGS OU-2

	NSlip-1/OM-1	NSlip-2/OM-2
Shoreline Bulkhead		
Length (ft)	670	670
Maximum depth (elevation in ft)	-47	-47
Penetrate into basal sand?	No	No
Final OU-1 ground elevation at shoreline (ft)	+4	+4
Interim OU-1 ground elevation while dredging (ft)	+4	+4

Note: Elevations are based on the NAVD88 datum (mean tidal elevation is +0.1 ft).

TABLE 7.3

DREDGING AND CAPPING QUANTITIES AND DURATIONS FOR THE NORTH BOAT SLIP AND FOR THE OLD MARINA ALTERNATIVES

HARBOR AT HASTINGS OU-2

	NSlip-1/OM-1	NSlip-2/OM-2
Dredging		
Volume (cubic yards)	8,900	23,000
Lowest cut elevation at shoreline (ft)	-0.9 (NSlip) None (OM)	-9 (NSlip) None (OM)
Percent PCB mass dredged (1)	0.2	0.4
Approximate dredging and debris removal duration (months)	3 to 4	6 to 7
Cap/Berm		
Area (acres)	1.9	1.9
Approximate installation time (months)	1 to 2	1 to 2

Notes:

(1) Percentages of mass are based on 100 percent being the mass within all sediment within OU-2.

LEGEND:

ALLOWABLE DREDGE CUT BASED ON ASSUMPTIONS OUTLINED IN APPENDIX B

NOTES:

1. PLAN PREPARED FROM AN ELECTRONIC BASE PLAN PROVIDED BY PARSONS.
2. DRAWING BASED ON NAVD 88 DATUM. TO CONVERT FROM NAVD88 TO NGVD29 DATUM ADD ONE FOOT TO NAVD88 ELEVATIONS. PLAN BASED ON NEW YORK 1988 STATE PLANE COORDINATE SYSTEM.
3. NO BERMS PLACED IN OLD MARINA AREA. NO CONSOLIDATION OF MARINE SILT ASSUMED.
4. ALL ENGINEERING ELEMENTS PROVIDED ON THIS PLAN WERE DEVELOPED BASED ON EXISTING INFORMATION FOR THE PURPOSE OF EVALUATING REMEDIAL ALTERNATIVES AT THE SUBJECT SITE. THE ACTUAL DESIGN ELEVATIONS, DIMENSIONS, AND OTHER ENGINEERING ASPECTS OF THE SELECTED REMEDY WILL BE DEVELOPED DURING REMEDIAL DESIGN.
5. DREDGE CUT ASSUMED FOR GEOTECHNICAL CALCULATIONS IS SHOWN ON BOTH THE PLAN AND SECTION VIEW DRAWINGS FOR THIS ALTERNATIVE. WHERE THE DREDGE CUT BASED ON ENVIRONMENTAL DATA (FIGURES 1.3 AND 1.4) WOULD BE LESS THAN THE DREDGE CUT ASSUMED IN THE GEOTECHNICAL CALCULATIONS, THE ENVIRONMENTAL DREDGE CUT IS ALSO SHOWN ON THE SECTION VIEW DRAWINGS FOR ALTERNATIVE OM-2.

0 30 60 90 120

SCALE IN FEET

HALEY & ALDRICH

UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

HARBOR AT HASTINGS SITE
SUPPLEMENTAL FEASIBILITY STUDY FOR OU-2
HASTINGS-ON-HUDSON, NEW YORK

OLD MARINA
ALTERNATIVE OM-2
PLAN VIEW

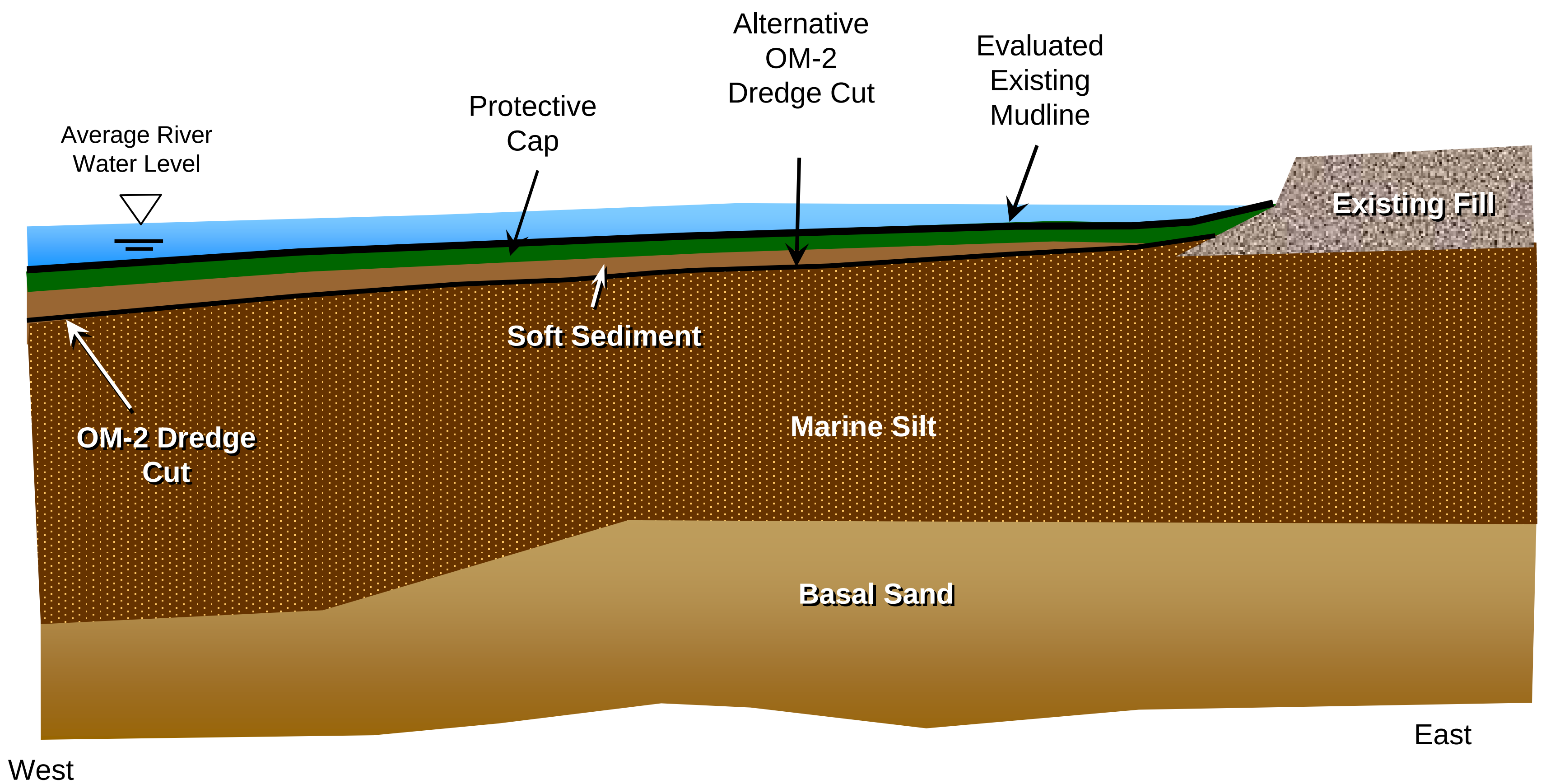
SCALE: AS SHOWN

18 APRIL 2006

28612-010 D137

FIGURE 7.1

Figure 7.2
Harbor-at-Hastings OU-2
Typical Cross Section for Old Marina



(not to scale)

SECTION 8

EVALUATION OF REMEDIAL ACTION ALTERNATIVES FOR THE BOAT SLIPS AND OLD MARINA AREA

Remedial action alternatives for the two boat slips and for the Old Marina Area presented in Section 7 are evaluated in this section based on the same NYSDEC evaluation criteria used in Section 4 to evaluate remedial action alternatives for the Northwest Corner Area and used in Section 6 to evaluation remedial action alternatives for the Southern Area. In the North Boat Slip, area-weighted average PCB concentrations are 1 to 2 ppm in the top 10 ft of sediment. In the South Boat Slip, average PCB concentrations are less than 1 ppm at all depths. In the Old Marina Area, area-weighted average PCB sediment concentrations are also less than 1 ppm at all depths (see Table 1.1). For the North Boat Slip and for the Old Marina Area, the remedial action alternatives are based on different dredge depths to address individual sediment locations that exceed sediment PRG for PCBs.

Similar to the Southern Area, sediment within the two boat slips and Old Marina Area is not nearly as impacted with PCBs as is sediment within the Northwest Corner Area. Only approximately 2 percent of the PCB mass within OU-2 sediment is in the boat slips and Old Marina Area combined.

Sediment is naturally accumulating in both the two boat slips and in the Old Marina Area. The RI Report for OU-2 (Earth Tech, 2000) reports a sedimentation rate of approximately 1 to 2 inches per year in the North Boat Slip. A similar range of sedimentation rates was measured by AR in the Northwest Corner Area and in the Southern Area as part of the 2004 supplemental investigation (Parsons, 2005a/b). Groundwater within OU-1 will be contained by a sealed shoreline bulkhead as part of the OU-1 remedy which will shut off any lateral movement of groundwater from OU-1 to the Southern Area of OU-2. As a result, future effects of groundwater from OU-1 on sediment quality within the Southern Area should not be a concern.

The evaluation of remedial action alternatives for the two boat slips and for the Old Marina Area is presented in Table 8.1 where the NYSDEC evaluation criteria are assessed separately for each individual alternative. The evaluation of remedial action alternatives for the two boat slips and for the Old Marina Area is summarized below.

8.1 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT (A THRESHOLD CRITERIA)

Consistent with the Northwest Corner Area and with the Southern Area, evaluating the degree to which sediment exceeding PRGs would no longer be in contact with fish and other forms of aquatic life is the primary factor for determining whether an alternative can meet the threshold criteria called protection of human health and the environment and also meet the remedial action objectives for OU-2 presented in Section 1.7.

Application of USEPA's 2005 ESB methodology to the acid volatile sulfides, simultaneously extracted metals, and total organic carbon site data collected in the Fall 2004 and Fall 2005 indicate that metals are not bioavailable or toxic at copper concentrations ranging up to at least 982 ppm in OU-2 sediments where OU-2 data show the highest concentrations of metals (see Appendix C). This information has been assessed in combination with previous sediment concentration and site toxicity investigation work at OU-2 to further demonstrate that 982 ppm is an appropriate and conservative preliminary remediation goal for copper in OU-2 sediment (see Appendix D). Moreover, this proposed PRG for copper and the corresponding proposed PRGs for lead, nickel and zinc are several orders of magnitude below the regulatory threshold of toxicity presented in the USEPA's 2005 ESB guidance.

8.1.1 Evaluation of Overall Protection of Human Health and the Environment Common to All Boat Slip and Old Marina Area Alternatives

Both of the remedial action alternatives for the North Boat Slip and the Old Marina Area would be protective of human health and the environment in the long term. Following dredging, direct exposures of fish and other local aquatic life to boat slip and Old Marina Area sediment that exceeds PRGs would be eliminated over the long term through capping. As a result, long-term impacts from OU-2 sediment associated with human health through fish consumption and sediment contact and long-term impacts associated with aquatic life would be eliminated.

Capping can effectively protect human health and the environment in the North Boat Slip and in the Old Marina Area over the long term for the reasons described in Section 2.2 and summarized in Sections 4.1 and 6.1. A protective cap has been employed successfully at many other sediment sites, because it can provide chemical isolation, erosion control, and habitat replacement. The protective cap could be monitored and maintained over the long term, and institutional controls can be implemented, such as an environmental easement, to assure the cap remains protective.

PCB concentrations in boat slip and Old Marina Area sediment are significantly lower than PCB concentrations in Northwest Corner Area sediment. Nonetheless, dredging by itself may not be protective of human health and the environment or meet PRGs throughout the North Boat Slip and the Old Marina Area, depending upon whether all of the sediment exceeding PRGs would be able to be removed based on post-dredging residuals that have been present at other dredging sites. Capping may or may not be needed to provide additional protectiveness and to meet PRGs. Sediment concentrations in the North Boat Slip and in the Old Marina Area exceed 1 ppm PCBs at scattered locations and depths as shown in Figure 1.3 and in Figure A.1 in Appendix A. For copper, none of the sediment concentrations in either boat slip or in the Old Marina Area exceed 982 ppm based on investigation results (see Figure 1.4).

Dredging and capping would disrupt the river bottom and the associated benthic community. However, by placing a top layer of a protective cap as presented in Section 2.2, benthic organisms are expected to recolonize the habitat surface layer of the cap (see Section 2.2) within 2 to 4 months during the biologically productive time of the year (i.e., April through November at this site) (Dernie, 2003). As most of the aquatic biota live within the top 3 to 6 inches of sediment, the lower erosion protection layer of the cap would prevent the biota from contacting contaminated sediment. Since OU-2 is known to accumulate sediment, the gradual natural deposition of native materials will also support restoration of local aquatic habitat following construction.

Monitoring of natural recovery within the South Boat Slip would also be protective of human health and the environment. In the South Boat Slip, the PRGs are met in all data for all parameters in the top eight feet. Further, the area weighted average concentrations are below the PRGs at all depths for all parameters. PCB concentrations are all below 1 ppm in the top 8 ft of sediment, with some values between 1 and 6 ppm at greater depths. The proposed copper PRG of 982 ppm has not been exceeded in any sediment sampled analyzed from the South Boat Slip for copper. Concentrations of lead, nickel and zinc in South Boat Slip sediment area also below their proposed PRGs based on equilibrium partitioning sediment benchmark analyses presented in Appendix C. As a result, remedial action objectives are being met in the South Boat Slip, and there is no exposure of aquatic biota to sediment exceeding PRGs. In addition, sediment within the South Boat Slip is accumulating naturally over time with less contaminated sediment and such infilling is expected to continue over the long term. Even if some erosion of the existing sediment were to take place due to an extreme storm event, exposure to sediment exceeding PRGs would in all likelihood not occur, because the top 8 ft of sediment would need to be eroded from the physically-secluded South Boat Slip in order for sediment PRGs to be exceeded. Furthermore, any groundwater from the southern portion of OU-1 is not as impacted as groundwater further north at OU-1 and this groundwater will no longer even reach OU-2 once the shoreline bulkhead is installed and sealed.

Monitoring would continue over the long term to ensure that the PRGs are maintained in surface sediment where aquatic organisms can be exposed to site contaminants. Institutional controls needed throughout OU-2 would further reduce the likelihood of contact with deep sediment that exceeds 1 ppm PCBs.

8.1.2 Comparative Evaluation of Overall Protection of Human Health and the Environment Among the Boat Slip and Old Marina Area Alternatives

Dredging would result in resuspension of sediment which would adversely impact river water quality in the short term, primarily within the area contained by the temporary silt curtain. Short-term impacts from resuspended sediment would be less adverse under Alternative OM-1 than under Alternative OM-2 based on a lower mass of PCBs being resuspended under Alternative OM-1 (see Table 8.2).

Similar to the Southern Area, the mass of contaminants resuspended due to dredging in the North Boat Slip or in the Old Marina Area would be much less than in the Northwest Corner Area, because the concentrations and masses of PCBs and metals are much lower than in the Northwest Corner Area. As shown in Table 8.2, masses of PCBs that could be resuspended into the water column for each of alternatives are much lower than for the Northwest Corner Area and estimated to be as follows based on AR's contaminant distribution model results: approximately 1 pound for Alternative NSlip-1/OM-1 and 11 pounds for Alternative NSlip-2/OM-2. Sediment resuspended due to dredging would not settle back into the sediment within a single tidal period based on column settling tests conducted on OU-2 sediment. Large amounts of debris that exist throughout the Old Marina Area soft sediment may results in disproportionately high amounts of sediment becoming resuspended while removing debris and obstructions. However, the North Boat Slip and the Old Marina Area are more physically secluded than the Northwest Corner Area or the Southern Area which should result in less sediment leaving the contained area than in the relatively open Northwest Corner Area or Southern Area. One goal while removing debris and obstructions and dredging would be to control sediment releases as practicable to meet a far-field point of water quality compliance guideline to be established by NYSDEC. The water quality point of compliance during dredging at other New York State PCB dredging sites has been a PCB water concentration of 2 micrograms per liter at a location one mile from dredging operations.

8.2 COMPLIANCE WITH STANDARDS, CRITERIA, AND GUIDELINES (A THRESHOLD CRITERIA)

Water quality standards, performance requirements, Village Code requirements, and other SCGs discussed in Section 4.2 for the Northwest Corner Area and in Section 6.2 for the Southern Area also apply to the boat slips and to the Old Marina Area. These various SCGs would be met while remediating sediment in the boat slips and in the Old Marina Area. State far-field water quality guidelines for PCBs while removing debris and obstructions and dredging would also be met to the extent practicable.

8.2.1 Evaluation of Compliance with Standards, Criteria and Guidelines Common to All Southern Area Alternatives

Over the long-term, each of these alternatives would meet the standards, criteria and guidelines to the extent practicable. All of the standards, criteria and guidelines could be met for any of the boat slip and Old Marina Area alternatives with the possible exception of short-term releases of PCBs to the water during dredging. Coordination with NYSDEC and USACE would be needed to determine acceptable extents of filling needed to help stabilize the shoreline bulkhead.

Due to tidal forces, river flow, and the conduit that releases water from Hastings Creek into the North Boat Slip, short-term releases of impacted water outside the North Boat Slip and Old Marina Area during dredging operations would be unavoidable as in the Northwest Corner Area and Southern Area. The likelihood of any short-term, far-field water quality exceedances would be lower from the North Boat Slip and from the Old Marina Area than from the Northwest Corner Area due to the much lower sediment PCB concentrations that exist in the North Boat Slip and in the Old Marina Area and also due to the North Boat Slip and the Old Marina Area being in more secluded locations.

The effects of residual contaminated sediment due to dredging and the necessity of maintaining a stabile shoreline bulkhead both result in the need for a berm in the boat slips and near the shoreline in the Old Marina Area. A protective cap may also be needed within and/or outside the berm area. Similar to the Northwest Corner Area and the Southern Area, placement of a berm - protective cap would mean dredge and fill requirements would need to be met based on Article 15 of the New York State Environmental Conservation Law (Use and Protection of Waters), Section 404 of the Federal Clean Water Act, and Section 10 of the Federal Rivers and Harbor Act. Based on these requirements, filling of nearshore aquatic locations would need to be shown to be reasonable and necessary to be approvable under Part 661 of Title 6 of the New York Code of Rules and Regulations particularly where water depths at low tide are less than

6 ft. Any movement inland of the shoreline along the South Boat Slip would also need to be approved by NYSDEC and by USACE. In lieu of placing a berm, remedial action alternatives for the Old Marina Area are based on retaining existing sediment along the south side of the Old Marina Area because of the relatively low levels of PCBs in marina sediment and due to the need to maintain stability of the shoreline bulkhead along the south side of the Northwest Corner Area.

None of the sediments that could be dredged from the North Boat Slip or from the Old Marina Area are believed to be regulated as hazardous under RCRA. TSCA requirements would not be applicable to sediment dredged from the North Boat Slip or from the Old Marina Area, because this sediment contains less than 50 ppm PCBs. Cleaner sediment containing less than 10 ppm PCBs could be contained (and reused) at OU-1 without being transported offsite. Subsurface soil can be retained at a site if its PCB concentration is 10 ppm or less based on NYSDEC's Technical and Administrative Guidance Memorandum 4046 (NYSDEC, 1994 and updated in 2001). Fill will be needed away from the shoreline area at OU-1 to raise the ground surface elevation in accordance with the federal consent decree. Most, if not all, of the sediment dredged from the North Boat Slip and from the Old Marina Area would likely contain less than 10 ppm PCBs based on available sediment sampling results. Site investigation results also show metal concentrations in OU-2 sediment do not result in porewater concentrations above state water quality standards, so metals from OU-2 sediment should not be mobile to an extent that would result in an adverse impact.

NYSDEC, as part of its solid waste management regulations under Part 360 in Title 6 of the New York Code of Rules and Regulations, allows for specific beneficial use determinations for material (in this case, sediment) that would otherwise be taken offsite. Such a beneficial use determination could be obtained from NYSDEC under the procedures in Section 1.15 of Part 360. Beneficial use of dredged material as fill on land has been granted by NYSDEC at other locations.

8.2.2 Comparative Evaluation of Compliance with Standards, Criteria and Guidelines Among Boat Slip and Old Marina Area Alternatives

Remedial action alternatives for the boat slips and for the Old Marina Area could meet dredge and fill requirements. Short-term, far-field water quality guidelines would be more likely met for Alternative NSlip-1/OM-1 than for Alternatives NSlip-2/OM-2 which would include larger amounts of dredging. Other standards, criteria and guidelines, such as sediment management and Village Code requirements, could be met under each of the alternatives.

Monitoring of natural recovery in the South Boat Slip would also comply with standards, criteria and guidelines. Accessible surface sediment already meets PRGs based on available sampling results.

8.3 SHORT-TERM EFFECTIVENESS

8.3.1 Evaluation of Short-Term Effectiveness Common to All Boat Slip and Old Marina Area Alternatives

As presented in Section 4 for the Northwest Corner Area and in Section 6 for the Southern Area, short-term impacts include effects on water quality during dredging operations, short-term effects of remediation activities on local residents and businesses outside OU-1 and OU-2, and worker risks. These short-term impacts are also applicable to the North Boat Slip and to the Old Marina Area. Short-term effects on water quality outside the area contained by a temporary silt curtain cannot be accurately predicted at this time. A lower quantity and a lower percentage of PCBs would be resuspended with sediment in the North Boat Slip and Old Marina Area than at the Northwest Corner Area due to lower sediment PCB concentrations and due to less debris. However, as described in Section 2.1, some sediment suspended due to removing debris and obstructions, dredging and other remedial activities would migrate around the silt curtain and away from the North Boat Slip and the Old Marina Area. These short-term effects on water quality would be monitored and controlled to the extent practicable.

Short-term effects of noise and other short-term effects of construction on local residents and businesses outside OU-1 would be controlled in accordance with Village Code requirements summarized in Section 4.3.

Worker risks would be controlled to the extent practicable through thorough health and safety planning and safe work practices. AR's safety program would be strictly followed to control these risks to the extent practicable.

Wick drains (or other consolidation devices) would likely not be needed in the North Boat Slip (see Appendix B). Consolidation devices would also not be needed in the Old Marina Area, because the berm within the Old Marina Area is existing sediment. Dredging this area would reduce the load on the underlying soils and would not trigger additional consolidation of these soils.

8.3.2 Comparative Evaluation of Short-Term Effectiveness Among Boat Slip and Old Marina Area Alternatives

Alternatives that include less dredging would result in less short-term disruption of the existing river habitat both in area of the river affected and in duration of the impact. Alternative Slip/OM-1 would, in addition to less short-term river habitat disruption, result in less sediment being resuspended into the river water column, less adverse and shorter duration adverse impacts on river water quality outside the temporary silt curtain, less adverse effects of noise and other construction impacts on the Village, and less worker risk than would Alternatives NSlip-2/OM-2.

Table 8.2 presents a quantitative comparison of the short-term release of PCBs anticipated due to resuspension of sediment from removing debris and obstructions, dredging and related remedial activities associated with each of the North Boat Slip and Old Marina alternatives. As shown in Table 8.2, resuspension of contaminated sediment into the water column and residual sediment concentrations after dredging (and prior to capping) would be slightly less with Alternative OM-1 than under Alternative OM-2.

The short term impact of the remedy includes any injuries that workers may suffer while implementing the remedy. Appendix F describes the methodology used to evaluate the risk of injuries to workers on site, and to workers that transport materials on and off site. Based on the rates of injury reported for similar projects and types of work (not necessarily related to site remediation work), the estimated risks of an on-site worker fatality would range from 1 in 278 for Alternative NSlip-1 to 1 in 59 for Alternative NSlip-2. For the Old Marina Area, the estimated risks of an on-site worker fatality range from 1 in 90 for Alternative OM-1 to 1 in 43 for Alternative OM-2 (see Table 8.3). For Alternative OM-2, this means that if the remedy was performed 43 times, it is likely there would be one fatal accident on site. Put another way, there is a 2.3 percent risk of at least one fatal on-site accident if OM-2 is chosen as a remedy. The risks of at least one fatal injury on site are lower for the other dredging options, but still are approximately 1 percent for Alternative OM-1 to 0.4 percent for Alternative NSlip-1. Most of this risk is associated with a high rate of reported injuries at barge dredging projects, where most fatal injuries are suffered by persons working on the barge (see App. F-6).

The risk of at least one fatal accident during transportation on or off site is approximately 1 percent. The methodology for estimating these risks is also presented in Appendix F, and is based on reported injury rates for similar projects and types of work.

AR will only undertake remedial action where it can develop a way to perform the work safely, without significant injury or fatalities. The combined risks of on-site and off-site worker injury for in the North Boat Slip and in the Old Marina are high in comparison to the risks that the work is designed to prevent (primarily exposure to low level PCBs where the area-weighted average already meets the 1 ppm PRG), indicating that the impact of worker injuries during dredging may exceed the potential long term benefits of dredging.

AR would seek to control all worker injury risks through health and safety planning and safe work practice. AR's safety management program would be strictly followed. However, the combined risk of injury from remediation work at all areas of OU-2 should be considered when selecting alternatives, and the risk of a fatal injury rises with the size of the area to be dredged, as well as the depth of dredging. The cumulative short term impact of all dredging alternatives must be considered and weighed against the benefits that dredging might achieve. Worker risks will be evaluated in more detail during remedial design, and remedial alternatives may need to be modified to ensure that the work can be performed safely.

The time needed to cut timber piles, remove debris, and dredge would vary from approximately 3 to 4 months under Alternative NSlip-1/OM-1 to approximately 5 to 6 months under Alternative NSlip-2/OM-2, assuming both the North Boat Slip and the Old Marina Area could be remediated in sequence (see Section 7 and Table 8.2). Placement of the berm and capping would require approximately 1 to 2 months following dredging for any of the boat slip and Old Marina Area alternatives. Along with 3 to 4 weeks to place the temporary silt curtain, the total remediation time for the boat slips and Old Marina Area is estimated to range from 5 to 6 months under Alternative NSlip-1/OM-1 to 7 to 9 months under Alternative NSlip-2/OM-2.

Under Alternative NSlip-1/OM-1, approximately 83 rail cars would enter OU-1 with soil for the berm and cap. Under Alternative Slip/OM-2, approximately two rail cars per day would leave OU-1 full of dredged sediment during the dredging timeframe, and approximately two rail cars per day would enter OU-1 with soil for the berm and cap. Under Alternatives NSlip-2/ OM-2, approximately three to four rails car per day would leave OU-1 during the 3 to 4-month dredging period full of dredged sediment and approximately four full rail cars per day would enter OU-1 with soil for the berm and cap.

Monitoring of natural recovery in the South Boat Slip would be effective in the short term. No adverse impacts to the environment, to workers, or to the community would arise due to implementing this alternative. In addition, there are no existing adverse environmental impacts in the South Boat Slip based on concentrations of PCBs and metals accessible to aquatic biota given sediment exceeding PRGs is at least 8 ft below the mudline. As a result, no time is needed for this alternative to achieve environmental protectiveness.

8.4 LONG-TERM EFFECTIVENESS AND PERMANENCE (A BALANCING CRITERIA)

8.4.1 Evaluation of Long-Term Effectiveness and Permanence Common to All Boat Slip and Old Marina Area Alternatives

Each of the North Boat Slip and Old Marina Area alternatives would be effective in the long term. USEPA (2005a) clarifies that sediment caps may provide acceptable levels of both short-term and long-term effectiveness and permanence and that there should not be a presumption that removal of contaminated sediments would necessarily be more effective or permanent than capping.

Conditions within the North Boat Slip and the Old Marina Area are suitable for capping. Capping would be protective with a properly-designed and properly-installed cap as described in Section 2.2 and in Section 4.4.1. Effective measures to maintain cap protectiveness are available as presented in Sections 2.2 and 4.4.1 as well. In addition, USEPA in their most recent guidance about contaminated sediment (2005b) reports that sediment caps can meet the long-term effectiveness and permanence criteria. The berm needed to help stabilize the shoreline would provide erosion protection that would otherwise be provided by a portion of the protective cap.

Dredging by itself may not be protective and effective for reasons presented in Section 4.4.1. Residual contaminated sediment would remain in the river following dredging. However, because sediment PCB concentrations are much lower in the North Boat Slip and in the Old Marina Area than in the Northwest Corner Area, residual sediment in the North Boat Slip and in the Old Marina Area following dredging may not contain PCB concentrations over 1 ppm. If residual PCB concentrations are less than 1 ppm, then at a minimum the chemical isolation portion of a protective cap would not be needed. However, a berm and habitat restoration layer may still be required for shoreline stability and habitat replacement reasons, respectively.

8.4.2 Comparative Evaluation of Long-Term Effectiveness and Permanence Among Boat Slip and Old Marina Area Alternatives

Without including resuspension of sediment during dredging, the AR's contaminant distribution modeling results provide estimates of the extent of PCB mass removable from the river as part of each remedial action alternative. Compared to Alternative NSlip/OM-1, additional PCB and copper removal under Alternative NSlip-2/OM-2 would be limited to approximately 1.8 percent and 20.7 percent, respectively.

Furthermore, the percentages of OU-2 PCB mass removed under any of the North Boat Slip/Old Marina Area alternatives would be very low compared to the Northwest Corner Area. PCB removal percentages for the North Boat Slip/OM alternatives range from 0.2 to 2.0 percent, compared to 61 percent of the PCBs removable under Alternative NW-1 (see Table 7.5). The PCB mass that would be removed per cubic yard of sediment dredged under these alternatives would range from approximately 0.01 to 0.03 pounds per cubic yard compared to 3.2 pounds per cubic yard under Alternative NW-1. Dredging efficiency in terms of pounds of PCBs removed per cubic yard of sediment would be at least 100 times higher for Alternative NW-1 than for any of the North Boat Slip/OM alternatives.

Sediment dredged from the river and residual solids generated from water treatment would be permanently removed offsite to a permitted, properly-contained facility, unless the sediment can be reused at OU-1 or offsite as fill material. Volumes of sediment to be dredged are presented in Table 7.2 and in Table 8.5.

Monitoring of natural recovery in the South Boat Slip would also be effective in the long-term. USEPA in their most recent guidance about contaminated sediment (2005b) reports that monitoring of natural recovery can meet the long-term effectiveness and permanence criteria. The top 8 ft of sediment in the South Boat Slip meets PRGs based on site investigation results. Erosion from a large storm event in the physically secluded South Boat Slip would not reduce effectiveness of permanence. Institutional controls that would be implemented for other areas within OU-2 would further ensure that contact with sediment below the top 8 ft would not occur. In addition, the sealed shoreline bulkhead being designed for OU-1 would prevent OU-1 groundwater from reaching OU-2 sediment.

In addition to burial by cleaner sediment, PCBs can also become less available to the environment slowly over many years through biotransformation, adsorption, and/or chemical modification. The relative importance of these mechanisms in reducing PCB levels in Hudson River sediment is not able to be estimated based on available data. Multiple processes may be ongoing at any given time and location within the river that could make PCBs less available to the river sediment.

8.5 REDUCTION OF TOXICITY, MOBILITY, AND VOLUME THROUGH TREATMENT (A BALANCING CRITERIA)

8.5.1 Evaluation of Reduction of Toxicity, Mobility, and Volume Through Treatment Common to Boat Slip and Old Marina Area Alternatives

Consistent with the Northwest Corner Area and Southern Area, water drained and/or dewatered from sediment would either be treated onsite to meet state discharge requirements, prior to releasing the treated water back to the river, or the water would be treated offsite.

8.5.2 Comparative Evaluation of Reduction of Toxicity, Mobility and Volume Through Treatment Among Boat Slip and Old Marina Area Alternatives

The extent that toxicity, mobility and volume would be reduced through treatment does not differ significantly for the North Boat Slip and Old Marina Area alternatives. More water would be treated as part of alternatives that include higher volumes of sediment to dredge, however the mass of PCBs and metals that would be treated in water would be a small portion of an already low percentage of OU-2 PCBs and metals that are present within North Boat Slip and Old Marina Area sediment.

For the South Boat Slip, no natural treatment would be evident except whatever natural dechlorination of PCBs to less toxic PCB compounds would take place within the sediment. No significant reduction in toxicity, mobility and volume would take place, but the existing sediment in contact with aquatic organisms meets PRGs. Some natural treatment of PCBs in sediment has been shown to take place as described in the most recent USEPA guidance on contaminated sediment. Natural reductions of PCBs in sediment are limited for the highly chlorinated PCBs present in OU-2 sediment unless natural conditions without oxygen are present for to naturally degrade site PCBs to a less chlorinated PCB (USEPA, 2005b).

8.6 IMPLEMENTABILITY (A BALANCING CRITERIA)

8.6.1 Evaluation of Implementability Common to All Boat Slip and Old Marina Area Alternatives

Dredging is provided as part of each remedial action alternatives for the North Boat Slip and the Old Marina Area. Dredging would remove contaminated sediment, provide water depth in shallow water nearshore for a berm needed to support the shoreline bulkhead, and provide water depth for a protective cap. Without some dredging, the berm and protective cap together would result in loss of some water depth.

Each of the remedial action steps outlined in Table 8.1 to implement the remedial action alternatives for the North Boat Slip and for the Old Marina Area would by themselves be able to be effectively completed. Geophysical investigations did not show an abundance of debris in the North Boat Slip, although approximately six subsurface magnetic anomalies were identified on the outskirts of the North Boat Slip. As shown in Figure 3.1, debris exists within sediment throughout the Old Marina Area. A sunken barge within the Old Marina Area would need to be removed as well (Parsons, 2005a/b). Removing debris and obstructions would be needed prior to and perhaps continuing throughout the dredging effort depending on the extent of debris vertically below the mudline. Separate barges in the river and separate processing area at OU-1 would likely be needed to handle the debris.

A temporary silt curtain would be implementable as part of the North Boat Slip and Old Marina Area alternatives, however keeping the silt curtain securely in place during storm events may be difficult. For extreme weather events, the curtain may need to be rolled up until the storm passes which would temporarily require removal of debris and obstructions and dredging to be stopped.

Small barges would be able to maneuver inside the North Boat Slip and inside the Old Marina Area. As indicated for the Northwest Corner Area and Southern Area alternatives, an initial assessment indicates sufficient space is available at OU-1 to unload and process debris and sediment dredged from OU-2. Debris and sediment could be stockpiled and processed at OU-1 away from the shoreline.

A 48-inch diameter conduit pipe to the river is in place in northern one third of the North Boat Slip. Placement of the shoreline bulkhead and dredging efforts in the North Boat Slip will need to account for discharges that continuously pass through this pipe to the river. Handling of water flowing from this conduit pipe during OU-2 remediation efforts is not believed to be a significant challenge or result in adverse impacts but the presence of the pipe and its outflows would need to be included in the remedial design.

A berm-cap is implementable based on success observed placing caps at other sites and based on shear strength available within site sediment. Berms and caps have been successfully placed at other sites (see Section 2.2.7). The maximum allowable final slope for a berm-cap would be determined during remedial design.

Institutional controls for monitoring of natural recovery and for capping would be the same as for the Northwest Corner Area and the Southern Area likely focusing on the State of New York acquiring one or more environmental easements. One purpose of these controls would be to further prevent contact with deeper sediment that exceeds PRGs (see Section 2.2.8). Items that would further protect a cap, such as boat anchoring restrictions and use of floating docks, can be included in an environmental easement. Pursuant to New York State law, enforcement of easement requirements would be at the discretion of NYSDEC. Institutional controls, such as an environmental easement, are available and can be implemented for both boat slips and for the Old Marina Area.

8.6.2 Comparative Evaluation of Implementability Among Boat Slip and Old Marina Area Alternatives

For the North Boat Slip, additional dredging as part of Alternative NSlip-2 beyond the dredging included in Alternative NSlip-1 could slow the pace of finalizing redevelopment of OU-1. More dredging in the North Boat Slip could add at least 2 months to complete the OU-2 remedy which could, in turn, add time to complete the OU-1 remedy to the extent the OU-2 remedy cannot be completed independent of the OU-1 remedy. For the Old Marina Area, additional dredging would less likely to extend the OU-1 remedy schedule, because placing additional berm material after dredging is not part of any of the remedial action alternatives for the Old Marina Area. Less dredging near the shoreline is evaluated for the Old Marina Area based on the relatively low concentrations of PCBs and metals in Old Marina Area sediment and based also on the need for a shoreline berm in the marina to ensure the long term stability of the shoreline.

Administratively, each of the North Boat Slip and Old Marina Area alternatives is implementable.

The extent of berm and cap to be placed in the North Boat Slip is presented in Table 8.4 based on the shoreline OU-1 grade being set at +4 ft and sloping up to +9 ft at 100 to 120 ft inland. The extent of berm and cap presented in Table 8.4 incorporates measures to reduce berm volume in the river, such as use of tieback anchors, and use of lightweight fill within 100 to 120 ft of the shoreline at OU-1 to the extent practicable. The berm required to provide shoreline stability in the North Boat Slip area is considerably less than for the Southern Area. The top elevation of the berm ranges from approximately eight to ten feet below the current mudline elevation.

Monitoring of natural recovery in the South Boat Slip is implementable and site conditions show this alternative would be reliable. This alternative would be easy to implement and the monitoring technologies that are needed are readily available. This alternative would also not have an effect on implementing the OU-1 remedy.

8.7 COSTS (A BALANCING CRITERIA)

A cost estimate has been prepared for each remedial action alternative for the North Boat Slip and for the Old Marina Area consistent with the cost estimates presented for the Northwest Corner Area and for the Southern Area and in accordance with USEPA guidance (USEPA, 2000a). The cost evaluation assesses estimated capital, annual operation and maintenance (O&M), periodic costs, and total net present value.

In addition to development of an estimated cost, alternatives are evaluated on the basis of cost-effectiveness under the comparative evaluation of alternatives. Part 375 (Subpart 1.10(c) (6) in Title 6 of the New York Code of Rules and Regulations, CERCLA Section 121, and the National Contingency Plan require that the selected remedy must be cost-effective. Overall effectiveness of a remedial alternative is determined by evaluating the following three of the five balancing criteria: long-term effectiveness and permanence; reduction in toxicity, mobility, and volume through treatment; and short-term effectiveness. Overall effectiveness is then compared to cost to determine whether the remedy is cost effective. In cases where several remedies offer the same degree of protection to human health and the environment, cost effectiveness principles would require the decision-maker to choose the least expensive of the remedial options.

Alternative	Estimated Capital Cost ($)	Estimated Annual O&M Cost ($)	Estimated Net Present Worth ($)
NSlip-1	$3.7 Million	$100,000	$4.8 Million
NSlip-2	$12.0 Million	$100,000	$13.1 Million
OM-1	$8.2 Million	$100,000	$9.3 Million
OM-2	$15.2 Million	$100,000	$16.3 Million

Capital costs are comprised of variable (also called non-fixed) costs and fixed costs. Variable costs are costs that vary from one alternative to another, such as costs for providing temporary containment, dredging, material management, and capping. Fixed costs are costs that do not vary from one alternative to another, such as costs for permitting and construction setup. Fixed costs have been apportioned equally amongst the areas of OU-2 since the sequence of construction among the OU-2 areas has not yet been established. Appendix E provides specific basis and compilations for the costs estimates for each remedial action alternative.

AR's contaminant distribution modeling results provide estimates of the PCB mass removable as part of each remedial alternative. Because so little PCB mass is found in these areas, the amount of mass removed under the alternatives is almost identical, and the cost of removal is high, ranging would range from approximately $260,000 to $460,000 per pound in North Boat Slip and Old Marina Area. When compared to the approximately $1,400 per pound cost for removing PCBs in Northwest Corner sediment under Alternative NW-1, none of the removal alternatives are a cost effective remedy for PCBs, and none would remove any metals above the proposed PRGs.

Both the containment and the removal remedies would achieve the same end result, which is to prevent exposure to contaminated sediments. Based on those factors, capping is the only cost effective remedy for these areas. However, it is not clear that the cap proposed under Alternative OM-1 is consistent with planned future marina uses. Further discussion with the marina owner may result in the development of a third alternative for NYSDEC's review.

8.8 EVALUATION SUMMARY FOR THE BOAT SLIPS AND FOR THE OLD MARINA AREA

Each of the three remedial action alternatives for the two boat slips and for the Old Marina Area is protective of human health and the environment and in compliance with standards, criteria, and guidelines. Capping would be protective on the basis of the protective cap presented in Section 2.2 and the evaluation of capping presented in Sections 4 and 6. Capping would meet the OU-2 remedial action objectives by providing a protective cap to eliminate exposure of fish, other aquatic life, and humans to sediment exceeding PRGs. Dredging could also be provided as a practicable measure to remove a small portion of contaminant mass and, at the same time, provide additional depth in shallow water area nearshore.

Dredging in the North Boat Slip and in the Old Marina Area, however, has its drawbacks as it does for the Northwest Corner Area and the Southern Area. The extent of debris and the silty, fine-grained nature of OU-2 sediment would result in contaminated sediment becoming suspended in the water both while the debris is being removed and while dredging. The temporary silt curtain would help control the spread of resuspended sediment away from OU-2, but this temporary silt curtain would not be 100 percent effective. Water quality would decline in the short term while removing debris and obstructions and while dredging, because resuspended sediment would not be able to settle completely before the next dredging shift or tidal cycle is underway. Practicable attempts would be made to meet far-field water quality guidelines away from OU-2, but meeting such guidelines may not be possible.

Monitoring of natural recovery meets the OU-2 remedial action objectives presented in Section 1.4 and is the appropriate remedy for the South Boat Slip, because the area is accumulating sediments naturally and the PRGs are already being met throughout the top 8 feet of sediment. Even among sediments located more deeply than eight feet, the PRGs are being met on an area weighted average basis. The South Boat Slip is hydraulically isolated, so natural events will in all likelihood not occur that would expose even the slightly contaminated underlying sediments.

Alternative NSlip-1/OM-1 would result in less of an adverse effect on water quality during construction due to lower quantities of PCBs becoming resuspended from sediment into the river. Alternative NSlip-1/OM-1 would also result in less of an adverse effect of construction noise and other aspects of construction on the Village and lower worker risk than would Alternative NSlip-2/OM-2. Alternative NSlip-1 would also be able to be completed independent of the remedial action for OU-1, while Alternative NSlip-2 would need to be completed in conjunction with the remedy for OU-1 which could delay OU-1 redevelopment. These benefits of Alternative NSlip-1/OM-1 are together more significant than the 2 percent of additional PCB mass that would be removed under Alternative NSlip-2/OM-2 (see Table 8.5). This is not to say additional dredging in the Old Marina Area could not be conducted for purposes promoting future use of the marina, but based on impacts and the other NYSDEC criteria evaluated herein, additional dredging is not warranted. Any additional dredging in the Old Marina Area would be limited near the health and tennis club buildings unless the buildings could be kept structurally stabile while dredging near the buildings would be ongoing.

PCB mass that could be removed per cubic yard of sediment dredged would be less than 0.01 to at most 0.03 pounds per cubic yard in the North Boat Slip or Old Marina compared to approximately 3.3 pounds per cubic yard under Alternative NW-1 (see Tables 4.5 and 8.5). Similarly, the dollars spent per pound of PCBs removed would be approximately $260,000 to $280,000 per pound of PCBs removed in North Boat Slip sediment and approximately $390,000 to $460,000 per pound of PCBs removed in Old Marina Area sediment compared to $1,400 for Alternative NW-1. Efficiency of PCB removal in dollars spent per pound of PCBs would therefore be 20 to over 200 times higher for Alternative NW-1 than for any of the North Boat Slip or Old Marina Area alternatives. No copper above the proposed PRG of 982 ppm has been measured in any of the sediment samples collected from the boat slips or from the Old Marina.

Given all of these evaluation factors, Alternative NSlip-1/OM-1 is recommended for the boat slips and for the Old Marina Area. Alternative NSlip-1/OM-1 would be protective of human health and the environment and meet OU-2 remedial action objectives by providing some dredging and additional water depth nearshore for aquatic habitat prior to capping. In fact, if a protective cap could be placed by itself in the North Boat Slip and/or in the Old Marina without dredging and without significant overall loss of water depth, then such a protective cap without any dredging would be equally protective of human health and the environment, compliant with standards-criteria-guidelines, effective, and implementable and therefore should be implemented. Additional dredging as evaluated under Alternative NSlip-2/OM-2 would not provide additional environmental protection. Additional dredging would remove only a very small additional fraction of PCBs from the environment, and in comparison to other alternatives, additional dredging would release more contaminated sediment into the river through resuspension during dredging, carry greater risks of worker injury, and pose more engineering and construction challenges in an already challenging river work environment.

TABLE 8.1

ALTERNATIVES EVALUATION SUMMARY FOR THE TWO BOAT SLIPS AND FOR THE OLD MARINA HARBOR AT HASTINGS OU-2

	Alternatives NSlip-1/OM-1 Dredge Up to 2 ft and Place Protective Cap	Alternatives NSlip-2/OM-2 Dredge to Limit of Bulkhead Stability	Alternative SSlip-1 Monitor Natural Recovery
Summary description (and possible construction sequence)	▪ Install the bulkhead along the existing OU-1 shoreline in the North Boat Slip area and along the OU-1 shoreline on the south side of the Old Marina area. ▪ Excavate OU-1 upland (to elevation 0 upland of the North Boat Slip, 9 ft below existing ground surface south of the Old Marina) and backfill to elevation +4 ft (final grade within 100 to 120 ft of the wall) with lightweight fill. Install bulkhead wall anchorage system during backfill operations. The bulkhead must remain unsealed and surcharge prohibited until after OU-2 work is complete. ▪ Install temporary silt curtain around the North Boat Slip if the southern area silt curtain is not in place. Install silt curtain around the north and west sides of the Old Marina where the mudline elevation is -15 ft. ▪ Cut timber piles, remove large debris (such as the sunken barge in the Old Marina) and dredge up to 2 ft of sediment where sediment exceeds PRGs. ▪ Remove the temporary silt curtain. ▪ Place integrated berm-cap as needed in North Boat Slip area. Where the southwest corner of the Old Marina Area interfaces with the Northwest Corner, the dredge depth would be deeper and a support berm-cap would be coordinated with the Northwest Corner Area alternative. • Drain-dewater dredged sediment on site. Treat water that is generated. ▪ Reuse dredged sediment at OU-1 or transport	▪ Install shoreline bulkhead, excavate and backfill OU-1 upland and install bulkhead wall anchorage as discussed for Alternative NSlip-1/OM-1. ▪ Install temporary silt curtain as discussed for Alternative NSlip-1/OM-1. ▪ Cut timber piles and remove large debris in dredge areas. ▪ Dredge where sediment exceeds PRGs to the limit of bulkhead stability. Dredge cut limits along the shoreline in the North Boat Slip would depend on stability constraints. The analysis herein is based on a shoreline dredge cut to elevation -9 ft at the bulkhead wall and sloping down away from shore. The dredge slope in the Old Marina would vary with location along the bulkhead wall because the design of the wall would vary. Also deep dredging adjacent to the shoreline was not evaluated due to the low quantify of PCBs in the sediment and the problems with dredging nearshore noted for the Northwest Corner Area alternative NW-2. ▪ In the North Boat Slip, the berm would be at elevation -6 ft. at the bulkhead and slope down to elevation -10 ft. and would then continue westward at elevation -10 over the entire dredged area. Berm thickness in this area would be 4 ft. In the Old Marina Area, the dredge slopes would be capped as needed. A berm-cap would be coordinated with the Northwest Corner Area alternative. ▪ Remove the temporary silt curtain.	▪ Monitor surface sediment conditions regularly as needed to confirm the impact from former Anaconda Wire and Cable operations on offshore sediment remains minimal as ongoing natural sediment deposition continues.

TABLE 8.1, Continued

ALTERNATIVES EVALUATION SUMMARY FOR THE TWO BOAT SLIPS AND FOR THE OLD MARINA HARBOR AT HASTINGS OU-2

	Alternatives NSlip-1/OM-1 **Dredge Up to 2 ft and Place Protective Cap**	**Alternatives NSlip-2/OM-2** **Dredge to Limit of Bulkhead Stability**	**Alternative SSlip-1** **Monitor Natural Recovery**
	dredged and drained-dewatered sediment offsite and place at permanent containment facility.	• Drain-dewater dredged sediment on site. Treat water that is generated. • Reuse dredged sediment at OU-1 or transport dredged and drained-dewatered sediment offsite and place at permanent containment facility.	
Protection of Human Health and the Environment (overall protection achieved over time by meeting PRGs thereby controlling site risks)	Alternative NSlip-1/OM-1 would be protective. A protective cap and naturally depositing sediment after dredging would: (a) eliminate risk to human consumption of fish and shellfish due to the site; (b) eliminate exposure to site contaminants and replace current aquatic habitat; and (c) minimize potential for long-term erosion or resuspension of sediment. • Short-term river habitat disruption would not be significant. Sediment biota would recover within 2 to 4 months from April through November. • Dredging most likely would not reduce long-term risk or provide additional long-term protection of human health or the environment. • Adverse, short-term resuspension of contaminated sediment during debris removal and dredging would take place over approximately 3 months. Resuspended mass would be less than 1 percent of the PCB mass so a protective cap may not be needed to address chemical isolation.	Same as Alternative NSlip-1/OM 1 except: • Greatest adverse short-term impacts to water quality due to resuspension of sediment during additional time for debris removal and dredging compared to Alternative NSlip-1/OM-1 with no improvement in long-term effectiveness.	• Remedial action objectives are being met in the South Boat Slip, and there is no exposure of aquatic biota to sediment exceeding PRGs. In addition, sediment within the South Boat Slip is accumulating naturally over time with less contaminated sediment and such infilling is expected to continue over the long term. • The top 8 ft of sediment meets PRGs and is therefore not adversely affected by site PCBs or metals. • Any groundwater effects from OU-1 must be minimal based on measured sediment concentrations and will be further abated once the sealed shoreline bulkhead is installed.

TABLE 8.1, Continued

ALTERNATIVES EVALUATION SUMMARY FOR THE TWO BOAT SLIPS AND FOR THE OLD MARINA HARBOR AT HASTINGS OU-2

	Alternatives NSlip-1/OM-1 Dredge Up to 2 ft and Place Protective Cap	Alternatives NSlip-2/OM-2 Dredge to Limit of Bulkhead Stability	Alternative SSlip-1 Monitor Natural Recovery
Compliance with NY State SCGs (standards, criteria and guidelines)	• Alternative NSlip-1/OM-1 would comply with site remedial goals and with SCGs in the long-term due to the effectiveness of capping. Dredging would not have any effect on compliance with SCGs. • During remedy implementation, there may be short-term, far-field exceedances of surface water SCGs in the river due to sediment resuspended during debris removal and dredging. These exceedances are expected to be limited in duration to the time when debris removal and dredging are ongoing and limited also by silt curtains installed to reduce resuspension losses. • 6 NYCRR Part 608 requirements, federal Rivers and Harbors Act, and federal Clean Water Act 404(b) (1) guidelines associated with filling within a water body would need to be met. • Coastal zone management requirements should not affect OU-2 remedial efforts	Compliance with SCGs would be the same as for Alternative NSlip-1/OM-1 except: • Short-term exceedances of far-field surface water SCGs would be the most likely of any of the SA alternatives and would last a few months longer than for Alternatives NSlip-1/OM-1 due to more extensive debris removal and dredging.	• Monitoring of natural recovery in the South Boat Slip would comply with SCGs.
Short-term Effectiveness (protection of community and workers, environmental impacts and time to achieve protection)	▪ Sediment resuspended due to debris removal and dredging would accumulate over multiple days throughout the water column inside the silt curtain, because needed settling time (45 hours from column settling tests) would exceed the settling time available between daily dredge shifts. PCB and metal concentrations resuspended in the water column after multiple consecutive days of dredging are affected by many variables and can not be predicted with any certainty. The silt curtain would reduce	Same as for Alternative BS/OM-1 except: ▪ Alternative NSlip-2/OM-2 would have the greatest short-term impact due to sediment resuspension and release because of more debris being removed, more sediment being dredged, and a longer river work effort. • Worker risk would be 4 times higher compared to Alternative NSlip-1/OM-1 (see Table 8.3). ▪ Safety of dredging and risk of shoreline instability adjacent to the shoreline	▪ No short term effects are anticipated. ▪ No time is needed for this alternative to become protective because the South Boat Slip is meeting remedial action objectives as is.

TABLE 8.1, Continued

ALTERNATIVES EVALUATION SUMMARY FOR THE TWO BOAT SLIPS AND FOR THE OLD MARINA HARBOR AT HASTINGS OU-2

	Alternatives NSlip-1/OM-1 **Dredge Up to 2 ft and Place Protective Cap**	**Alternatives NSlip-2/OM-2** **Dredge to Limit of Bulkhead Stability**	**Alternative SSlip-1** **Monitor Natural Recovery**
	resuspension impacts outside the North Boat Slip, but some sediment would escape due to site conditions such as the 4-ft tidal range, permitted public discharges, and also due to normal operations. Best practical attempts would be made to meet far-field river water quality goals. ▪ Worker risk would be 0.01 or a chance of a fatality of 1 in 100 projects (approximately the same occupational risk as for Alternative NW-1). See Appendix F. ▪ Intermittent noise could be noticeable while hammers are used to place the shoreline bulkhead along the edge of the boat slips. The Village Code would be followed so noise would not be evident outside of work hours included in the ordinance. ▪ Odors from sediment should not be noticeable based on experience at other dredging sites. ▪ Dredged sediment that could not be reused at OU-1 would leave the site up to approximately 89 full rail cars or 450 fully-loaded trucks over a 3 to 4-month dredging period.	bulkhead would be more problematic than for the other Slip/Marina alternatives due to a greater depth and duration of dredging. ▪ Due to the extent of debris removal and dredging, river work (and resuspension of sediment) would extend a few more months. ▪ Dredged sediment that could not be reused at OU-1 would leave the site up to approximately 230 full rail cars or 1,150 fully-loaded trucks over an estimated 6 to 7-month period. More barge traffic to and from OU-1 and mooring locations offsite would also be required.	
Long-term effectiveness and permanence (quantity and characteristics of residuals remaining after remediation, reliability of long-term controls)	▪ Covering residual contamination with a berm, a cap and with naturally-depositing sediment would provide reliable long-term protection against erosion from wind-waves and against erosion from ice scour (see Section 2.2). Protectiveness would be ensured with cap monitoring and maintenance. ▪ Long-term monitoring of capping is proven from work at other sites. ▪ Dredging alone would most likely not achieve sediment PRGs due to post-dredging residual	▪ No significant additional long-term effectiveness would be provided compared to Alternative NSlip-1/OM-1. Residuals exposed to the local environment would be the same as under Alternative NSlip-1/OM-1.	▪ Long-term effects are expected to continue to be beneficial due to naturally occurring deposition. ▪ Institutional controls implemented as part of the remedy for other areas within OU-2 would further ensure that contact with sediment below the top 8 ft would not occur.

TABLE 8.1, Continued

ALTERNATIVES EVALUATION SUMMARY FOR THE TWO BOAT SLIPS AND FOR THE OLD MARINA HARBOR AT HASTINGS OU-2

	Alternatives NSlip-1/OM-1 Dredge Up to 2 ft and Place Protective Cap	Alternatives NSlip-2/OM-2 Dredge to Limit of Bulkhead Stability	Alternative SSlip-1 Monitor Natural Recovery
	contamination (see Section 2.1.1). ▪ Institutional controls such as environmental easements have some precedence and should be effective. ▪ Dredging in the North Boat Slip and Old Marina would be much less effective than in the Northwest Corner based on the low mass of PCBs and copper that would be removed. No copper has been measured above 982 ppm in boat slip or Old Marina sediment. ▪ The temporary silt curtain would be effective and implementable as presented, but also hindered by the small silty size of sediment particulates, river currents, effluent from permitted public discharges, and tidal fluctuations (see Section 2.1.3.1).		
Reduction of toxicity, mobility and volume through treatment (treatment technologies used, degree or reduction of toxicity, mobility and volume, permanence of treatment, residuals remaining on site)	▪ Water separated from dredged material would be permanently treated to meet State discharge limits and thereby reduce mass of PCBs and metals in the return water.	▪ Same as for Alternative NSlip-1/OM-1.	▪ Only limited natural treatment would take place.

TABLE 8.1, Continued

ALTERNATIVES EVALUATION SUMMARY FOR THE TWO BOAT SLIPS AND FOR THE OLD MARINA HARBOR AT HASTINGS OU-2

	Alternatives NSlip-1/OM-1 **Dredge Up to 2 ft and Place Protective Cap**	**Alternatives NSlip-2/OM-2** **Dredge to Limit of Bulkhead Stability**	**Alternative SSlip-1** **Monitor Natural Recovery**
Implementability (technical feasibility, administrative feasibility and availability of resources)	This alternative is feasible to implement. ▪ Dredging would not be as difficult as for Alternative NSlip-2/OM-2 due to shallower dredge cuts and smaller volumes of sediment to dredge. ▪ The temporary silt curtain would be effective and implementable but also limited by the small silty size of sediment particulates, river currents, permitted public discharges, and tidal fluctuations (see Section 2.1.3.1). ▪ Dredging in debris areas would be implementable but difficult. ▪ Sediment shear strength needed for cap placement is available (see Section 2.2.7). ▪ Caps have been successfully placed at other sites. ▪ Needed resources and work space would likely be available at OU-1. ▪ Administrative feasibility for this alternative is considered to be routine as long as the long-term mudline elevation in the river would not change significantly and environmental easements are not complex to implement. ▪ Dredged sediment would likely be able to be reused as fill at OU-1.	Same as Alternative NSlip-1/OM-1 except: ▪ Dredging would be more difficult than for Alternative NSlip-1/OM-1 due to deeper dredge cuts. ▪ Any delay of the OU-1 remedial action due to coordination with the OU-2 remedial action could delay onshore redevelopment by a minimum of 2 to 3 years.	▪ Readily implementable and measureable using available monitoring technologies.
Costs (capital, annual, and present worth costs. Capital = construction, non-construction, and contingency)	Capital: $ 3.7 million and $8.2 million Long-Term Annual: $100,000 Present Worth: $ 4.8 million and $9.3 million	Capital: $ 12.0 million and $15.2 million Long-Term Annual: $100,000 Present Worth: $ 13.1 million and $16.3 million	Capital: $ 0 million Long-Term Annual: included with the remedy for other OU-2 areas Present Worth $0 million

TABLE 8.2

MASS OF PCBs IN DREDGED SEDIMENT FOR THE BOAT SLIP AND OLD MARINA AREA ALTERNATIVES

Alternative	Mass of PCBs Resuspended (total pounds)	Estimated Duration for Debris Removal and Dredging (months)	Estimated Average Sediment PCB Concentration In Dredged Sediment (ppm) (2)
NSlip-1	Less than 1	1 to 2	3.6
NSlip-2	Less than 1	2 to 3	2.5
OM-1	1	1 to 2	1.5
OM-2	10	3 to 4	1.6

(1) Based on 2 percent of the dredged sediment by weight becoming resuspended due to site conditions (see Section 2.1).

(2) Based on the volume weighted-average PCB concentration of dredged sediment, the mass of PCBs removed, and a sediment unit weight of 1 ton per cubic yard.

TABLE 8.3

SUMMARY OF SHORT-TERM WORKER RISK OF FATALITY FOR THE NORTH BOAT SLIP AND OLD MARINA AREA ALTERNATIVES

Remedial Action Alternative	Risk of Fatality for Site Workers	Risk of Fatality for Transportation Workers and Non-workers
NSlip-1	0.0036 or 1 in 278 projects	0.0088 or 1 in 114 projects
NSlip-2	0.017 or 1 in 59 projects	0.0088
OM-1	0.011 or 1 in 90 projects	0.0088
OM-2	0.023 or 1 in 43 projects	0.0088

TABLE 8.4

APPROXIMATE NET RIVER BERM-CAP VOLUME REQUIRED ABOVE THE EXISTING MUDLINE TO SUPPORT THE SHORELINE BULKHEAD ALONG THE NORTH BOAT SLIP

HARBOR AT HASTINGS OU-2

Alternative	Net Sediment Volume Increase (+) or Decrease (-) Following Dredging and Placement of Berm and Cap (cubic yards) (1)	Percent Change in River Cross Section (2)
NSlip-1	+700	-0.05 (3)
NSlip-2	+6,100	-0.3

(1) Based on an OU-1 final grade elevation of +4 ft with the shoreline sloping upward to +9 ft at 100 to 120 ft inland based on NAVD88 datum (average tidal water level is +0.1 ft). These sediment volume changes do not include the beneficial effect of settlement from berm-cap placement. For example, a berm-cap with a total thickness of 5 ft above existing grade would have a total settlement over time of approximately 1.5 to 2 ft (see Appendix B).

(2) Based on the existing river cross section at Hastings-on-Hudson being approximately 4,000 ft wide with an average water depth of approximately 40 ft.

(3) Example calculation: 5,000 cubic yards over a 140 ft river width and a 900 ft river length corresponds to a 1.1 ft average increase in water depth. 1.1 ft over a 140 ft river width divided by 40 ft over a 4,000 ft wide river (from note 2 above) is 0.1 percent (or one tenth of one percent).

TABLE 8.5

SEDIMENT DREDGE VOLUMES AND CONTAMINANT MASSES FOR THE BOAT SLIP AND OLD MARINA AREA ALTERNATIVES

Alternative	Volume of Sediment to Dredge (cy)	Mass of PCBs Removable (lbs)	Pounds of PCBs Removable per Cubic Yard	Percentage of Removable OU-2 PCB / Elevated Copper Mass in Sediment
NSlip-1	2,100	15	Less than 0.01	Less than 0.1 / 0
NSlip-2	8,400	42	Less than 0.01	0.2 / 0
OM-1	7,000	50	Less than 0.01	0.2 / 0
OM-2	15,000	510	0.03	1.9 / 0

SECTION 9

REMEDIAL ACTION ALTERNATIVES FOR THE OFFSHORE AREA

This section describes remedial action alternatives for the Offshore Area, that portion of OU-2 that is west of the Northwest Corner Area and the Southern Area. The Offshore Area has sediment containing PCBs and/or metals exceeding PRGs in isolated locations. The Offshore Area encompasses a total of approximately 22 acres. Remedial action alternatives for the Offshore Area consist of monitoring natural recovery and capping. The Offshore Area capping alternative is assessed in this report based on three different extents of capping according to copper concentration and according to two different modeled quantifications of cap area (Earth Tech's quantification in the 2003 FS Report and AR's quantification presented in this report).

PCBs in offshore sediment above 1 ppm are isolated (see Figure 1.3). Earth Tech's depictions prepared in 2003 and presented in Figures 2.7c and 2.7d in the 2003 OU-2 FS Report (Earth Tech, 2003) also show offshore PCBs to be scattered. The area weighted average for PCBs in the top 2 ft of Offshore Area sediment is only 0.2 ppm, and area weighted average concentrations are lower than 0.2 ppm below the top 2 ft (see Table 1.1).

USEPA's 2005 ESB guidance (USEPA, 2005b) provides a rigorous methodology for assessing the factors that limit the bioavailability and toxicity of metals. This guidance recognizes the importance of acid volatile sulfides and organic carbon in sequestering (or binding up) metals in sediments thereby limiting their introduction into porewater, which is the primary route of exposure for benthic organisms. This USEPA 2005 ESB guidance also establishes a scientific method for evaluating the bioavailability and toxicity of metals in sediments, and provides detailed methodology for quantitatively assessing the metal binding capacity of sediments.

Site-specific acid volatile sulfides, organic carbon and metal porewater data have since been obtained during supplemental sediment investigations of OU-2 conducted in 2004 and 2005. These data fill previous data gaps and allow the site-specific bioavailability and toxicity of metals to be evaluated based on the methods presented in the USEPA's 2005 ESB guidance. The results of this analysis are summarized in Section 1 and presented in more detail in Appendix C to show that a copper concentration of 982 ppm is a conservative, site-specific, no observed adverse effects sediment concentration that is proposed as a PRG for the Offshore Area and for the other areas comprising OU-2.

Copper concentrations measured in Offshore Area sediments only exceed the proposed 982 ppm PRG in a small area off the northern half of former Building 15 (see Figure 1.4). A copper concentration of 88.7 ppm was presented in the 2003 OU-2 FS as a background concentration of copper. Sediment offshore that contains copper above average background concentrations is not necessarily solely impacted by former Anaconda site operations.

Sediment copper concentrations generally exceed the background copper concentration of 88.7 ppm to a distance of 150 to 200 ft offshore and south of ARCO's southern property line.

Copper sediment samples available from south of OU-2 were collected just off the Tappan Terminal site. The Tappan Terminal Site adjoins the southern boundary of OU-1 and, like OU-1, was created from industrial fill imported during the late 1800s and early 1900s. Over 88 percent of the upland samples taken at the Tappan Terminal during its RI/FS exceeded 88.7 ppm. The 34 upland soil samples from the Tappan Terminal site averaged 1,131 ppm of copper (Remedial Investigation Report Tappan Terminal Site, September 1999). The copper values reported in sediments south of OU-2 are low compared to soils present at the adjacent Tappan Terminal site.

Approximately 75 to 100 debris locations were identified by AR during 2004 and 2005 supplemental OU-2 investigation efforts in the Offshore Area. The debris locations in the Offshore Area contained unidentified material, pilings, magnetic anomalies (both surficial and subsurficial), tires and other man made objects (Parsons 2005a/b).

Table 9.1 provides a listing of the elements of the two remedial action alternatives for offshore which include monitoring of natural recovery (Alternative Offshore-1) and placing a protective cap (Alternative Offshore-2). Both alternatives include long-term monitoring to confirm remedy effectiveness. Concentrations of PCBs and metals in sediment offshore do not significantly exceed PRGs, and offshore sediment is not able to be contained with a temporary barrier or a temporary silt curtain. Dredging would likely not significantly reduce sediment concentrations due to resuspension caused by dredging and is therefore not warranted offshore. Capping, on the other hand, would reduce exposure of aquatic organisms to localized sediment that exceeds PRGs.

Specific information about any remedial action alternatives is presented in this Supplemental FS only for the purpose of evaluating each alternative. Any elevations or other specific information presented herein about any alternative is preliminary, approximate, and subject to change during remedial design.

9.1 ALTERNATIVE OFFSHORE-1: MONITORED NATURAL RECOVERY

Sediment deposition occurs within an estuarine system like the lower Hudson River particularly in nearshore areas like OU-2. Deposition takes place as sediment originating from erosive areas with high water velocities settles through the water column at downstream areas where water velocities are lower. The lower water velocities near the mouth of a river are due to flatter slopes longitudinally along the river’s direction of water flow and lower water velocities nearshore away from the main channel. In addition, tidal forces moving upstream from the ocean increase the residence time for water in lower portions of rivers further encouraging sediment settling.

Radioisotope analyses were performed at four OU-2 locations as part of the Fall 2004 Supplemental OU-2 Investigation (Parsons, 2005a/b). These analyses confirmed that deposition is occurring at an average rate of approximately 1 inch per year at areas within 100 to 140 ft of shore and away from steeply sloped areas. Two of these four 2004 radioisotope dating locations were located further than 60 to 80 ft from shore. None of the four 2004 radioisotope dating locations were further from shore than 140 ft, but deposition is also believed to be taking place in the offshore area further from shore. Water velocities measured during intensive fall 2004 oceanographic investigation efforts (see Parsons, 2005d) were reasonably close to water velocities measured nearer to shore where radioisotope dating showed sediment deposition is ongoing. Average near-bottom water velocities were measured to be approximately 1 to 2 ft per second in the Offshore Area and similar to water velocities measured 50 to 100 ft from shore where samples for radioisotope analyses were collected (see Parsons, 2005d). Comparing fall 2004 water velocity meter readings 50 ft from shore to the meter readings located 200 ft from shore, the velocities were about 0.5 ft per second greater 200 ft from shore.

Given that sediment deposition is taking place and given the relatively low concentrations of PCBs and metals offshore originating from former Anaconda operations, monitoring of natural recovery offshore is an alternative evaluated herein.

9.2 ALTERNATIVE OFFSHORE-2: PLACE A PROTECTIVE CAP

Under this alternative, a protective cap would be placed over areas with sediment shown in available sample results to exceed the PRGs in the top 1 to 2 ft of sediment. The top 0.5 to 1 ft of offshore sediment is the sediment potentially accessible to aquatic life on a routine basis.

Figure 9.1 depicts the portions of the Offshore Area evaluated for capping in this alternative. This figure conservatively shows areas where PRGs are exceeded in the top 2 to 4 ft of sediment, which encompasses approximately 5.8 acres. The total offshore area shown in Figure 9.1 that exceeds the proposed 982 ppm PRG for copper is approximately 0.5 acre off former Building 15 (see Figure 1.4 also). These areas are based on AR's contaminant distribution modeling efforts conducted for AR for this Supplemental Feasibility Study, using available analytical data (see Section 1.3 and Appendix A). Figure 9.2 is the closest comparison to Figure 9.1 available from the Earth Tech 2003 FS Report for OU-2. Figure 9.2 is based on 1 ppm PCBs and 887 ppm copper because the 982 ppm PRG for copper had not yet been proposed as of 2003. The total capping area shown in Figure 9.2 is approximately 13.6 acres. Alternatively, Figure 9.3 presents the total capping area for sediments that exceed both the 1 ppm PRG for PCBs and the background copper concentration of 88.7 ppm based on AR's contaminant distribution modeling results. The total capping area shown in Figure 9.3 is approximately 11.3 acres. These capping areas are approximate and would be adjusted during remedial design as warranted.

The protective cap would provide the same erosion protection and a habitat surface as described in Section 2.1, but the additional one foot of cap thickness for chemical isolation would most likely not need to be provided based on a lack or groundwater flow moving upward into a cap at a distance offshore beyond the Northwest Corner Area or Southern Area and due to the sealed shoreline bulkhead to be installed as the shoreline to cut off flow of OU-1 groundwater into the river. The protective cap would be approximately 1 ft thick to provide a transition with underlying sediment, erosion protection, and aquatic habitat restoration. As described in Section 2.2.6, the cap would provide erosion control using fine gravel with a mixture of sands and silts as needed to restore aquatic habitat.

Prior to placing a cap in the offshore area, large debris would be removed to provide for a consistent and even cap placement. Following removal of debris and obstructions, a berm would be placed in combination with the protective cap if needed in any offshore areas where additional shoreline support offshore from the Northwest Corner Area or offshore from the Southern Area is required to physically stabilize the shoreline.

The protective cap would be placed without temporary containment at locations designated for capping based on cap placement successfully completed without containment at other sites as described in Section 2.2.7. A cap within locations offshore could require up to approximately three months to place. The protective cap would be incorporated into the top portion of any support berm along the Northwest Corner Area or along the Southern Area. Once placed, the cap would be monitored long term and maintained over time to assure its continuing protectiveness.

TABLE 9.1

REMEDIAL ACTION ALTERNATIVES FOR THE OFFSHORE AREA

HARBOR AT HASTINGS OU-2

Alternative	General Description
Offshore-1: Monitor Natural Recovery	Monitor ongoing natural recovery based on long-term sediment deposition to assure sediment concentrations of PCBs continue to be protective of human health and the environment over the long term (for example, an area-weighted average sediment concentration of PCBs below 1 ppm).
Offshore-2: Place a Protective Cap	Place a protective cap that would include chemical isolation if needed, erosion protection, and aquatic habitat replacement where sediments within the uppermost 1 to 2 ft exceed PRGs. Three different cap areas are evaluated based on: (a) 2006 AR modeling results showing PCBs greater than 1 ppm and copper greater than 982 ppm (5.8 acres); (b) 2003 Earth Tech figures showing PCBs greater than 1 ppm and copper greater than 887 ppm (the closest information to 982 ppm available on a figure) (13.6 acres); and (c) 2006 AR modeling results showing PCBs greater than 1 ppm and copper greater than 88.7 ppm (11.3 acres). The cap would consolidate over time.

Notes: Sediment PRGs are 1 ppm for PCBs and 982 ppm proposed for copper. Capping Offshore Area sediment exceeding 88.7 ppm copper is also considered.

TOTAL CAP AREA = 254,106 SF, 5.83 ACRES

200 100 0 200 400

SCALE: 1"=200'

REFERENCES:

1.) TOPOGRAPHY AND PLANIMETRICS PROVIDED BY GEOD PHOTOGRAMMETRIC SCIENCES SURVEY TECHNOLOGIES. MAPPED BY PHOTOGRAMMETRIC METHODS FROM AERIAL PHOTOGRAPHS TAKEN 12-08-1995. GRIDS BASED ON NEW YORK 1988 STATE PLANE COORDINATE SYSTEM. VERTICAL DATUM IS BASED ON NAD 1983. RI SAMPLE LOCATIONS SURVEYED BY GEOD.

2.) HISTORICAL SAMPLING LOCATIONS BASED ON DOLPH ROTFELD, FIGURE 4, DATED 1976, PARISH & WEINER, PLATE 2, DATED OCTOBER 1989 AND RETEC, FIGURE 2-8, DATED DECEMBER 1993. THESE LOCATIONS ARE APPROXIMATE ONLY, AS LAND SURVEYING DATA ARE NOT AVAILABLE.

3.) EXISTING BUILDING DESIGNATIONS ARE BASED ON DOLPH ROTFELD ASSOCIATES FIGURE 4, DATED NOVEMBER 1996. BUILDING INTERIOR DIVISION LOCATIONS ARE APPROXIMATE ONLY.

LEGEND:

- APPROXIMATE SITE BOUNDARY
- AREA TO BE CAPPED
- AREA OF PCB >1ppm AND COPPER CONCENTRATION >982ppm
- BUILDINGS

NOTE:
COPPER & PCB AREAS BASED ON COPPER & PCB CONTOURS (AT ALL DEPTHS) PROVIDED BY ESI FIGURE DATED MARCH 8, 2006.

AR and AERL

FIGURE 9.1
OFFSHORE CAP AREA FROM ESI OUTPUT BASED ON PCBs >1ppm AND COPPER >982ppm

PARSONS
290 ELWOOD DAVIS ROAD, SUITE 312, LIVERPOOL, N.Y. 13088, PHONE: 315-451-9560

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TOTAL CAP AREA = 593,830 SF, 13.63 ACRES

200 100 0 200 400

SCALE: 1"=200'

LEGEND:

- APPROXIMATE SITE BOUNDARY
- AREA TO BE CAPPED
- AREA OF COPPER CONCENTRATION >887ppm
- AREA OF PCB >1ppm
- BUILDINGS

REFERENCES:

1.) TOPOGRAPHY AND PLANIMETRICS PROVIDED BY GEOD PHOTOGRAMMETRIC SCIENCES SURVEY TECHNOLOGIES. MAPPED BY PHOTOGRAMMETRIC METHODS FROM AERIAL PHOTOGRAPHS TAKEN 12-08-1995. GRIDS BASED ON NEW YORK 1988 STATE PLANE COORDINATE SYSTEM. VERTICAL DATUM IS BASED ON NAD 1983. RI SAMPLE LOCATIONS SURVEYED BY GEOD.

2.) HISTORICAL SAMPLING LOCATIONS BASED ON DOLPH ROTFELD, FIGURE 4, DATED 1976, PARISH & WEINER, PLATE 2, DATED OCTOBER 1989 AND RETEC, FIGURE 2-8, DATED DECEMBER 1993. THESE LOCATIONS ARE APPROXIMATE ONLY, AS LAND SURVEYING DATA ARE NOT AVAILABLE.

3.) EXISTING BUILDING DESIGNATIONS ARE BASED ON DOLPH ROTFELD ASSOCIATES FIGURE 4, DATED NOVEMBER 1996. BUILDING INTERIOR DIVISION LOCATIONS ARE APPROXIMATE ONLY.

NOTE:
COPPER & PCB AREAS BASED ON COPPER & PCB CONTOURS (AT ALL DEPTHS) PROVIDED BY THE NYSDEC IN THE 2003 OU-2 PRAP.

AR and AERL

FIGURE 9.2
OFFSHORE CAP AREA FROM 2003 PRAP OUTPUT BASED ON PCBs >1ppm AND COPPER >887ppm

PARSONS
290 ELWOOD DAVIS ROAD, SUITE 312, LIVERPOOL, N.Y. 13088, PHONE: 315-451-9560

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XREFs: X441532C01.DWG

TOTAL CAP AREA = 492,432 SF, 11.30 ACRES

200 100 0 200 400

SCALE: 1"=200'

REFERENCES:

1.) TOPOGRAPHY AND PLANIMETRICS PROVIDED BY GEOD PHOTOGRAMMETRIC SCIENCES SURVEY TECHNOLOGIES. MAPPED BY PHOTOGRAMMETRIC METHODS FROM AERIAL PHOTOGRAPHS TAKEN 12-08-1995. GRIDS BASED ON NEW YORK 1988 STATE PLANE COORDINATE SYSTEM. VERTICAL DATUM IS BASED ON NAD 1983. RI SAMPLE LOCATIONS SURVEYED BY GEOD.

2.) HISTORICAL SAMPLING LOCATIONS BASED ON DOLPH ROTFELD, FIGURE 4, DATED 1976, PARISH & WEINER, PLATE 2, DATED OCTOBER 1989 AND RETEC, FIGURE 2-8, DATED DECEMBER 1993. THESE LOCATIONS ARE APPROXIMATE ONLY, AS LAND SURVEYING DATA ARE NOT AVAILABLE.

3.) EXISTING BUILDING DESIGNATIONS ARE BASED ON DOLPH ROTFELD ASSOCIATES FIGURE 4, DATED NOVEMBER 1996. BUILDING INTERIOR DIVISION LOCATIONS ARE APPROXIMATE ONLY.

LEGEND:

- APPROXIMATE SITE BOUNDARY
- AREA TO BE CAPPED
- AREA OF PCB >1ppm AND COPPER CONCENTRATION >88.7ppm
- BUILDINGS

NOTE:
COPPER & PCB AREAS BASED ON COPPER & PCB CONTOURS (AT ALL DEPTHS) PROVIDED BY ESI FIGURE DATED MARCH 8, 2006.

AR and AERL

FIGURE 9.3
OFFSHORE CAP AREA FROM ESI OUTPUT BASED ON PCBs >1ppm AND COPPER >88.7ppm

PARSONS
290 ELWOOD DAVIS ROAD, SUITE 312, LIVERPOOL, N.Y. 13088, PHONE: 315-451-9560

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XREFs: X441532C01.DWG

SECTION 10

EVALUATION OF REMEDIAL ACTION ALTERNATIVES FOR THE OFFSHORE AREA

The two remedial action alternatives presented in Section 9 for offshore are evaluated in this section by applying the NYSDEC evaluation criteria used to evaluate the remedial action alternatives for the other areas within OU-2.

Area-weighted average sediment PCB concentrations in sediment offshore are below 1 ppm at any depth below the mudline based on AR's contaminant distribution modeling results (see Table 1.1), and sediment PCB concentrations measured in the top 6 inches of sediment are generally lower than sediment PCB concentrations measured from 6 to 24 inches below the mudline indicating natural settling of cleaner sediment is ongoing. Copper concentrations are below 982 ppm throughout sediment at any location offshore, except in two isolated areas off the northern portion of former Building 15 (see Figure 1.4 and figures in Appendix C). Concentrations of lead, nickel and zinc in Offshore Area sediment are also generally below PRGs proposed from the equilibrium sediment partitioning sediment benchmark analysis presented in Appendix C. The only exceedances in the Offshore Area for lead, nickel, and zinc is in an isolated portion that also shows copper greater than 982 ppm. At only one sampled location (SD-62A) is the zinc PRG exceeded in the top 1 ft of sediment that is potentially accessible to aquatic life forms. As a result, the primary focus for sediment offshore is the isolated locations where PCB concentrations in surface and near-surface sediment exceed 1 ppm. The area-weighted average PCB concentration at all sediment depths in the Offshore Area, as is presented in Table 1.1, is far below 1 ppm based on AR's contaminant distribution modeling results. A dense debris field was documented offshore between the North and South Boats slips, spanning approximately 700 ft of the shoreline and extending approximately 150 ft from the shoreline. This debris field is characterized by wooden pilings, sections of sheet piling, sub-surficial magnetic debris, tires, and other man-made objects. Geophysical data and sampling results are also indicative of shell beds in this portion of the Offshore Area. Sediment in the Offshore Area greater than 150 to 200 ft from shore contains less but still noteworthy, debris compared to the Offshore Area closer to shore.

Groundwater within OU-1 will be contained by a sealed shoreline bulkhead as part of the OU-1 remedy which will limit any movement of groundwater from OU-1 to OU-2. As a result, groundwater within OU-1 will not affect sediment quality within any part of OU-2.

The evaluation of remedial action alternatives for offshore sediment is presented in Table 10.1 where the NYSDEC evaluation criteria are assessed separately for both remedial action alternatives. With the three capping options, the only difference is the surface area of the protective cap based on Earth Tech (2003) and AR (2006) depictions of PCBs and copper and based on copper concentrations of 982 ppm and 88.7 ppm as presented in Section 9.2 and in Figures 9.1 through 9.3. The evaluation of remedial action alternatives for offshore sediment is summarized below.

10.1 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT (A THRESHOLD CRITERIA)

Consistent with the other portions of OU-2, evaluating the degree to which sediment exceeding PRGs would no longer be in contact with fish and other forms of aquatic life is the primary factor for determining whether an alternative can meet the threshold criteria called protection of human health and the environment and also meet the remedial action objectives for OU-2.

Alternative Offshore-1 would be protective of human health and the environment. PCB concentrations measured as background locations as part of the RI OU-2 remedial investigation indicate PCBs as high as 1.2 ppm were detected in background sediment. By comparison, offshore sediment samples show an area-weighted average PCB concentration of 0.2 ppm in the top 2 ft of sediment (see Table 1.1) or one sixth of the highest site background sediment PCB concentration. Less than 1 percent of the PCB mass in OU-2 sediment and approximately 35 percent of the copper mass in OU-2 sediment exceeding the proposed PRG of 982 ppm are contained within offshore sediment.

Monitored natural recovery under Alternative Offshore-1 would be protective of human health and the environment as long as sediment deposition is significant enough over the sediment areas where PRGs are exceeded. Sediment deposition rates measured in the North Boat Slip (Earth Tech, 2000) and in the Northwest Corner Area and Southern Area (Parsons, 2005a/b) are 1 to 2 inches per year or 3 to 12 years over the biologically-active top 6 to 12 inches of sediment. Further, the area weighted average PCB concentrations are below the PRGs at all depths for all parameters. With the exception of a few samples isolated off former Building 15, the proposed copper PRG of 982 ppm has not been exceeded in any sediment sampled analyzed from the Offshore Area for copper. With only the same few sample exceptions as for copper, the concentrations of lead, nickel and zinc in Offshore Area sediment area also below their proposed PRGs based on equilibrium partitioning sediment benchmark analyses presented in Appendix C.

In addition to burial by cleaner sediment, PCBs can also become less available to the environment slowly over many years through biotransformation, adsorption, and/or chemical modification. The relative importance of these mechanisms in reducing PCB levels in Hudson River sediment is not able to be estimated based on available data. Multiple processes may be ongoing at any given time and location within the river that could make PCBs less available to the river sediment.

Application of USEPA’s 2005 ESB methodology (USEPA, 2005b) to the acid volatile sulfides, simultaneously extracted metals, and total organic carbon site data collected in the Fall 2004 and Fall 2005 indicate that metals are not bioavailable or toxic at copper concentrations ranging up to at least 982 ppm in OU-2 sediments where OU-2 data show the highest concentrations of metals (see Appendix C). This information has been assessed in combination with previous sediment concentration and site toxicity investigation work at OU-2 to further demonstrate that 982 ppm is an appropriate and conservative preliminary remediation goal for copper in OU-2 sediment (see Appendix D). Similar conservative PRGs have been proposed for lead, nickel and zinc in accordance with USEPA’s 2005 ESB guidance (see Appendix C).

The option within Alternative Offshore-2 that includes capping based on 88.7 ppm copper instead of 982 ppm copper (Option C) would result in approximately 5 to 6 additional acres of the Offshore Area being capped, but impacts from these areas on human health and the environment are not adverse and not significant.

The difference in cap area from AR's contaminant distribution modeling results and the Earth Tech 2003 modeling results result from different modeling procedures as described in Appendix A. The Earth Tech modeling work was done in two dimensions, while the AR contaminant distribution modeling work was done in three dimensions. The Earth Tech modeling results represent data based on the maximum concentration found at a location regardless of the depth below the mudline where the PRG exceedance was measured. AR's contaminant distribution modeling results account for sample depths below the mudline. Other aspect of the Earth Tech modeling, such as how uncertainty was addressed, has not been reported. In addition, the data set used by Earth Tech included some results that were modified as a result of data validation as presented in Appendix A.

From the analysis of alternatives for the Northwest Corner Area, Southern Area, and the boat slips and Old Marina Area, direct exposures of fish and other local aquatic life to offshore sediment that exceeds PRGs would be eliminated over the long term through capping (Alternative Offshore-2). There are no field conditions that would make capping less protective offshore compared to locations closer to shore. As a result, long-term impacts to human health from site sediment through fish consumption and sediment contact would also be eliminated by placing a protective cap.

Capping can effectively protect human health and the environment offshore over the long term for the reasons described in Section 2.2 and summarized in Section 4.1. Aquatic biota live within the top 6 to 12 inches of sediment, so the lower portion of the protective cap would prevent the biota from contacting contaminated sediment. A protective cap has been employed successfully at many other sediment sites, because it can provide chemical isolation, erosion control, and habitat replacement. The protective cap could be monitored and maintained over the long term, and institutional controls can be implemented, such as an environmental easement, to assure the cap remains protective.

Capping under Alternative Offshore-2 would temporarily disrupt the river bottom and the associated benthic community. However, with the top layer of a protective cap as presented in Section 2.2, benthic organisms would be expected to recolonize the habitat surface layer of the cap (see Section 2.2) within 2 to 4 months during the biologically productive time of the year (i.e., April through November at this site) (Dernie, 2003). As most of the aquatic biota live within the top 3 to 6 inches of sediment, the lower erosion protection layer of the cap would prevent the biota from contacting contaminated sediment. Since OU-2 is known to accumulate sediment, the slow natural deposition of native materials will also support restoration of local aquatic habitat following construction.

10.2 COMPLIANCE WITH STANDARDS, CRITERIA, AND GUIDELINES (A THRESHOLD CRITERIA)

Standards, criteria, and guidelines pertaining to monitoring of natural recovery and to capping include sediment PRGs discussed in Section 10.1, performance requirements for capping, and Village Code requirements that may apply for onshore support activities. Capping offshore would not reach into the navigation routes for river barges. The various standards, criteria and guidelines would be met under either remedial action alternative for the Offshore Area. Area-weighted concentrations of PCBs and metals are below their respective PRGs without capping.

10.3 SHORT-TERM EFFECTIVENESS (A BALANCING CRITERIA)

There are no short-term effectiveness factors associated with natural deposition of sediment. Monitoring of natural recovery in the Offshore Area would be effective in the short term. No adverse impacts to the environment, to workers, or to the community would arise due to implementing this alternative.

Short-term exceedances of water quality guidelines while placing a cap should not arise under Alternative Offshore-2 as long as the protective cap would be placed carefully following example cap placement efforts at other environmental sites (see Section 2.2).

Worker risks associated with capping would be controlled to the extent practicable through thorough health and safety planning and safe work practices, but based on incidence rates reported from other locations, some worker risks are unavoidable.

The short term impact of the remedy includes any injuries that workers may suffer while implementing the remedy. Appendix F describes the methodology used to evaluate the risk of injuries to workers on site, and to workers that transport materials on and off site. Based on the rate of injury reported for similar projects and types of work, the estimated risk of an on-site worker fatality range for capping work offshore would range from 1 in 212 (0.5 percent) to 1 in 497 (0.2 percent). Risks of a fatality for site workers are approximately 2.5 times higher for the largest cap area under Alternative Offshore-2 compared to the smallest cap area evaluated under that alternative.

AR will only undertake remedial action where it can develop a way to perform the work safely, without significant injury or fatalities. AR would seek to control all worker injury risks through health and safety planning and safe work practice. AR’s safety management program would be strictly followed. However, the combined risk of injury from remediation work at all areas of OU-2 should be considered when selecting alternatives, and the risk of a fatal injury rises with the size of the area to be dredged, as well as the depth of dredging. Worker risks will be evaluated in more detail during remedial design, and remedial alternatives may need to be modified to ensure that the work can be performed safely.

Capping under Alternative Offshore-2 would extend over approximately 3 months. Under Alternative Offshore-2, approximately 94, 220, or 180 rail cars would enter OU-1 with soil for the various areas of a protective cap associated with Options A, B and C respectively.

10.4 LONG-TERM EFFECTIVENESS AND PERMANENCE (A BALANCING CRITERIA)

The monitoring of natural recovery and capping alternatives would both be effective over the long-term in the Offshore Area. The USEPA December 2005 sediment remediation guidance clearly states that both monitored natural recovery and capping can be effective over the long term. Conditions in the offshore area are suitable for both natural sediment deposition and capping. The rate and variability of natural sediment deposition in the offshore area would need to be better quantified. As sediment settles, the older sediment underlying the new sediment becomes more consolidated and likely to remain in place. Existing exposure is low offshore given the average concentrations of PCBs in offshore sediment, and infilling is ongoing continuously over time. With a properly-designed and properly-installed cap as described in Section 2.2 and in Section 4.4.1, capping is also a protective remedy. Effective measures to maintain cap protectiveness are available as presented in Sections 2.2 and 4.4.1 as well. Any change in the hydraulic carrying capacity of the river due to placing a cap that would be 1 to 2 ft thick would be minimal. The cross sectional area covered by even a 2 ft thick cap would be at most approximately one half of one percent of the cross sectional area through which river water is transmitted from upstream locations to locations further downstream. This estimate conservatively does not take into account that a 1 to 2-ft thick cap at OU-2 would settle up to 11 inches over time following placement (see Appendix B). A flood routing analysis could be done during remedial design if needed to further evaluate this impact during, for example, a worst case hydrologic condition.

10.5 REDUCTION OF TOXICITY, MOBILITY, AND VOLUME THROUGH TREATMENT (A BALANCING CRITERIA)

For the Offshore Area, no natural treatment would be evident except whatever natural dechlorination of PCBs to less toxic PCB compounds would take place within the sediment. However, such transformations are limited for highly chlorinated PCBs unless natural conditions without oxygen are present for these PCBs to naturally degrade to a less chlorinated (and less toxic) PCB (USEPA, 2005a).

10.6 IMPLEMENTABILITY (A BALANCING CRITERIA)

Each of the remedial steps outlined at the beginning of Table 10.1 is implementable for both Offshore Area alternatives. Monitoring tools are available to assess natural sediment deposition. Monitoring of natural recovery would be easy to implement and the monitoring technologies that are needed are readily available. Placing a cap in deeper water that exists offshore has been successfully completed at other contaminated sites as discussed in Section 2.2.

Prior to capping, the extent of debris offshore would be evaluated to assess whether individual objects in the Offshore Area would be significant enough to affect cap placement. If the debris were determined to be large enough to affect a cap, it could be removed prior to capping.

Placement of a berm offshore would be an extension of a berm placed along the Northwest Corner Area, along the North Boat Slip, or along the Southern Area to help stabilize the shoreline bulkhead. Placement of a berm is from an implementation standpoint, the same as placing a cap.

A berm-cap is implementable based on success observed placing caps at other sites and based on shear strength available within site sediment. Berms and caps have been successfully placed at other sites (see Section 2.2.7). The maximum allowable final slope for a berm-cap would be determined during remedial design.

Approval would likely be needed from NYSDEC and from the USACE under Alternative Offshore-2 since the alternative would constitute some filling of a small portion of the river. However, the filling would be at water depths that exceed 15 ft at low tide which would not affect the ability of the river to support aquatic life. As indicated in Section 10.4 (long-term effectiveness), only a very small reduction in the river's hydraulic carrying capacity in cross section would result from capping.

Institutional controls under either alternative, such as an environmental easement, would be the same controls as for other areas of OU-2 (see Section 2.2.8). These controls are available and can be implemented for the Offshore Area.). Controls that would further protect the cap, such as boat anchoring restrictions and use of floating docks, could be included in an environmental easement. Pursuant to New York State law, enforcement of easement requirements would be at the discretion of NYSDEC.

10.7 COSTS (A BALANCING CRITERIA)

A cost estimate has been prepared for the two remedial action alternatives for offshore consistent with the cost estimates presented for the Northwest Corner Area and for the Southern Area and in accordance with USEPA guidance (USEPA, 2000a). The cost evaluation assesses estimated capital, annual operation and maintenance (O&M), periodic costs, and total net present value. Monitored natural recovery in the Offshore Area (Alternative Offshore-1) would not include any capital costs.

In addition to development of an estimated cost, alternatives are evaluated on the basis of cost-effectiveness under the comparative evaluation of alternatives. Part 375 (Subpart 1.10(c) (6) in Title 6 of the New York Code of Rules and Regulations, CERCLA Section 121, and the National Contingency Plan require that the selected remedy must be cost-effective. Overall effectiveness of a remedial alternative is determined by evaluating the following three of the five balancing criteria: long-term effectiveness and permanence; reduction in toxicity, mobility, and volume through treatment; and short-term effectiveness.

Alternative	Estimated Capital Cost ($)	Estimated Annual O&M Cost ($)	Estimated Net Present Worth ($)
Offshore-1	$0	$130,000	$1.3 Million
Offshore-2 Option A	$4.5 Million	$100,000	$5.6 Million
Offshore-2 Option B	$6.8 Million	$100,000	$8.0 Million
Offshore-2 Option C	$6.1 Million	$100,000	$7.3 Million

Capital costs are comprised of variable (also called non-fixed) costs and fixed costs. Variable costs are costs that vary from one alternative to another, such as costs for providing temporary containment, dredging, material management, and capping. Fixed costs are costs that do not vary from one alternative to another, such as costs for permitting and construction setup. Fixed costs have been apportioned equally amongst the areas of OU-2 since the sequence of construction among the OU-2 areas has not yet been established. Appendix E provides specific basis and compilations for the costs estimates for each remedial action alternative.

The capping options proposed under Alternative Offshore-2 would likely yield little, if any, long term benefit for the additional cost incurred. A significant percentage of the PCBs in this portion of the river do not match the profile of PCBs used on site, and appear to come from unrelated locations up and down the lower Hudson River. Because this area is impacted by continuing off-site sources of PCB contamination in the lower Hudson River that AR cannot eliminate or control, the most cost effective alternative is for AR to remove and contain the most significant source of PCB mass from OU-2 (by implementing Alternative NW-1) and then monitor the Offshore Area (Alternative Offshore-1) to confirm the elimination of this nearshore source of contamination from the rest of the river.

Capital costs for capping only the area offshore adjacent to the Southern Area near former Building 15 where the proposed copper PRG of 982 ppm is exceeded would total approximately $0.2 million.

10.8 EVALUATION SUMMARY FOR OFFSHORE SEDIMENT

Both remedial action alternatives for offshore sediment would meet the OU-2 remedial action objectives presented in Section 1.7 and be protective of human health and the environment and in compliance with standards, criteria, and guidelines as long as natural deposition is ongoing as measured closer to shore within OU-2. The protectiveness and long-term effectiveness of natural sediment deposition would need to be further assessed with monitoring efforts that would start during remedial design. Capping also would be protective, but capping for PCBs is not warranted, as the area weighted average concentration of PCBs in the top 2 feet of sediment already meets PRGs. In addition, a significant percentage of the PCBs in the Offshore Area do not appear to come from the wire and cable plant site, suggesting that continuing off-site sources of PCB contamination could re-contaminate any cap that AR installed here. A relatively small, isolated area of elevated metal contamination could also be capped for a capital cost of approximately $200,000, without capping a substantial portion of the Offshore Area. On this basis, Alternative Offshore-1 is recommended, with possible assessment of capping for isolated elevated metals during remedial design.

TABLE 10.1

REMEDIAL ACTION ALTERNATIVES FOR OFFSHORE (BEYOND TEMPORARY CONTAINMENT) HARBOR AT HASTINGS OU-2

	Alternative Offshore-1 **Monitored Natural Recovery**	**Alternative Offshore-2** **Place a Protective Cap**
Summary description and possible construction sequence (see Section 9)	• Monitor surface sediment conditions regularly as needed to confirm the impact from former Anaconda Wire and Cable operations on offshore sediment is minimal.	▪ Complete the OU-1 remedy, nearshore elements of the OU-2 remedy, and redevelop OU-1 independent of any remedial action in the offshore area. ▪ Remove large debris as needed to place a berm and cap. ▪ Place berm in the offshore area where needed to stabilize shoreline. ▪ Place a 1-foot to 2-foot thick protective cap over berm and over other areas where PRGs for PCBs and/or copper are exceeded. (Three extents of capping are included under this alternative as shown in Figures 9.1 though 9.3. The three cap area options range from 5.8 to 13.6 acres.)
Protection of Human Health and the Environment (overall protection achieved over time by meeting PRGs thereby controlling site risks)	• The total PCBs area weighted average for the surface sediments in the Offshore Area is already only 20 percent of the PRG, and a portion of these are not site related. Current effects, if any, are very small. • Less than 0.1 percent of the sediment PCB and approximately 15 percent of the sediment copper mass are in the offshore area. • Maximum background concentrations of PCBs in the site vicinity are 1.2 ppm compared to area-weighted average surface sediment concentrations of 0.2 ppm in the offshore area (see Table 1.1). • Groundwater flow to this portion of OU-2 is likely very small, if it is occurring at all particularly once the shoreline bulkhead is installed and sealed. • PCBs naturally attenuate gradually over time, although the extent of this attenuation cannot be well defined.	• Alternative Offshore-2 would be protective. A protective cap would: (a) eliminate risk to human consumption of fish and shellfish due to the site; (b) eliminate exposure to site contaminants and replace current aquatic habitat; and (c) control impacts of long-term erosion or resuspension of sediment. • Short-term river habitat disruption would not be significant. Sediment biota would recover within 2 to 4 months from April through November of bioactivity (April – November annually)

TABLE 10.1, Continued

REMEDIAL ACTION ALTERNATIVES FOR OFFSHORE (BEYOND TEMPORARY CONTAINMENT) HARBOR AT HASTINGS OU-2

	Alternative Offshore-1 **Monitored Natural Recovery**	**Alternative Offshore-2** **Place a Protective Cap**
Compliance with NY State SCGs (standards, criteria and guidelines)	• Exceedances of PRGs are limited in the offshore area and not solely due to former Anaconda Wire and Cable operations. • The area-weighted average PCB concentration in the top 12 inches of sediment is much less than 1 ppm. • Any ongoing natural deposition of sediment could lower surface sediment concentrations further.	• Alternative Offshore-2 would comply with site remedial goals and with SCGs in the long-term due to the effectiveness of capping. • The offshore cap would be approximately 1 ft at most above the existing mudline after settlement occupying only 0.2 percent of the river cross sectional area. • Coastal zone management requirements should not affect OU-2 remedial efforts.
Short-term Effectiveness (protection of community and workers, environmental impacts and time to achieve protection)	• No short term effects are anticipated.	▪ Worker risk would be 0.002 to 0.005 or a chance of a fatality 2 in 1000 projects to 5 in 1000 projects compared to 0.01 for Alternative NW-1. See Appendix F. ▪ Cap placement effects on water quality are expected to be minor. ▪ River work would last approximately 3 months.
Long-term effectiveness and permanence (quantity and characteristics of residuals remaining after remediation, reliability of long-term controls)	▪ Long-term effects are expected to result in an improvement due to naturally occurring deposition.	▪ Placing a protective cap would provide reliable long-term protection against erosion from wind-waves and against erosion from ice scour (see Section 2.2). Protectiveness would be ensured with long-term cap monitoring and maintenance. ▪ Long-term monitoring of a cap has been proven to be effective from work at other sites. ▪ Institutional controls, such as environmental easements, have some precedence in New York State and should be effective. ▪ Change in hydraulic carrying capacity of the river would be insignificant based on a small long-term decrease in water depth following cap settlement (less than 0.5 percent of the area of the river cross section would be affected the length of OU-2.

TABLE 10.1, Continued

REMEDIAL ACTION ALTERNATIVES FOR OFFSHORE (BEYOND TEMPORARY CONTAINMENT) HARBOR AT HASTINGS OU-2

	Alternative Offshore-1 Monitored Natural Recovery	**Alternative Offshore-2 Place a Protective Cap**
Reduction of toxicity, mobility and volume through treatment (treatment technologies used, degree or reduction of toxicity, mobility and volume, permanence of treatment, residuals remaining on site)	• Only limited natural treatment would take place.	• No treatment would take place.
Implementability (technical feasibility, administrative feasibility and availability of resources)	• Readily implementable and measureable using available monitoring technologies.	▪ Placing a cap in deep water is implementable and has been successfully completed at other sites (see Section 2.2.7). ▪ Sediment shear strength needed to place a cap is available. ▪ Needed resources and work space would likely be available at OU-1. Sediment dredged from clean navigational dredge sites may be useable for the berm and cap. ▪ Approvals would be needed from the NYSDEC and from the US Army Corps of Engineers for some filling within the river. ▪ Establishing environmental easements with the State are not expected to be complex.
Costs (capital, annual, and present worth costs. Capital = construction, non-construction, and contingency)	Capital: $ 0 million Long-Term Annual: $130,000 Present Worth: $ 1.3 million	Capital: $ 4.5 to $6.8 million based on cap area Long-Term Annual: $100,000 Present Worth: $ 5.6 to $ 8.0 million

SECTION 11

RECOMMENDED REMEDIAL ACTION ALTERNATIVES

Based on the comparative analyses performed in Section 4, 6, 8 and 10, the following alternatives have been selected as the recommended remedial action alternatives for Harbor at Hastings OU-2:

- Alternative NW-1: Place a temporary rigid containment barrier, dredge to elevation -7 ft to remove a majority of the PCB contamination from the river (over 61%), and contain the remainder in place with a berm - protective cap, and submerged bulkhead;
- Alternative SA-1: Contain contaminated sediments exceeding PRGs in this area with a berm - protective cap in a manner that does not significantly reduce water depth more than is necessary.
- Alternative NSlip-1/OM-1/SSlip-1: Dredge up to 2 ft in the North Boat Slip and in the Old Marina Area as needed and place a protective cap. In the North Boat Slip, a berm will also likely be needed to help provide shoreline stability. In the South Boat Slip, monitor natural recovery that occurs as a result of natural sediment deposition.
- Alternative Offshore-1: Monitored natural recovery..

11.1 BASIS FOR RECOMMENDED REMEDIAL ACTION ALTERNATIVES

The recommended remedial action alternatives would remove a majority of the PCB contaminated sediment mass in OU-2 and provide a protective cap over the remainder, eliminating future exposure to sediment that exceeds the PRG of 1 ppm for PCBs and the proposed PRG of 982 ppm for copper. Dredging would provide sufficient water depth to restore aquatic habitat to stabilize the shoreline bulkhead once a berm and a protective cap are placed. At the same time, dredging the most contaminated sediment would remove 61 percent of the PCBs in OU-2 sediment. Capping by itself would be protective of human health and the environment and meet SCGs where sufficient water depth is available following placement of the berm and cap.

The recommended remedial action alternatives for OU-2 include the following key benefits:

- Protection of human health and the environment thereby meeting site remedial action objectives;
- Achievement of remedial goals outlined in Section 1 and compliance with SCGs, including PRGs, to the extent practicable;
- Long term effectiveness by providing significant mass removal of PCBs and metals and a protective cap that would eliminate unacceptable exposures to sediment exceeding PRGs and eliminate sediment toxicity. The cap would be monitored, maintained and repaired over the long term to assure its continuing effectiveness;

- Restoration of natural habitats, benthic and other aquatic communities in approximately 6 acres of river habitat nearshore, through the use of habitat friendly protective capping and monitored natural recovery; and
- Implementation in a timely manner that should not unnecessarily delay redevelopment of OU-1.

11.2 DESCRIPTION OF RECOMMENDED REMEDIAL ACTION ALTERNATIVES

The recommended remedial action alternatives consist of the following primary elements, as shown in Figure 11.1:

- For the Northwest Corner Area following placement of berm material in the river, preparing OU-1 and placing the shoreline bulkhead, install a temporary rigid containment barrier approximately 50 ft from shore, cut timber pilings, remove debris, dredge to elevation -7 ft in the river adjacent to the shoreline, place a protective cap, and cut the temporary barrier near the mudline to form a submerged bulkhead. This recommended dredging would result in removing approximately 61 percent of the PCBs from sediment in Operable Unit 2.
- For the Southern Area, following placement of lightweight fill at Operable Unit 1 close to shore, following placement of the shoreline bulkhead, cut timber piles and remove debris in the river as needed, place a berm in the river as needed to support the shoreline, and place a protective cap in conjunction with the berm where PRGs are exceeded in surface sediment (which includes replacing aquatic habitat covered by the berm-cap).
- For the North Boat Slip, determine during remedial design whether placing a protective cap without prior dredging could be completed in conjunction with placing lightweight fill and the shoreline bulkhead at Operable Unit 1 without significantly decreasing river water depth. Following remedial design and placement of lightweight fill at Operable Unit 1 close to shore as well as following placement of the shoreline bulkhead, and if dredging is determined to be necessary, install a temporary silt curtain along the river side of the slip (unless the silt curtain for the Southern Area can be used), cut timber pilings, remove debris, dredge up to 2 ft on average, remove the temporary silt curtain, and place a berm within the slip as needed to support the shoreline and a protective cap where PRGs are exceeded in surface sediment. A similar remedy that is viable for the North Boat Slip would be to install a berm-cap without dredging but only if the net rise in the sediment mudline following berm-cap placement would be accepted as reasonable and necessary to meet regulatory requirements. Other measures at OU-1 would likely be needed to allow a berm-cap to be placed in the North Boat Slip without dredging prior to placing the berm-cap.
- For the South Boat Slip, monitor natural recovery to assure sediment PCB concentrations continue to be protective of human health and the environment over the long term. The primary element of natural recovery is ongoing gradual infilling of the South Boat Slip with sediment from the river that does not exceed sediment PRGs.

- For the Old Marina Area, following placement of the shoreline bulkhead along the southern shoreline of the marina (which is also the northern shoreline of the Northwest Corner Area), install a temporary silt curtain along the river side of the marina, cut timber pilings, remove debris (including a sunken barge), dredge up to 2 ft on average, remove the temporary silt curtain, and place a protective cap. AR may also complete additional dredging to allow recreational boats to access the marina in the future. Agreement as to the extent of additional dredging that may be completed would be worked out by AR with local property owners. Should dredging for recreational purposes not be conducted in the Old Marina, a similar remedy that is viable would be to install a cap without dredging but only if the net rise in the sediment mudline following cap placement would be accepted as reasonable and necessary to meet regulatory requirements. Other measures at OU-1 would likely be needed to allow a cap to be placed in the Old Marina without dredging prior to placing the berm-protective cap. As for the Southern Area and the North Boat Slip, an analysis of capping without dredging may be completed during remedial design to determine if capping, in conjunction with remediation of Operable Unit 1, could be implemented without dredging and not significantly reduce water depth in the Old Marina.

- For the Offshore Area, sediment PRGs are already being achieved on an area weighted average basis, but with scattered point exceedances. For the Offshore Area, remove the larger obstructions as needed and extend the NW-1 and SA-1 integrated berm-caps into the Offshore Area as needed based on the future design of remedies for the Northwest Corner and for the Southern Area. Then, monitor Offshore Area sediment conditions long term for natural recovery in uncovered portions based on sediment deposition and for berm-cap maintenance in covered portions. The purpose of monitoring for natural recovery would be to assure sediment concentrations of PCBs continue to be protective of human health and the environment over the long term. Like for the South Boat Slip, the primary element of natural recovery is ongoing gradual infilling with river sediment containing less than 1 ppm PCBs and less than the proposed PRGs for metals.

The recommended remedial action for the Northwest Corner Area, Southern Area, North Boat Slip and Old Marina Area would also include draining and/or dewatering dredged sediment as needed. Drained/dewatered sediment would be transported offsite to a permitted permanent containment facility, or if less than 10 ppm PCBs, reused as fill. Water brought on land from sediment dredging operations would be treated and released back to the river.

11.3 RECOMMENDED ALTERNATIVES AND EVALUATION CRITERIA

The recommended remedial action alternatives for OU-2 would meet the remedial action objectives for OU-2 and achieve the best balance among the various alternatives using the evaluation criteria specified in the NCP at 40 CFR Part 300.430. The evaluation of the recommended alternatives is summarized below. The recommended alternatives would be fully protective of human health and the environment, achieve remedial goals, and be implementable, effective, and permanent over the long term.

11.3.1 Overall Protection of Public Health and the Environment

The recommended alternatives are fully protective of human health and the environment. Sediment in excess of the 1 ppm PRG for PCBs and the proposed 982 ppm PRG for copper would be removed by dredging where practicable and residual sediment in excess of these PRGs would be contained beneath a protective cap. In fact, capping would provide sediment accessible to aquatic life that would be at or below background sediment concentrations for PCBs and for the site metals.

Dredging to a depth to remove the most contaminated sediment at OU-2, and capping would optimize habitat, minimize erosion effects, and provide chemical isolation to meet the PRGs. Dredging would remove sediment expected to pose the most risk to human and ecological receptors through direct toxicity to aquatic organisms and through accumulation of contaminants to fish that feed on bottom-dwelling organisms at OU-2. Capping would provide new sediment for benthic species colonization and protection against impacts from residual contamination that is unavoidable from any dredging effort. Additional dredging would not provide additional protection of human health and the environment, because residual contamination would need to be capped regardless of the extent of dredging conducted.

With the exception of Alternative NW-4, each of the recommended remedial action alternatives would effectively protect of human health and the environment; however, the higher extent of short-term releases of resuspended sediment to the river and associated greater risks to human health and the environment, longer construction timeframes, need to stabilize the shoreline bulkhead over the long term, and higher implementation costs for little added benefit (little additional removal of contaminant mass) are significant drawbacks for the remedial action alternatives not recommended for OU-2 that would include additional dredging. Alternative NW-4 would not be protective of human health and the environment, because penetrating the basal sand at the Northwest Corner would create cause a linear breach in the site confining layer near the area where DNAPL was previously confirmed. Such a breach would results in exceedances of groundwater quality standards for PCBs within the uncontaminated basal sand. Short-term impacts and exceedances of water quality guidelines and adverse short-term surface water quality impacts are unavoidable given the debris that would need to be removed. Silty sediment resuspending into the water column would not completely settle out of the water between dredging shifts and tidal cycles resulting in silty sediment escaping from the containment of a temporary barrier or silt curtain. Unavoidable short-term impacts also include construction worker accident potential during construction that would be greater for the remedial action alternatives that involve more dredging than for the recommended alternatives. Larger sediment volumes to dredge, greater dredging depths, and long timeframes required for construction would also result in more time needed before OU-1 could be fully redeveloped. The alternatives not recommended that include more dredging would also result in higher costs for small incremental increases in removal of PCB and metal mass from OU-2 sediment.

AR's recommended remedial action alternatives for OU-2 would protect human health and the environment, meet OU-2 remedial action objectives, meet SCGs to the extent practicable, meet PRGs, and provide the most balanced attainment of the NYSDEC evaluation criteria as determined through the comparative analysis presented in Sections 4, 6, 8, and 10 for all of remedial action alternatives. The recommended alternatives maximize the environmental and community value gained for the costs incurred. Unavoidable, adverse short-term impacts on river water quality due to resuspending sediment would be managed working with NYSDEC. Unavoidable local inconvenience during construction, such as noise and construction traffic, would be controlled to the extent practicable and in accordance with Village requirements. For the recommended alternatives, these impacts would be relatively short-lived. For example, the estimated duration of time for removing debris and obstructions and dredging under the recommended alternatives totals 6 to 8 months compared to up to 18 months for the alternatives that included the most dredging.

The December 2005 USEPA guidance on remediating contaminated sediment lists three residual risks associated with a protective cap, all of which can be controlled at OU-2 over the long term . The three residual risks are (USEPA, 2005a, page 3-16):

- cap erosion exposing contaminants;
- contaminant migration up through a cap; and
- risks from contaminants in uncapped areas.

At OU-2, the residual risk of cap erosion can be controlled by designing a cap with an erosion protection layer to protect the well-modeled hydrodynamic conditions of the lower Hudson River Estuary as discussed in Section 2.2. In addition, a protective cap placed at OU-2 would be monitored and maintained over the long term to minimize cap erosion. The residual risk of upward migration through a cap at OU-2 would be minimal as long as the basal sand is not penetrated at the Northwest Corner, because the sealed bulkhead at the shoreline would minimize flow of groundwater from the site that could transport contaminants upward into the river. In addition, a cap can be designed with a chemical isolation layer as discussed in Section 2.2 to attenuate residual site PCBs that could migrate upward. Residual risk associated with contaminants from uncapped areas would only apply possibly to the offshore area. Based on results from approximately 40 sampling locations in the offshore area, only five locations contained PCBs greater than 1 ppm in the top foot of sediment. The area weighted average PCB concentration in the top 2 feet of sediment in the offshore area is 0.2 ppm (see Table 1.1).

Contaminants will remain in place in OU-2 regardless of which OU-2 remedy is implemented. Sediment becomes resuspended due to removing debris and obstructions and dredging, Results from many completed dredging projects show that residual contamination remains after dredging (see Section 2.1). Capping is needed to reduce residual sediment concentrations in dredged areas to achieve the PRGs. The goal of any dredging project should be to remove a reasonable amount of contamination while minimizing resuspension with its adverse effects on water quality and ensuring the project can be completed in a reasonable timeframe (USEPA, 2005a). This goal is consistent with the remedial action alternatives recommended in this Supplemental FS Report for OU-2.

The December 2005 USEPA guidance on remediating contaminated sediment also lists 10 conditions conducive to capping, all of which are met at OU-2 (USEPA, 2005a, page 5-2). These 10 conditions are: (1) suitable types and quantities of available cap materials; (2) compatible infrastructure needs, such as piers and buried cables; (3) water depth to accommodate a cap; (4) controllable human actions, such as use of large boat anchors; (5) habitat can be restored; (6) hydrodynamic conditions such as floods, winds, and tides can be accommodated with the cap design. (7) groundwater would not release unacceptable quantities of contaminants through a cap; (8) sediment can support a cap; (9) contaminants have low rates of movement through a cap; and (10) areas can be entirely capped to avoid patch capping. Sand and gravel are available from quarries in counties north of the site. Impacts from infrastructure and human activities can be managed using institutional controls such as an environmental easement provided previously by NYSDEC for statewide application. Two feet or more of dredging is recommended in areas that can be contained so a cap can be placed even in shallow water areas. Habitat is expected to restore itself as part of a habitat top layer of a cap within 2 to 4 months of active river biological activity. Hydrodynamic conditions monitored for the lower Hudson River (such as Hurricane Floyd) have been included in an available hydrodynamic model for the lower Hudson River that was used to assess the long-term effectiveness and permanence of the protective cap. OU-2 sediment is capable of supporting a cap as presented in Section 2.2. Groundwater movement through a cap at OU-2 will be minimized once the sealed shoreline bulkhead being designed as part of the OU-1 remedy is installed. And finally, larger contiguous areas would be covered with a berm to help stabilize the shoreline bulkhead and with a protective cap.

11.3.2 Compliance with SCGs

The recommended alternatives would comply with all chemical-, location-, and action-specific SCGs to the extent practicable. Short-term, far-field NYSDEC water quality guidelines for PCBs while removing debris and obstructions and while dredging may not be able to be met as discussed in Section 11.3.1 above. The extent that these short-term water quality guidelines would be exceeded is higher under alternatives that include more dredging, particularly Alternatives NW-2 and NW-4 in the Northwest Corner.

The recommended alternatives would not result in the conversion of any water surface area to upland habitat or the loss of any water depth nearshore where waters are less than 6 ft deep.

11.3.3 Short-Term Effectiveness

Implementation of the recommended remedy has inherent short-term impacts typical of major construction projects. The short-term effects of this remedy during construction would include temporary loss of river habitat, temporary impacts on water quality during dredging and capping activities, increased risk of onsite worker accidents, increased risk of material transportation accidents, noise in particular while the bulkhead and temporary rigid barrier are being placed, localized odors where debris and dredged material are processed, and quality of life impacts such as temporary use restrictions along the river shoreline and at OU-1 construction support areas. These short-term impacts can be effectively managed to the extent practicable through the use of common engineering controls and through safe work practices.

11.3.4 Long-Term Effectiveness and Permanence

The recommended remedy would provide long-term effectiveness and permanence by either reusing dredged sediment onsite or placing dredged sediment at a permitted, secure facility offsite. Long-term effectiveness and permanence would also be provided by reducing contaminant exposure to benthic aquatic life at OU-2. The effectiveness and permanence of the recommended remedial action alternatives for OU-2 rely in part on the construction of a sealed shoreline bulkhead that would cut off ongoing migration of PCBs and metals to the river from OU-1. Long-term effectiveness and permanence would primarily be achieved by dredging and capping, by containment of the dredged sediments within a secure facility offsite, and by capping sediment offshore that exceeds PRGs. Effective ongoing monitoring and maintenance by AR and effective institutional controls would be important components of an effective and permanent protective cap.

11.3.5 Reduction of Toxicity, Mobility, and Volume Through Treatment

The recommended alternatives would reduce the toxicity, mobility, and volume of PCBs and metals through consolidation and draining/dewatering of dredged sediment, and through treatment of water from drained/dewatered sediment prior to release back into the dredged area work zone. Treatment of water resulting from drained/dewatered sediment would result in a reduction in the toxicity, mobility, and volume of PCBs and metals through treatment. Capping would also reduce the mobility of PCBs and metals remaining in the river sediment, although not through treatment.

11.3.6 Implementability

The recommended remedy is readily implementable. The technology, equipment, subcontractors, personnel, and facilities required to implement this remedy successfully and to monitor and maintain the protective cap are readily available. Dredging, capping, and post-remediation monitoring components are all readily implementable although challenges would become evident due to the tidal water level variation of 4 ft that occurs twice daily, the water current velocities that typically exceed 1 ft per second, and the many obstructions that are present. Geotechnical analyses presented in Appendix B have indicated that this remedy has an adequate factor of safety.

11.3.7 Cost and Cost Sensitivity

The estimated total cost of the recommended remedy is approximately $37 Million to $47 Million depending on which alternative is implemented for the Southern Area. This includes $34 Million or $44 Million in capital costs and a present worth value of $3 Million in operating and maintenance costs. Specific information about the cost estimates, including assumptions, is presented in Appendix E.

As shown in Table 11.1 and in Figure 11.2, it is estimated to cost approximately $1,400 per pound to remove PCBs from the Northwest Corner Area under Alternative NW-1. The cost of removal is substantially higher for the other alternatives in other areas, and capping is recommended at the only cost effective option for those areas.

11.4 REMEDIATION SEQUENCING

The Record of Decision for OU-2 is anticipated to be issued by NYSDEC during the third quarter of 2006, or in early 2007. Following issuance of the ROD, and the signing of the design consent order for OU-2, AR would conduct pre-design investigations as needed and perform the remedial design. Remediation of OU-2 would be planned in conjunction with and largely follow the northern area remedial excavation work that is part of the OU-1 remedy to avoid creating unstable structural loads on the shoreline bulkhead.

An important benefit of the recommended alternatives is that OU-1 remediation activities could continue independent of the remediation activities for OU-2. If significantly more dredging were to be conducted within OU-2 than is recommended, remediation activities for OU-1 would need to be delayed so the OU-2 design and implementation activities could catch up and be conducted at the same time as design and implementation activities for OU-1. Such a delay would likely add 2 to 3 years to the remediation timeframe before OU-1 could be redeveloped.

The recommended alternatives would allow OU-2 remedial activities to proceed following excavation and backfill at OU-1. Aquatic habitat replacement efforts would be part of the capping effort. Operation and maintenance of the remedy, including long-term monitoring of the protective cap, would commence after remedial activities are completed.

11.5 SUMMARY

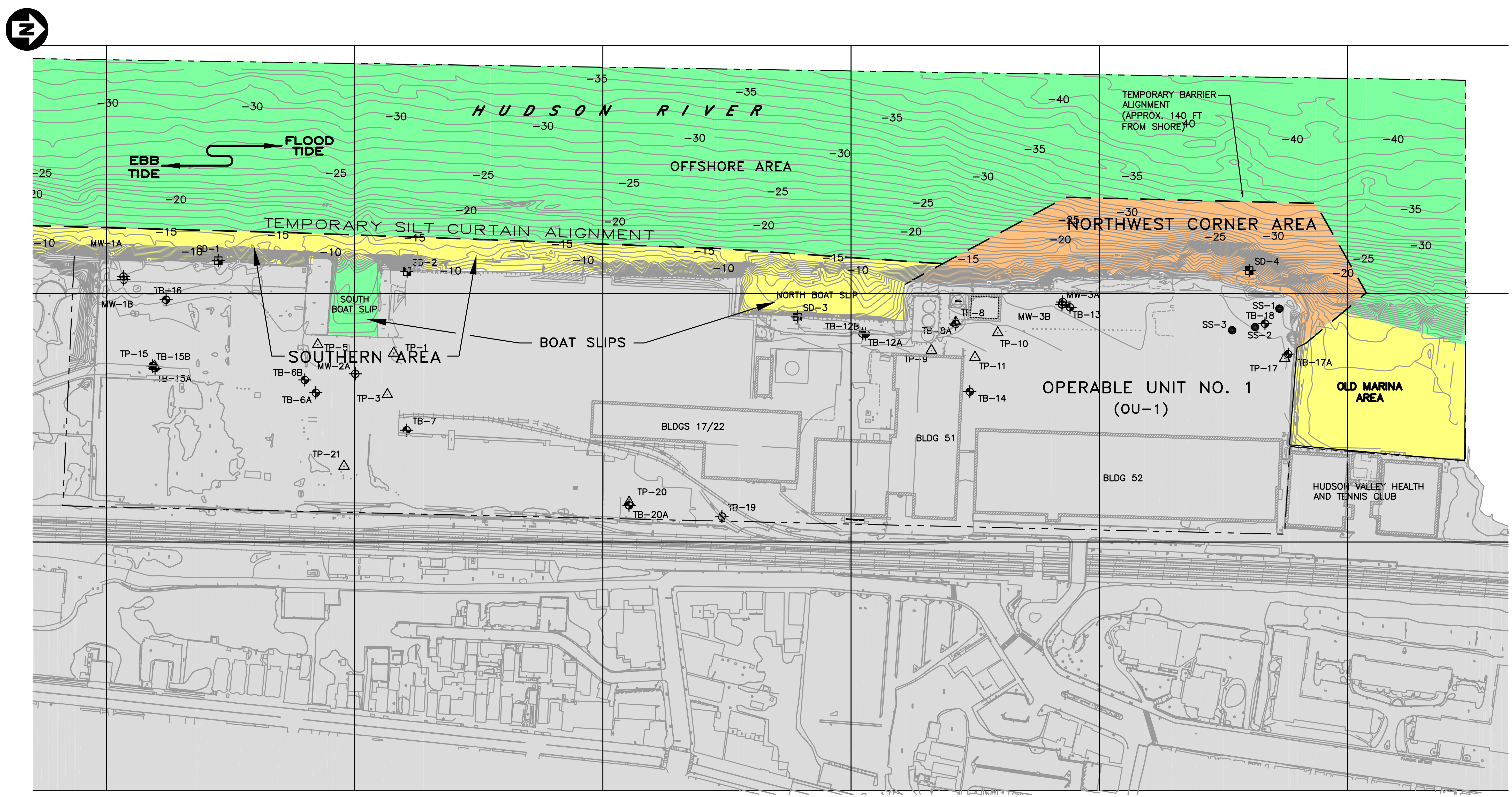
This Supplemental FS builds upon the conclusions reached in the OU-2 RI and the OU-2 FS reports to provide the basis for recommending appropriate remedial action alternatives to implement through an analysis of the site conditions, remedial goals and objectives, and technologies pertaining to the remediation OU-2 sediment. The remedy selection process used in this Supplemental FS is consistent with the New York State Environmental Conservation Law, the NY Code of Rules and Regulations, the National Contingency Plan regulations, and relevant NYSDEC and CERCLA guidance. The recommended alternatives include dredging to remove significant mass of PCBs and capping to provide the best combination of alternatives for individual areas within OU-2 based on a comparative analysis of all reasonable alternatives. In summary, AR's recommended alternatives for OU-2 would protect human health and the environment, replace temporarily lost aquatic habitat, and restore a nearshore portion of the Hudson River which would meet remedial action objectives and likely enhance local redevelopment opportunities at OU-1. Additional dredging prior to capping would not provide any additional protection of human health and the environment, compliance with SCGs, effectiveness, or other benefits. In fact, additional dredging would likely delay redevelopment of OU-1, because the remedies for OU-1 and OU-2 would need to be completed in conjunction with each other during the same timeframe.

TABLE 11.1

COST EFFECTIVENESS SUMMARY FOR THE OU-2 REMEDIAL ACTION ALTERNATIVES

HARBOR AT HASTINGS OU-2

Remedial Action Alternative	Dredge Volume (cubic yards)	Pounds of PCBs Removable Per Cubic Yard Dredged	Estimated Total Present Worth Cost Per Pound of PCBs Dredged
NW-1	5,900	2.8	$1,400
NW-2, Options A and B	19,000 and 27,000	0.8 to 1.1	$2,200 to $2,700
NW-3	18,000	0.03	$110,000
NW-4	51,000	0.5	$3,600
SA-2 through SA-4	6,900 through 16,000	Less than 0.002	$1.7 million to $2.3 million
NSlip-1 and NSlip-2	2,100 and 8,400	Less than 0.01	$260,000 and $280,000
OM-1 and OM-2	6,800 and 15,000	Less than 0.01 and 0.03	$460,000 and $390,000



NOTES:

1.) BASE MAP GENERATED BY BOSWELL, 2005.

2.) RIVER BATHYMETRY BASED ON ALPINE, 1997. VERTICAL DATUM IS BASED ON NAVD88.

3.) SHADED AREA IS OU-1 (ON SHORE).

LEGEND:

——— – – ———	APPROXIMATE STUDY AREA BOUNDARY
— —— —— —	TEMPORARY SILT CURTAIN OR BARRIER ALIGNMENT
(yellow)	CAP OR DREDGE 2 FT AND CAP (SOUTHERN AREA, NORTH BOAT SLIP & OLD MARINA AREA)
(orange)	DREDGE TO ELEVATION -7 FT AND CAP (NORTHWEST CORNER AREA)
(green)	MONITOR NATURAL RECOVERY (SOUTH BOAT SLIP AND OFFSHORE AREA)
(gray)	OPERABLE UNIT NO.1 (OU-1)

APPROXIMATE SCALE

200 100 0 200 400

SCALE: 1"=200'

FIGURE 11.1

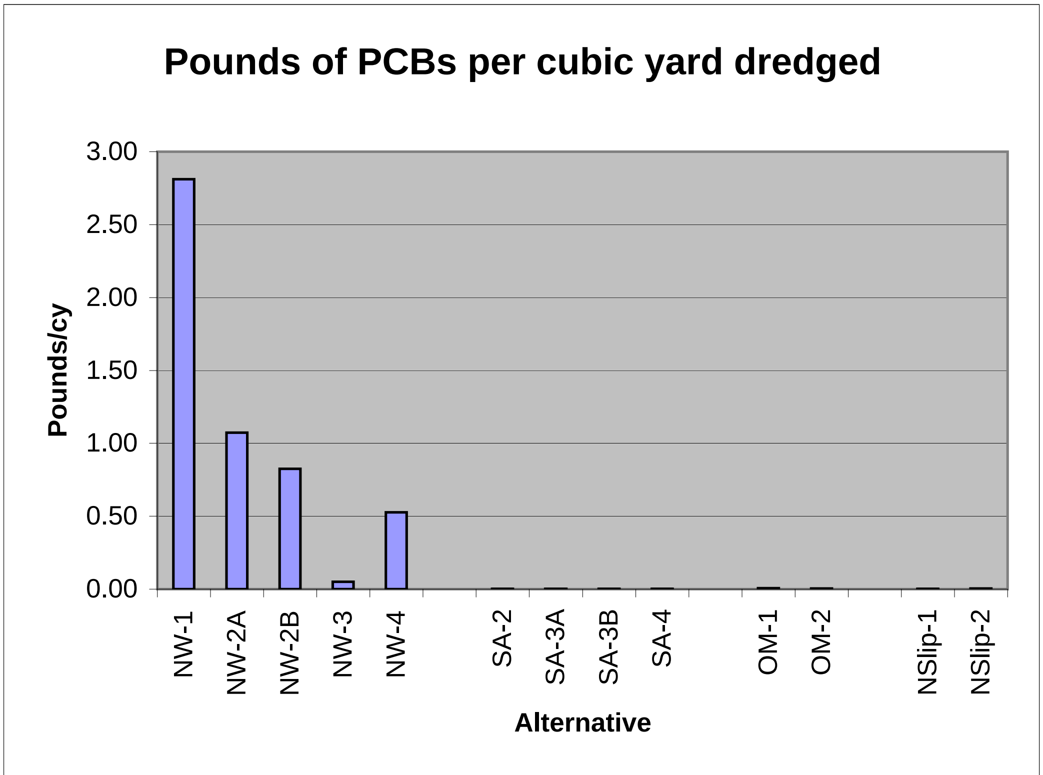
RECOMMENDED REMEDIATION ALTERNATIVES FOR OU-2 AREAS
HASTINGS-ON-HUDSON, NEW YORK

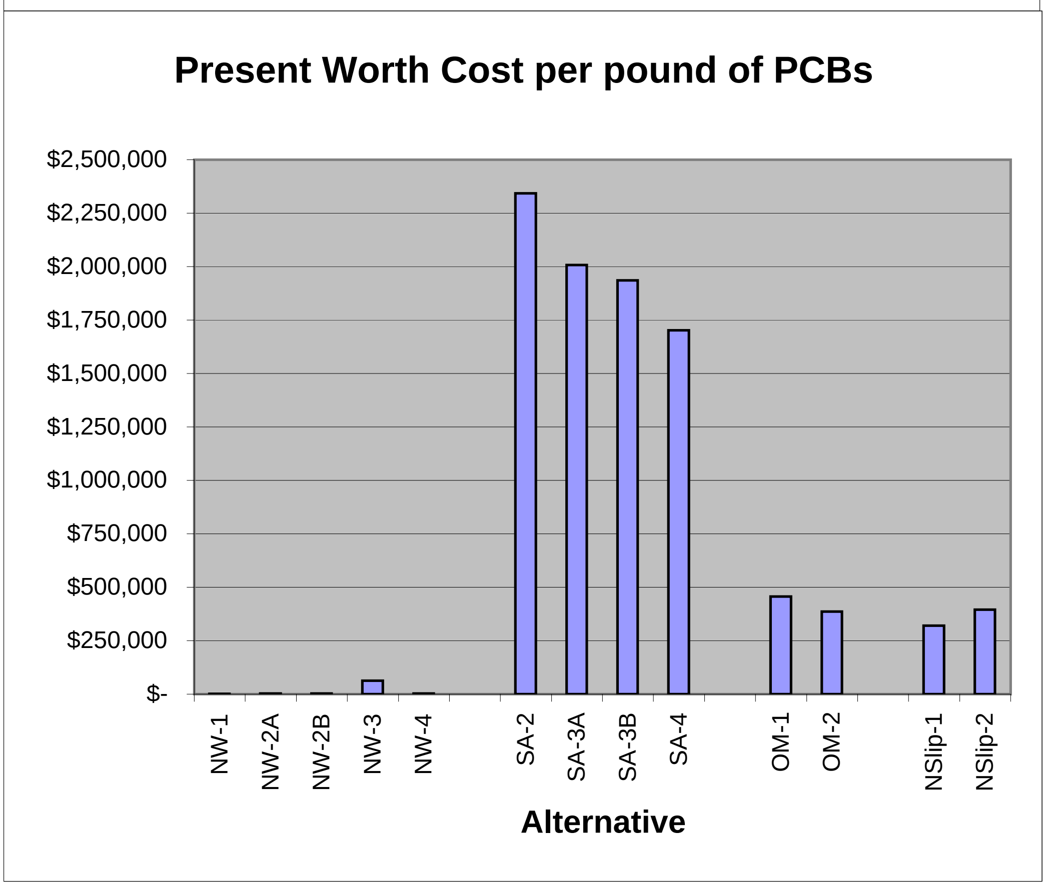
PARSONS

290 ELWOOD DAVIS ROAD, SUITE 312, LIVERPOOL, N.Y. 13088, PHONE: 315-451-9560

441532.01000 ** 1532C001A(FIG 11.1).DWG ** CLW **4/13/06

FIGURE 11.2
Remedial Alternative Effectiveness





SECTION 12

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- Memorandum II Supplemental Evaluation of Geotechnical Site Conditions Relative to Wall Structures and Capping,
- Memorandum III AR Supplemental Offshore Investigation Assessment of Feasibility of Capping and
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2005b Contaminated Sediment Remediation Guidance for Hazardous Waste Sites. Office of Solid Waste and Emergency Response, Washington, D.C. EPA-540-R-05-012. December.

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APPENDIX A

CONTAMINANT DISTRIBUTION MODELING BY ENVIRONMENTAL STANDARDS, INC. FOR HARBOR AT HASTINGS OPERABLE UNIT 2

APPENDIX A

TABLE OF CONTENTS

Page

TABLE OF CONTENTS
(CONTINUED)

LIST OF FIGURES

LIST OF ATTACHMENTS

APPENDIX A

CONTAMINANT DISTRIBUTION MODELING BY ENVIRONMENTAL STANDARDS, INC. FOR HARBOR AT HASTINGS OPERABLE UNIT 2

A1 INTRODUCTION

To aid in the assessment and evaluation of available analytical data, a three-dimensional contaminant distribution model has been developed for Harbor-at-Hastings Operable Unit No. 2 (OU-2). The model was developed by Environmental Standards, Inc. (Environmental Standards) for the Atlantic Richfield Company (AR) using the Mining Visualization System (Version 8.0) software package developed by CTech, Inc. The Mining Visualization System (MVS) software package allows for the modeling and display of environmental site data in a three-dimensional framework and has been used extensively by US EPA, other regulatory agencies, and industry. MVS utilizes Kriging, a geostatistical interpolation method based on a weighted moving average, for chemical distribution prediction. Constituents modeled by Environmental Standards include polychlorinated biphenyls (PCBs), copper, lead, nickel, and zinc in OU-2 sediment.

MVS was used by Environmental Standards to integrate data for OU-2 from a wide variety of project data sources. Modeled data include both historical data generated by New York State Department of Environmental Conservation (NYSDEC) and AR, as well as data generated from recently completed sampling efforts conducted by AR between November 2004 and November 2005. Previous OU-2 mapping performed by Earth Tech on behalf of NYSDEC was two-dimensional and was based on the highest concentration measured at each sample location. As a result, volumes and masses of constituents could not be quantified in three dimensions solely using the Earth Tech maps. In addition, validation results for NYSDEC data from validation work performed by Environmental Standards in 2003-2004 have been incorporated into the model. Available and acceptable OU-1 data were also included in the PCB model to increase data density in the model and reduce data uncertainties within OU-2.

The Environmental Standards model and the associated output was custom developed for OU-2 and is composed of individual grid cells that are 10 ft by 10 ft in size and 2 ft deep, resulting in an OU-2 model consisting of approximately one million cells. Environmental Standards modeling results for OU-2 constituents of concern are displayed as three-dimensional sampling locations, three-dimensional sediment volumes based on preliminary remediation goals for PCBs and metals, and three-dimensional Kriged geological surfaces. Predicted chemical volume and mass calculations from each of these cells have been used to develop remedial sediment volume and contaminant mass estimates for each remedial area (Northwest Corner, Southern Area, Boat Slips and Old Marina, and Offshore) and their associated scenarios. The modeling output allows for minimum, nominal, and maximum volume and mass predictions. Animations of the modeling output have also been created to display site conditions from different three-dimensional views. The MVS software developer (CTech) provided peer review of Environmental Standards' model input data, settings, and output.

A2 DATA ACCRETION AND MANIPULATION

Available and acceptable historical and contemporary OU-1 and OU-2 PCB and metals analytical data were used in the Environmental Standards model. Project analytical data were gathered from the sources listed below.

A2.1 Historical Data Sources

- Final Feasibility Study Report Harbor at Hastings Site (OU-2). NYSDEC/Earth Tech of New York. March 2003.
- Remedial Investigation Report for the Offshore Portion of the Harbor at Hastings Site (OU-2). NYSDEC/Earth Tech of New York. December 8, 2000.
- Remedial Investigation Report Harbor-At-Hastings Site Hastings-On-Hudson, New York. Prepared for ARCO Environmental Remediation, L.L.C. by IT Corporation. October 27, 2000.

A2.2 Contemporary Data Sources

- *Field Work Summary Report for Fall 2004 Atlantic Richfield Supplemental Offshore Investigation Former Anaconda Plant Site Operable Unit No. 2.* Prepared for Atlantic Richfield Company and ARCO Environmental Remediation, L.L.C. by Parsons. January 2005.
- *Field Work Summary Report for Summer 2005 Physical Site Characterization and Sediment Sampling Effort Former Anaconda Plant Site Operable Unit No. 2.* Prepared for Atlantic Richfield Company and ARCO Environmental Remediation, L.L.C. by Parsons. November 2005.
- Fall 2005 Field Sampling Summary Report – Focused AVS-SEM Sediment Sampling Operable Unit 2 (OU-2) of Harbor-at-Hastings Site (Site 3-60-022). Hastings-on-Hudson, New York. February 7, 2006.

A2.3 Data Validation

PCB and metals analytical data from the above-cited sources were incorporated into the Environmental Standards modeling data set. After consolidating all the data into a comprehensive project database, various operations were performed to create a data file for modeling purposes. The first operation performed was data validation to determine if the presented results were accurate, reliable, and acceptable for use in predicting PCB and metals distribution within OU-2. PCB and metals data generated during the contemporary sampling events conducted by AR in 2004 and 2005 have been validated. Validated results have been used for modeling purposes.

Between 2003 and 2004, Environmental Standards performed data validation on historical NYSDEC/Earth Tech PCB and metals data on behalf of AR. Details regarding the validation efforts are contained in "Correspondence to Mr. George Heitzman (NYSDEC) from Mr. Werner A. Sicvol (Atlantic Richfield Company) referenced as "The Harbor at Hastings Site (Site 3-60-022) Operable Unit 2" dated January 26, 2004". As a result of Environmental Standards' validation efforts, some data values were corrected and, therefore, the data set used by Environmental Standards for modeling purposes are not identical to those presented by NYSDEC in the 2000 Remedial Investigation Report (RI) and the 2003 Final Feasibility Study Report (FS). In addition, some data were qualified as a result of the validation efforts. Data determined to be unusable (rejected during validation) were not included in the modeling data set. All modeling data input results for metals and PCBs were converted to mg/kg (or parts per million – ppm).

AR evaluated the PCB Aroclor results reported in the NYSDEC data set produced in the OU-2 RI and FS reports. The results of this evaluation are detailed in "Comments on Select Aroclor Analytical Data Sets Generated by Earth Tech on Behalf of the New York State Department of Environmental Conservation for the Former Anaconda Wire and Cable Plant Site – Operable Unit 2" (contained herein as Attachment A.1). AR's evaluations, which extended to a review of the data packages, identified incorrect GC column reporting, incorrect identification of Aroclors (false positives), calculation errors, transcription errors, and grossly anomalous results for two field duplicate pairs. The revised data set reflecting the corrections and collective changes identified in Attachment A.1 was used in this model.

A2.4 Summation of PCB Aroclors

For modeling of PCBs, total Aroclor values were used. The total Aroclor value was calculated by summation of the individual Aroclor values at each sample location. Aroclors 1016, 1221, 1232, 1242, 1248, 1254, 1260, 1262, and 1268 were included in this summation. The summation method employed by Environmental Standards was identical to the method employed by NYSDEC/Earth Tech in the 2003 OU-2 FS.

A2.5 Treatment of Non-Detects

For modeling purposes, it was necessary to assign a value to sample results when a compound (PCB or metals) was not detected above the associated reporting limit (non-detects). Based on guidance from CTech, Inc. and previous experience with similar modeling projects, Environmental Standards assigned non-detects in OU-1 and OU-2 a value equal to 10% of the final reporting limit for each individual sample.

A2.6 Georeferencing of Sampling Locations

All data points were georeferenced for inclusion in the Environmental Standards model. Horizontal (X,Y) coordinates were available for historical and contemporary data based on either global positioning system (GPS) measurements or professional land surveys. Environmental Standards determined vertical coordinates by plotting the data point on a geographic information system (GIS) project basemap. Elevations within the GIS basemap were provided by previous bathymetric and topographic surveys conducted at the project site by Alpine Ocean Seismic Survey, Inc. (bathymetry) (presented as Appendix A in the 2000 OU-2 RI report by Earth Tech) and by Boswell Engineering (land topography) (completed during 2005). Once a data point was plotted on the basemap, a top-of-sediment (also called mudline) elevation (in the case of OU-2) or a surface elevation (in the case of OU-1) was determined. Elevations of individual depth intervals were determined based on distances below the mudline or ground surface.

A2.7 Stratigraphic Data

Stratigraphic information from available boring logs and tabulated boring log data contained in the historical project reports as well as stratigraphic data acquired during the recent AR sampling events were used to model geological units within OU-2. A geological data input file was created by interpreting the stratigraphic data and determining depths below mudline, or ground surface, where stratigraphic changes occurred. For the purposes of modeling, each data point with available stratigraphic information, was classified and grouped into one of the following geologic units: fill, soft sediments, marine silt, and basal sand. After the geological data file was created, MVS was used to create Kriged geological surfaces, thus resulting in a “geological model”. Creation of the geological model allowed for interpretation of the extent of chemical distribution within each geological unit and identification of anomalous stratigraphic and chemical distribution data.

A2.8 Borings Located Beyond the Limits of Bathymetry

The following borings that were advanced by NYSDEC/Earth Tech were located beyond the limits of the available bathymetry for OU-2: EB-4, EB-5, EB-6, EB-7, EB-8, EB-9, EB-18, EB-32, EB-33, EB-35, EB-37, and EB-38. Accurate mudline elevations are required for the areas around each of these borings in order to properly model the associated data. Since mudline elevations were not available for the areas located beyond the limits of the available bathymetry, the data from these borings were not included in the Environmental Standards PCB or metals modeling data sets. Of these borings, only EB-8, EB-35, and EB-38 contained PCB concentrations above 1 ppm.

A2.9 Additional Data Exceptions

A2.9.1 RB-20

During evaluation of the PCB and geologic modeling results, several anomalies were observed at boring RB-20. RB-20, which was collected in 1998, was advanced using drive and wash methods and sampling was conducted via split spoon samplers. The data from sediment samples collected at RB-20 were previously classified by AR as "unreliable based on field sampling issues". Specifically cited sampling issues included poor recoveries, no specific recovery data, and no blow count data. In addition, the depth of the marine silt layer was significantly deeper at RB-20 than nearby borings and the PCB analytical data did not appear consistent with neighboring samples (*e.g.*, PCB contamination was much deeper at RB-20). Two vibracore borings, SD-50 and SD-52, were advanced during the summer 2005 PCB sampling effort conducted by Parsons on behalf of AR in an attempt to bound the predicted PCB plume associated with the reported RB-20 chemistry and depth data. SD-50 was collected 14.7 ft away from RB-20 and SD-52 was collected 34.2 ft from RB-20. Based on PCB analytical results and stratigraphic information obtained at SD-50 and SD-52, AR and Environmental Standards determined that the PCB sample depth and stratigraphic data previously reported for RB-20 were unreliable and, therefore, were not included in the PCB modeling data set.

RB-20 was omitted from the modeling data set for the following reasons:

- RB-20 was previously classified as "unreliable based on field sampling issues." The accuracy of the depth intervals was highly suspect due to these issues.
- Two borings were advanced in the immediate vicinity of RB-20 with high recoveries and high confidence in the depth intervals during the summer 2005 AR sampling effort.
- The stratigraphy in these borings was starkly different than that reported from RB-20. Specifically, the marine silt layer was reportedly encountered at approximately 22 ft below the mudline in RB-20. The marine silt layer in SD-50 and SD-52, however, was approximately 10 ft below the mudline.
- PCB data are remarkably different. Specifically, elevated PCB concentrations were present in RB-20 at significantly deeper depths compared to SD-50, SD-52, and other nearby samples.

A2.9.2 OU-1 Data

PCB Modeling. OU-1 data were included in the modeling data set for PCBs. The site conceptual model of PCB deposition and transportation through the subsurface (underground flow of PCB-containing dense non-aqueous phase liquid in the Northwest Area) from OU-1 to OU-2, as presented in the RI, is consistent with the use of OU-1 data for modeling purposes. The use of OU-1 PCB data in the model increased data density and helped to reduce data uncertainties within OU-2.

Metals Modeling. For the modeling of metals in OU-2, however, OU-1 data were not included in the modeling data set. The site conceptual model of metals deposition as presented in the RI indicates that metals were deposited in OU-2 as metals-laden wastewater via discharges such as outfall pipes. As such, the inclusion of OU-1 metals data in the model was not warranted.

Figures A.1 through A.5 present the OU-2 data sets used by Environmental Standards for modeling of PCBs, copper, lead, nickel, and zinc.

A3 VISUALIZATION

Once detailed data analysis, compilation, and validation tasks were completed, the focus of Environmental Standards' efforts shifted to presentation of results. A web-based Geographical Information System (GIS) is currently employed to convey visual information to the project team.

During the course of the project, various data sources (*e.g.*, bathymetry, side-scan sonar imagery, building features, magnetometry data, and aerial photographs) were consolidated in a visual framework that allowed for a straightforward comparison of data sets. Query tools were also used to interactively view and download selected analytical data sets.

Figures 1.4 and 1.5 in this Supplemental FS Report are 3-dimensional visualization of PCBs greater than 1 ppm and copper greater than 982 ppm, respectively.

A3.1 Three-Dimensional Modeling

The modeling results for each constituent of concern were displayed as three-dimensional sampling locations, three-dimensional sediment volumes based on action levels for PCBs and metals, and three-dimensional Kriged geological surfaces.

A3.2 Kriging

The MVS model performs all interpolation using a geostatistical process called Kriging. Kriging is a weighted moving average interpolation (extrapolation) method that minimizes the estimated variance of a predicted point (node) with the weighted average of its neighbors. The weighting factors and the variance are calculated using a semivariogram model that describes the differences versus distance for pairs of samples in the input dataset. In MVS, the difficult process of determining an optimal semivariogram model is automated with an expert system.

A3.3 Model Setting Adjustments

The models were built on a grid that incorporated both OU-2 and OU-1 data points for PCBs and OU-2 data points only for metals. The grid used is 3030 ft long, 940 ft wide, and 100 ft in elevation. Individual grid cells are 10 ft by 10 ft in size and 2 ft deep. After the cells above the mudline and ground level are removed, the model consists of approximately one million cells. Horizontal and vertical anisotropy settings were extensively evaluated and have been set to a reasonable value based on available site data, professional judgement based on Environmental Standards' previous modeling experience, and Ctech's peer review.

A3.4 Uncertainty Analysis

An 80% confidence minimum, nominal, and maximum value was also calculated for each modeling cell. This information was used to determine minimum-maximum volume of contamination ratios for particular remedial areas. The ideal ratio is 1.0 (*i.e.*, no variation between minimum and maximum values) with higher numbers indicating increasingly poor characterization of the site.

A3.5 Additional Data Manipulations

After a thorough review of the modeling output, it was determined that certain areas within the model deserved additional attention due to factors such as high uncertainty, elevated laboratory reporting limits, and validation changes. The following is a description of the instances where additional data manipulations were performed based on the modeling output review.

A3.5.1 PCBs in the Southern Area

In the Southern Area, several modifications to the standard modeling assumptions were made related to PCB distribution predictions. Data validation changes for incorrect Aroclor identifications were reset to their pre-validation values. There were several results that were set at “non-detect” as a consequence of validation that have since been reset to the original laboratory value. Specific non-detects were also removed from borings in the Southern Area to limit the constraining effect that non-detects were exhibiting within the model. The typical southern boring is characterized by a 10-foot penetration (approximately), had surficial detections of PCBs, and little, if any, detections below the first one or two depth intervals. In borings displaying these characteristics, non-detects between the surficial detection(s) and the bottom most non-detect were removed. The non-detect from the lowest depth interval in the boring remained in the model for bounding purposes.

A3.5.2 CS Series Borings

NYSDEC/EarthTech collected a series of core samples in October 1999 using viboracore technology. These borings were identified as CS-01 through CS-48 (CS series borings). A significant number of the samples collected from the CS series borings exhibited unusually high laboratory reporting limits. Environmental Standards honored all detections from the CS series borings, but the non-detects from these borings were handled differently from the other non-detects in the modeling data set. Since using 10 percent of the final reporting limit was not a feasible option for the samples from the CS series borings due to the high reporting limits, a value of 0.01 mg/kg was assigned to non-detects from the CS series samples. The 0.01 mg/kg value was based on an evaluation of average method detection limits (MDLs) for Aroclors within the PCB modeling data set. The average Aroclor MDL was approximately 0.001 mg/kg. Based on previous modeling experience and professional judgment, Environmental Standards used a value of 10 times the average MDL as a reasonable non-detect value for the CS series borings.

A3.5.3 Predicted Copper Concentrations Above 982 ppm

Based on metals toxicity study results, one of the modeling scenarios evaluated during the OU-2 copper modeling effort was copper concentrations above the 982 ppm PRG proposed for copper. A detailed analysis of the modeled copper plume above 982 ppm and the copper analytical dataset was performed. The maximum depth where copper concentrations above 982 ppm were found in the analytical dataset was 5 ft below the mudline. Based on this result, a two ft buffer was added and the modeled copper plume above 982 ppm was constrained at 7 feet below the mudline throughout OU-2 for volume and mass estimating purposes.

A3.5.4 Predicted Concentrations of Lead, Nickel, and Zinc Exceeding PRGs

Modeling scenarios were also developed for lead, nickel, and zinc within OU-2 sediment based on proposed sediment PRGs of 379 ppm for lead, 160 ppm for nickel, and 1050 ppm for zinc (see Appendix C for a discussion of how these proposed PRGs were developed). Maximum depths where lead above 379 ppm, nickel above 160 ppm, and zinc above 1050 ppm were found were 5, 1, and 9 ft below the mudline, respectively. Figures A.6, A.7, and A.8 are 3-dimensional visualizations of lead greater than 379 ppm, nickel greater than 160 ppm, and zinc greater than 1050 ppm respectively. The modeled zinc plume above 1050 ppm was constrained at 11 feet below the mudline throughout OU-2 for volume and mass estimating purposes.

A4 MODEL OUTPUT AND ANALYSIS

The MVS modeling environment is very strong in visualization and in providing high-level or large-area mass and volume calculations. The size of this project, the spatial complexity, and the number of constituents were drivers for developing methods to perform analysis at a more detailed level than available using EVS. To support the needs of the project, data were exported from the model and manipulated to enable the team to better understand the site. Two specific functions were needed in order to support this fine analysis: an export function in EVS that created detailed data and a data aggregation function that enabled analysis of the exported data by individual remedial scenarios.

Two custom pieces of software were written to address the needed functions. A module was written for MVS that enabled a highly detailed export of the site model to be created, and a series of database functions were created to provide the remedial scenario volume and mass aggregation function. Details for the custom software and outputs are provided below.

A4.1 Modeling Environment Export Functionality

As indicated in Section A1, the spatial model is a rectilinearly-bound space 3030 ft long, 940 wide, and 100 ft in elevation. This space is divided into cells 10 ft x 10 ft x 2 ft high. Each cell potentially is further subdivided into as many as 5 tetrahedrons depending on the complexity of the cell based on its location with respect to geology or contamination. Each cell or sub cell has associated data that is written as an individual record in the export. The exported data output based on this matrix potentially has between 1.4 and 7.1 million records for each constituent. In practice, the typical record count was roughly 1.2 million records. The data elements available in the export are shown on Table A.1.

Table A.1 – MVS Export Elements

Data Element	Description
Analyte	The name of the Analyte being modeled
X Center	The X coordinate of the cell or sub cell
Y Center	The Y coordinate of the cell or sub cell
Z Center	The Z coordinate of the cell or sub cell
ISO Level	The ISO_Level of the constituent to be addressed in this scenario
Total Volume	The total volume of the cell or sub cell in cubic yards
Overburden Volume	The volume of the cell or sub cell that is calculated to be Overburden in cubic yards
Soil Volume	The volume of the cell or sub cell that is calculated to be contaminated in cubic yards
Chemical Mass	The mass of the predicted contamination in lbs for the cell or sub cell in pounds
Average Concentration	The average concentration of the Analyte in the cell or sub cell in PPM
Min Soil Volume	Predicted volume at -1.5 Standard Deviation
Min Chemical Mass	Predicted mass at -1.5 Standard Deviation
Max Soil Volume	Predicted volume at 1.5 Standard Deviation
Max Chemical Mass	Predicted mass at 1.5 Standard Deviation

Data were exported for PCBs and metals at several ISO levels. Total count exceeded seven million and disk space exceeded two gigabytes for cell and sub-cell mass and volume records. Due to the high record count and disk space, these data are stored and retrieved from an Oracle Relation Database Management System (RDBMS).

A4.2 Data Aggregation Functionality

Database functions have been written to support the definition of potential contaminated soil removal or remedial scenarios, to take into account various factors in defining the actual volume of space addressed by an individual scenario, and to provide summary level and detailed output of all constituents found within that volume. The process defined below addresses the exported data using Visual Basic (VB) and Structured Query Language (SQL). The steps for any given remedial scenario analysis are as follows:

- Create the remedial scenario area definition.

  The horizontal definition is created using a GIS system. A plan view of each area of concern is developed. The grid of cells in the model is queried using this plan view to develop a set of columns identified by an X and Y centriod coordinate. This set of centroid coordinates representing column locations are used in setting the vertical limit for any potential contamination removal scenario.

  The vertical limit for each column in the area is set by reviewing the proposed remedial scenario specifications and applying planned dredge elevations appropriately to the centroid coordinate. A cross-section of the proposed scenario is most useful for determining the per column planned removal bottom elevation. Once the columns centriod data are established, other values for each column are applied such as elevations for mudline, and the marine silt layer.

  The scenario area data definition is provided on Table A.2.

Table A.2 – Remedial Scenario Data Definition

Data Element	Description
Scenario Name	The Remedial Scenario name
X_COORD	The X coordinate of the columns centroid
Y_COORD	The Y coordinate of the columns centroid
Elevation_Planned	The elevation of the planned dredge depth
Elevation_MarineSilt	The elevation of the marine silt layer
Elevation_Mudline	The elevation of the mudline

- Define the Scenario Volume and Mass Runtime Options

  Each scenario will be defined by several key aspects in addition to the overall horizontal and vertical extent defined above. Within this extent, only a portion of the volume is affected by specific contamination profiles. Setting the options shown on Table A.3 will determine the basis for querying the cell level data and producing the summary level output.

Table A.3 - Scenario Volume and Mass Runtime Options

Data Element	Description
Scenario	The Remedial Scenario name
Description	A description of the scenario
Creation Date	Date the scenario was created
Number of Columns	Number of columns or centriods in the scenario
Use_Planned_Depth	True/False - Depths can be define as a specific lowest elevation or to bottom of contamination
PCB	True/False - Base volume calculations on existence of this constituent in a particular cell
PCB_ISO	The ISO_Level of the constituent to be addressed in this scenario
Copper	True/False - Base volume calculations on existence of this constituent in a particular cell
Copper_ISO	The ISO_Level to of the constituent to be addressed in this scenario

- Data Process

  The data process consists of five key steps:

  - Generate the scenario specific volume based on the runtime options.
  - Query the cell level data within the specific volume.
  - Calculate clean overburden.
  - Create summary volume and mass values.
  - Output detailed volume and mass data by column.

  Data are processed in five main steps: generate the scenario specific volume based on the runtime options, query the cell level data within the specific volume, calculate clean overburden, create summary volume and mass values, and output detailed volume and mass data by column. These tasks are described in more detail as follows.

- Generate Scenario Specific Volume

  Within a given area scenario's defined horizontal and vertical limits exists a predicted volume of contaminated material. The entire volume of the scenario will not typically be contaminated. Within each individual 10 x 10 column of cells for a given centroid, there exists a top of contamination and a bottom of contamination. This step in the process will review the data in each column and determine the top and bottom values. If contamination is not encountered, the column is considered to be clean. This process is fairly straightforward for a volume that has only one constituent to consider. For scenarios where multiple constituents define the removal volume, the process is repeated for each subsequent constituent, and the top and bottom results are compared to the initial values. If the subsequent tops are greater and / or the subsequent bottoms are less than the previous values, the appropriate value for each column is revised.

- Query the Cell Level Data within the Generated Volume

  After the generation of the specific volume in a given scenario is completed, data are queried based on the previously determined tops and bottoms for each column of the area. The purpose in separating the volume determination step from the data query step is to allow for the existence of individual constituents within the volume that are not drivers for the removal to be queried and summarized. Only columns that have a defined top and bottom will be addressed in this query operation. These data are used directly in summarizing the removal values for a particular scenario

- Calculate Clean Overburden

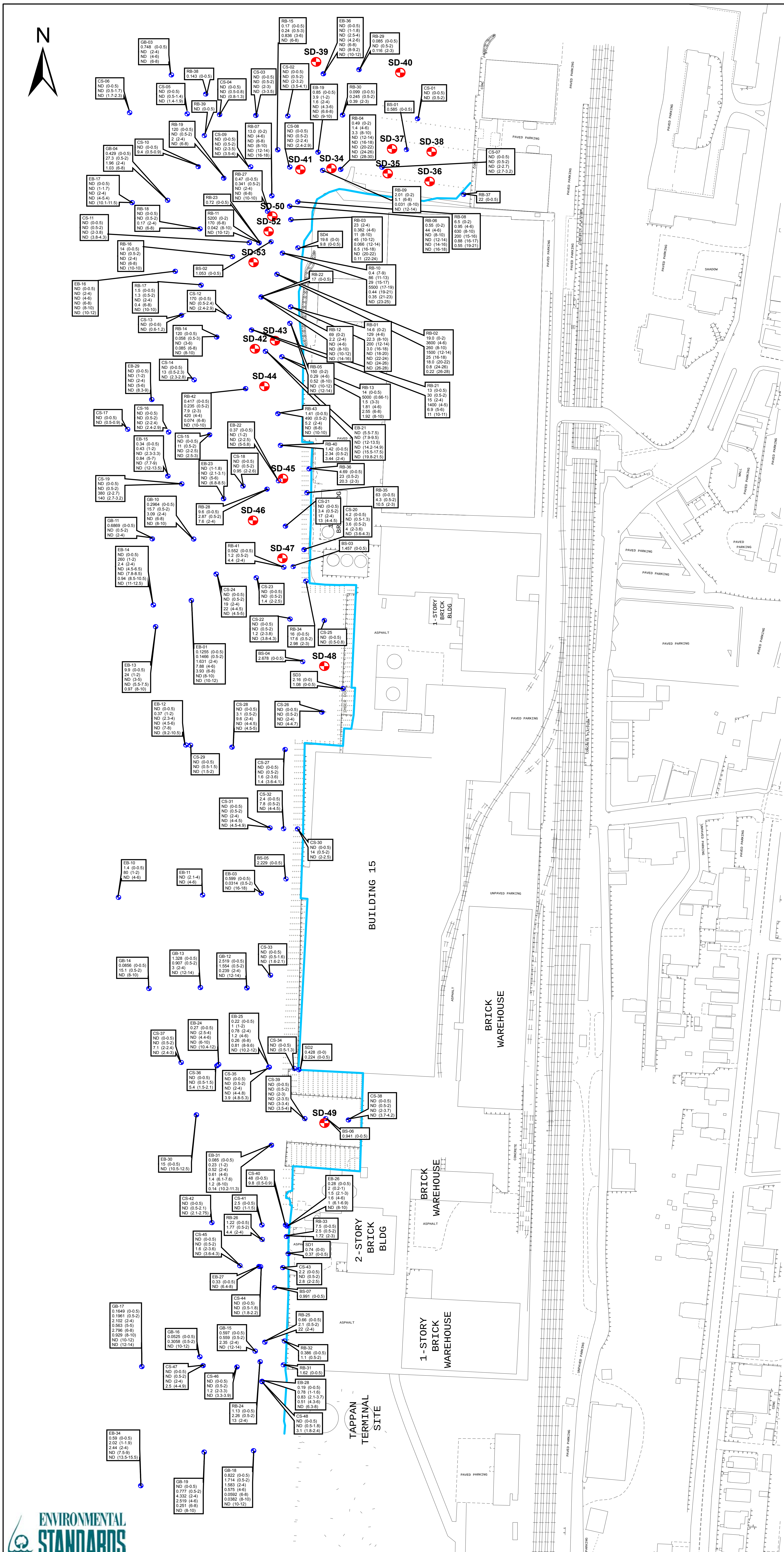
  There is a possibility that clean material may be located within the specified volume and above the top of predicted contamination. This volume is calculated by reviewing each column within the area for which a top of contamination exists and calculating the volume between the top of contamination and the mudline. These data are used directly for summarizing the overburden in a given scenario.

- Create Detailed Volume and Mass Data by Column

  Data collected at a detailed level are available for each column in an area. The data are summarized by column for chemical mass, contaminated volume, overburden volume, and total volume in cubic yards. Tables for detailed depths by column are also generated providing values for the planned depth of the column, the top and bottom of contaminates, and the mudline elevation.

- Create Summary Volume and Mass Values for each Area

  Data for volume and mass for each area, irrespective of column location are summarized into area-wide values by constituent. Summarized data are available for overall chemical mass, contaminated volume, overburden volume, and total volume in cubic yards.



FORMER ANACONDA PLANT SITE
OPERABLE UNIT No. 2

Atlantic Richfield Company and
ARCO Environmental Remediation, LLC

Village of Hastings on Hudson
Westchester County, New York

SUMMER 2005 SAMPLING SUMMARY

SD-34	SD-35	SD-36	SD-37	SD-38
1.13 (0-2)	5.1 (0-2)	1.75 (0-2)	0.37 (0-2)	2.54 (0-2)
3.75 (2-4)	6.8 (2-4)	0.84 (2-4)	2.95 (2-4)	7.17 (2-4)
2.06 (4-6)	2.56 (4-6)	3.29 (4-6)	2.95 (4-6)	5.95 (4-6)
2.76 (6-8)	ND (6-8)	11.6 (6-8)	2.42 (6-8)	ND (6-8)
13.8 (8-10)	ND (8-10)	ND (8-10)	ND (8-10)	ND (8-10)
17 (10-12)	ND (10-12)	ND (10-12)	ND (10-12)	ND (10-12)
ND (12-14)	ND (12-14)	ND (12-14)	ND (12-14)	ND (12-14)
ND (14-16)	ND (14-16)	ND (14-16)	ND (14-16)	ND (14-16)
ND (16-18)	ND (16-18)	ND (16-18)	ND (16-18)	ND (16-18)
ND (18-20)	ND (18-20)	ND (18-20)	ND (18-20)	ND (18-20)
ND (20-22)	ND (20-22)			
ND (22-24)	ND (22-24)			
ND (24-26)				
ND (26-27.5)				

SD-39	SD-40	SD-41	SD-42	SD-43
0.36 (0-2)	0.47 (0-2)	ND (0-2)	ND (0-2)	2.06 (0-2)
1.33 (2-4)	2.08 (2-4)	ND (2-4)	0.43 (2-4)	81 (2-4)
7.5 (4-6)	2.22 (4-6)	1.28 (4-6)	23.1 (4-6)	9200 (4-6)
19.2 (6-8)	3 (6-8)	2.74 (6-8)	0.56 (6-8)	14.3 (6-8)
ND (8-10)	ND (8-10)	12.5 (8-10)	ND (8-10)	66 (8-10)
ND (10-12)	ND (10-12)	1.7 (10-12)	ND (10-12)	2.37 (10-12)
ND (12-14)	ND (12-14)	ND (12-14)	ND (12-14)	0.5 (12-14)
ND (14-16)	ND (14-16)	ND (14-16)	ND (14-16)	0.91 (14-16)
ND (16-18)	ND (16-18)	ND (16-18)	ND (16-18)	ND (16-18)
ND (18-20)	ND (18-20)	ND (18-20)	ND (18-20)	ND (18-20)

SD-44	SD-45	SD-46	SD-47	SD-48
ND (0-2)	6.3 (0-2)	0.86 (0-2)	2 (0-2)	0.4 (0-2)
ND (2-4)	4.21 (2-4)	0.96 (2-4)	6.6 (2-4)	2.83 (2-4)
ND (4-6)	6.4 (4-6)	ND (4-6)	5.09 (4-6)	5.69 (4-6)
ND (6-8)	1.54 (6-8)	ND (6-8)	7.3 (6-8)	7.7 (6-8)
ND (8-10)	ND (8-10)	ND (8-10)	ND (8-10)	8.6 (8-10)
ND (10-12)	ND (10-12)	ND (10-12)	ND (10-12)	14.9 (10-12)
ND (12-14)	ND (12-14)	ND (12-14)	ND (12-14)	1240 (12-14)
ND (14-16)	ND (14-16)	ND (14-16)	ND (14-16)	18.9 (14-16)
ND (16-18)	ND (16-18)	ND (16-18)	ND (16-18)	4.2 (16-18)
ND (18-20)		ND (18-20)	ND (18-20)	

SD-49	SD-50	SD-52	SD-53
ND (0-2)	ND (0-2)	153 (0-2)	1960 (0-2)
ND (2-4)	ND (2-4)	31.1 (2-4)	24.7 (2-4)
0.38 (4-6)	9.1 (4-6)	290 (4-6)	9.5 (4-6)
0.71 (6-8)	ND (6-8)	34.3 (6-8)	4.5 (6-8)
1.25 (8-10)	ND (8-10)	6 (8-10)	3 (8-10)
2.02 (10-12)	ND (10-12)	13.3 (10-12)	ND (10-12)
2.02 (12-14)	ND (12-14)	ND (12-14)	ND (12-14)
2.11 (14-16)	ND (14-16)	ND (14-16)	ND (14-16)
2.67 (16-18)	ND (16-18)	ND (16-18)	ND (16-18)
5.96 (18-20)	ND (18-20)	ND (18-20)	ND (18-20)
	ND (20-22)		
	ND (22-24)		
	ND (24-26)		
	ND (26-28)		
	ND (28-30)		

Legend

- Shoreline
- Piling Line
- Piling
- PCB Sample Locations
- Summer 2005 Sample Locations

CS-28	Sample Location ID
ND (0-0.5)	First Column:
3.1 (0.5-2)	Sediment total PCB concentrations in mg/Kg (USEPA SW846
9.6 (2-4)	Method 8082).
ND (4-4.5)	Second Column:
ND (4.5-5)	Depth range where PCB sample was collected.
	Depth is in feet below mudline.

FIGURE A.1 ENVIRONMENTAL STANDARDS
OU2 PCB MODELING DATA SET

0 100 200 300 400 500 600
SCALE IN FEET

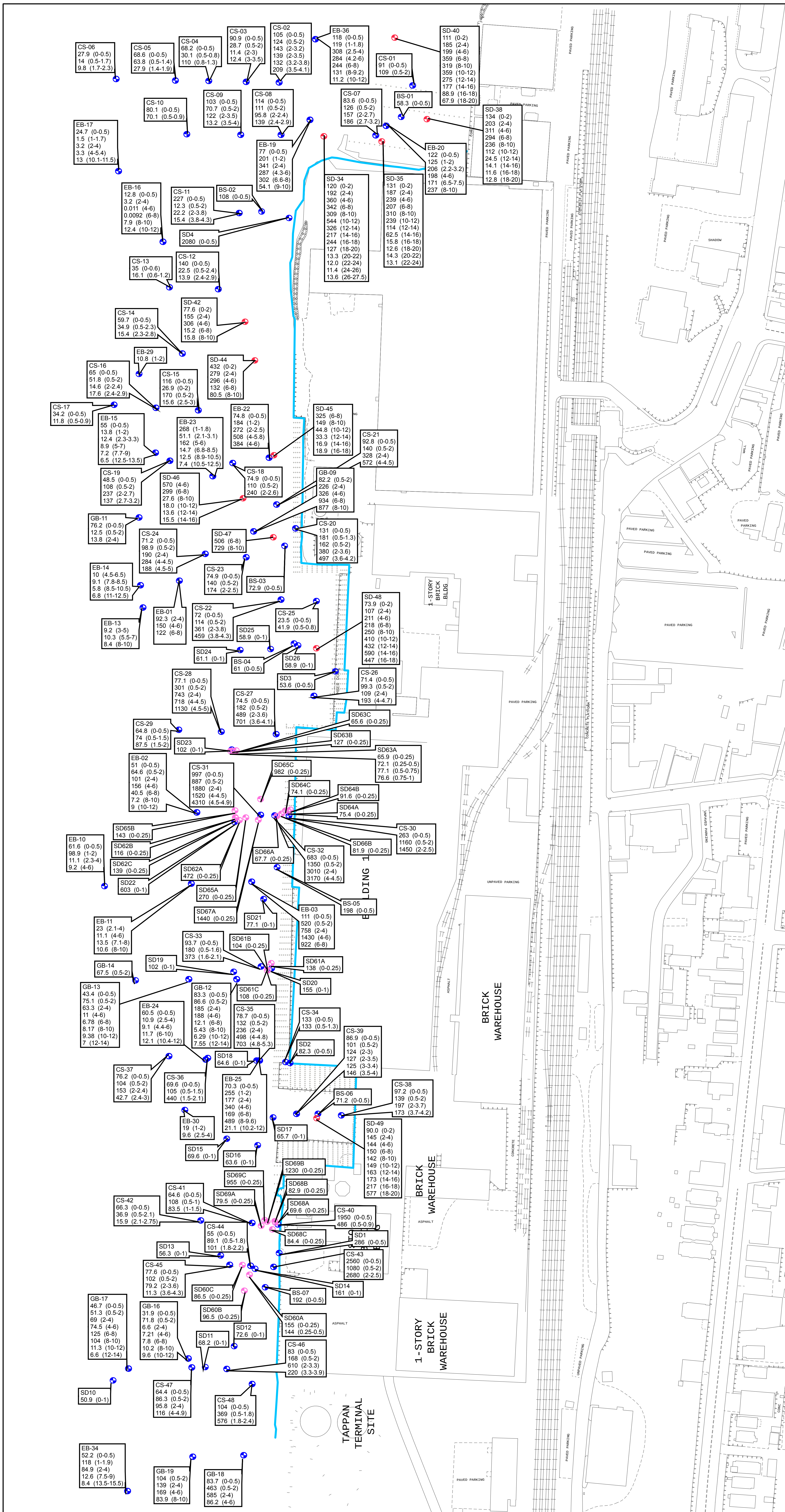
MARCH 14, 2006

ENVIRONMENTAL STANDARDS

FORMER ANACONDA PLANT SITE
OPERABLE UNIT No. 2

Atlantic Richfield Company and
ARCO Environmental Remediation, LLC

Village of Hastings on Hudson
Westchester County, New York



Legend

- 2005 AVS/SEM CU Sample Locations
- Summer 2005 CU Sample Locations
- Historic CU Sample Locations
- Shoreline
- Piling Line
- Piling

CS-20	
131	(0-0.5)
181	(0.5-1.3)
162	(0.5-2)

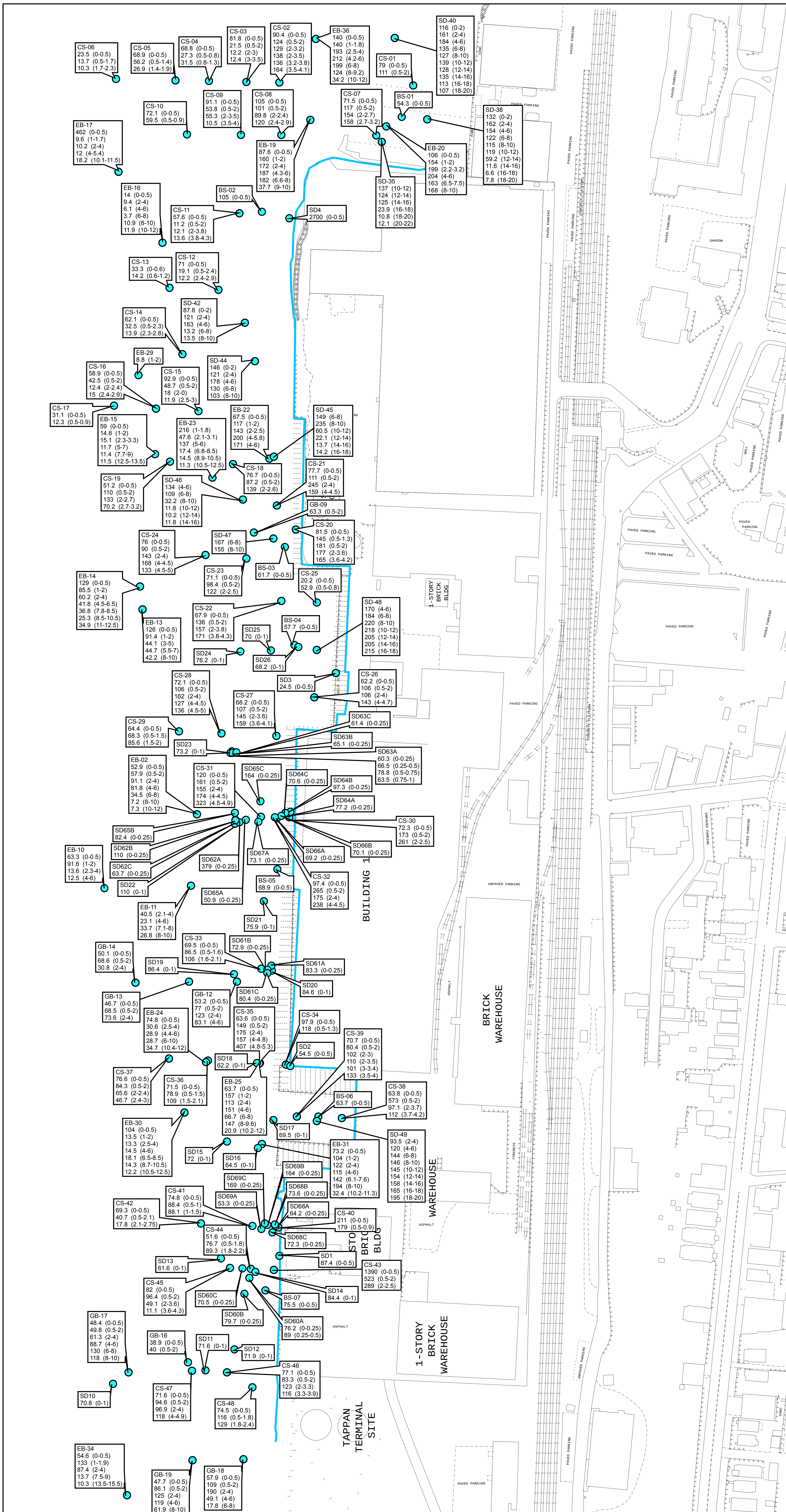
Sample Location ID
First Column:
Copper concentration in mg/Kg. ND is non-detect.
Second Column:
Depth range where Copper sample was collected.
Depth is in feet below mudline.

FIGURE A.2 ENVIRONMENTAL STANDARDS OU2 COPPER MODELING DATA SET

0 75 150 300 450 600
Feet

MARCH 14, 2006

ENVIRONMENTAL STANDARDS



FORMER ANACONDA PLANT SITE
OPERABLE UNIT No. 2

Atlantic Richfield Company and
ARCO Environmental Remediation, LLC

Village of Hastings on Hudson
Westchester County, New York

Legend

- LEAD SAMPLE LOCATION
- Shoreline
- Piling Line
- Piling

CS-20
131 (0-0.5)
181 (0.5-1.3)
162 (0.5-2)

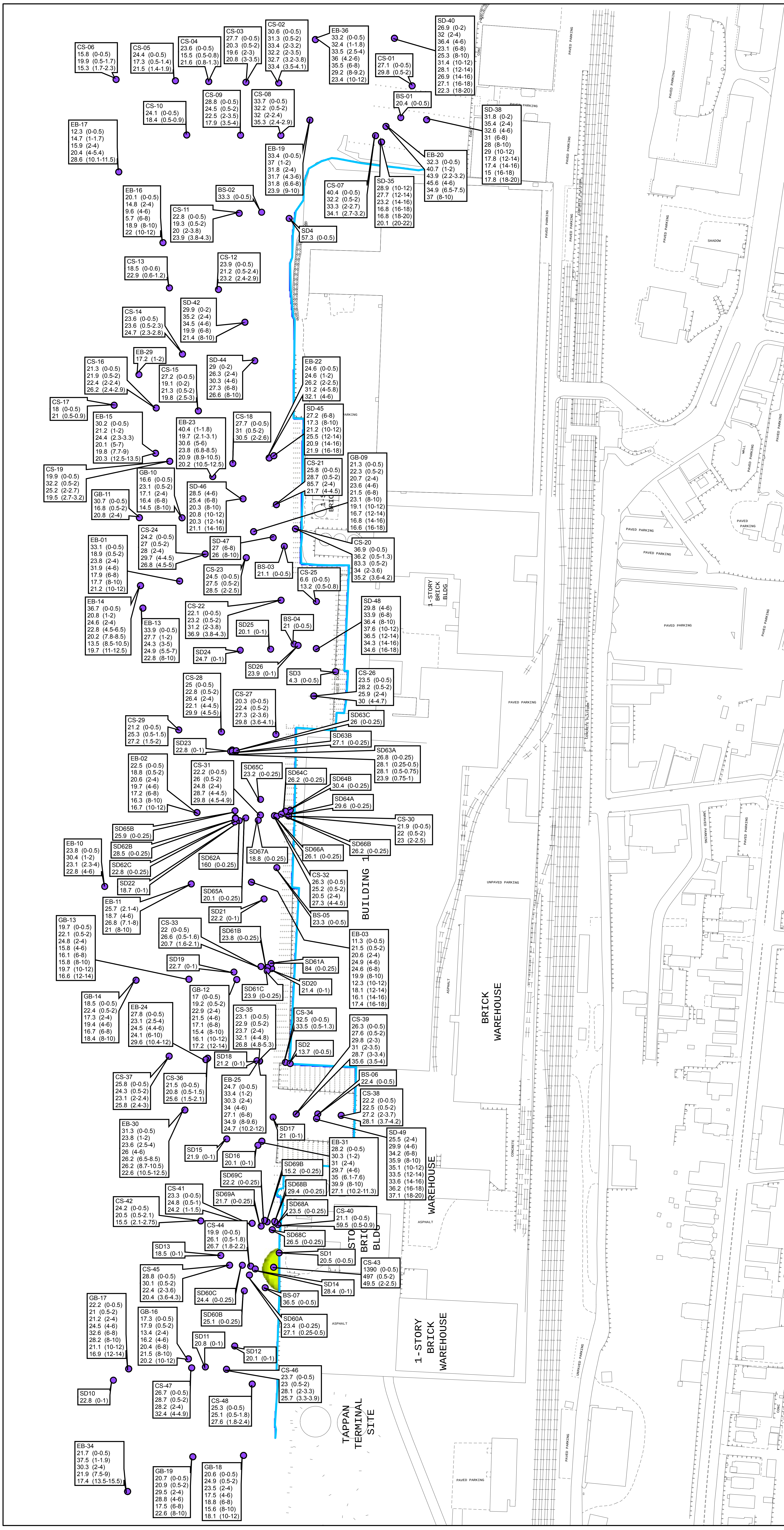
Sample Location ID
First Column:
Lead concentration in mg/Kg. ND is non-detect.
Second Column:
Depth range where Lead sample was collected.
Depth is in feet below mudline.

FIGURE A.3 ENVIRONMENTAL STANDARDS
OU2 LEAD MODELING DATA SET

0 100 200 300 400 500 600
Feet

MARCH 14, 2006

ENVIRONMENTAL STANDARDS



FORMER ANACONDA PLANT SITE
OPERABLE UNIT No. 2

Atlantic Richfield Company and
ARCO Environmental Remediation, LLC

Village of Hastings on Hudson
Westchester County, New York

N

Legend

- Shoreline
- Piling Line
- Piling
- NICKEL SAMPLE LOCATIONS

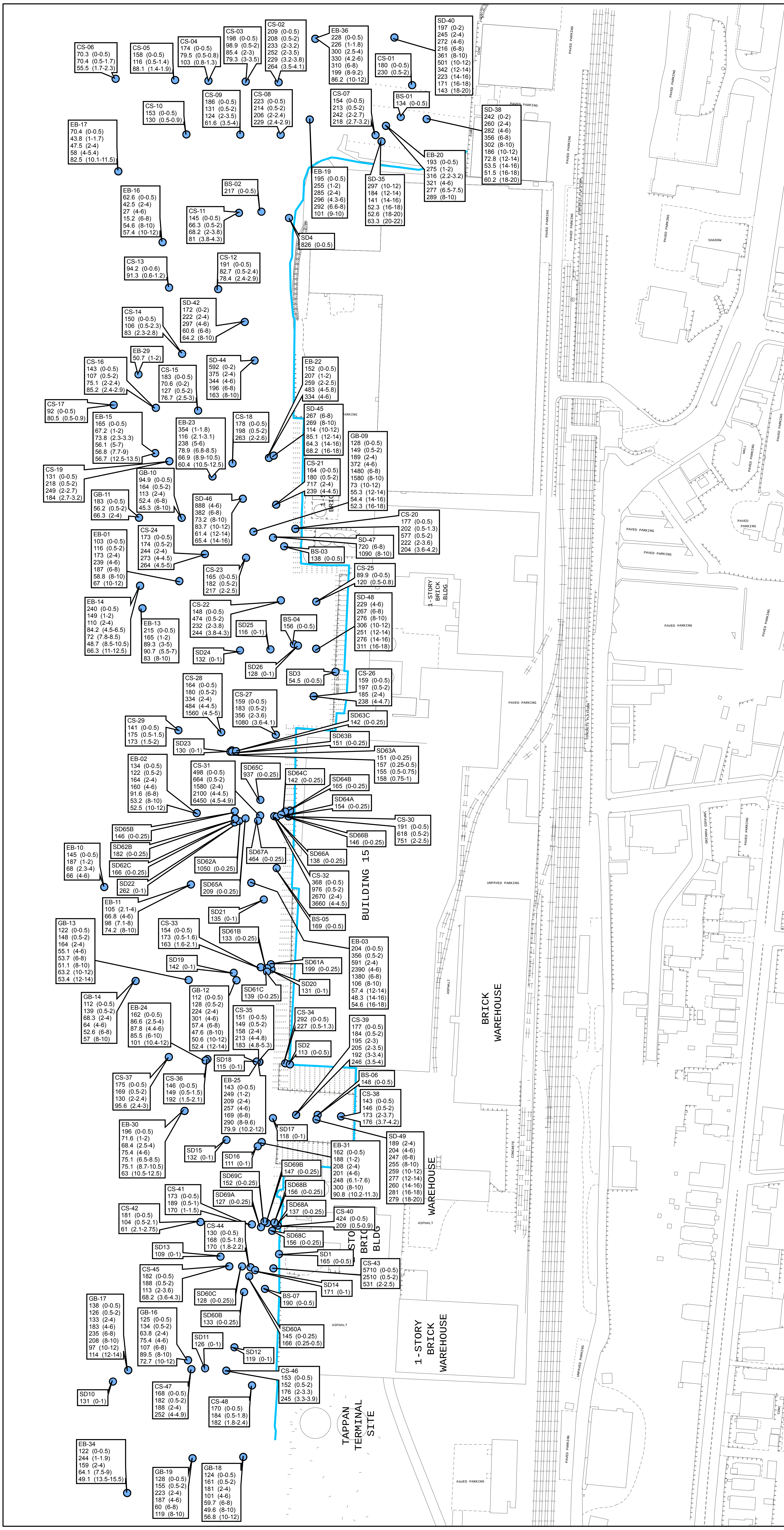
CS-20 131 (0-0.5) 181 (0.5-1.3) 162 (0.5-2)	Sample Location ID First Column: Nickel concentration in mg/Kg. ND is non-detect. Second Column: Depth range where Nickel sample was collected. Depth is in feet below mudline.

FIGURE A.4 ENVIRONMENTAL STANDARDS
OU2 NICKEL MODELING DATA SET

0 100 200 300 400 500 600
Feet

MARCH 14, 2006

ENVIRONMENTAL STANDARDS



FORMER ANACONDA PLANT SITE
OPERABLE UNIT No. 2

Atlantic Richfield Company and
ARCO Environmental Remediation, LLC

Village of Hastings on Hudson
Westchester County, New York

N

Legend

Shoreline

Piling Line

Piling

ZINC SAMPLE LOCATIONS

CS-20
131 (0-0.5)
181 (0.5-1.3)
162 (0.5-2)

Sample Location ID
First Column:
Zinc concentration in mg/Kg. ND is non-detect.
Second Column:
Depth range where Zinc sample was collected.
Depth is in feet below mudline.

FIGURE A.5 ENVIRONMENTAL STANDARDS OU2 ZINC MODELING DATA SET

0 100 200 300 400 500 600
Feet

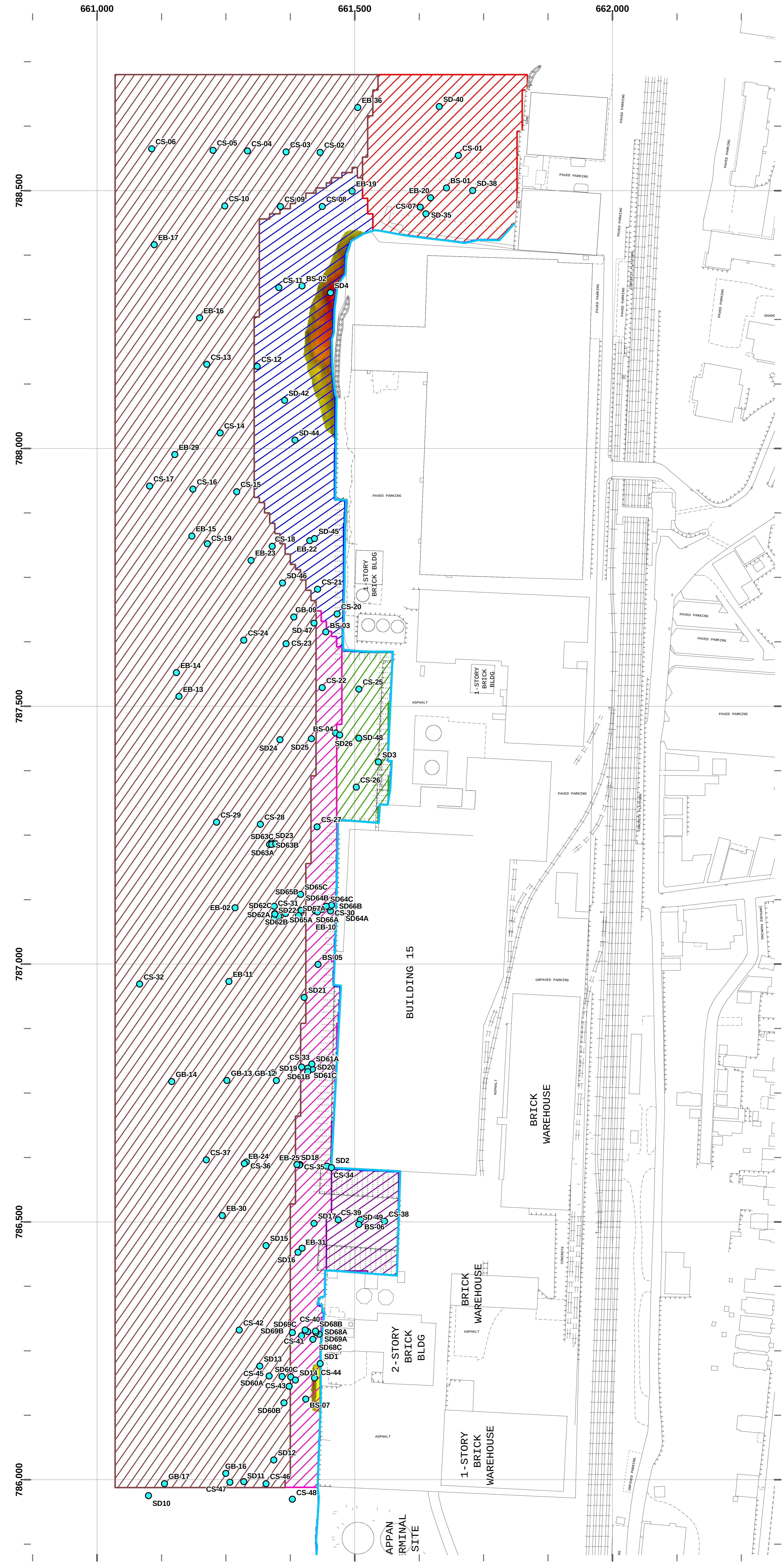
MARCH 14, 2006

ENVIRONMENTAL STANDARDS

FORMER ANACONDA PLANT SITE
OPERABLE UNIT No. 2

Atlantic Richfield Company and
ARCO Environmental Remediation, LLC

Village of Hastings on Hudson
Westchester County, New York



Legend

- Shoreline
- Piling Line
- Piling
- LEAD SAMPLE LOCATIONS

DEFINED AREAS

- OLD MARINA
- NORTHWEST CORNER
- NORTH BOATSLIP
- SOUTHERN AREA
- SOUTH BOATSLIP
- OFFSHORE AREA

LEAD CONCENTRATION

1,000 mg/kg

379 mg/kg

FIGURE A.6 MAP OF LEAD CONCENTRATIONS IN SEDIMENT ABOVE 379 MG/KG (PPM)

0 90 180 270 360 450 540

SCALE IN FEET

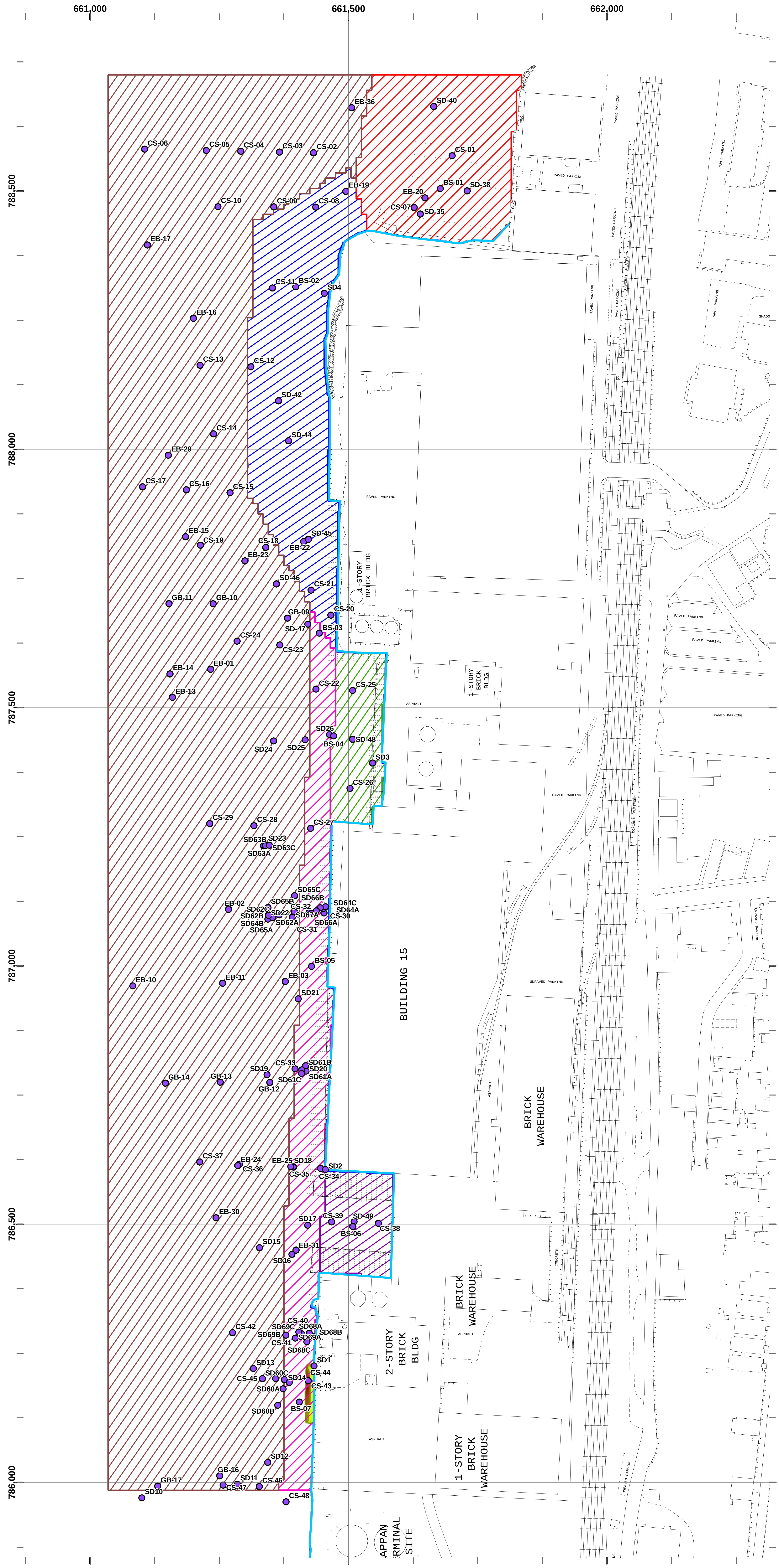
APRIL 7, 2006 rev. 2

ENVIRONMENTAL STANDARDS

FORMER ANACONDA PLANT SITE
OPERABLE UNIT No. 2

Atlantic Richfield Company and
ARCO Environmental Remediation, LLC

Village of Hastings on Hudson
Westchester County, New York



Legend

- NICKEL SAMPLE LOCATIONS
- Shoreline
- Piling Line
- Piling

DEFINED AREAS

- OLD MARINA
- NORTHWEST CORNER
- NORTH BOATSLIP
- SOUTHERN AREA
- SOUTH BOATSLIP
- OFFSHORE AREA

NICKEL CONCENTRATION

1,000 mg/kg
300 mg/kg
160 mg/kg

FIGURE A.7 MAP OF NICKEL CONCENTRATIONS IN SEDIMENT ABOVE 160 MG/KG (PPM)

0 100 200 300 400 500 600

SCALE IN FEET

APRIL 7, 2006 rev. 2

ENVIRONMENTAL STANDARDS

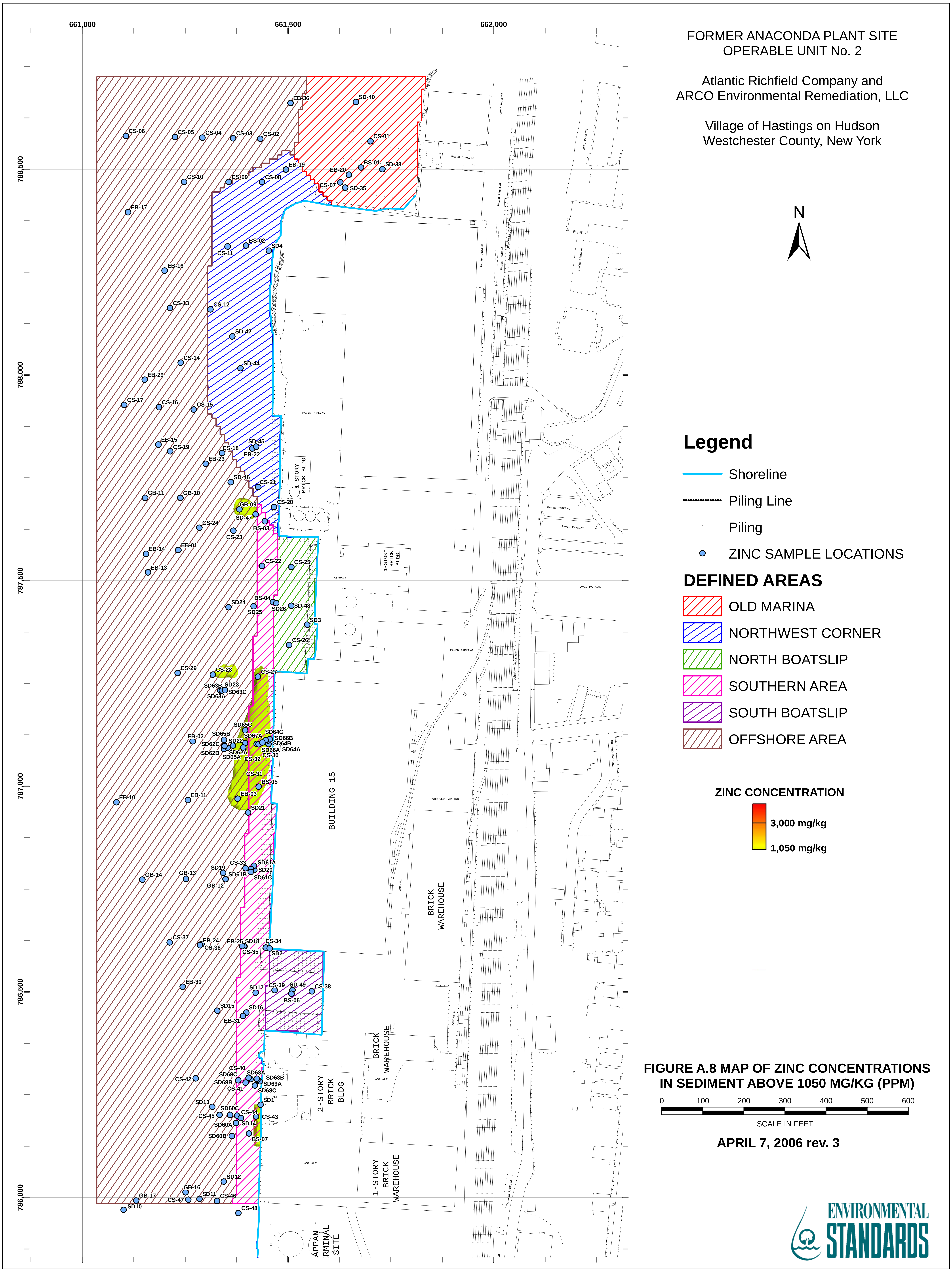


FIGURE A.8 MAP OF ZINC CONCENTRATIONS IN SEDIMENT ABOVE 1050 MG/KG (PPM)

APRIL 7, 2006 rev. 3

ATTACHMENT A.1 TO APPENDIX A

COMMENTS ON SELECT AROCLOR ANALYTICAL DATA SET

Comments on Select Aroclor Analytical Data Sets Generated by Earth Tech on Behalf of the New York State Department of Environmental Conservation for the Former Anaconda Wire and Cable Plant Site – Operable Unit 2

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Environmental Standards, Inc.
Valley Forge, PA 19482

1.0 Background

The Harbor at Hastings Proposed Remedial Action Plan (PRAP) for Operable Unit 2 (OU-2) (NYSDEC 2003a) is based upon a remedial investigation of sediment and river conditions conducted by Earth Tech of New York, Inc. ("Earth Tech") for New York State Department of Environmental Conservation (NYSDEC). Summaries of the data developed through 2003 are contained in the Remedial Investigation (RI) and Feasibility Study (FS) Reports prepared by Earth Tech for NYSDEC (NYSDEC, 2000a and 2003a, respectively).

Atlantic Richfield Company (AR) has reviewed both the RI Report and the FS Report. AR has also conducted a review of certain underlying laboratory analytical data.

The analytical laboratories generated the Aroclor analytical data utilizing the NYSDEC ASP 10/95 Method according to the data packages.

AR reviewed Earth Tech-generated Data Usability Summary Reports (DUSRs) for the data generated by Northeast Analytical Laboratories, Environmental Testing Laboratories, and Mitkem Corporation. Several issues, including Earth Tech's revision of laboratory-reported results, were identified from the DUSRs.

AR reviewed the analytical data generated by Northeast Analytical Laboratories, Environmental Testing Laboratories, and Mitkem Corporation. Several issues, including incorrect GC column reporting, incorrect identification of Aroclors (false positives), calculation errors, transcription errors, and several grossly anomalous field duplicate results, were identified for the data sets.

AR evaluated the Earth Tech analytical database reported in the RI and FS documents. The Aroclor results contained in the database were evaluated against the results reported by Interteck Testing Services Environmental Laboratories (now Severn Trent Laboratories, Vermont), Northeast Analytical Laboratories, Environmental Testing Laboratories, and Mitkem Corporation as documented in the data packages and summary reports provided with the DUSRs.

2.0 Observations

AR observed issues with regard to the laboratory-reported Aroclor results as well as the Earth Tech-reported Aroclor results. The observed issues are discussed in Sections 2.1 through 2.4 and Attachment 1 provided herein.

2.1 Incorrect GC Column Reporting

During the evaluation of the reported positive results performed as part of the data review, several positive results that had been changed (*i.e.,* handwritten edits on the analysis summaries) to report the higher of the two results from the dual-column GC analyses were identified. These changed values were reported in the RI and FS documents and were utilized to develop the PRAP.

NYSDEC ASP 10/95 Methods 8082, 8000A, and 8000B (Proposed Draft) do not provide direction relative to reporting dual-column results, thereby leaving the judgment as to which result to report to the laboratory analyst. According to NYSDEC ASP 10/95 Method 8082 (Sections 1.5, 1.6, and 7.6.4), NYSDEC ASP 10/95 Method 8000A (Section 7.6.9.1), and NYSDEC ASP 10/95 Method 8000B (Section 7.10.4), only a confirmation of Aroclor identifications by a second dissimilar column or GC/MS is required and a quantitative second column analysis is not required. Of these NYSDEC methods, only NYSDEC ASP 10/95 Method 8000B addresses the comparison of the dual-column results. NYSDEC ASP 10/95 Method 8000B (Section 7.10.4) does not stipulate if the lower or the higher of the two analytical columns should be reported and states the following: "If one result is significantly higher (*e.g.*, > 40%), check the chromatograms to see if an obvious overlapping peak is causing an erroneously high result." The only other NYSDEC ASP 10/95 method for Aroclor determination (Analytical Procedures for Superfund-CLP Pesticides/Aroclors NYSDEC Method 95-3) directs the laboratory to report the *lower* (emphasis added) of the two GC columns. Thus, the NYSDEC ASP 10/95 methods direct the lower of the two column results to be reported (in the event both columns are quantitatively accurate). A comprehensive review of the raw data and summary forms associated with the following analyses indicated that the laboratory reported the appropriate results for these samples.

The fact that Earth Tech personnel appear to have chosen different results (without any record of laboratory concurrence) by relying on guidance from the application of an analytical method that was not performed appears unjustified and has significant ramifications relative to the use of the Aroclor data for application to the remedial efforts.

Table 2.1 provides a summary of the results that were incorrectly changed to the GC column with the higher Aroclor result by Earth Tech personnel. For the results presented in the summary below, the lower GC column result reported by the laboratory (in Table 2.1 as the "Validated Results") were used by AR for the purposes of assessing the extent of Aroclor contamination at OU2.

Table 2.1

Sample Delivery Group	Sample	Aroclor	Laboratory Result (μg/kg)	Hand-Edited Result (μg/kg)	Validated Result (μg/kg)
HHS001	GB-11 S1A (0-0.5)	Aroclor-1260	61.9	71.62	61.9
	GB-10 S1B (0.5-2.0)	Aroclor-1260	15700	17700	15700
	GB-10 S2 (2-4)	Aroclor-1260	3090	4026	3090
	GB-10 S1A	Aroclor-1248	250	293	250
	GB-10 DUP2	Aroclor-1260	47	58.2	47
HHS002	EB-1 S1A (0-0.5)	Aroclor-1248	97.3	105.42	97.3
	EB-1 S1A (0-0.5)	Aroclor-1260	31.6	35.69	31.6

Table 2.1

Sample Delivery Group	Sample	Aroclor	Laboratory Result (µg/kg)	Hand-Edited Result (µg/kg)	Validated Result (µg/kg)
HHS002 (Cont.)	EB-1 S1B (0.5-2.0)	Aroclor-1248	96.2	103.4	96.2
	EB-1 S1B (0.5-2.0)	Aroclor-1260	50.4	64.14	50.4
	EB-1 S2 (2-4)	Aroclor-1260	1080	1187.8	1080
	EB-1 S3 (4-6)	Aroclor-1248	1430	1758	1430
	EB-1 S3 (4-6)	Aroclor-1260	5530	5692	5530
	EB-1 S4 (6-8)	Aroclor-1260	3930	4622	3930
	EB-3 S1A (0-0.5)	Aroclor-1248	254	290.6	254
	EB-3 S1A (0-0.5)	Aroclor-1260	345	350	345
HHS003	GB-15 S1A (0-0.5)	Aroclor-1248	213	260.2	213
	GB-15 S1A (0-0.5)	Aroclor-1260	384	387.8	384
	GB-15 S1B (0.5-2)	Aroclor-1248	323	340.8	323
	GB-15 S2 (2-4)	Aroclor-1260	1180	1182	1180
HHS004	GB17 S1A (0-0.5)	Aroclor-1248	104	111.8	104
	GB17 S1B (0.5-2)	Aroclor-1248	114	130.48	114
	GB17 S2 (2-4)	Aroclor-1260	856	1005.4	856
	GB17 S3 (4-6)	Aroclor-1248	434	460	434
	GB17 S4 (6-8)	Aroclor-1248	766	957.4	766
	GB17 S4 (6-8)	Aroclor-1260	2030	3230	2030
	GB17 S5 (8-10)	Aroclor-1248	287	322.6	287
	GB17 S5 (8-10)	Aroclor-1260	642	774.6	642
	GB16 S1A (0-0.5)	Aroclor-1248	39.7	44.52	39.7
	GB16 S1B (0.5-2)	Aroclor-1260	248	299.2	248
HHS005	GB-12 S1A (0-0.5)	Aroclor-1260	2200	2406	2200
	GB-12 S1B (0.5-5)	Aroclor-1248	484	511	484
	GB-12 S1B (0.5-5)	Aroclor-1260	1070	1264.6	1070
	GB-12 S2 (2-4)	Aroclor-1260	106	132	106
	GB-13 S1A (0-0.5)	Aroclor-1248	733	849.4	733
	GB-13 S1A (0-0.5)	Aroclor-1260	595	673	595
	GB-13 S1B (0.5-2)	Aroclor-1260	358	396.4	358
	GB-13 S2 (2-4)	Aroclor-1248	1240	1451	1240
	GB-13 S2 (2-4)	Aroclor-1260	1760	2664	1760
	DUP5	Aroclor-1248	363	393.2	363
	DUP5	Aroclor-1260	346	400.4	346
HHS006	GB-14 S1A (0-0.5)	Aroclor-1260	85.6	96.08	85.6
	GB-19 S1B (0.5-2)	Aroclor-1248	589	608.2	589
	GB-19 S2 (2-4)	Aroclor-1260	612	618.8	612
HHS007	GB-18 S1A (0-0.5)	Aroclor-1260	273	379	273
	GB-18 S1B (0.5-2.0)	Aroclor-1260	913	933.8	913
	GB-18 S2 (2-4)	Aroclor-1248	433	482.6	433
	GB-18 S2 (2-4)	Aroclor-1260	1150	1183.8	1150
	GB-18 S3 (4-6)	Arcolor-1248	141	167.28	141

Table 2.1

Sample Delivery Group	Sample	Aroclor	Laboratory Result (μg/kg)	Hand-Edited Result (μg/kg)	Validated Result (μg/kg)
HHS007 (Cont.)	GB-18 S3 (4-6)	Aroclor-1260	434	488	434
	GB-18 S5 (8-10)	Aroclor-1260	38.2	44.68	38.2
	GB-4 S1A (0-0.5)	Arcolor-1260	72	81.2	72
	GB-4 S1B (0.5-2)	Aroclor-1260	27300	33660	27300
	GB-4 S2 (2-4)	Aroclor-1260	1960	2026	1960

2.2 Incorrect Aroclor Identifications (False Positives)

During the evaluation of the reported positive results for Aroclors in select data sets for OU2, a comprehensive review of the raw data revealed some results that have been judged to be false positives due to chromatographic interferences (*viz.*, poor Aroclor matching quality). Determination of the presence of Aroclors by gas chromatographic methods utilized to generate the OU2 site data relies upon the pattern of peaks distinctive to each Aroclor. Chromatographic interferences (*i.e.*, organic compounds that elute near or at the same retention time as some Aroclor peaks) are minimized by the use of two dissimilar analytical columns. The dissimilar analytical columns separate the components of the Aroclors at different rates and/or processes resulting in different peak patterns for the Aroclors. The different separation techniques also impact the elution of the interference, allowing the analyst to differentiate the presence of Aroclors from other organic compounds in the sample. The NYSDEC ASP 10/95 Methods utilized require that at least three Aroclor peaks be observed to identify the presence on an Aroclor.

The reported positive results for the following Aroclors in the samples listed below will be considered “not-detected” results by AR for purposes of assessing the extent of Aroclor contamination at OU2. Based on careful evaluation of the associated sample chromatograms on both GC columns relative to Aroclor calibration standards provided, the data do not provide adequate evidence of the presence of Aroclors in the samples. The peaks observed at the few Aroclor retention times were judged to be interferences that preclude the accurate identification of Aroclors at or below the concentration corresponding to the reported values.

Table 2.2 provides a summary of the Aroclor Validated Results that were judged to be false positives during data validation. These Validated Results were used for the purposes of assessing the extent of Aroclor contamination at OU2.

Table 2.2

Sample Delivery Group	Sample	Aroclor	Reported Result (μg/kg)	Validated Result (μg/kg)
80994	EB16(0-0.5)	Aroclor-1260	3000	3000 U
	EB16(6-8)	Aroclor-1260	460	460 U
	DUP1	Aroclor-1260	370	370 U
	EB06(0.36-0.5)	Aroclor-1242	200	200 U
	EB06(1-2)	Aroclor-1242	110	110 U
81011	EB-14(0-0.5)	Aroclor-1248	620	620 U
81042	EB-12(1.0-2.0)	Aroclor-1248	370	370 U
81059	EB22(1.0-2.0)	Aroclor-1260	15000	15000 U
	DUP7	Aroclor-1260	68	68 U
	EB23(1.0-1.8)	Aroclor-1260	3800	3800 U
	EB23(5.0-6.0)	Aroclor-1260	710	710 U
	EB22(1.0-2.0)	Aroclor-1242	17000	17000 U
81060	EB19(4.3-6.0)	Aroclor-1254	7600	7600 U
	EB19(6.6-8.0)	Aroclor-1254	860	860 U
	EB19(9.0-10.0)	Aroclor-1254	1600	1600 U
	EB22(0-0.5)	Aroclor-1254	630	630 U
	EB22(2.0-2.5)	Aroclor-1254	1600	1600 U
	EB22(5.0-5.8)	Aroclor-1254	1800	1800 U
	EB23(2.1-3.1)	Aroclor-1254	10000	10000 U
	EB19(2-4)	Aroclor-1254	1700	1700 U
	EB22(2.0-2.5)	Aroclor-1248	540	540 U
	EB22(5.0-5.8)	Aroclor-1248	390	390 U
81096	EB-24(0-0.5)	Aroclor-1248	270	270 U
81106	IMEB6-0-0.5	Aroclor-1248	400	400 U
81108	EB-36(0-0.5)	Aroclor-1248	700	700 U
	EB-36(1.0-1.8)	Aroclor-1248	720	720 U
	EB-36(2.5-4.0)	Aroclor-1248	1300	1300 U
	EB-36(0-0.5)	Aroclor-1254	260	260 U
	EB-36(1.0-1.8)	Aroclor-1254	310	310 U
	EB-36(2.5-4.0)	Aroclor-1260	1300	1300 U
	EB-36(4.2-6.0)	Aroclor-1260	18000	18000 U
	EB-36(6.0-8.0)	Aroclor-1260	9900	9900 U
	EB-36(8.0-9.2)	Aroclor-1260	7100	7100 U
81121	EB34(0-0.5)	Aroclor-1248	340	340 U
	EB34(1.0-1.9)	Aroclor-1248	1400	1400 U
	EB34(2.0-4.0)	Aroclor-1248	1800	1800 U
	EB35(0-0.5)	Aroclor-1248	420	420 U
	EB35(1.0-2.0)	Aroclor-1248	1100	1100 U
	EB35(2.0-4.0)	Aroclor-1248	1700	1700 U
	DUP10	Aroclor-1248	3800	3800 U
	EB34(0-0.5)	Aroclor-1254	250	250 U

Table 2.2

Sample Delivery Group	Sample	Aroclor	Reported Result (µg/kg)	Validated Result (µg/kg)
81121 (Cont.)	EB34(1.0-1.9)	Aroclor-1254	620	620 U
	EB34(2.0-4.0)	Aroclor-1254	640	640 U
	EB35(0-0.5)	Aroclor-1254	270	270 U
	EB35(1.0-2.0)	Aroclor-1254	240	240 U
	EB35(2.0-4.0)	Aroclor-1254	340	340 U
	DUP10	Aroclor-1254	840	840 U
81130	DUP10	Aroclor-1254	1400	1400 U
	EB-25 (0-0.5)	Aroclor-1254	220	220 U
	EB-25 (1.0-2.0)	Aroclor-1254	1000	1000 U
	EB-25 (2.0-4.0)	Aroclor-1254	780	780 U
	EB-25 (6.0-8.0)	Aroclor-1254	260	260 U
	EB-25 (8.0-9.6)	Aroclor-1254	810	810 U
	EB-25 (4.0-6.0)	Aroclor-1254	1200	1200 U
81150	EB-30 (0-0.5)	Aroclor-1260	15000	15000 U
	EB-26 (6.1-6.9)	Aroclor-1260	1000	1000 U
	EB-31 (6.1-7.6)	Aroclor-1248	1400	1400 U
	EB-31 (0-0.5)	Aroclor-1248	85	85 U
	EB-31 (8.0-10.0)	Aroclor-1248	1200	1200 U
81629	EB41(0-0.5)	Aroclor-1248	200	200 U
991029	99-10-393.3(BS-2)	Aroclor-1248	0.463	0.463 U
	99-10-393.8(BS-8)	Aroclor-1248	0.385	0.385 U
	99-10-393.1(BS-1)	Aroclor-1248	0.312	0.312 U
	99-10-393.7(BS-7)	Aroclor-1248	0.286	0.286 U
	99-10-393.4(BS-3)	Aroclor-1248	0.322	0.322 U
	99-10-393.6(BS-6)	Aroclor-1248	0.376	0.376 U

U – The analyte was not detected and the associated numerical value is the laboratory-reported quantitation limit

2.3 Calculation Errors

During the evaluation of the reported Aroclor positive results in the data set for OU2, AR was unable to quantitatively reproduce several Aroclor results reported by the laboratory. The laboratory-reported positive results for the following Aroclors in the samples indicated below varied significantly (*i.e.*, > 10% difference) from the results calculated by AR. For the results in question, AR utilized the initial calibration information provided in the data package for quantitation and verification of the reported results. For the three sample results summarized on Table 2.3, AR used the corrected AR-Calculated Results for the purposes of assessing the extent of Aroclor contamination at OU2.

Table 2.3

Sample Delivery Group	Sample	Aroclor	Laboratory-Reported Result (μg/kg)	AR-Calculated Result (μg/kg)
HHS002	EB-1 S1A (0-0.5)	Aroclor-1260	31.6	28.2
	EB-1 S3 (4-6)	Aroclor-1260	5530	6450
	EB-3 S1B (0.5-2.0)	Aroclor-1260	41.9	31.4

2.4 Transcription Errors and Omissions

AR reviewed the NYSDEC-supplied database for Aroclor results. Earth Tech generated the NYSDEC database in support of the RI and FS reports. The NYSDEC-supplied database included results generated from Aroclor analyses performed by Intertek Testing Services Environmental Laboratories (now Severn Trent Laboratories, Vermont), Northeast Analytical Laboratories, Environmental Testing Laboratories, and Mitkem Corporation.

The results in the database were reviewed against the results reported by the contracted laboratories based on the data packages and DUSRs received. The review was performed by comparing the results in the database against the analytical summary forms provided as attachments to the DUSRs and as part of the laboratory data packages. Transcription errors included omitted samples, incorrect reporting limits, omitted Aroclor results, and incorrect positive results. Attachment 1 presents a summary of the results that were incorrectly reported.

Various transcription errors and omissions were noted and are summarized on Attachment 1. These transcription errors are described in the following bulleted statements:

- Upon comparison of the Earth Tech database to the laboratory reports, it was noted that some sample results were not included in the database. After identifying the sample results that should have been included in the database, the results were added and qualified, as necessary, based on the laboratory reports received from NYSDEC.

- The Earth Tech database included a number of non-detect (“ND”) records with a result in the result field and some non-detect (“ND”) records with “null” in the result field. In the interest of consistency, all non-detect records were modified to show “null” results in the result field, "U" in the qualifier field, and a reported detection limit (RDL) in the RDL field.

- The Earth Tech database lacked RDLs for some samples. Upon examination of the laboratory reports, the corrected RDLs were included in the database.

- The Earth Tech database lacked results for some samples. Upon examination of the laboratory reports, the laboratory-reported results were included in the database, some with appropriate data validation qualifiers.

- Upon comparison of the Earth Tech database to the laboratory reports, some sample results were associated with an incorrect sample delivery group (SDG). After identifying the correct SDG for each sample, the database was updated.

- The Earth Tech database results for some sample results did not match the results reported by the laboratory. After it was confirmed that these results were not corrected as a result of data validation, the database was updated to reflect the correct laboratory-reported results, some with appropriate data validation qualifiers.

The AR-corrected results (summarized in Attachment 1) were used by AR for the purposes of assessing the extent of Aroclor contamination at OU2.

2.5 Grossly Anomalous Field Duplicates

During Earth Tech's sampling of OU2 sediment samples, a variety of quality control samples, including field duplicates, was collected. As part of the data usability assessments, field duplicate results were compared to provide an indication of sample representativeness and, to a limited extent, analytical precision. The data quality objective for solid sample duplicates in the AR 2005 Quality Assurance Project Plan is $\leq$50% relative percent difference (Parsons 2005). During the review of the various field duplicates collected by Earth Tech, two field duplicate pairs, for which the difference between the sample result and the Earth Tech–designated field duplicate was substantial, were observed. The magnitude of the disagreement in results for these two field duplicate pairs is outside of any regulatory validation guidance relating to field duplicate assessment; consequently, these Aroclor data points (the original and the Earth Tech–designated field duplicate) are anomalous and highly unreliable for use. Summarized on Table 2.5 (in bold) are the two data points with grossly differing field duplicate Aroclor results.

The additional data (regular font) summarized on Table 2. 5 for the boring intervals above and below both data/duplicate sets (Aroclors were not detected) further substantiate the highly questionable nature of these two data points. Accordingly, based on the significant weight of evidence, AR has judged that the data points corresponding to both sample/duplicate pairs (bolded below) are anomalous and highly unreliable, and these two data points were not used by AR for the purposes of assessing the extent of Aroclor contamination at OU2.

Table 2.5

Sample	Designated Field Duplicate	Aroclor	Sample Result (µg/kg)	Field Duplicate Result (µg/kg)
EB-14 (7.8-8.5)	-	All Aroclors	ND	-
EB-14 (8.5-10.5)	**DUP3 [Duplicate of EB-14 (8.5-10.5)]**	**Aroclor-1260**	**940**	**36,000**
EB-14 (11-12.5)	-	All Aroclors	ND	-
EB-15 (2.3-3.3)	-	All Aroclors	ND	-
EB-15 (5.0-7.0)	**DUP5 [Duplicate of EB-15 (5.0-7.0)]**	**Aroclor - 1260**	**840**	**22,000**
EB-15 (7.7-9)	-	All Aroclors	ND	-

3.0 Summary of Aroclor Data Review

AR evaluated the Aroclor results reported in the NYSDEC database utilized for the RI and FS reports. AR's evaluation extended to a review of the data packages. AR's evaluation identified incorrect GC column reporting, incorrect identification of Aroclors (false positives), calculation errors, transcription errors, and grossly anomalous results for two field duplicate pairs. Based on the findings of this evaluation, AR revised the NYSDEC-supplied database to reflect the corrections and collective changes identified in Sections 2.1 through and including 2.5 of this document.

4.0 References

Atlantic Richfield Company 2004. Correspondence to Mr. George Heitzman (NYSDEC) from Mr. Werner A. Sicvol (Atlantic Richfield Company) referenced as "The Harbor at Hastings Site (Site 3-60-022) Operable Unit 2" dated January 26, 2004.

New York State Department of Environmental Conservation (NYSDEC) 2003a. Final Feasibility Study Report. Harbor at Hastings Site (OU#2) Site 3-60-22. New York State Department of Environmental Conservation, Superfund Standby Program, Albany, NY.

NYSDEC 2000a. Remedial Investigation Report. Harbor at Hastings (OU-2) Site 3-60-022. New York State Department of Environmental Conservation, Superfund Standby Program, Albany, NY.

New York State Department of Environmental Conservation Analytical Services Protocol 10/95 Revisions.

Parsons 2005. "Quality Assurance Project Plan Former Anaconda Plant Site Operable Unit No. 2, Village of Hastings-on-Hudson, Westchester County, New York." Prepared for Atlantic Richfield Company, June 2005.

US EPA, "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846," 3rd Edition.

ATTACHMENT 1

Samples and Results not Included in Original Submission

Sample Delivery Group	Sample	Aroclor	Reported Result (mg/kg)	Validated Result (mg/kg)
70475	RB-16 (.5- 2)	Aroclor 1016	0.060	0.060 U
	RB-16 (.5- 2)	Aroclor 1221	0.120	0.120 U
	RB-16 (.5- 2)	Aroclor 1232	0.060	0.060 U
	RB-16 (.5- 2)	Aroclor 1242	0.060	0.060 U
	RB-16 (.5- 2)	Aroclor 1248	0.060	0.060 U
	RB-16 (.5- 2)	Aroclor 1254	0.060	0.060 U
	RB-16 (.5- 2)	Aroclor 1260	0.060	0.060 U
	RB-16 (0- .5)	Aroclor 1016	5.6	5.6 UJ
	RB-16 (0- .5)	Aroclor 1221	11	11 UJ
	RB-16 (0- .5)	Aroclor 1232	5.6	5.6 UJ
	RB-16 (0- .5)	Aroclor 1242	5.6	5.6 UJ
	RB-16 (0- .5)	Aroclor 1248	5.6	5.6 UJ
	RB-16 (0- .5)	Aroclor 1254	5.6	5.6 UJ
	RB-16 (0- .5)	Aroclor 1260	14	14 J
	RB-16 (10- 10)	Aroclor 1016	0.055	0.055 UJ
	RB-16 (10- 10)	Aroclor 1221	0.110	0.110 UJ
	RB-16 (10- 10)	Aroclor 1232	0.055	0.055 UJ
	RB-16 (10- 10)	Aroclor 1242	0.055	0.055 UJ
	RB-16 (10- 10)	Aroclor 1248	0.055	0.055 UJ
	RB-16 (10- 10)	Aroclor 1254	0.055	0.055 UJ
	RB-16 (10- 10)	Aroclor 1260	0.055	0.055 UJ
	RB-16 (2- 4)	Aroclor 1016	0.058	0.058 UJ
	RB-16 (2- 4)	Aroclor 1221	0.120	0.120 UJ
	RB-16 (2- 4)	Aroclor 1232	0.058	0.058 UJ
	RB-16 (2- 4)	Aroclor 1242	0.058	0.058 UJ
	RB-16 (2- 4)	Aroclor 1248	0.058	0.058 UJ
	RB-16 (2- 4)	Aroclor 1254	0.058	0.058 UJ
	RB-16 (2- 4)	Aroclor 1260	0.058	0.058 UJ
	RB-16 (6- 8)	Aroclor 1016	0.046	0.046 UJ
	RB-16 (6- 8)	Aroclor 1221	0.091	0.091 UJ
	RB-16 (6- 8)	Aroclor 1232	0.046	0.046 UJ
	RB-16 (6- 8)	Aroclor 1242	0.046	0.046 UJ
	RB-16 (6- 8)	Aroclor 1248	0.046	0.046 UJ
	RB-16 (6- 8)	Aroclor 1254	0.046	0.046 UJ
	RB-16 (6- 8)	Aroclor 1260	0.046	0.046 UJ
70685	Duplicate 11 (0- .5)	Aroclor 1016	9.2	9.2 U
	Duplicate 11 (0- .5)	Aroclor 1221	19	19 U
	Duplicate 11 (0- .5)	Aroclor 1232	9.2	9.2 U
	Duplicate 11 (0- .5)	Aroclor 1242	9.2	9.2 U

Samples and Results not Included in Original Submission

Sample Delivery Group	Sample	Aroclor	Reported Result (mg/kg)	Validated Result (mg/kg)
	Duplicate 11 (0- .5)	Aroclor 1248	9.2	9.2 U
	Duplicate 11 (0- .5)	Aroclor 1254	9.2	9.2 U
	Duplicate 11 (0- .5)	Aroclor 1260	1.1	23 J
	Duplicate 12 (.5- 2)	Aroclor 1016	0.120	0.120 U
	Duplicate 12 (.5- 2)	Aroclor 1221	0.240	0.240 U
	Duplicate 12 (.5- 2)	Aroclor 1232	0.120	0.120 U
	Duplicate 12 (.5- 2)	Aroclor 1242	0.120	0.120 U
	Duplicate 12 (.5- 2)	Aroclor 1248	0.120	0.120 U
	Duplicate 12 (.5- 2)	Aroclor 1254	0.140	0.140
	Duplicate 12 (.5- 2)	Aroclor 1260	0.350	0.350
	Duplicate 13 (6- 8)	Aroclor 1016	0.058	0.058 U
	Duplicate 13 (6- 8)	Aroclor 1221	0.120	0.120 U
	Duplicate 13 (6- 8)	Aroclor 1232	0.058	0.058 U
	Duplicate 13 (6- 8)	Aroclor 1242	0.058	0.058 U
	Duplicate 13 (6- 8)	Aroclor 1248	0.058	0.058 U
	Duplicate 13 (6- 8)	Aroclor 1254	0.058	0.058 U
	Duplicate 13 (6- 8)	Aroclor 1260	0.051	0.051 J
	Duplicate 14 (6- 8)	Aroclor 1016	0.068	0.068 UJ
	Duplicate 14 (6- 8)	Aroclor 1221	0.140	0.140 UJ
	Duplicate 14 (6- 8)	Aroclor 1232	0.068	0.068 UJ
	Duplicate 14 (6- 8)	Aroclor 1242	0.068	0.068 UJ
	Duplicate 14 (6- 8)	Aroclor 1248	0.068	0.068 UJ
	Duplicate 14 (6- 8)	Aroclor 1254	0.068	0.068 UJ
	Duplicate 14 (6- 8)	Aroclor 1260	0.068	0.068 UJ
80793	BKGD-09 (0- .5)	Aroclor 1016	0	0.084 UJ
	BKGD-09 (0- .5)	Aroclor 1221	0	0.084 UJ
	BKGD-09 (0- .5)	Aroclor 1232	0	0.084 UJ
	BKGD-09 (0- .5)	Aroclor 1242	0	0.084 UJ
	BKGD-09 (0- .5)	Aroclor 1248	0	0.084 UJ
	BKGD-09 (0- .5)	Aroclor 1254	0	0.084 UJ
	BKGD-09 (0- .5)	Aroclor 1260	0	0.084 UJ
81060	EB-22 (5- 5.8)	Aroclor 1016	0	0.068 UJ
	EB-22 (5- 5.8)	Aroclor 1221	0	0.068 UJ
	EB-22 (5- 5.8)	Aroclor 1232	0	0.068 UJ
	EB-22 (5- 5.8)	Aroclor 1242	0	0.068 UJ
	EB-22 (5- 5.8)	Aroclor 1248	0	0.39 U
	EB-22 (5- 5.8)	Aroclor 1254	0	1.8 U
	EB-22 (5- 5.8)	Aroclor 1260	0	0.068 UJ
81096	DUP 8 (4.4- 6)	Aroclor 1016	0	0.056 U

Samples and Results not Included in Original Submission

Sample Delivery Group	Sample	Aroclor	Reported Result (mg/kg)	Validated Result (mg/kg)
	DUP 8 (4.4- 6)	Aroclor 1221	0	0.056 U
	DUP 8 (4.4- 6)	Aroclor 1242	0	0.056 U
	DUP 8 (4.4- 6)	Aroclor 1248	0	0.056 U
	DUP 8 (4.4- 6)	Aroclor 1254	0	0.056 U
	DUP 8 (4.4- 6)	Aroclor 1260	0	0.056 U
81108	EB-36 (1- 1.8)	Aroclor 1016	0.066	0.066 UJ
	EB-36 (1- 1.8)	Aroclor 1221	0.066	0.066 UJ
	EB-36 (1- 1.8)	Aroclor 1232	0.066	0.066 UJ
	EB-36 (1- 1.8)	Aroclor 1242	0.066	0.066 UJ
	EB-36 (1- 1.8)	Aroclor 1260	0.066	0.066 UJ
	EB-36 (2.5- 4)	Aroclor 1016	0.064	0.064 U
	EB-36 (2.5- 4)	Aroclor 1221	0.064	0.064 U
	EB-36 (2.5- 4)	Aroclor 1232	0.064	0.064 U
	EB-36 (2.5- 4)	Aroclor 1242	0.064	0.064 U
	EB-36 (4.2- 6)	Aroclor 1016	0.67	0.67 UJ
	EB-36 (4.2- 6)	Aroclor 1221	0.67	0.67 UJ
	EB-36 (4.2- 6)	Aroclor 1232	0.67	0.67 UJ
	EB-36 (4.2- 6)	Aroclor 1242	0.67	0.67 UJ
	EB-36 (4.2- 6)	Aroclor 1248	0.67	0.67 UJ
	EB-36 (4.2- 6)	Aroclor 1254	0.67	0.67 UJ
	EB-36 (8- 9.2)	Aroclor 1016	0.68	0.68 UJ
	EB-36 (8- 9.2)	Aroclor 1221	0.68	0.68 UJ
	EB-36 (8- 9.2)	Aroclor 1232	0.68	0.68 UJ
	EB-36 (8- 9.2)	Aroclor 1242	0.68	0.68 UJ
	EB-36 (8- 9.2)	Aroclor 1248	0.68	0.68 UJ
	EB-36 (8- 9.2)	Aroclor 1254	0.68	0.68 UJ
81121	EB-34 (2- 4)	Aroclor 1016	0.61	0.61 U
	EB-34 (2- 4)	Aroclor 1221	0.61	0.61 U
	EB-34 (2- 4)	Aroclor 1232	0.61	0.61 U
	EB-34 (2- 4)	Aroclor 1242	0.61	0.61 U
	EB-34 (2- 4)	Aroclor 1260	0.61	0.61 U

Samples and Results Originally Submitted with Incorrect Results

Sample Delivery Group	Sample	Aroclor	Reported Result (mg/kg)	Validated Result (mg/kg)
69718	RB-4 (0-2)	Aroclor 1254	0.160 J	0.190 J
69861	RB-8 (4-6)	Aroclor 1254	0.240 U	0.200 J
80793	BKGD-01 (0-0.5)	Aroclor 1248	J	0.16 J
	BKGD-03 (0-0.5)	Aroclor 1248	0.24	0.2
	BKGD-03 (0-0.5)	Aroclor 1260	0.52 J	0.29
	BKGD-04 (0-0.5)	Aroclor 1248	0.24 J	0.13
	BKGD-05 (0-0.5)	Aroclor 1248	0.29	0.24
	BKGD-06 (0-0.5)	Aroclor 1248	0.22 J	0.15
80960	EB-04 (0-0.5)	Aroclor 1248	0.46 J	0.25 J
	EB-04 (0-0.5)	Aroclor 1254	0.38 J	0.34 J
	EB-04 (0.5-1)	Aroclor 1254	0.45 J	0.42
	EB-05 (8-10)	Aroclor 1254	0.14 J	0.11
80975	BKGD-09 (0-0.5)	Aroclor 1248	J	1.2 J
	BKGD-09 (1-2)	Aroclor 1248	2.1 J	2.1
81011	EB-13 (8-10)-Duplicate	Aroclor 1260	0.84 J	0.51 J
	EB-13 (8-10)	Aroclor 1260	1.6 J	0.97 J
	EB-14 (8.5-10.5)-Duplicate	Aroclor 1260	57 J	36 J
81042	EB-10 (0-0.5)	Aroclor 1260	2.1 J	1.4 J
	EB-10 (1-2)	Aroclor 1260	97 J	80
	EB-15 (0-0.5)	Aroclor 1248	0.46 J	0.34 J
	EB-15 (1-2)	Aroclor 1260	0.47 J	0.43
	EB-15 (5-7)-Duplicate	Aroclor 1260	34 J	22 J
	EB-15 (5-7)	Aroclor 1260	1.1 J	0.84 J
81059	EB-24 (4.4-6)-Duplicate	Aroclor 1016	0.056 U	0.063 U
	EB-24 (4.4-6)-Duplicate	Aroclor 1221	0.056 U	0.063 U
	EB-24 (4.4-6)-Duplicate	Aroclor 1232		0.063 U
	EB-24 (4.4-6)-Duplicate	Aroclor 1242	0.056 U	0.063 U
	EB-24 (4.4-6)-Duplicate	Aroclor 1248	0.056 U	0.063 U
	EB-24 (4.4-6)-Duplicate	Aroclor 1254	0.056 U	0.063 U
81060	EB-19 (0-0.5)	Aroclor 1248	0.49 J	0.45 J
	EB-19 (0-0.5)	Aroclor 1254	0.44 J	0.36 J
	EB-19 (2-4)	Aroclor 1248	1.7 J	1.6 J
	EB-22 (0-0.5)	Aroclor 1248	0.39	0.37 J
81130	EB-37 (2-3)	Aroclor 1254	0.12 J	0.083
81150	EB-26 (0-0.5)	Aroclor 1260	0.34 J	0.28 J
	EB-26 (0.2-1)	Aroclor 1260	2.8 J	2 J
	EB-26 (2.1-3)	Aroclor 1260	2.7 J	1.5
	EB-26 (4-6)	Aroclor 1260	2.7 J	1.6 J
	EB-28 (1-1.6)	Aroclor 1260	1.2 J	0.78 J
	EB-28 (2.1-3.7)	Aroclor 1260	1.2 J	0.83
	EB-28 (4.3-6)	Aroclor 1260	0.78 J	0.51 J
	EB-31 (1-2)	Aroclor 1260	0.27	0.23
	EB-31 (2-4)	Aroclor 1248	0.69 J	0.52
	EB-31 (4-6)-Duplicate	Aroclor 1248	0.81 J	0.6 J
	EB-31 (4-6)	Aroclor 1248	0.79 J	0.61

Samples and Results Originally Submitted with Incorrect Results

	EB-31 (10.2-11.3)	Aroclor 1248	0.28 J	0.14 J
81629	EB-41 (0.5-2)	Aroclor 1248	0.52	0.49
	EB-41 (4-4.5)	Aroclor 1248	1.3	1.2
991029TOX	BS-2 (0-0.5)	Aroclor 1242	0.631	0.612 J
	BS-2 (0-0.5)	Aroclor 1260	0.491	0.441 J
	BS-3 (0-0.5)	Aroclor 1242	0.455	0.367 J
	BS-3 (0-0.5)	Aroclor 1260	1.130	1.090 J
	BS-4 (0-0.5)	Aroclor 1242	0.951	0.822 J
	BS-4 (0-0.5)	Aroclor 1248	1.190	1.340 J
	BS-4 (0-0.5)	Aroclor 1260	0.556	0.516 J
	BS-5 (0-0.5)	Aroclor 1242	0.436	0.374 J
	BS-5 (0-0.5)	Aroclor 1248	0.498	0.575 J
	BS-5 (0-0.5)	Aroclor 1260	1.570	1.280 J
	BS-6 (0-0.5)	Aroclor 1242	0.547	0.453 J
	BS-6 (0-0.5)	Aroclor 1260	0.116	0.112 J
	BS-7 (0-0.5)	Aroclor 1242	0.430	0.386 J
	BS-8 (0-0.5)	Aroclor 1242	0.542	0.503 J
	BS-9 (0-0.5)	Aroclor 1242	2.290	2.060 J
	BS-9 (0-0.5)	Aroclor 1248	3.620	3.810 J
	BS-9 (0-0.5)	Aroclor 1260	1.220	1.170 J

Samples and Results Originally Submitted without Reporting Detection Limit

Sample Delivery Group	Sample	Aroclor	Validated Detect Limit (mg/kg)
70557	RB-21 (10-11)-Duplicate	Aroclor 1221	65
	RB-21 (10-11)-Duplicate	Aroclor 1232	32
	RB-21 (10-11)-Duplicate	Aroclor 1242	32
	RB-21 (10-11)-Duplicate	Aroclor 1248	32
	RB-21 (10-11) -Duplicate	Aroclor 1254	32
80793	BKGD-01 (0-0.5)	Aroclor 1016	0.079
	BKGD-01 (0-0.5)	Aroclor 1221	0.079
	BKGD-01 (0-0.5)	Aroclor 1232	0.079
	BKGD-01 (0-0.5)	Aroclor 1242	0.079
	BKGD-01 (0-0.5)	Aroclor 1254	0.079
	BKGD-01 (0-0.5)	Aroclor 1260	0.079
	BKGD-02 (0-0.5)	Aroclor 1016	0.044
	BKGD-02 (0-0.5)	Aroclor 1221	0.044
	BKGD-02 (0-0.5)	Aroclor 1232	0.044
	BKGD-02 (0-0.5)	Aroclor 1242	0.044
	BKGD-02 (0-0.5)	Aroclor 1248	0.044
	BKGD-02 (0-0.5)	Aroclor 1254	0.044
	BKGD-02 (0-0.5)	Aroclor 1260	0.044
	BKGD-03 (0-0.5)	Aroclor 1016	0.067
	BKGD-03 (0-0.5)	Aroclor 1221	0.067
	BKGD-03 (0-0.5)	Aroclor 1232	0.067
	BKGD-03 (0-0.5)	Aroclor 1242	0.067
	BKGD-03 (0-0.5)	Aroclor 1254	0.067
	BKGD-04 (0-0.5)	Aroclor 1016	0.087
	BKGD-04 (0-0.5)	Aroclor 1221	0.087
	BKGD-04 (0-0.5)	Aroclor 1232	0.087
	BKGD-04 (0-0.5)	Aroclor 1242	0.087
	BKGD-04 (0-0.5)	Aroclor 1254	0.087
	BKGD-04 (0-0.5)	Aroclor 1260	0.087
	BKGD-05 (0-0.5)	Aroclor 1016	0.067
	BKGD-05 (0-0.5)	Aroclor 1221	0.067
	BKGD-05 (0-0.5)	Aroclor 1232	0.067
	BKGD-05 (0-0.5)	Aroclor 1242	0.067
	BKGD-05 (0-0.5)	Aroclor 1254	0.067
	BKGD-05 (0-0.5)	Aroclor 1260	0.067
	BKGD-06 (0-0.5)	Aroclor 1016	0.069
	BKGD-06 (0-0.5)	Aroclor 1221	0.069
	BKGD-06 (0-0.5)	Aroclor 1232	0.069
	BKGD-06 (0-0.5)	Aroclor 1242	0.069
	BKGD-06 (0-0.5)	Aroclor 1254	0.069
	BKGD-06 (0-0.5)	Aroclor 1260	0.069
	BKGD-07 (0-0.5)	Aroclor 1016	0.061
	BKGD-07 (0-0.5)	Aroclor 1221	0.061
	BKGD-07 (0-0.5)	Aroclor 1232	0.061
	BKGD-07 (0-0.5)	Aroclor 1242	0.061

Samples and Results Originally Submitted without Reporting Detection Limit

	BKGD-07 (0-0.5)	Aroclor 1248	0.061
	BKGD-07 (0-0.5)	Aroclor 1254	0.061
	BKGD-07 (0-0.5)	Aroclor 1260	0.061
	BKGD-10 (0-0.5)	Aroclor 1016	0.063
	BKGD-10 (0-0.5)	Aroclor 1221	0.063
	BKGD-10 (0-0.5)	Aroclor 1232	0.063
	BKGD-10 (0-0.5)	Aroclor 1242	0.063
	BKGD-10 (0-0.5)	Aroclor 1248	0.063
	BKGD-10 (0-0.5)	Aroclor 1254	0.063
	BKGD-10 (0-0.5)	Aroclor 1260	0.063
80941	BKGD-08 (1-2)	Aroclor 1016	0.15
	BKGD-08 (1-2)	Aroclor 1221	0.15
	BKGD-08 (1-2)	Aroclor 1232	0.15
	BKGD-08 (1-2)	Aroclor 1242	0.15
	BKGD-08 (1-2)	Aroclor 1248	0.15
	BKGD-08 (1-2)	Aroclor 1254	0.15
	BKGD-08 (1-2)	Aroclor 1260	0.15
	BKGD-08 (2-4)	Aroclor 1016	0.16
	BKGD-08 (2-4)	Aroclor 1221	0.16
	BKGD-08 (2-4)	Aroclor 1232	0.16
	BKGD-08 (2-4)	Aroclor 1242	0.16
	BKGD-08 (2-4)	Aroclor 1248	0.16
	BKGD-08 (2-4)	Aroclor 1254	0.16
	BKGD-08 (2-4)	Aroclor 1260	0.16
	BKGD-08 (4-6)	Aroclor 1016	0.17
	BKGD-08 (4-6)	Aroclor 1221	0.17
	BKGD-08 (4-6)	Aroclor 1232	0.17
	BKGD-08 (4-6)	Aroclor 1242	0.17
	BKGD-08 (4-6)	Aroclor 1248	0.17
	BKGD-08 (4-6)	Aroclor 1254	0.17
	BKGD-08 (4-6)	Aroclor 1260	0.17
	BKGD-08 (6-8)	Aroclor 1016	0.17
	BKGD-08 (6-8)	Aroclor 1221	0.17
	BKGD-08 (6-8)	Aroclor 1232	0.17
	BKGD-08 (6-8)	Aroclor 1242	0.17
	BKGD-08 (6-8)	Aroclor 1248	0.17
	BKGD-08 (6-8)	Aroclor 1254	0.17
	BKGD-08 (6-8)	Aroclor 1260	0.17
	BKGD-08 (8-10)	Aroclor 1016	0.18
	BKGD-08 (8-10)	Aroclor 1221	0.18
	BKGD-08 (8-10)	Aroclor 1232	0.18
	BKGD-08 (8-10)	Aroclor 1242	0.18
	BKGD-08 (8-10)	Aroclor 1248	0.18
	BKGD-08 (8-10)	Aroclor 1254	0.18
	BKGD-08 (8-10)	Aroclor 1260	0.18
80975	BKGD-09 (0-0.5)	Aroclor 1016	0.067
	BKGD-09 (0-0.5)	Aroclor 1221	0.067
	BKGD-09 (0-0.5)	Aroclor 1232	0.067

Samples and Results Originally Submitted without Reporting Detection Limit

	BKGD-09 (0-0.5)	Aroclor 1242	0.067
	BKGD-09 (0-0.5)	Aroclor 1254	0.067
	BKGD-09 (0-0.5)	Aroclor 1260	0.067
	BKGD-09 (1-2)	Aroclor 1016	0.059
	BKGD-09 (1-2)	Aroclor 1221	0.059
	BKGD-09 (1-2)	Aroclor 1232	0.059
	BKGD-09 (1-2)	Aroclor 1242	0.059
	BKGD-09 (1-2)	Aroclor 1254	0.059
	BKGD-09 (1-2)	Aroclor 1260	0.059
	BKGD-09 (2-4)	Aroclor 1016	0.058
	BKGD-09 (2-4)	Aroclor 1221	0.058
	BKGD-09 (2-4)	Aroclor 1232	0.058
	BKGD-09 (2-4)	Aroclor 1242	0.058
	BKGD-09 (2-4)	Aroclor 1254	0.058
	BKGD-09 (2-4)	Aroclor 1260	0.058
	BKGD-09 (4-6)	Aroclor 1016	0.044
	BKGD-09 (4-6)	Aroclor 1221	0.044
	BKGD-09 (4-6)	Aroclor 1232	0.044
	BKGD-09 (4-6)	Aroclor 1242	0.044
	BKGD-09 (4-6)	Aroclor 1248	0.044
	BKGD-09 (4-6)	Aroclor 1254	0.044
	BKGD-09 (4-6)	Aroclor 1260	0.044
	BKGD-09 (6-8)	Aroclor 1016	0.055
	BKGD-09 (6-8)	Aroclor 1221	0.055
	BKGD-09 (6-8)	Aroclor 1232	0.055
	BKGD-09 (6-8)	Aroclor 1242	0.055
	BKGD-09 (6-8)	Aroclor 1248	0.055
	BKGD-09 (6-8)	Aroclor 1254	0.055
	BKGD-09 (6-8)	Aroclor 1260	0.055
	BKGD-09 (8-10)	Aroclor 1016	0.056
	BKGD-09 (8-10)	Aroclor 1221	0.056
	BKGD-09 (8-10)	Aroclor 1232	0.056
	BKGD-09 (8-10)	Aroclor 1242	0.056
	BKGD-09 (8-10)	Aroclor 1248	0.056
	BKGD-09 (8-10)	Aroclor 1254	0.056
	BKGD-09 (8-10)	Aroclor 1260	0.056
80994	EB-06A (1-2)	Aroclor 1016	0.053
	EB-06A (1-2)	Aroclor 1221	0.053
	EB-06A (1-2)	Aroclor 1232	0.053
	EB-06A (1-2)	Aroclor 1248	0.053
	EB-06A (1-2)	Aroclor 1254	0.053
	EB-06A (1-2)	Aroclor 1260	0.053
81096	DUP 8 (4.4-6)-Duplicate	Aroclor 1232	0.056
81150	EB-31 (0-0.5)	Aroclor 1248	0.069

Samples and Results Originally Submitted without Results

Sample Delivery Group	Sample	Aroclor	Validated Result (mg/kg)
80994	EB-06A (1-2)	Aroclor 1242	0.110 U
	EB-06A (1-2)	Aroclor 1254	0.053 U

Samples and Results Originally Associated with the Incorrect Sample Delivery Group

Sample Delivery Group	Sample	Aroclor	Reported Result (mg/kg)	Validated Result (mg/kg)
80793	BKGD-08 (0-0.5)-Duplicate	Aroclor 1016	0.071 U	0.071 UJ
	BKGD-08 (0-0.5)-Duplicate	Aroclor 1221	0.071 U	0.071 UJ
	BKGD-08 (0-0.5)-Duplicate	Aroclor 1232	0.071 U	0.071 UJ
	BKGD-08 (0-0.5)-Duplicate	Aroclor 1242	0.071 U	0.071 UJ
	BKGD-08 (0-0.5)-Duplicate	Aroclor 1248	0.081 J	0.081 U
	BKGD-08 (0-0.5)-Duplicate	Aroclor 1254	0.071 U	0.071 UJ
	BKGD-08 (0-0.5)-Duplicate	Aroclor 1260	0.071 U	0.071 UJ
	BKGD-08 (0-0.5)	Aroclor 1016	0.072 U	0.072 UJ
	BKGD-08 (0-0.5)	Aroclor 1221	0.072 U	0.072 UJ
	BKGD-08 (0-0.5)	Aroclor 1232	0.072 U	0.072 UJ
	BKGD-08 (0-0.5)	Aroclor 1242	0.072 U	0.072 UJ
	BKGD-08 (0-0.5)	Aroclor 1248	0.13	0.130 U
	BKGD-08 (0-0.5)	Aroclor 1254	0.072 U	0.072 UJ
	BKGD-08 (0-0.5)	Aroclor 1260	0.072 U	0.072 UJ

APPENDIX B

GEOTECHNICAL ANALYSIS
FOR HARBOR AT HASTINGS OU-2

PREPARED BY HALEY & ALDRICH

21 APRIL 2006

APPENDIX B SUMMARY

The Supplemental Feasibility Study (Supplemental FS) for the Harbor at Hastings Operable Unit No. 2 includes evaluation of potential remedies that have a significant geotechnical engineering component. This appendix is intended to document geotechnical engineering analyses performed to support the evaluation of remedial alternatives considered in the Supplemental FS.

The geotechnical aspects of any potential remedy at this site are significant with respect to implementability, long-term effectiveness and cost. Determination of the constructability of geotechnical and structural engineering components is paramount for the selected remedy to be successful.

All alternatives discussed in this appendix appear to be constructible based on the available geotechnical data and our analyses to date. Some of these alternatives are complex and would require an extended period of time and high level of construction skill and care to implement.

Site conditions along the shoreline, including the presence of fill materials underlain by a soft marine silt layer, makes the geotechnical engineering at the site both complex and challenging. These challenges are exacerbated by the significant level of debris and former waterfront structures present along the alignments of steel sheet pile bulkheads which will support the upland during dredging and for the long term. All of these factors contribute to geotechnical and construction implementation challenges/limitations on the depth of dredging that can be safely conducted immediately adjacent to and down-slope from the shoreline.

There are several factors that control or influence the design and construction of geotechnical engineering components at OU-2. These factors include:

- Environmental Considerations: As discussed in detail in the Harbor at Hastings Operable Unit No. 1 (OU-1) Feasibility Study, the NYSDEC issued OU-1 Proposed Remedial Action Plan and the NYSDEC issued Record of Decision for OU-1, the presence of dense non-aqueous phase liquids (DNAPL) at the fill/marine silt interface at or near the proposed shoreline bulkhead wall located in the Northwest Corner Area makes it very risky to drive the shoreline bulkhead wall into the currently uncontaminated basal sand aquifer. The basal sand groundwater could be contaminated by drag-down and/or remobilization of DNAPL along preferential pathways created by the shoreline bulkhead wall installation into the basal sand. Accordingly, three of the Northwest Corner Area alternatives discussed herein are based on the toe of the shoreline bulkhead wall terminating in the marine silt above the basal sand.
- Slope Stability: A significant geotechnical factor controlling construction and long-term shoreline bulkhead stability is slope stability. This is particularly true for the Northwest Corner Area alternatives where slope stability controls the dredge depth that can be safely constructed and also other geotechnical

considerations including dredge slope cuts, underwater berms, inland elevations during dredging and the placement of lightweight fill along the inland shoreline. The same is true for the Southern Area alternatives where a berm is necessary to stabilize the shoreline bulkhead structure following dredging and in the Old Marina where specific dredge slopes are needed to address slope stability over the long term.

In general, the following measures are required to address slope stability and allow for safe construction while maximizing dredge depth:

1. Reduce the weight (load) of the inland area adjacent to the shoreline both during and after dredging. Measures to accomplish this reduction in the shoreline load include reducing the final elevation of the shoreline area as part of OU-1 construction, filling along the shoreline using lightweight fill as part of OU-1 construction, limiting the weight of equipment and other appurtenances on the shoreline during OU-2 dredging, and waiting to seal the shoreline bulkhead until after OU-2 construction is complete.
2. Design and build underwater berms to support the wall after construction is complete.

Several remedial alternatives were evaluated in this report and were separated into distinct areas of OU-2 including the Northwest Corner Area, the Southern Area, North Boat Slip and the Old Marina Area. A summary of the results of our evaluation for the remedial alternatives in each area is provided below.

<u>Northwest Corner Area</u>

Four alternatives were evaluated for the Northwest Corner Area. The primary differences between the alternatives are as follows:

- The depth at which the shoreline bulkhead is installed/constructed.
- The timing of construction between OU-1 and OU-2.
- The location of the shoreline bulkhead.
- The dredge depth that can be achieved given the above.

All of the Northwest Corner Area alternatives include dredging to specified depths, the installation of a temporary rigid containment barrier, on-shore anchorage of the bulkhead wall, placement of lightweight fill, restoration of the river bottom including the installation of a support berm and protective cap following dredging, and final elevation of the shoreline at elevation +4 ft (based on the NAVD88 North American Vertical Datum).

The unique features of each of the alternatives are described below.

<u>Northwest Corner Area Alternative NW-1</u>

The NW-1 alternative allows for the remediation of OU-2 to take place independent of OU-1, which has the significant advantage of allowing OU-1 construction to proceed independently of OU-2 construction. To support the long term OU-1 loads, an underwater berm would be constructed prior to OU-2 dredging. This berm would not extend into the area to be dredged. The NW-1 alternative includes dredging to elevation -7 ft near the shoreline bulkhead, which would be installed into the marine silt to avoid contamination of the currently uncontaminated basal sands below. Below elevation -7 ft, dredging would reduce the factor of safety for bulkhead wall stability to below acceptable levels. Once dredging is complete, the river bottom will be restored with the placement of a protective cap and berm. Also, the temporary containment barrier will be cut off at the mudline as part of the river restoration process.

Northwest Corner Area Alternative NW-2

The NW-2 alternative allows for dredging to greater depths than NW-1 by combining OU-1 and OU-2 construction. Accordingly, this alternative requires the close coordination of the on-shore excavation work and the dredging work and may delay completion of OU-1 construction. Like NW-1, the shoreline bulkhead wall would be installed into the marine silt to avoid contamination of the currently uncontaminated basal sands below. After installation of the bulkhead wall and excavation of OU-1, the OU-1 on- and near-shore area would be backfilled with lightweight fill, the remainder of OU-1 would need to be graded to an interim elevation that is lower than final required grades, and the bulkhead wall would remain unsealed. Dredging would then be undertaken to elevation -9 ft or elevation -14 ft depending on the configuration of slopes adjacent to the bulkhead wall. Dredging deeper would reduce the factor of safety for bulkhead wall stability to below acceptable levels. Once dredging is complete, the river bottom would be restored with the placement of a protective cap and berm, the temporary containment barrier would be removed, final grades would be constructed in OU-1 and the bulkhead wall would be sealed.

Northwest Corner Area Alternative NW-3

Alternative NW-3 is unique because it moves the shoreline bulkhead approximately 40 to 100 ft into the current river location. On the river side of the bulkhead wall, dredging would be undertaken to remove all sediments to below remedial action goals. Once dredging is complete, the river bottom would be restored with a protective cap and support berm and the site will be backfilled to build land to the shoreline bulkhead. It is noted that backfilling between the current land and the new bulkhead location for this alternative has a time element of possibly several years to construct, allowing 1 year for settlement associated with placement of the fill onto soft marine silt sediments.

Northwest Corner Area Alternative NW-4

Alternative NW-4 includes the installation of the bulkhead wall into the basal sands and dredging to the limit of bulkhead wall stability (elevation -32 ft). The alternative was included at the request of the NYSDEC and carries the significant potential of contaminating the currently uncontaminated basal sand aquifer during bulkhead wall installation. As noted above and in previous documents regarding

OU-1, such an occurrence may have a significant undesirable environmental impact.

Southern Area Alternatives

The Southern Area differs from the Northwest Corner because the area is characterized by deeper water close to shore resulting in structurally weaker sediments at a given elevation within the soil profile. This factor makes the Southern Area geotechnically distinct from the Northwest Corner. The Southern Area alternatives include capping only, dredging up to 2 ft below the existing mudline and capping, and dredging to depths up to elevation -14 ft (at the shoreline bulkhead) followed by capping.

Due to the relatively weak soils in the Southern Area, all of the alternatives include placement of lightweight fill on the landward side of the wall, restriction of the land elevation to elevation +4 ft, installation of a bulkhead wall, restricting equipment and other appurtenances near the shoreline during dredging, installing bulkhead wall anchorage and installing a berm in the river to support the shoreline bulkhead wall after dredging. Even alternatives assuming no dredging or very shallow dredging would need to incorporate some if not all of these measures to support long term loads with an adequate factor of safety.

Given the above geotechnical requirements/components, the maximum calculated dredge depth adjacent to the bulkhead wall that meets the factor of safety requirements set forth herein is elevation -14 ft. This assumes the bulkhead wall is installed into the marine silt. If the bulkhead wall is extended into the basal sands in this area, then the maximum calculated dredge depth adjacent to the shoreline bulkhead wall that is geometrically possible and meets the factor of safety requirements set forth herein is approximately elevation -29 ft. This dredge depth would need to slope upward to elevation -15 ft outward into the river to the location of the temporary silt curtain.

North Boat Slip

The North Boat Slip alternatives include dredging to 2 ft below the existing mudline and dredging to elevation -14 ft at the shoreline bulkhead. The dredge area would be capped following dredging under both of these alternatives. The latter alternative was geotechnically evaluated and it was determined that this alternative could be designed and constructed to an acceptable factor of safety. In order to meet this factor of safety level, this alternative included dredging along a prescribed slope, prohibiting heavy equipment and other appurtenances within 100 ft of the shoreline during dredging, placement of lightweight fill landward and adjacent to the shoreline bulkhead, limiting the final shoreline elevation to elevation +4 ft, sealing the shoreline bulkhead after OU-2 construction is complete and placing a berm in the river adjacent to the boat slip to provide long-term structural support.

Old Marina Area

The Old Marina alternatives included dredging up to 2 ft below the existing mudline and subsequent capping; and dredging to the depth necessary to remove site-related contamination to applicable remediation goals. Following dredging, the dredge slope in the Old Marina Area would serve as the final bulkhead support berm so long term upland loading conditions were used in stability analysis for this area. In order to evaluate these alternatives geotechnically, an analysis was performed to determine the slope configuration that could be undertaken while maintaining a prescribed factor of safety. The analysis found that the allowable slope configuration varied depending on location. Beyond these required slopes, dredging could proceed to the required depth without impact to shoreline structures. The evaluation assumed dredging in these areas would be less than approximately elevation -12 ft.

APPENDIX B TABLE OF CONTENTS

Page

LIST OF TABLES

TABLE OF CONTENTS
CONTINUED

LIST OF FIGURES

TABLE OF CONTENTS
CONTINUED

LIST OF FIGURES
(continued)

APPENDIX B

GEOTECHNICAL ANALYSIS
HARBOR AT HASTINGS OU-2

B1 INTRODUCTION

The remedial alternatives evaluated within this Supplemental Feasibility Study (Supplemental FS) for Harbor at Hastings Operable Unit No. 2 (OU-2) have a significant geotechnical engineering component. This appendix is intended to document the geotechnical engineering analysis of the remedial alternatives evaluated in the Supplemental FS.

The geotechnical aspects of any potential remedy at this site are significant with respect to implementability/constructability, long-term effectiveness and cost. Determination of the constructability of geotechnical and structural engineering components is paramount for the selected remedy to be successful.

All alternatives discussed in this appendix appear to be constructible based on the available geotechnical data and our analyses to date. Some of these alternatives are complex and would require an extended period of time and high level of construction skill and care to implement.

Extensive engineering effort went into establishing the constructability of these remedial alternatives. However, one is cautioned that the Remedial Design phase of the project is the point in the process at which the alternative(s) to be constructed is known and during which field data are collected to permit a final design to be produced. The Remedial Design process will provide the final designs for stable slope grades, OU-1 loading changes, etc. The engineering conducted to this point was undertaken to ensure that unconstructible alternatives would be identified and to support cost estimation efforts reported elsewhere in the Supplemental Feasibility Study. All engineering elements discussed in Appendix B and shown on the figures were developed based on the information available at the time the evaluations were performed.

The figures presented in this Appendix B reflect dredging assumptions made as part of the geotechnical assessment of environmental alternatives. Geotechnical assessment and contaminant modeling efforts occurred simultaneously and as a result there are some differences between the dredge depths assumed in the geotechnical analysis and the limits of contamination exceeding PRGs based on AR's contaminant distribution modeling. For this reason, the dredge limits based on PRGs is also shown on the Appendix B Figures where the geotechnical calculations assumed a deeper dredge depth than is required to meet remediation goals. Appendix B Figures ENV-1A and ENV-1B show, in plan view, the results from AR's contaminant distribution modeling for the Northwest Corner Area. Also refer to Figures 1.3 and 1.4 for AR contaminant modeling results for PCBs and copper respectively.

Note that elevations presented in this appendix are based on the NAVD88 datum. The mean tidal elevation at OU-2 is at elevation +0.11 ft based on NAVD88.

B1.1 Summary of Subsurface Conditions

The OU-1 upland in the vicinity of the existing shoreline, generally has a surficial layer of urban fill overlying a thick marine silt stratum overlying a basal sand stratum. Each of these strata is discussed briefly below. Subsurface conditions within OU-2 are similar except that the fill stratum is generally only found close to shore in the Northwest Corner Area. Therefore, marine silt is found at the surface of the existing river bottom over most of OU-2.

The fill is generally loose and comprised mostly of ash, cinders, and rubble. The depth of the fill along the shoreline bulkhead alignment varies. The bottom of the shallowest fill extends to elevation -14 and the deepest to over elevation -35 in the upland area along the shoreline bulkhead alignment. The bottom of the fill zone at the Northwest Corner of OU-2 is mixed with the top of the marine silt layer. While the fill is considered a poor material relative to compacted granular backfill, it is generally a stronger material than the existing marine silt.

The marine silt stratum extends down below the fill to approximately elevation -70 along the shoreline bulkhead alignment at the Northwest Corner and down to approximately elevation -65 in the southern half of OU-2. Further from shore, the marine silt appears to extend from the river bottom to approximately elevation -88 approximately 160 ft away from shore west of the alignment of the temporary rigid containment barrier.

A review of the available undrained shear strength test data of the marine silt at OU-2 was undertaken and a shear strength versus effective vertical stress relationship developed. Since the primary failure mode of concern is slope stability, a shear strength relationship was developed based on an equivalent direct simple shear test. The developed relationship is as follows:

> $S_{DSS} = 0.21\sigma'_{v0}$ where S_{DSS} is the undrained shear strength as would be measured in a direct simple shear test, and σ'_{v0} is the effective vertical stress that currently exists on OU-2 at any point within the marine silt stratum. Effective vertical stress is calculated as the buoyant unit weight of the soil times the depth below the ground surface. It is assumed that soils are normally and fully consolidated. This relationship between the effective vertical stress and the marine silt shear strength is used extensively in the calculations discussed in this appendix.

The marine silt exposed on the river bottom could be less precisely described as "mud". This mud is very soft so that if someone tried to walk into shallow water in this area, the mud would not be able to support their weight and they would sink at least up to their shins if not deeper.

The basal sand layer, which underlies the marine silt layer, consists of medium to very dense sand and fine gravel with occasional lenses of stiff silt and clay. This layer is also an uncontaminated aquifer and requires protection as discussed below.

B1.2 Environmental Considerations Affecting the Shoreline Bulkhead

Due to the presence of dense non-aqueous phase liquids (DNAPLs) in the fill and at the top of the marine silt in the Northwest Corner Area, most bulkhead alternatives considered in this appendix assume that the shoreline bulkhead would not penetrate through the marine silt confining layer. One remedy evaluated (Alternative NW-4) is based on driving the shoreline bulkhead through the marine silt and into the basal sand in the Northwest Corner Area. However, the risk of contaminating the basal sand aquifer (an uncontaminated aquifer) in the Northwest Corner Area outweighs the structural benefit of driving the shoreline bulkhead into the basal sand layer.

Driving the shoreline bulkhead into the basal sand is also considered as one possible remedial approach for constructing the bulkhead in the area of former Building 15, an area that does not appear to be impacted by DNAPL.

B1.3 Stability of Existing Slopes

Global stability, expressed as a factor of safety, is the ratio of the ultimate resisting strength of the soil along a particular failure plan to the forces driving soil to flow down hill. Topography, soil profile, upland loading, bulkhead wall penetration, and dredge depth, all affect the stability of an alternative.

As a first step in calculating the global stability factor of safety for each of the alternatives, the factor of safety of the existing slope / deteriorated bulkhead was calculated. In areas of the northwest corner where no functioning bulkhead is visible, the factor of safety calculated at different sections was often less than 1.0 or only slightly higher than 1.0. Where the factor of safety was less than 1.0, it is postulated that the existing slope is being partially supported by the buried remnants of bulkheads and foundation piles which are not currently visible.

Calculations suggest that the existing slopes in the Northwest Corner Area are only marginally stable. It is postulated that much of the fill that is in the river in this area arrived there by having been placed along the shoreline and being allowed to slump into the river. The low factor of safety in this area may be an issue when excavations are made to remove debris and obstructions in the river as this debris may be contributing to the support of the slope.

B1.4 Geotechnical Considerations Common to all Remedial Action Alternatives

The new shoreline bulkhead structure must sufficiently reinforce existing conditions to support any new upland loads due to changes in the site grade and proposed live loads (referred to as surcharge loading in this appendix). The shoreline bulkhead would also be sealed and it will therefore support a significant differential water pressure load after being sealed. In addition to these new loadings, the proposed bulkheads would need to have a factor of safety at all stages of construction (including dredging) which is consistent with current design standards.

The bulkhead analyses discussed in this appendix have been developed based on the following principles:

1. Global stability (also called slope stability) controls allowable dredge depth for all of the alternatives considered except NW-4 and SA-4 (global stability controls wall embedment for NW-4 and SA-4). There are geotechnical limits on the dredge depth immediately next to a shoreline bulkhead and west of the bulkhead. Exceeding these limits would cause a slope failure resulting in the bulkhead and contaminated upland soils collapsing into the river. These geotechnical limits are primarily due to the low soil shear strength of the marine silt supporting the shoreline bulkhead and due to site topography.

2. The shoreline bulkhead discussed in this appendix is assumed to be supported with a deadman anchorage system. Bulkhead height and loading precludes cantilevering the bulkheads, especially when dredging is considered. A deadman anchor system is comprised of corrosion protected steel anchor rods or tendons spaced at regular intervals along the length of the bulkhead. The anchor rods would extend horizontally

back from the bulkhead approximately 100 ft to 150 ft to concrete reaction blocks buried in compacted structural fill.

3. The allowable dredge depth can be increased by unloading the OU-1 upland area. Unloading of the upland area using lightweight fill (and other measures) is assumed for all of the alternatives considered and is necessary to allow for dredging. Remedial excavation to 9 ft below the existing ground (elevation -6) surface at OU-1 is currently mandated by the OU-1 remedy in the northwest portion of OU-1. Because of this, lightweight fill placement is assumed to extend to elevation -6 in this area. In the Southern Area and boat slip areas, OU-1 remedial excavation is not mandated except in limited areas and so an objective is to minimize the amount of lightweight fill placed while still achieving the remedial action objectives.

4. Several different types of lightweight fill material are available covering a wide range of unit weights. For the engineering assessments presented in this document, expanded shale aggregate is assumed which has a saturated unit weight of approximately 75 pounds per cubic foot (pcf). This material is stronger than the fill currently at the site and poses no restrictions to redevelopment of the site. Any specific soil and geotextile layers that are prescribed as part of environmental cap in the Northwest Corner of OU-1 can be accommodated without changing the total load in the upland area. Materials that weigh more than 75 pcf for the cap can be balanced by use of lightweight material below the cap which weighs less than 75 pcf so that the resulting total load is the same.

5. The differential soil loading acting on the shoreline bulkhead as a result of dredging represents a temporary loading condition if it is assumed that the dredged area would be backfilled at the completion of the work. To allow for deeper dredging during this temporary loading case, upland surcharge loading can be prohibited within the zone of influence of the shoreline bulkhead. Sealing of the bulkhead interlocks to make the bulkhead watertight can also be delayed until after the dredge area is backfilled, avoiding having to support a differential water load during this critical loading case.

6. A 200 pound per square foot (psf) vertical surcharge loading has been assumed as a live load over the entire upland area for the long term loading case for all of the alternatives considered. This loading is based on American Association of State Highway and Transportation Officials (AASHTO) guidelines for traffic loading, although is slightly less than what is normally assumed. A 5-foot differential water loading it is also assumed for the long term case after the bulkhead interlocks are sealed. This loading is based on tidal fluctuations at this site. The possible long term mounding of water upland of the sealed bulkhead would have to be investigated and the loading on the bulkhead modified as appropriate.

7. Alternatives evaluated all include the construction of a support berm in the dredged area to support the shoreline bulkhead in the long term. The size of the berm required is dependent on many design factors (including consolidation strength gain) as discussed in this appendix but would be significantly smaller for alternatives which assume that any increase in site grade would be set back from the existing shoreline by approximately 100 ft.

8. The undrained shear strength of the marine silt, which varies with depth below the existing ground surface in accordance with the shear strength relationship discussed in Section B1.1 above, is a key parameter affecting stability.

9. The target minimum global stability factor of safety for analyzing both the temporary construction and permanent cases is 1.5. The global stability factor of safety is a ratio of resisting forces over driving forces along a critical slip surface. Due to the many uncertainties involved in this calculation, it is appropriate to assume a minimum factor of safety when assessing stability. For pre-remedial design phase evaluations, a factor of safety of 1.5 is appropriate, given the level of uncertainty and risk. Alternatives in which the factor of safety is calculated at between 1.3 and 1.5 are questionable but still may be possible, depending on the results of future geotechnical soil testing, loading conditions, and other factors. As with all of the calculations discussed in this document, future remedial design investigation results and remedial design activities will provide the specifications for the remedial action.

10. The elevation of the fill/marine silt interface in the OU-1 upland area varies between elevation -14 and elevation -35 in the Northwest Corner Area along the shoreline (see Figures ENV-1A and ENV-1B). Calculations to test the alternatives discussed in this Supplemental FS were performed at two cross sections where the fill/marine silt interface is at elevation -17 and elevation -25, reflecting much of the variation of OU-1 upland conditions in the Northwest Corner Area.

B1.5 Analysis Methods

In general, global stability was found to control the analysis of all of the alternatives considered. As a result, most of the calculation effort was performed using SLIDE (a slope stability program) and PLAXIS (a finite element based program which can be used for both slope stability and structural analysis).

Although global stability, in general, controls the allowable dredge cut and the extent of the berm in the river, other failure modes are also important and have been considered. For example, bulkhead calculations have been checked using a United States Army Corps of Engineers (USACE) program for the analysis of sheet-pile walls by classical methods called CWALSHT. A factor of safety of 1.5 has been applied to passive earth pressures in all CWALSHT calculations. Bending moments, deflections, and anchorage loads have been calculated using the computer programs CWALSHT, PLAXIS, and WALLAP to check the structural adequacy of the bulkheads and the temporary barrier.

In general, CWALSHT and WALLAP look at comparatively localized failure modes associated with lateral loading on the steel sheeting and the soil support of the sheeting. SLIDE assesses more globally-based failure surfaces which extend from the upland down to below the shoreline bulkhead and then out to the toe of the dredge slope or through some portion of the slope. PLAXIS was used to evaluate local sheeting failure modes and global stability failure modes simultaneously and, as a finite element program, PLAXIS was used to model comparatively more complex cases. The program was only used for those cases that required such analysis.

All of the programs mentioned above are in wide use in the industry and are generally accepted as providing realistic results.

B1.6 Bulkhead Support Berm

Placing fill into the river at the completion of dredging to create a bulkhead support berm would be required for most of the alternatives considered. Berm size and shape to achieve stability under long term loading condition vary with the alternative being considered and at each cross section for a particular alternative. Berm size required is dictated by a number of factors, as discussed above, including the long term OU-1 loading conditions, how much the OU-1 area has been unloaded by placing lightweight fill or loaded by raising the grade. The initial strength of the marine silt sediments supporting the bulkhead wall and assumed consolidation under the weight of the berm, also influence berm size as does sheeting length. An effort has been made to minimize berm size.

If a berm thicker than approximately 5 ft is required, it would most likely be constructed of crushed stone/crushed rock of uniform gradation (unit weight of 120 to 125 pounds per cubic foot or pcf) which can be placed in thin (4 to 18 inches) uniform lifts through the water column. The initial lifts would likely be sand and subsequent lifts would grade to crushed stone.

Construction of an underwater berm would likely start where the slope of the existing mudline is relatively flat (near the toe of the steeper slope which supports the upland). As the thickness of a berm placed in this area increases, the berm would be extended closer to shore where the existing slope is steeper, using the previously placed berm as a supporting buttress. Staged construction and careful lift control would be used to prevent the berm material from sliding down the slope when placed.

B1.7 Consolidation Time and Wick Drains

Each of the alternatives considered in this appendix require a support berm. The berm for some cases would require no consolidation. Other cases require partial consolidation (20 percent) of the underlying marine silt under the weight of berm. This can be often achieved by waiting approximately a year or less. Alternatives which require a higher degree of consolidation, such as NW-3, were assumed to utilize wick drains to reduce consolidation time. A 90 percent consolidation strength gain is needed within the marine silt for the NW-3 conceptual case, as discussed in Section B4.

Wick drains are strips of geotextile fabric installed vertically with a mandrel at approximately 5 ft center to center grid spacing. These drains are used to greatly accelerate the time it takes to achieve consolidation in low permeability soils. For alternatives that need wick drains, the drains are assumed to be installed in the berm and in the new NW-3 upland fill areas because that is where the greatest load increase and greatest increase in marine silt strength would occur.

Since it is very important that the basal sand be protected from contamination, the wick drains would only be installed through the upper one half to two thirds of the marine silt deposit. Used in this way, the drains would only allow for accelerated drainage to the surface of the mudline and not into the basal sand.

Table B-1 summarizes the calculated berm consolidation requirements for each of the alternatives considered including the time estimated to achieve that consolidation and whether or not wick drains are required as part of the alternative.

B1.8 Limitations

The calculations presented here are based on the geotechnical data available at this time. Additional geotechnical data may be needed from OU-2 at a later time to design the selected OU-2 remedy.

All engineering elements presented in Appendix B were developed based on existing information for the purpose of evaluating remedial alternatives for OU-2. The elevations, dimensions, and other engineering aspects presented in this appendix should be viewed as preliminary, approximate, and subject to change.

B2 NORTHWEST CORNER AREA ALTERNATIVE NW-1

The Northwest Corner portion of OU-2 is the area of the river between the North Boat Slip and the Old Marina Area which will be contained on the west by a temporary rigid containment barrier and on the east by the existing shoreline.

The discussion below is a conceptual analysis of possible options for the construction of Northwest Corner Alternative NW-1. This alternative assumes that the shoreline bulkhead can be completed and the OU-1 upland filled to final grade as part of OU-1 construction prior to the start of OU-2 dredging. NW-1 involves dredging to elevation -7 near the bulkhead within the area confined by a temporary rigid containment barrier (the submerged bulkhead) installed approximately 50 ft from shore. The width of the dredge area between the shoreline bulkhead and the elevation -7 contour is 10 ft to 40 ft depending on location. Following dredging, a berm and protective cap would be placed between the temporary rigid containment barrier and the shoreline bulkhead. Calculations were performed at two typical soil profiles to assess the effect of dredging on global stability. Section B2.1 presents an evaluation of the stability of the existing shoreline and the proposed shoreline bulkhead assuming that there would not be any dredging. Section B2.2 below discusses the calculations related to Alternative NW-1.

Two possible upland grade elevations are evaluated. In the first case the upland grade is assumed to be at elevation +9 based on the OU-1 federal consent decree. In the second case the upland grade is assumed to be at elevation +4 within 100 ft of the shoreline bulkhead prior to increasing to elevation +9. This upland grade configuration has many advantages as demonstrated by the calculations discussed below. Various berm alternatives are associated with these two cases as discussed below.

B2.1 Shoreline Bulkhead Assuming No Dredging

As part of the NW-1 analysis, the stability of the existing slope was calculated to provide a basis for analyzing Alternative NW-1. The factor of safety was found to be close to 1.0 for the existing slope. The stability of the proposed shoreline bulkhead under long-term loading conditions was then calculated assuming that a shoreline bulkhead wall was installed and anchored, no dredging would be required, and that the OU-1 ground surface elevation was increased to elevation +9 for redevelopment purposes. The placement of lightweight fill between elevation -6 and +9 was also assumed as part of this assessment. The factor of safety for this case was found to be insufficient.

Various alternatives were reviewed to increase stability and achieve a factor of safety of 1.5 for this case. An underwater berm constructed entirely below elevation -10 was found to increase stability to acceptable levels. The top of the berm would be at elevation -10 adjacent to the existing shoreline, and the berm would be approximately 20 to 70 ft (horizontal distance perpendicular to the shoreline) wide at this location. The berm would then extend down and away from shore at an approximately 6 horizontal to 1 vertical (i.e., 6H:1V) slope to where it intersects the existing grade.

B2.2 Alternative NW-1: Dredge for Cap Stability

Alternative NW-1 involves dredging to elevation -7 along the face of the proposed shoreline bulkhead and out to the existing elevation -7 contour line (where the dredge cut would daylight). The dredge area would be contained within a temporary rigid containment barrier (which would be converted into a submerged bulkhead) located approximately 50 ft from shore. At the completion of dredging the submerged bulkhead would be cut off near the top of the final berm elevation. A protective cap would be incorporated into the berm design in the area between the shoreline bulkhead and submerged bulkhead. A protective cap would also be incorporated into the design of the berm installed below the elevation -10 contour line so that the entire Northwest Area (from the shoreline to approximately 140 west of the shoreline) would be covered with a protective cap.

Construction of the OU-1 (onshore) remedy that NYSDEC selected in its March 2004 Record of Decision (NYSDEC, 2004) could be completed prior to implementing Alternative NW-1 dredging with the use of lightweight backfill in the upland and the placement of a support berm prior to raising the OU-1 grade. The required support berm would be as described in Section B2.1. Figures N1-1 through N1-3 show proposed Alternative NW-1 in plan and section for the case where the upland is backfilled to elevation +9 at the bulkhead wall.

Figure N1-1 is a plan view of the Northwest Corner Area during proposed NW-1 dredging. The alignments of the proposed shoreline bulkhead and submerged bulkhead (the temporary rigid containment barrier at the time of dredging) are shown. A horizontal dredge cut at elevation -7 adjacent to the shoreline bulkhead is shown as a shaded area. Figure N1-1 also shows a support berm, constructed as part of OU-1 construction prior to dredging to support the increase in upland grade. The shaded area outboard of the elevation -10 contour line would be the top of the berm, which would be filled to elevation -10 and then slope down at 6H:1V outboard of the shaded area.

The analysis of Alternative NW-1 builds on the analysis of the shoreline bulkhead assuming no dredging. NW-1 assumes dredging to elevation -7 between the bulkhead and the elevation -7 contour line on the river bottom. Other than the dredging, the conditions are the same as assumed in Section B2.1. Dredging decreases the factor of safety of 1.6 (without dredging) to 1.51. The conditions assumed for this temporary case are as follows:

- A cross section cut approximately 220 ft south of Section B on Figure N1-1 was assumed. The bottom of the fill was assumed to be at an average elevation of -21 in the upland area based on available soil boring results.
- The bulkhead would be sealed and the inboard water level would be approximately 5 ft higher than the outboard water level. Lightweight fill would be placed between elevation -6 and elevation +9 within approximately 100 ft of the shoreline bulkhead. There would be a uniform 200 psf surcharge loading applied over the upland area. The bulkhead would be anchored at elevation 0. The zone of lightweight fill placement is approximate and would vary from 80 to 120 ft wide or more.

- The assumed berm would not interfere with the proposed dredging as the top of the berm would be at elevation -10 and the dredge depth would be elevation -7. Consolidation strength gain under the loading of the berm is not assumed for this case.

As shown on Figure N1-2, a substantial berm would be required. To see if the berm size could be reduced, some additional analyses were performed assuming deeper sheeting penetration (from elevation -35 to elevation -54). The required berm would be smaller as illustrated on Figure N1-2 (shown as a dashed line for Sections A and B). The global stability factor of safety is 1.55 for this case which has an approximately 7 ft thick berm (above existing river bottom).

NW-1 Shoreline Bulkhead sheeting CWALSHT analyses indicate that a Waterloo WEZ 95 sheet pile wall (or equivalent) would be sufficient for the conditions depicted in the SLIDE analyses. Global stability controls sheeting embedment.

For Alternative NW-1, a temporary rigid containment barrier would be installed approximately 50 ft from the shoreline in relatively shallow (approximately 15 ft deep at mean tide) water as shown in Figure NW1-1. The temporary barrier would be approximately 800 to 900 ft long with the top of the temporary barrier at elevation +5 and the toe at elevation -61 which is approximately 14 ft above the top of the basal sand. The top of the barrier would be set above the high tide water level so the temporary barrier can contain suspended sediment during dredging. The barrier would not be watertight and water levels on opposite sides of the wall would be allowed to equilibrate during tide cycles. At the completion of dredging, the barrier would be cut off at the top of the berm and would then serve as the submerged bulkhead. Characteristics of this temporary barrier are discussed in Section B6.1 of this appendix.

B2.3 NW-1 Assuming a Grade Increase Setback

Figures N1-4 through N1-6 illustrate Alternative NW-1 assuming that the final upland grade is at elevation +4 for a distance of 100 ft inland from the bulkhead prior to sloping up to elevation +9 at 120 ft from the bulkhead. The zone of lightweight fill placement is approximate and may vary from 80 to 120 ft wide or more. In these figures, the berm slopes have been modified to not be any steeper than 4H:1V. The 4H:1V berm slope may have to be flattened even more during construction if there is any difficulty placing it. SLIDE calculations for Section A assume conditions during OU-2 dredging, after completion of the OU-1 remedy. A factor of safety of 1.53 was calculated for this condition.

A factor of safety of 1.54 was calculated for Section B during the dredging condition. The extent of the berm shown on Figures N1-4 through N1-6 only considers slope and bulkhead stability requirements. The lateral extent of the protective cap is not shown on the figures but would extend beyond the limits of the berm.

Comparing the sizes of the berms required for the two final OU-1 grade options, it is clear that a much smaller berm is needed if the final upland grade adjacent to the shoreline is elevation +4. In addition, it is likely aesthetically pleasing to have the shoreline bulkhead wall only 6 ft above the water level at low tide as opposed to 11 ft.

B3 NORTHWEST CORNER AREA ALTERNATIVE NW-2: DREDGE TO THE LIMITS OF BULKHEAD STABILITY

Northwest Corner Area Alternative NW-2 involves dredging to the maximum depth possible outboard of the shoreline bulkhead by unloading the upland area as much as practical at the time of dredging. The two basic NW-2 Options are discussed below:

- Option A assumes that dredging extends to elevation -9 at the shoreline bulkhead and then slopes down at 5 horizontal to 1 vertical. This dredge cut is possible where the upland fill/marine silt interface is between elevation -14 and elevation -24.
- Option B assumes that dredging extends to elevation -14 at the shoreline bulkhead and then slopes down at 5 horizontal to 1 vertical. This dredge cut is only possible where the upland fill/marine silt interface is at elevation -25 or lower. To achieve a dredge cut to elevation -14 in areas where the upland fill/marine silt interface is between elevation -14 and elevation -24 it is necessary to dredge horizontally 25 ft at an elevation of -14 prior to sloping down at 5 horizontal to 1 vertical. Note that all dredge elevations and horizontal widths are approximate and subject to change during remedial design.

At the completion of dredging, it is necessary to construct a berm and protective cap in the dredge area prior to fully loading the OU-1 upland area. The size of this berm / protective cap is dependent on the final upland grade and other loads applied. Berm size is also independent of dredge depth. Two cases are considered with respect to final grade, an upland grade of elevation +9 and, the preferred case, which assumes that the final OU-1 grade at elevation +4 within 100 ft of the bulkhead prior to sloping up to elevation +9 120 ft inland of the bulkhead. An upland grade of elevation +4 is preferred because the size of the required support berm is smaller than for the elevation +9 option. The combination of the two NW-2 options and the two final grade options results in the four cases for NW-2 discussed below.

The Option B dredge limits are illustrated in plan view on Figure N2-1. Figures N2-3 and N2-4 show section views of the dredge limits upon which the geotechnical calculations are based. The Option A geotechnical dredge limits is illustrated in plan view on Figure N2-5. Figures N2-6 and N2-7 show in section view the Option A geotechnical dredge limits. The dredging analysis for both of these options is independent of the final upland grade because the grade is assumed at an interim elevation of elevation +4 without surcharge or differential water loading at the time of dredging. The final upland grade was assumed to be elevation +9 for the cases depicted on Figures N2-1 through N2-7.

The Option A dredge cut would be similar to Option B dredging except that the dredge cut at the face of the shoreline bulkhead would be at elevation -9 and there would be no horizontal bench cut at Sections B and C. The toe of the dredge slope would be at the same location at Sections B and C but at slightly different locations at Sections A and D.

The required submerged berm to support this increase in grade is shown in section (profile) view on Figures N2-3, N2-4, N2-6 and N2-7. Figure N2-2 shows what this berm would look like for Option B. Twenty percent consolidation of the marine silt stratum under the weight of the berm shown would be required prior to increasing the OU-1 elevation grade to elevation +9, sealing the shoreline bulkhead, and allowing surcharge loading.

The toe of shoreline bulkhead is assumed at elevation -54 which is approximately 16 ft above the basal sand elevation in this area. Lightweight fill placement is assumed to extend approximately 100 ft inboard of the shoreline bulkhead and from elevation -6 to the ground surface. The zone of lightweight fill placement is approximate and would vary from 80 to 120 ft wide or more. Deadman anchorage of the shoreline bulkhead is shown at elevation 0. The berm is shown as a shaded area on the sections.

Calculations were performed at only 1 or 2 select sections for each variation and the results presented on the figures have been extended by extrapolation to the four sections (A through D) shown. Refinement to the dredge cut and berm size would likely occur during remedial design should this alternative be selected.

Under Alternative NW-2, much of the required OU-1 remedy would need to be completed prior to OU-2 remediation. OU-1 work includes the construction of the shoreline bulkhead and installation of the deadman anchorage system as shown. The OU-1 upland would be excavated to elevation -6 along the shoreline and then backfilled with lightweight fill to an interim elevation of approximately elevation +4 prior to dredging. Backfilling the upland to elevation +4 avoids flooding within OU-1 at high tide.

Sealing of the shoreline bulkhead would be delayed until completion of OU-2 dredging and capping operations in order to maintain a sufficient global stability factor of safety.

Where the dredge cut required based on the AR contaminant distribution modeling (see Figures ENV-1A & ENV-1B and Figures 1.3 and 1.4 in the main text) would be less than the cut assumed in the geotechnical calculations; the environmental dredge limit is also shown on the Appendix B figures.

The dredge area for this alternative would be contained by the temporary rigid containment barrier. At the completion of dredging, a berm and cap would be placed in the area between the shoreline bulkhead and temporary rigid containment barrier. In some instances, this berm and cap may need to be extended beyond the limits of the temporary rigid containment barrier as shown on Figure N2-2.

B3.1 Summary of NW-2 Calculations

Two calculation cases (NW2-17 and NW2-25) were investigated representing two different soil profiles in different areas of this site. Because soil conditions for the NW2-25 case are more favorable, a deeper dredge elevation was assumed for this case than for the NW2-17 case.

For each of the calculation cases discussed below, an analysis was first completed on the existing slope. If the factor of safety of the existing slope was calculated as less than 1.0, soil strength was increased to account for other influences on bulkhead stability. The factor of safety for the dredge case was calculated and the depth of dredging was adjusted as required to achieve a sufficient factor of safety.

B3.1.1 Slope Stability Assuming Bottom of Upland Fill at Elevation -17

Global stability calculations for the temporary dredge cut case were performed using the program SLIDE assuming a soil profile in which the loose fill/marine silt interface in the upland area is at elevation -17 as shown in Sections B and C on Figures N2-3 and N2-6. This soil profile is assumed representative of areas along the shoreline bulkhead where the top of the marine silt elevation appears to vary from elevation -14 to elevation -24.

A minimum factor of safety of 1.6 was calculated in the SLIDE global stability analysis for failure surfaces extending under the shoreline bulkhead for this case. For the same case, a factor of safety of 1.43 was calculated for a surficial failure along the face of the dredge slope. It would be unlikely that such a failure surface would develop and, given that the calculated factor of safety approaches the minimum desired factor of safety of 1.5, such conditions were determined to be acceptable. Staged construction of the berm toward the shoreline would likely prevent such local failure surfaces from developing.

A variation of the case discussed above assumes a 25 ft wide bench cut would be dredged to elevation -14 adjacent to the shoreline bulkhead prior to cutting a 5H:1V dredge slope down to elevation -34. The resulting factor of safety is 1.61. To achieve these results, the following conditions were assumed:

- The toe of the bulkhead was assumed at elevation -54.
- Dredging at the face of the shoreline bulkhead is assumed to extend from elevation -9, slope down at 5H:1V to elevation -34, then extend horizontally further from shore at elevation -34. Assuming this dredge cut, the elevation of the cut would be -14 ft at a distance 25 ft from the face of the shoreline bulkhead. A variation of this dredge cut which was also analyzed assumes that the soil above elevation -14 would be removed creating a 25 ft wide bench cut at elevation -14 at the face of the bulkhead.
- Note that the current maximum dredge depth at this section is -39 ft at the temporary rigid containment barrier while the calculations assumed a cut to elevation -34. By inspection of the two dredge cut options, the difference between the calculated and proposed alternative appears to be insignificant due to the presence of the temporary rigid containment barrier at the toe of the slope.
- The upland area is assumed to be backfilled from elevation -6 to an interim elevation of elevation +4 with lightweight fill weighing an average of 75 pcf. The area of lightweight fill placement is assumed to extend to 100 ft behind the shoreline bulkhead. The zone of lightweight fill placement is approximate and would vary from 80 to 120 ft wide or more.
- A uniform surcharge load of 200 psf is assumed, however, it would be necessary to restrict this loading to the area beyond 100 ft from the shoreline bulkhead during the time period that the dredge cut would be open.

B3.1.2 Slope Stability Assuming Bottom of Upland Fill at Elevation -25

Global stability calculations for the temporary dredge cut case were performed using the program SLIDE assuming a soil profile in which the loose fill/top of the marine silt interface in the upland area would be at elevation -25 such as at Section A on Figures N2-3 and N2-6. This soil profile would be assumed representative of areas along the shoreline bulkhead where the actual top of marine silt elevation appears to be at elevation -25 or deeper based on the available subsurface data.

PLAXIS was used to calculate the global stability factor of safety for the various stages of NW-2 construction including, the dredging case, the construction of a berm, and the final OU-2 backfill and long term loading case. PLAXIS was also used to check the results of a SLIDE analysis for this case in which a factor of safety of 1.40 was calculated.

PLAXIS specific parameters assumed for the analyses include:

- The modulus of elasticity of the silt (a measure of how much the marine silt will deform when loaded) was assumed to be E = 500 times Su where Su is the undrained soil shear strength.
- Horizontal displacement at the anchorage level is restricted. The program allows the development of a restraining force at the anchorage level to maintain zero horizontal displacement. Vertical displacement at the anchorage level and for the bulkhead in general is not restricted by the model.
- WEZ 95 barrier sheeting with a section modulus of 24.9 $inches^3$ per foot of bulkhead and a moment of inertia of 134 $inches^4$ per foot is assumed. Section modulus and moment of inertia are geometric properties of the sheeting cross section and are related to how much the sheeting will bend when loaded.
- The existing slope topography, soil profile, depth of dredge cut, shoreline bulkhead penetration depth, surcharge loading, and lightweight fill usage, bulkhead anchorage, and surcharge loading restrictions, were all assumed the same as in previous cases for NW-2.

B3.1.2.1 Stability during Dredging

It is assumed that at Section A the dredge cut would extend to elevation -14 at the shoreline bulkhead and then slope down at 5H:1V to elevation -40, approximately 130 ft outboard of the shoreline bulkhead. The dredge cut is assumed to stay at elevation -40 until it daylights with the existing slope. The critical factor of safety for this case is 1.66.

B3.1.2.2 Stability at Section A during Berm Construction and OU-1 Grade Increase

- After dredging, a berm would be required. At Section A, the berm would extend 33 ft outboard of the shoreline bulkhead at elevation -14 and then slope downward at a 6H:1V to elevation -40. The factor of safety for this case is 2.13 for failure surfaces extending beneath the shoreline bulkhead and 1.44 for failures surfaces in the berm area. After 20 percent consolidation strength gain in the marine silt under the weight of the berm, the berm factor of safety increases to 1.50. It is estimated that it would take 2 to 4 months to achieve 20 percent average consolidation within the silt stratum without the use of wick drains.
- After 20 percent consolidation strength gain in the marine silt under the weight of the berm, the upland grade would be increased to elevation +9 using lightweight fill within approximately 100 ft of the shoreline bulkhead. The zone of lightweight fill placement is approximate and would vary from 80 to 120 ft wide or more. A 200 psf surcharge loading is assumed with the shoreline bulkhead assumed to be sealed providing an inboard water elevation of +4 and an outboard water elevation of -1.0. For this case, the factor of safety is 1.5 for failure surfaces extending beneath the

bulkhead. The factor of safety for failures surfaces in the berm area is unchanged from what was calculated above. The maximum bulkhead deflection would be less than 1.5 inches and the maximum bending moment would be 25,000 ft-pounds. WEZ95 sheeting has sufficient strength to support this amount of bending moment and deflection.

B3.1.3 NW-2 Shoreline Bulkhead Sheet Pile Analyses

Although global stability (calculated using SLIDE and PLAXIS) appears to control characteristics of the shoreline bulkhead for the each of the NW-2 options, sheet pile calculations using the programs CWALSHT and WALLAP were performed to check the sheeting calculations. The results are summarized below:

- WEZ95 ($S_{avail.}$ = 24.9 inches^3) for barrier sheeting would be sufficient.
- The global stability analysis controls the sheeting depth which would extend to elevation -54.
- Independent check calculations using the program WALLAP yielded results similar to CWALSHT.

B3.2 NW-2 BERM CONFIGURATION ASSUMING A GRADE INCREASE SETBACK

The required final berm configuration for Alternative NW-2, Option A at Section A was calculated using PLAXIS for the case where the upland would be backfilled to elevation +4 within 100 ft of the shoreline bulkhead prior to ramping up to elevation +9 at a distance 100 to 120 ft inland from the shoreline bulkhead. The topography and soil conditions of Section A as shown on Figure N2-11 were used with the modification to the top of the upland marine silt layer was assumed at a higher elevation than -25. This change was made to ensure that the results of this analysis could be applied to other areas in the Northwest Corner where the top of the marine silt is higher than elevation -25.

<u>NW-2, Option A</u>

As shown on Figures N2-11 and N2-12 a berm/protective cap configuration starting from elevation -7 at the shoreline bulkhead and then sloping downward at 6H:1V to elevation -40 is assumed. The upland area is assumed to be backfilled to elevation +4 with lightweight fill for 100 ft. The zone of lightweight fill placement is approximate and would vary from 80 to 120 ft wide or more. The assumed grade then increases over a distance of 20 ft to elevation +9. A surcharge load of 200 psf in the upland area and a 5-ft water differential loading are then assumed applied to the shoreline bulkhead. The factor of safety calculated for this case is 1.59.

<u>NW-2, Option B</u>

As shown on Figures N2-8, N2-9, and N2-10, a berm which is 30 ft wide at elevation -12 and then slopes down at 6H:1V is assumed. The factor of safety calculated for this case is 1.55.

For consistency, the berms shown on Figures N2-8, N2-9, N2-10, N2-11 and N2-12 are at the same top elevation and have the same slope except that the top of the berm for Option B would be at elevation -12 in areas where a 30-ft wide bench adjacent to the shoreline bulkhead would be required. Note that the berm required with the upland grade at elevation +4 would be significantly smaller than what would be required with a final upland grade at elevation +9 at the bulkhead.

It has not been necessary to assume marine silt strength gain from consolidation as part of any of the NW-2 analyses; therefore, it would not be necessary to wait for consolidation after placement of the berm before completing the OU-1 remedy as shown. All cases assume a 5-ft water differential surcharge, based on the shoreline bulkhead being sealed, and an upland surcharge of 200 pounds per foot.

If there would be a time allowance for consolidation strength gain (with or without wick drains) the size of the berm assumed for both the elevation +4 and elevation +9 final upland grade cases would be somewhat smaller. There would be less benefit to waiting for consolidation strength gain for the case with the upland at elevation +4 because the relatively small berms do not add significant new loading to the underlying soil profile.

B4 ALTERNATIVE NW-3: REDIVIDE OU-1 AND OU-2

Northwest Corner Alternative NW-3 was developed to provide a remedy which would provide a way to remove, on a cutline basis, all sediments containing more than the PRG of 1 part per million of PCBs from the river in the Northwest Corner Area. This remedial alternative would establish the boundary between OU-1 and OU-2 on the basis of whether the riverward sediments could be accessed by dredging. Impacted sediments which are too deep to be accessed geotechnically would therefore be contained and closed in the same protective manner as the current OU-1 soils. The remainder of the sediments west of the NW-3 bulkhead would be targeted for dredging. This approach would reduce resuspension losses by avoiding dredging in the areas of densest pilings and other obstructions.

The proposed alignment of the NW-3 bulkhead is shown on Figure N3-1. The bulkhead's distance from the existing shoreline would vary between approximately 80 to 100 ft in the area of Sections A and B to approximately 11 ft away from shore in the area of Section C and 22 ft away from shore in the area of D. A proposed wall along the existing shoreline to facilitate upland excavation is also shown on Figure N3-1 as is the temporary rigid containment barrier alignment.

A factor of safety has been calculated for two different cross sections for the dredging stage of construction with the upland backfilled to an interim grade. Calculations for the staged construction of a berm, new land creation, and upland grade change were also performed at two sections. Two cases were assumed for the final upland grade, one where final grade within 100 ft of the bulkhead would be elevation +4 and one where the grade in this area would be elevation +9. The case with the final upland grade to elevation +4 is the preferred option and is discussed in detail. The other case with upland at elevation +9 is only referred to briefly below.

The toe of the support berm required to fill behind the shoreline bulkhead (extending the upland area) and to raise the OU-1 elevation grade to elevation +4 is shown on Figure N3-1. The dredge cut is not shown on Figure N3-1 but is shown in section view on Figures N3-2 and N3-3 which also show Sections A through D at the end of OU-2 and OU-1 remediation construction.

<u>Factor of Safety</u>

The factor of safety at Section A during the dredging, was calculated to be 1.36 assuming that the dredge cut was to elevation -42. Alternatives in which the calculated FS is between 1.3

and 1.5 are questionable but still possible, depending on the results of future geotechnical soil testing and other factors. The limits of dredging based on AR's contaminant distribution modeling (see Figures ENV-1A & ENV-1B and Figures 1.3 and 1.4 in the main text) indicate that the dredge depth at Section A would be elevation -39 at the NW-3 bulkhead and would then slope up to the existing mudline (elevation -32) approximately 25 ft west of the NW-3 bulkhead. The depth and lateral extent of the dredge cut is less than what was assumed in the calculations and the actual factor of safety during dredging in this area would likely exceed 1.5 during dredging. The dredge cut is shown at elevation -39 for Section A and B on Figure N3-2. The factor of safety at Section A was above 1.5 for all of the other stages of construction assessed.

B4.1 Construction Sequence

A possible construction sequence for Alternative NW-3 is as follows:

1. Install the permanent 35 ft long wall along the shoreline to allow for controlling water during OU-1 remediation.
2. Excavate to elevation -6 and then backfill the OU-1 excavation area with lightweight fill within 100 ft of the shoreline bulkhead. The zone of lightweight fill placement is approximate and would vary from 80 to 120 ft wide or more. Backfill to approximately elevation 0 (elevation +1 in the area of Sections C and D) within 100 ft of the shoreline and to elevation +5 further inland. This results in a net unloading of the upland area. Note that some flooding of the upland area may occur with the upland at elevation 0 (elevation +1 in the area of Sections C and D).
3. Install the new NW-3 bulkhead at the location shown on Figure N3-1. Brace the NW-3 bulkhead to the OU-1 shoreline sheet piling with steel beam bracing. Anchor the NW-3 bulkhead with anchor rods extending to a deadman reaction block in the OU-1 upland area. The steel bracing and anchor rods spanning between the shoreline bulkhead and the NW-3 bulkhead would be vertically supported by spud piles at mid span.
4. Where the alignment of the NW-3 bulkhead returns to the existing shoreline, would continue along the shoreline to the south (for the southern portion of the bulkhead) and to the east (for the northern portion of the bulkhead) creating a continuous sealed bulkhead in the Northwest Corner.
5. Install the temporary rigid containment barrier.
6. Remove debris and dredge in the contained area between the NW-3 bulkhead and the temporary rigid containment barrier.
7. Backfill the dredge area in thin uniform lifts until area is filled and then continue to backfill on both sides of the NW-3 shoreline bulkhead until a berm is formed to the shoreline. The required slope of the berm is anticipated to be 6H:1V. Install wick drains to accelerate consolidation strength gain in the marine silt under the weight of the berm. After waiting approximately one year to achieve 90 percent consolidation, backfill the new upland fill area and existing upland area to finished grade as shown in Figures N3-2 and N3-3.

B4.2 Summary of Calculations

To assess the viability of Northwest Corner Alternative NW-3, calculations were performed at two cross sections, one of which corresponds to Section A and the other to Section C on Figure N3-1. At Section A, the shoreline bulkhead would be constructed 100 ft away from shore, where the mudline is at elevation -30. The finite element program PLAXIS was used to analyze this complex section. At Section C, the shoreline bulkhead would be constructed 11 ft away from shore, where the mudline is at elevation -5. Section C was analyzed using the slope stability program SLIDE.

Figures N3-2 and N3-3 present Sections A through D. For each section, the existing ground surface, proposed dredge depth, support berm, land created by filling, location of the NW-3 bulkhead, wall at the existing shoreline, and the temporary rigid containment barrier are all shown. Note that allowable dredge depth and berm configurations shown at Sections B and D are extrapolated from the Section A and C calculations.

B4.2.1 Assumptions for NW-3 Section A PLAXIS Analysis

- Installation of the NW-3 bulkhead and shoreline wall to facilitate OU-1 excavations would need to be completed prior to the start of OU-2 dredging. Lightweight fill placement, anchorage installation, and interim grade are assumed as discussed in the construction sequence.
- A sheet pile wall (approximately 35 ft long) would be required along the existing shoreline to allow for upland excavation in-the-dry and to support bracing spanning between the NW-3 bulkhead and the shoreline.
- Both WEZ95 Waterloo Barrier sheeting and heavier sheeting were assessed. The toe of the NW-3 bulkhead sheeting was assumed to driven to El -65 approximately 15 ft above the assumed basal sand elevation 100 ft from the shoreline.
- The water level in the river and upland area was assumed balanced during dredging operations and at elevation -1 (approximately 1 foot above mean low-low water NAVD88) which is the case that gives the lowest factor of safety for slope stability analysis. Sealing the NW-3 bulkhead is assumed to occur after completion of dredging, capping, and backfilling operations.

B4.2.2 NW3 PLAXIS Analysis Results for Section A

A PLAXIS computer model analysis was used to calculate the factor of safety for dredging and at numerous intermediate stages of berm construction and upland backfilling for the case where the final upland grade in the new upland fill area within 100 ft of the shoreline bulkhead is elevation +4. Critical stages of construction have been identified as discussed below.

<u>Stage 1 - Dredging</u>

OU-1 excavation/backfill and shoreline wall installation would be completed. Dredging would then proceed to elevation -42 ft outboard of the bulkhead with the upland at elevation 0 for +100 ft inboard of the shoreline. The resulting factor of safety is 1.36.

The revised dredge depth at Section A is elevation -39 which is 3 ft less that assumed in the calculations for this section. The factor of safety during dredging in this area is likely now over 1.5.

Stage 2 - Construct Berm

At the completion of dredging, a berm would be incrementally constructed with a 6H:1V slope as shown in Section A on Figure N3-2.

The top of the berm would be at approximately elevation -13 at the face of the shoreline NW-3 bulkhead and would continue to slope up to elevation 0 within the new upland fill area. The top of the berm in this area is assumed to be approximately 20 ft wide at elevation 0. The factor of safety during this stage of construction is 1.49 which is judged sufficient.

Stage 3 - Consolidation of Marine Silt under Berm Surcharge Load

To achieve the required global stability factor of safety of 1.5, it was found necessary to assume 90 percent consolidation strength gain would be achieved under the weight of the berm described above prior to completing backfilling in the new upland fill area as shown on Figure N3-2. Wick drains would be required to achieve this amount of consolidation strength gain in a timely manner (about one year).

Stage 4 - Final Backfill and Application of Surcharge and Differential Water Loading

The upland is assumed backfilled to elevation +4 in the land fill area and within 100 ft of the existing shoreline prior to ramping up to elevation +9 120 ft inland from the existing shoreline (for a total of 220 ft from the NW-3 bulkhead). Ninety percent consolidation strength gain under the weight of the berm is assumed under Stage 3. To get a sufficient factor of safety for this case, the stabilizing effect of the temporary rigid containment barrier has also been included in the calculations. The factor of safety calculated for this case is FS = 1.51.

The berm geometries shown on Figures N3-2 and N3-3 are all based on calculations at Sections A and C and have been extrapolated to the other two sections using engineering judgment.

Note that the presence of the temporary rigid containment barrier was included in the analysis of the final Stage 4 case to achieve a factor of safety over 1.5. The location of this temporary barrier with respect to the proposed NW-3 bulkhead varies and other sections would have to be assessed during remedial design for each representative case. The temporary barrier would also likely need to be cut off at the mudline and used as permanent slope reinforcement.

The case where the final grade of the new fill area and OU-1 upland area would be elevation +9 was also assessed. NW-3 bulkhead wall structural requirements for the two cases are similar; however, the berm associated with backfilling to elevation +9 extends out 207 ft from the face of the NW-3 bulkhead at Section A as opposed to 152 ft with the final grade at elevation +4. Berm construction would also have to be completed in stages requiring a construction delay to wait for consolidation under each stage instead of one consolidation period with the final grade at elevation +4. The overall construction time with the grade at elevation +9, assuming wick drains could be in excess of several years. Clearly, backfilling the OU-1 upland area to elevation +4 has many advantages over backfilling to elevation +9.

B4.2.3 Wall Deflections and Structural Requirements

Shoreline bulkhead deflection, bending moment, and anchorage load were calculated as part of the PLAXIS analysis at various stages of construction, based on a range of parameters. The following results are based on the final grade being at elevation +9. Deflections and moments were not calculated for the case with the final grade at elevation +4 but both would be less than what is presented here.

Four sets of results are presented accounting for two different sheet pile sizes (both structurally adequate) and two different soil modulus values. The following model considerations are noted:

- If Waterloo Barrier WEZ95 sheeting was used for the bulkhead, the deflection would be between 10 and 12 inches horizontally. It is uncertain if the bulkhead sheeting interlocks could be sealed after such deflection. The anchorage loading for the final stage of construction would be approximately 24,000 pounds per foot of wall length along the shoreline which would require a substantial anchorage support system. The required section modulus for this case is less than that provided by the WEZ95 sheeting.

- Vertical displacement of the bulkhead was calculated to be between 3 and 4 inches. This does not include displacements due to consolidation of the underlying soils. Settlement would affect the anchorage system and may make NW-3 unfeasible to construct in the manner currently envisioned. It may be possible to reduce the negative affects of this problem with careful construction monitoring and periodic retensioning of the deadman anchor rods as necessary.

- If Arbed AZ-48 sheeting was used, the deflection would be between 7 and 9 inches horizontally. It is uncertain that this bulkhead type could be sealed. Calculated vertical displacement is similar to that calculated for WEZ95 sheeting, raising the same issues as above. The anchorage loading for the final stage of construction would be between 27,000 and 29,000 pounds per foot which would require a substantial anchorage support system. The required section modulus for this case is less than that provided by the Arbed AZ-48 sheeting.

- To keep the toe of the sheeting above the basal sand, it has been assumed that the bulkhead would not only be laterally supported by an anchorage system but also by internal bracing. Loads on the bulkhead that necessitate bracing act from the river towards the landside and include currents, waves, differential water, ice loading, and a nominal impact loading. Other loading would come from the incremental placement of fill on each side of the bulkhead.

- Calculations have not been made for internally bracing the bulkhead. However, it is envisioned that a bracing frame supported by spud piles (bearing in the fill) could be braced to deadman anchor blocks along the shoreline. This bracing frame could then be used to support the tie rods to reduce sag of the rods over the span between the anchor blocks and the shoreline bulkhead.

B4.3 Assumptions for NW-3 Section C

A SLIDE global stability analysis was used for NW-3 Section C. The required dredge cut geometry with respect to the location of the shoreline and NW-3 bulkhead is different at Section C than at Section A. Because of this, it was found necessary to assume a different construction sequence for Section C to achieve the required dredge depth.

Dredging at Section C for Alternative NW-3 would need to be performed in two stages separated by placement of an interim berm. The required sequence would be as follows:

1. Install the permanent shoreline sheet pile wall. Excavate the upland area to elevation -6 and then backfill to elevation 1 within 100 ft of the shoreline. Install a deadman anchorage system at elevation 0 as the area is backfilled. Restrict surcharge loading from the upland area during dredging.
2. Install the NW-3 bulkhead at the alignment shown on Figures N3-1 through N3-3. Extend the deadman anchorage to the NW-3 bulkhead and brace between the NW-3 bulkhead and shoreline sheet pile wall.
3. Dredge to elevation -34 at the temporary rigid containment barrier. Continue the dredge cut progressing towards the shoreline until it is at El. -32 approximately 62 ft east of the containment barrier. From this point the required dredge cut is defined by a 3H:1V line sloping upward to the existing mudline. This line intercepts the mudline at approximately 95 ft east of the containment barrier. Soon after this area is dredged, place an interim berm to approximately restore the existing mudline as shown on Figure N3-2, Section C as the Stage 1 berm.
4. Dredge to elevation -21 in the area extending 45 ft west of the NW-3 bulkhead wall to complete Section C dredging.
5. Place a berm and protective cap in the Stage 2 dredge area and over the interim berm previously place. Construct the berm incrementally with a 6H:1V slope until it is of the dimensions shown on Figure N3-2. Backfill west of the existing shoreline to elevation 4 with lightweight fill. Install wick drains are regular spacing throughout the berm.
6. After waiting approximately 1 year to achieve 90 percent consolidation strength gain under the weight of the berm, complete backfilling to elevation 4 between the NW-3 bulkhead and the shoreline sheet pile wall. Seal the wall. Surcharge loads (200 psf) would no longer restricted near the bulkhead after achieving the targeted marine silt strength gain as discussed above.

The minimum factor of safety achieved for the various stages of construction discussed above was 1.5 as calculated in the SLIDE global stability analysis.

B5 NORTHWEST CORNER ALTERNATIVE NW-4

Alternative NW-4 assumes that the shoreline bulkhead would be driven into the basal sand stratum. Because of the additional toe support this dense soil layer would provide, deeper dredging adjacent to the bulkhead would be possible. The environmental implications of driving the shoreline bulkhead into the basal sand are discussed elsewhere in this Supplemental FS.

Figures N4-1 through and N4-3 illustrate Alternative NW-4 in plan and section view. A final upland grade of elevation +4 is shown for the area within 100 ft of the bulkhead wall. It would also be possible to backfill to elevation +9 adjacent to the bulkhead wall for this option, as long as dredging was performed with the OU-1 grade at elevation +4 or less. While it is conceivable that a wall could be designed to support the upland at elevation +9 during dredging, this would be an uneconomical way to perform this work, and would require a stronger wall and stronger anchorage.

The dredge cuts shown on Figures N4-2 and N4-3 illustrate approximately the required dredge depth to achieve PRGs at each of the four sections.

Conceptual calculations were previously performed to check a case similar to the one shown, however, no calculations specific to the conditions shown have been performed. Based on the previous calculations in which the dredge depth adjacent to the wall was El. -32, a king pile wall was judged necessary for the NW-4 shoreline bulkhead. There are several technical issues not fully resolved with respect to this alternative that affect environmental feasibility and cost.

A king pile wall, constructed of interlocking H piles and sheet piles, can not be easily sealed. Swelling joint sealants are unlikely to work at this site due to the large number of obstructions which will likely be encountered and the delays in driving the wall which would result. One possible method of sealing the bulkhead would be to construct a jet grout wall immediately adjacent to and on the upland side of the bulkhead. A jet grout wall would be constructed by drilling a series of closely space boreholes and then injecting high pressure grout while rotating a nozzle 180 degrees in the borehole. The grout stream cuts into the soil and creates a circular soil-cement column. Overlapping columns create a wall. It is likely that this wall could be constructed with a sufficiently low permeability to meet the requirements of the OU-1 remedy.

The jet grout columns would most likely be constructed with the upland grade at elevation +4 and would have to be carefully positioned at 3 to 5 ft spacing to avoid the bulkhead wall anchor rods buried at approximately elevation 0. One disadvantage of jet grout walls is that a slurry of contaminated soil and waste grout would be brought to the surface and need to be dried out and disposed.

The deep dredging immediately adjacent to the bulkhead wall associated NW-4 would need to be supported by a very large deadman reaction block or a series of reaction blocks. Drilled in tieback anchors extending into the basal sand might also be an option. Tieback anchors would represent another potential route for contamination to reach the basal sand layer, however. The anchor rods (for either tieback or deadman anchors) would have to be installed in oversized pipe sleeves to avoid getting grouted when the jet grout wall is constructed.

B6 CONTAINMENT BARRIERS

B6.1 Submerged Shoreline bulkhead

Alternative NW-1 assumes only very limited dredging outboard of the shoreline bulkhead prior to capping. This allows for the shoreline bulkhead to be constructed and the OU-1 remedy be completed prior to dredging. To protect the cap and to provide containment during dredging, a temporary rigid containment barrier would be installed approximately 50 ft away from shore of the shoreline bulkhead where the river bottom is elevation -15. After dredging is complete, the temporary rigid containment barrier would be cut off at the top of the cap and serves a permanent barrier to erosion and as a provider of aquatic habitat in the nearshore cap area.

Dredging is assumed to occur to elevation -7 and to be completed within one summer season. Once dredging is complete, the temporary barrier would be cut off and converted to a submerged bulkhead. As a result, the submerged bulkhead could be completed in one summer season and not subjected be to ice loading.

The marine silt thickness below the existing bottom (elevation -15) is assumed to be 60 ft thick and the top of the basal sand is assumed to be elevation -75 based on a straight line interpolation between the basal sand elevation at Boring GB-6 and GB-20.

A factor of safety of 1.5 was applied to the passive soil pressures in the calculations. One foot of differential water loading, a 500 pcf impact loading (applied at elevation +5), and wave and current loading were assumed applied to the outboard side of the shoreline bulkhead.

Summary of Results

Wall stability calculations were performed using a United State Army Corps of Engineers (USACE) program for the analysis of sheet-pile walls by classical methods called CWALSHT.

- An AZ-36 Sheet Pile was found to be required (Sreq =59 in^3).
- Required toe embedment was found to be elevation -61 (14 ft above the assumed top of Basal Sand elevation of elevation -75).
- Independent check calculations using the program WALLAP (developed by Geosolve) yielded results with respect to required section modulus but calculated a deeper required embedment to achieve a factor of safety of 1.5. The types of parameters input into each program and method of calculation are different so the results can be expected to be different. The results of the CWALSHT program are judged adequate for this engineering evaluation.

B6.2 Temporary Rigid Containment Barrier

The alignment of the temporary rigid containment barrier is shown on the plan view drawings for Northwest Corner Alternatives NW-2, NW-3, and NW-4. The barrier extends out from the shoreline approximately 150 ft and into water at a maximum mean tide depth of 35 ft. The temporary barrier is assumed to be a steel barrier along its entire length. The north and south ends of the temporary barrier would extend to the shoreline, however, it is possible that the barrier could terminate approximately 50 ft away from shore where the water depth is approximately 15 ft at mean tide level in order to allow work boats to pass to and from the contained dredge area. A silt curtain could then be used to tie the steel barrier into the shoreline. The purpose of the temporary barrier would be to contain suspended dredge sediment during dredging operations. The temporary barrier is not intended to be watertight, rather to sufficiently retain suspended sediments to meet environmental requirements.

Wall stability calculations were performed using PLAXIS and CWALSHT. The calculations are based on Section A where the existing mudline is at elevation -35 and a dredge elevation of -42 (actually -39 based on PRGs) is proposed. The basal sand elevation below the containment barrier at Section A is approximately elevation -88. The undrained shear strengths of the silts were calculated from the strength vs. in-situ vertical effective stress relationship, s_u =

$0.21\sigma'_v$. The effective stresses were calculated from the buoyant unit weight of the soil assuming that the unit weight of water is 64 pcf. The basal sand was assumed to have an angle of friction (ϕ') of 36 degrees. This section is believed to represent the "worst case" loading conditions for the barrier.

The top of the temporary barrier is assumed to be at elevation +5 (approximately 3 ft above mean high tide) and the bottom of the temporary barrier is assumed to penetrate into the basal sand layer at this location. Loadings on the barrier include differential soil, differential water, wave, current, and seasonal ice loading. The seasonal ice loading can also be considered to represent low-speed small-vessel impact loading when there is no ice on the river. The loads on the barrier are as follows:

- As mentioned earlier, a 7-foot differential soil load is assumed based on the proposed dredge depth at Section A.
- A 1-foot maximum differential water loading has been assumed based on the lag time necessary for water to flow into or out of the structure's steel interlocks during tidal cycles. This differential water loading is applied as a 64 psf distributed load acting from elevation +2 to the bottom of the barrier (no seepage is assumed).
- Wave loading has been conservatively approximated as a 200 psf distributed load acting from elevation +2 to the mudline at elevation -35. This loading is based on an assumed 3 ft wave height. Waves comprise a complex dynamic loading but to simplify the calculations a uniform 200 psf distributed loading is assumed applied as static loading.
- Current loading is modeled as a triangular distributed load of 70 psf at the water surface and 0 at the mudline in accordance with an assumed maximum current of 5 ft/sec. This loading has been developed based on AASHTO guidelines for bridge piers and is assumed applied statically.
- An ice loading of 1,500 pounds per linear foot (plf) applied at elevation +5 is based on input from Dr. George Ashton (AR, 2005).

The temporary rigid contained barrier was assessed as a cantilever wall. A factor of safety of 1.5 was applied to passive soil pressure in the CWALSHT analysis. The results of this analysis are discussed below.

The temporary barrier was found to require a section modulus of 266 cubic inches per foot of barrier suggesting that a HZ975-D26/AZ18 king pile wall section would be required. A king pile wall is comprised of alternating sheet pile pairs and interlocking H-beams driven vertically to form a continuous barrier. The required toe elevation was found to be elevation -104 (which would be 16 ft into the basal sand) making the required length 109 ft. An HZ975-D26/AZ18 wall has a combined section modulus of 273.5 in^3 per foot of wall and a moment of inertia of 5345.7 in^4 per foot of wall.

Deflection along the top of the barrier was calculated to be 30 inches. While 2.5 ft of deflection is certainly noticeable, the barrier is a temporary structure and will not fail with that amount of deflection at the top. The wall will be mostly below the water level so much of the deflection will be hidden. The effect of wall deflection in the corners of the structure will have to be looked at closely during remedial design. It is likely that the corners will need to be stiffened to reduce deflection and avoid overstressing the interlocks.

PLAXIS Analysis

Subsurface and loading conditions assumed for the PLAXIS analysis are the same as for the CWALSHT analysis. In addition to the soil parameter discussed above for the CWALSHT analysis, additional parameters needed for the PLAXIS finite element analysis were developed. The silt modulus (E_{silt}) was computed using a correlation based on the undrained shear strength, $E_{silt} = 500s_u$. The silt modulus is a measure of how much the silt will deform when loaded. The undrained shear strength and modulus increase with depth because of their assumed relationship to the in-situ vertical effective stress.

A factor of safety was applied to the PLAXIS finite element model to reflect the uncertainty and importance of the parameters assumed in the model. To account for this uncertainty, the undrained shear strength (s_u) of silt was divided by 1.5 and the tan ϕ' of the basal sand was divided by 1.25 (i.e., $\phi'_{modified}$=30 degrees). These modified values were used in the Plaxis simulations. This method of applying a safety factor (FS = 1.5) is analogous with the method used in the CWALSHT analysis.

Based partly on the results of the CWALSHT analysis, an HZ 975 D-26/AZ18 wall section was assumed in the PLAXIS analysis and the toe of the barrier was assumed to be at elevation -110. The toe of the barrier is assumed slightly deeper than what was calculated in the CWALSHT analysis. Assuming a deeper, more conservative depth does not significantly affect the results of the analysis.

The PLAXIS analyses show that in order to achieve fixity (or the depth of no deflection at the base of sheeting), it would be necessary to extend the toe of the temporary barrier to at least elevation -100. This is the elevation below which the horizontal wall deflection remains zero. Given that the top of the wall is at elevation +5, the temporary barrier would need to be at least 105 ft long in order to achieve the embedment required for fixity.

A maximum horizontal wall deflection (at the top of the barrier) of about 20 inches is calculated in the PLAXIS analysis compared to a deflection of about 30 inches calculated using CWALSHT. The maximum bending moment calculated in PLAXIS is 525,000 ft-pounds (with the required section modulus of 191 $inches^3$ per foot) which is less than that calculated using CWALSHT. As discussed earlier, the PLAXIS wall embedment is 4 ft less than as calculated by CWALSHT. Based on the results of analysis using the two different computer programs, a HZ 975 D-26/AZ18 wall was considered to be appropriate for the temporary rigid containment barrier.

B7 SOUTHERN AREA

The Southern Area extends from the south end of the North Boat Slip to the southern property line. This area, shown in plan view on Figure S-1, is distinctly different than the Northwest Corner Area as follows:

- The existing bulkhead structures still support the upland over much of this area.

- The amount of fill on the river side of the shoreline bulkhead is much less and the water depth at the shoreline is currently deeper. This results in the marine silt outboard of the shoreline bulkhead being less consolidated and, therefore, weaker.

- The OU-1 remedy requires environmental excavation to 9 ft below the existing upland grade in the Northwest Corner. There is no such requirement in the Southern Area although there are some local areas of excavation.

- A sealed shoreline bulkhead was recently constructed as part of an IRM between the South Boat Slip and the southern property line.

- Calculations have been performed based on the assumption that the final OU-1 grade would be elevation +4 within 100 ft of the shoreline shoreline bulkhead prior to sloping up to elevation +9 at 120 ft from the shoreline. Previous calculations assuming the final upland grade to be elevation +9 are briefly referred to and summarized.

The many existing pilings (both vertical and batter piles) along the Southern Area shoreline will be cut off during dredging. Accordingly, any possible reinforcement effect that these piles might have on bulkhead stability is difficult to quantify and is therefore not taken into account. Pulling of piles could have an adverse effect on soil strength and bulkhead stability; therefore it is assumed that these piles will be cut off at the mudline or dredge line.

The target minimum factor of safety for both the temporary and permanent construction cases is 1.5. The NW-1 calculations discussed here all achieved a factor of safety of at least 1.5.

A summary of proposed Southern Area dredge cases SA-1, SA-2, SA-3 and SA-4 is provided below:

- SA-1 assumes capping with no dredging.

- SA-2 assumes dredging up to 2 ft below the existing mudline elevation followed by capping. However, the maximum dredge slope is 5H:1V which requires dredging deeper than 2 ft adjacent to the shoreline bulkhead in some areas.

- SA-3 Option A assumes dredging to elevation -9 adjacent to the shoreline bulkhead and then at a 5H:1V slope out to the silt curtain (which is located approximately 60 to 70 ft away from shore).

- SA-3 Option B assumes dredging to elevation -14 adjacent to the shoreline bulkhead and then at 5H:1V slope. Because of the proximity of the silt curtain, it is estimated that the lowest dredge depth that can be achieved is elevation -20 for this alternative.

- SA-4 assumes dredging a horizontal cut to elevation -20 at the shoreline bulkhead and then sloping up to elevation -15 at the silt curtain on a 5H:1V slope. The shoreline bulkhead is assumed to penetrate into the basal sand stratum in Alternative SA-4.

The dredge cuts associated with the alternatives discussed above are illustrated on Figures S-1, S-2, and S-3. Note that dredging is not required to meet PRGs in all areas of the southern area and the sections associated with the geotechnical calculations were not cut in the areas requiring dredging close to the shoreline. The conditions modeled are typical for the southern area, however, and the results apply to the areas where dredging could be required (depending on the alternative selected).

B7.1 Building 15 Area

The shoreline bulkhead in the area of former Building 15 would support the required dredging and final upland loading conditions for each alternative as discussed above. It is assumed that the final OU-1 grade would be elevation +4 within 100 ft of the bulkhead sloping up to elevation +9, 120 ft inland from the bulkhead. A 200 psf upland surcharge load (live load) and a 5 foot differential water load (from sealing the shoreline bulkhead) are also assumed for the long-term loading case. To allow for this increase in OU-1 loading it is necessary to place a support berm into the river to buttress the shoreline bulkhead for Southern Area Alternatives SA-1, SA-2, and SA-3. A berm is also likely required for SA-4 but its size was not calculated.

The results of Building 15 area calculations and assumed construction sequence are as follows:

- Install the shoreline bulkhead. The sheeting interlocks are assumed to not be grouted until near the end of construction, as discussed below. The required toe penetration would be to elevation -47 (56 ft deep) which would be approximately 18 ft above the top of the basal sand stratum.
- Excavate down to elevation -4 and backfill the upland area from elevation -4 to elevation +4 with lightweight fill within approximately 100 ft of the shoreline. Install a deadman anchorage system at elevation 0 as the area is backfilled. Note that for Alternative SA-3, the upland excavation extends down to elevation -6 prior to backfilling with lightweight fill.
- Backfill to elevation +5 in the anchor block area with compacted granular fill.
- Prohibit surcharge loading within 100 ft of the shoreline bulkhead during dredging. Assume a 200 psf maximum surcharge in areas more than 100 ft inboard of shoreline bulkhead. Water levels on both sides of the bulkhead are assumed balanced and at elevation -1 for this stage of construction.
- Dredge calculations performed at Section E (Figure S-2) for the Alternative SA-2 dredge cut resulted in a factor of safety of 1.53.
- A factor of safety of 1.46 is calculated for dredge Alternative SA-3 Option A and 1.48 for Alternative SA-3 Option B (Figure S-3). The depth to the bottom of the lightweight fill was deepened to elevation -6 to achieve this result for Option B. Both SA-3 options represent the maximum depth that can be dredged given the set of conditions assumed. Although these factors of safety are slightly less than 1.5, additional refinement of the case by modestly deepening the lightweight fill depth would increase the factor of safety to over 1.5.
- Figure S-2, Sections E and F also show the proposed Alternative SA-4 dredge cut in the Building 15 Area. The depth of the cut is restricted by the location of the silt curtain and a maximum dredge slope of 5H:1V. The shoreline bulkhead embedment is assumed to penetrate the basal sand layer for this alternative. This alternative is discussed in more detail in Section B7.2 below.

- WEZ95 barrier sheeting Sx=24.9 would be sufficient to support the applied loads for the SA-1, SA-2, and SA-3 Alternatives.
- The size of the berm required to get an adequate factor of safety for the long term loading case for Alternatives SA-1, SA-2, and SA-3 is shown on Figures S-1 through S-3. The berm would have its top at elevation at -2 for a 10 ft width at the shoreline bulkhead and then would slope down 6H:1V to the existing mudline grade. The berm intercepts the existing grade at approximately 100 ft from the bulkhead. The berm extends past the limits of the proposed silt curtain alignment which would be installed approximately 60 ft away from shore. A factor of safety of approximately 1.5 was calculated for this case. To achieve this result it was necessary to assume that 40 percent consolidation under the weight of the berm is achieved prior to sealing the bulkhead and allowing surcharge loading. It is estimated that it would take between 1 and 3 months to achieve this amount of consolidation utilizing wick drains. Alternatively, a larger berm could be placed in this area without waiting for consolidation, although that option was not calculated.

<u>Final Upland Grade at Elevation +9</u>

Calculations were performed to investigate the required size of the berm assuming a final grade of elevation +9 at the shoreline bulkhead as currently proposed as part of the OU-1 federal consent decree. The required berm has a 10 ft wide bench at the face of the bulkhead at elevation 0. The berm then slopes down at an 8H:1V until it intercepts the existing grade at approximately 200 ft from the bulkhead. This berm is substantially larger than that described above assuming a grade increase setback. Constructing the final grade to elevation +4 within 100 ft of the bulkhead wall; therefore, is the preferred option.

B7.2 Alternative SA-4

Alternative SA-4 assumes that the shoreline bulkhead can penetrate into the basal sand stratum. This alternative is considered for the Building 15. Driving the bulkhead into the basal sand would be protective of the environment in this area, because the risk of contaminating the basal sand aquifer is much less than in the Northwest Corner.

The SA-4 dredge depth would be restricted by geometry. The deepest water depth in which the silt curtain in the Southern Area can be constructed is 15 ft (measured at mean tide). The steepest stable dredge slope for a shallow cut in the marine silt is assumed to be 3H:1V slope, and that the deepest dredge depth required to achieve PRGs is elevation -20 base on the environmental dredging models. The calculations discussed below, however, assume that dredging extends from El. -29 at the bulkhead wall to El. -15 at the silt curtain. The calculations are, therefore, somewhat conservative for this case.

For consistency with the other alternatives, it is assumed that, at the time of dredging, the upland grade is at elevation +4, that a deadman anchorage system would be installed at elevation 0, and that lightweight fill is used to backfill from elevation 0 to the ground surface. It is also assumed that surcharge loading would be prohibited within 100 ft of the shoreline bulkhead during dredging and that the shoreline bulkhead would not be sealed at the time of dredging. It is further assumed that the dredged area would be backfilled following dredging, and a berm would be placed which is the same geometry as for the other Southern Area Alternatives. After the berm is constructed, the shoreline bulkhead would be sealed and surcharge loading would be allowed in the upland area. A smaller berm might be sufficient for this alternative, however, and this can be investigated as part of remedial design.

There are several technical issues which have not been fully resolved with respect to Alternative SA-4 which affect environmental feasibility and cost. The wall requires sheet piling with a high section modulus such as AZ-48 and sealable sheet piling may not be available in this size. Sealing a wall not specifically designed to be sealed after installation may be difficult and costly. Swelling joint sealants are unlikely to work at this site due to the large number of obstructions which will likely be encountered and the delays in driving the wall which will result.

As discussed for the NW-4 Alternative, one possible method of sealing the bulkhead is to construct a jet grout wall immediately adjacent to and on the upland side of the bulkhead. Installation of such a wall would be problematic as discussed in Section B5 because the wall anchor rods need to be avoided. Waste grout and soil return would also have to be disposed.

The deep dredging immediately adjacent to the SA-4 shoreline bulkhead would need to be supported by a large deadman reaction block or a series of reaction blocks. Drilled in tieback anchors extending into the basal sand might also be an option.

CWALSHT and PLAXIS calculations were performed for the SA-4 case and the shoreline bulkhead requirements are as follows:

- AZ-48 (and possibly AZ-36) steel sheeting would be adequate.
- Minimum sheeting embedment would be 10 ft into the basal sand (80 ft long sheets required).

B7.3 Interim Remedial Measure (IRM) Bulkhead Previously Installed

The 1998 Golder Site Investigation Report does not contain drawings or calculations that appear to be representative of the IRM Barrier bulkhead structure which was installed between the South Boat Slip and the southern property line. While construction of this bulkhead is well documented in the Golder "As-Built" report, drawings and calculations for the bulkhead have not been located. The toe of the IRM bulkhead is at elevation -29.5.

Calculations were not performed to assess dredging in the IRM bulkhead area specifically; however, calculations to determine berm size were. Subsurface conditions are similar to the Building 15 Area where calculations were performed so the dredge calculations performed in the Building 15 Area are assumed to apply to the IRM Bulkhead Area.. The sheeting penetration required for an adequate global stability factor of safety for cases in the Building 15 Area is elevation -47. If the existing IRM Bulkhead is to be subjected to the same dredging and final state loading as assumed for the Building 15 Area, it is apparent that it would have to be reinforced if dredging is conducted.

For the cases discussed below, dredging is assumed to occur with the upland area unloaded as much as practical and that the final OU-1 grade is assumed to be at elevation +4 within 100 ft of the shoreline. Alternatives to avoid needing to install a new shoreline bulkhead in this area include the following:

- Perform only shallow dredging or no dredging at all in this area and place a substantial berm to support the bulkhead under its final loading condition. Figure S-1 shows that a berm with a 10 ft wide bench at elevation -2 adjacent to the shoreline bulkhead and then a 6H:1V slope down to the existing river bottom would be required in the IRM Bulkhead Area. It was found necessary to assume 90 percent marine silt consolidation strength gain under the weight of the berm to achieve a sufficient factor of safety for this alternative. It is expected that it would take less than 1 year to achieve the required consolidation utilizing wick drains.

- Drive soldier piles to depth immediately in front of the bulkhead to increase its effective embedment. These soldier piles would likely need to penetrate into the basal sand to provide sufficient support. Drive battered soldier piles and connect them to a wale supporting the bulkhead. Dredge and backfill as required to the limits of the bulkhead. The required support berm for this case would likely be smaller than that described.
- Sequentially dredge in small slot shaped areas adjacent to the existing shoreline bulkhead and immediately backfill the dredge area. At the completion of dredging, place a substantial berm and cap to support the increased OU-1 loading as discussed in the first bullet point above.

B8 NORTH AND SOUTH BOAT SLIP AREAS

There are two dredge alternatives currently under consideration for the North Boat Slip Area as outlined below:

- Alternative NSlip -1 involves dredging up to 2 ft below the existing mudline and placing a cap.
- Alternative NSlip -2 involves dredging to elevation -9 ft and then sloping down at 5H:1V to a maximum depth of elevation -14.

A factor of safety in excess of 1.5 was calculated for the NSlip -2 dredge case, which has the deepest dredge depth of the Boat Slip alternatives. Dredging to elevation -14 at the bulkhead wall is also possible based on this alternative. To maximize dredged depth during the temporary dredging condition, surcharge would be prohibited within 100 to 120 ft of the shoreline, the upland would be at an elevation of elevation +4, and the shoreline bulkhead would not be sealed. Lightweight fill is assumed to be placed within 100 to 120 ft of the shoreline bulkhead from elevation 0 to the elevation +4. The zone of lightweight fill placement is approximate and would vary from 80 to 120 ft wide or more. Figure S -2, Section L, shows the two boat slip dredge alternatives and the berm required to support the upland surcharge loading and long term differential water pressure.

On Figure S-1 the shoreline bulkhead is shown along the existing shoreline in the South Boat Slip Area. No dredging is proposed in the South Boat Slip Area. The shoreline bulkhead sheeting would extend to elevation -47 and would be sealed. Standard compacted backfill is assumed after installation of anchorage at elevation 0 to elevation +4 within 80 ft of the shoreline bulkhead. The OU-1 ground surface elevation would increase to elevation +9 ft within 100 to 120 ft of the shoreline bulkhead and surcharge loading is assumed throughout the upland area. This scenario has a calculated factor of safety of 1.85. The sheeting embedment can probably be reduced in this area.

B9 OLD MARINA AREA

The Old Marina is defined as being that portion of the Hudson River north of OU-1 and west of the Hudson Valley Health and Tennis Club shoreline. The western boundary of the Old Marina Area is approximately defined by a northern extension of the site's existing west shoreline alignment. The northern boundary is approximately 340 ft north of the OU-1 upland at the northern end of the tennis club property (see Figure Marina-1). The two alternatives considered for this area are:

- Alternative Old Marina-1 (OM-1) assumes dredging up to 2 ft and placing a protective cap.
- Alternative Old Marina-2 (OM-2) assumes dredging to the depth required to remove all contamination above PRGs. In some areas, the OM-2 dredge depth would be limited by the need to maintain bulkhead stability.

Figures Marina-1 (plan view), Marina-2, and Marina-3 (section views) show the proposed environmental dredge depths associated with the OM-1 and OM-2 alternatives. The bulkhead stability calculations performed for the Old Marina area focus on the OM-2 alternative which involves significantly deeper dredging than OM-1.

Deep dredging immediately adjacent to the shoreline bulkhead under interim loading conditions was not considered for the Old Marina Area and dredge slopes at Sections H and I shown on the plans start at elevation 0 at the shoreline bulkhead. Dredging deeper adjacent to the shoreline bulkhead than considered in the calculations and shown on the figures is possible but limited due to the shorter sheeting penetration in this area (as compared to the bulkhead sheeting penetration at Section A). If deeper dredging were to be undertaken, a berm would need to be constructed at the completion of dredging back to the elevation of the dredge slopes currently shown to support the shoreline.

Figure Marina-1 also indicates the location of the alignment of the temporary rigid containment barrier around the Northwest Corner and the approximate location for a temporary silt curtain to enclose the Old Marina Area. This silt curtain would be installed where the mudline is at elevation -15 or less which is a reasonable water depth, likely to produce an effective silt curtain.

The following discussion presents the results of our SLIDE global stability analyses at each of the cross-sections shown on Figure Marina-1. The OM-1 and OM-2 dredge depths are shown in section view on Figures Marina-2 and Marina-3.

B9.1 Section H

The dredge case is the permanent case for this section and permanent loading conditions are applied to the shoreline bulkhead to assess dredging. The assumptions, construction sequence, and analysis results for the SLIDE global stability analysis of the permanent case for Section H are as follows:

- Based on limited geotechnical information, the top of the basal sand at Section H has been estimated to be at approximately elevation -50. The top of the upland marine silt is estimated to be at elevation -10.

- Based on the above basal sand elevation, a new shoreline bulkhead in this area will have a toe at or near elevation -35.
- Due partly to the relatively short bulkhead sheeting, placement of lightweight fill from elevation -6 to elevation +4 within approximately 100 ft of the inboard side of the shoreline bulkhead is needed for global stability to achieve the required factor of safety of 1.5.
- The permanent ground surface elevation within 100 ft of the shoreline bulkhead is assumed to be elevation +4. Beyond 100 ft, the ground surface elevation can slope up to elevation +9.
- The shoreline bulkhead is assumed anchored at elevation 0.
- A 200 psf surcharge load is assumed over the entire upland area. The shoreline bulkhead is assumed sealed with the water level inboard of the bulkhead being 5 ft higher than outboard water level.
- The assumed dredge cut would be from elevation 0 at the face of the shoreline bulkhead to elevation -12 at a distance of 72 ft outboard of the bulkhead (a 6H:1V dredge slope) Note that the actual OM-2 dredge depth is anticipated to be elevation -11 to elevation -9 at this section. In the final condition, a protective cap would be placed on the slope.
- For the set of conditions discussed above, a factor of safety of 1.47 is calculated. A factor of safety of 1.5 would likely be achievable by reducing the dredge cut to elevation – 11 or increasing the amount of lightweight fill slightly.

If the final grade within 100 ft of the shoreline bulkhead is raised to elevation +9 (it has been assumed to be elevation +4), then the factor of safety at Section H decreases to 1.03 for the conditions assumed above, assuming lightweight fill would be used to raise the grade. Based on the above, a substantial reduction in the allowable Old Marina dredge depth would be necessary to achieve the required factor of safety for a landside elevation of +9 at the shoreline bulkhead. Alternatively, dredging would have to occur with the upland at an interim elevation and then a berm constructed prior to backfilling the upland area to final grade.

B9.2 Section I

Section I is cut approximately 80 ft west of Section H. The existing topography at Section I is shown on Figure Marina-2.

Assumptions, approximate construction sequence, and analysis results for the SLIDE global stability analysis of the long term loading case are discussed below:

- Based on subsurface information in this area, the top of the basal sand is estimated to be elevation -65. The top of the upland marine silt is estimated to be at elevation -20 to -25.
- Based on the above basal sand elevation, the shoreline bulkhead in this area will have a toe at or near elevation -45.
- Placement of lightweight fill would be required from elevation -6 to elevation +4 within approximately 100 ft of the inboard side of the bulkhead. Environmental

excavation to elevation -6 is required in this portion of OU-1 as part of the OU-1 remedy.

- The permanent ground surface elevation, surcharge loading, and bulkhead anchorage are as assumed for the Section H analysis.
- The assumed dredge cut would be from elevation 0 at the face of the bulkhead to elevation -12 at a distance of 60 ft outboard of the bulkhead (a 5H:1V dredge slope). Note that the actual required OM-2 dredge cut appears to be between elevation -9 and elevation -11 along this section. For the final condition, a protective cap would be placed on the slope.
- For the set of conditions discussed above, a factor of safety of 1.75 was calculated.

If the final grade within 100 ft of the Shoreline bulkhead must be raised to elevation +9, then the factor of safety at Section I decreases to 1.25 for the conditions assumed above, assuming lightweight fill would be used to raise the grade. It is evident that a substantial reduction in the allowable Old Marina dredge depth would be necessary to achieve the required factor of safety. Alternatively, dredging with the upland at an interim elevation (with surcharge loading prohibited and the bulkhead unsealed) and construction of a bulkhead support berm prior to raising site grade (and applying surcharge and differential water loads) would be required.

B9.3 Section K

Section K is cut east/west through the shoreline of the existing tennis club property to the north of the site and out beyond the limits of the temporary rigid containment barrier as shown on Figures Marina-1 and Marina-3.

Based on the sudden grade change along the shoreline of the tennis club property, it is likely there is currently some type of bulkhead or revetment wall supporting the slope. The condition of this structure is unknown so it is uncertain what the existing factor of safety against a global stability failure is for this area. For this evaluation, it is assumed that the existing structure can support the proposed dredging.

B10 OFFSHORE AREA

B10.1 Settlement Analysis

Remediation alternatives currently being considered for OU-2 include sediment capping and the construction of a berm where needed to support the shoreline bulkhead (mostly along the shoreline but also, in some cases, extending into the Offshore Area). The Offshore Area sediment cap is expected to be approximately 1 to 2 ft thick. The berm thickness would vary with alternative and location but could exceed 10 ft. If the weight of the protective cap / support berm exceeds the weight of soil dredged at a given location, the underlying marine silt stratum will consolidate resulting in settlement of the cap / support berm.

For cohesive soils (such as the marine silt at this site), settlement is often divided into three parts: initial, primary consolidation, and secondary compression. Initial settlement occurs instantaneously with loading and is the result of undrained lateral deformations due to the shear stresses induced by the loading.

Primary consolidation settlement results from an increase in effective stress in the soil due to a new loading. The loading is first carried by excess pore fluid pressure and is slowly transferred to the soil skeleton with the passage of time as water seeps from the soil. Settlement for primary consolidation usually is larger that than that for initial and secondary settlement. Primary consolidation settlement is estimated based on one-dimensional consolidation theory. Secondary compression is a time-dependent type of settlement that is normally assumed to commence after primary consolidation is completed.

Geotechnical laboratory data for the marine silt were available from previous site investigations by others (see references). In addition, unpublished preliminary geotechnical laboratory data were available from the 2006 OU-1 site investigation program conducted by Haley & Aldrich, Inc. The relevant parameters are summarized below.

With the silt assumed to be normally consolidated, only estimates of compression ratio (CR) are required to calculate consolidation settlement. The embedded table below shows a summary of available CR data from different sources. The CR ranges from 0.11 to 0.34. However, about 67 percent of the values fall between 0.16 and 0.24. In the settlement calculations, an average value based on all data (CR=0.2) is used. Furthermore, there is no apparent variation of CR with depth so it is assumed that CR is constant with depth within the marine silt stratum.

Summary of compression ratio (CR) data

Source	Number of Data	Min. CR	Max. CR	Average CR	St. Dev. of CR
Golder (ref. 3)	4	0.13	0.22	0.17	0.05
Olko (ref. 2)	4	0.20	0.29	0.24	0.04
Shaw (ref. 4)	8	0.17	0.21	0.18	0.02
NYDEC (ref. 4)	8	0.11	0.22	0.16	0.04
H&A	20	0.12	0.34	0.23	0.06
All	44	0.11	0.34	0.20	0.06

An estimate of secondary compression settlement requires information on the secondary compression index (C_α) and the coefficient of consolidation (c_v). A limited amount of available data from Advance Testing (partial laboratory results) specific to the Harbor at Hastings site gives an average $C_\alpha \approx 0.007$. For normally-consolidated soils, the C_α/CR ratio is typically 0.045±0.015. Given the average CR = 0.2 from available data, the C_α/CR ratio of 0.035 in this case is within the range of typical values. For this analysis, $C_\alpha \approx 0.007$ is used and it is further assumed that secondary compression commences only after primary consolidation is completed.

The variation of vertical stress increase with depth in the marine silt layer generally depends on the plan dimensions of the loaded area. For simplicity, the plan dimensions of the loaded area are assumed to be several times greater than the marine silt layer thickness so that there would be an approximately uniform increase in stress across the layer. Four different granular fill thicknesses are considered: 1 ft, 2 ft, 5 ft, and 10 ft.

The marine silt stratum is estimated to be 45 to 55 ft thick. The granular fill cap and the underlying basal sand deposits are assumed to provide drainage for the marine silt layer during consolidation.

The magnitude of initial settlement is largely dependent of the care of construction. If the berm and cap loading would be placed uniformly and in thin lifts, then initial settlements could be relatively insignificant. The magnitude of consolidation settlement for each of the assumed cap/berm thicknesses is presented in the embedded table below. The settlements corresponding to 60 percent and 90 percent consolidation are also shown.

Summary of Estimated Consolidation Settlements in Ft

		Settlement (ft)		
Granular Fill Thickness (ft)	**Marine Silt Layer Thickness (ft)**	**Final (100 percent)**	**60 percent of Final**	**90 percent of Final**
1	45	0.6	0.4	0.5
2	45	0.9	0.5	0.8
5	45	1.7	1.0	1.6
10	45	2.7	1.6	2.4

A 2-foot thick cap can eventually result in roughly 1 ft of settlement. This estimate is conservative because the assumed stress increase in the marine silt is uniform and equal to the stress increase at the mudline. Consolidation settlement near the edges of the loaded area would be less than that under the center of the loaded area. For example, the soil beneath the edge of a large 2 foot-thick cap would settle approximately 0.5 ft instead of 0.9 ft.

Assuming that secondary compression commences only after primary consolidation is completed, the amount of secondary compression settlement 20 years after construction would be approximately 3 inches.

REFERENCES

1. Standard Specification for Highway Bridges, 17th Edition-2002, American Association of State Highway and Transportation Officials (AASHTO), paragraph 3.20.3.
2. Soils, Foundations and Shore Edge Treatment – Engineering Report" (December 1998), by Olko Engineering for The Harbor at Hastings Associates.
3. Report (1998), by Golder Associates, Inc. for Fluor Daniel, herein referred to as "Golder report". (The title page of the report is missing and we have been unable to find reference to the name of this report.)

4. “Excavation Evaluation Summary Report – Operable Unit #1” (September 5, 2002), by Shaw Environmental & Infrastructure, Inc. and Haley & Aldrich, Inc. for Atlantic Richfield Company.

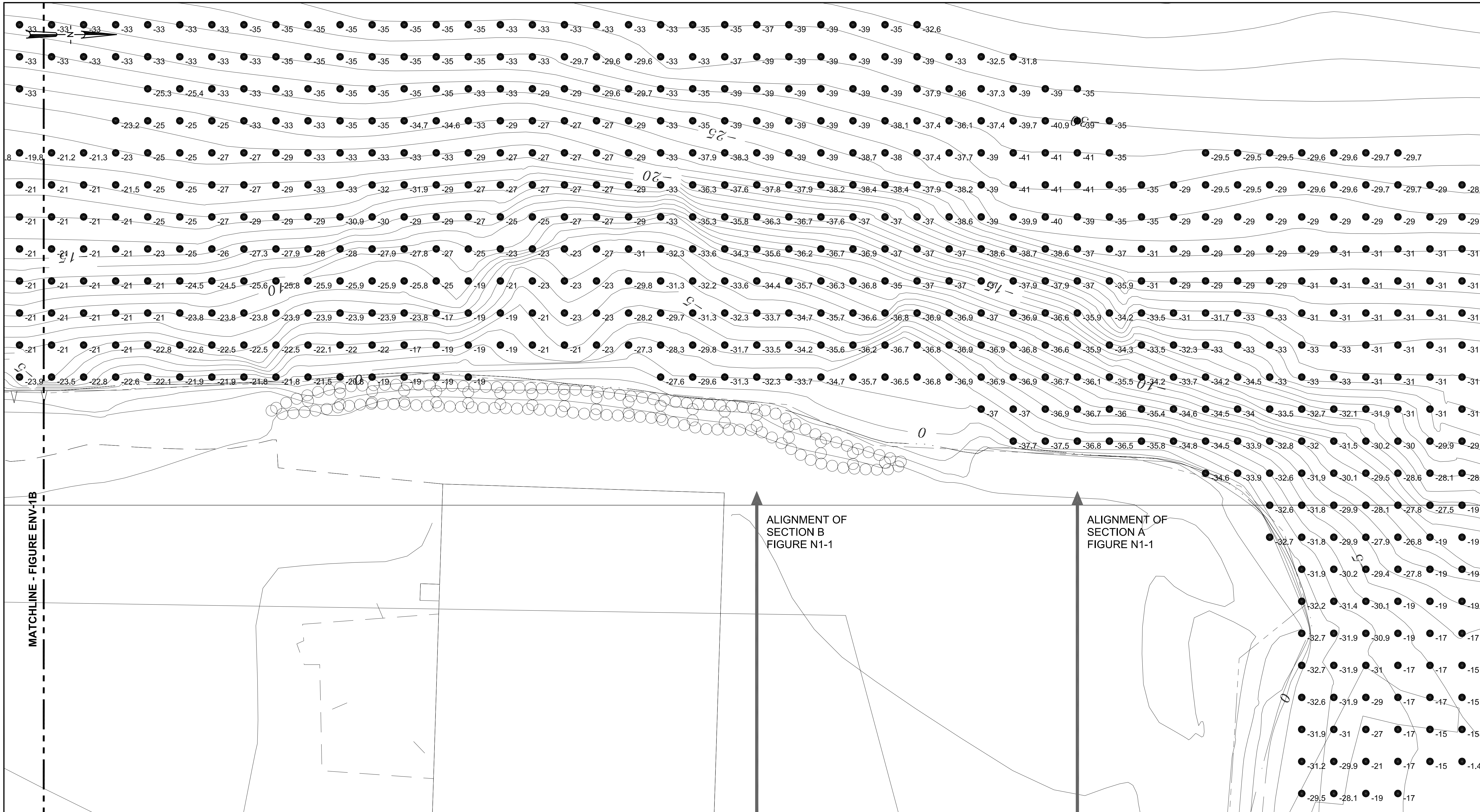
5. “Final Feasibility Study Report – Harbor at Hastings Site (OU#2)” (March 7, 2003), by Earth Tech of New York, Inc., for the New York State Department of Environmental Conservation (NYDEC)

TABLE B-1

SUMMARY OF REQUIRED MARINE SILT CONSOLIDATION FOR EACH REMEDIAL ALTERNATIVE INCLUDING ESTIMATED CONSOLIDATION TIME WITH AND WITHOUT WICK DRAINS

LOCATION	Remedial Alternative	Sub-Alternative	Percent Marine Silt Consolidation Required	Time to Achieve Required Consolidation Without Wick Drains	Time to Achieve Required Consolidation With Wick Drains
			Percent	**Months**	**Months**
Boat Slips	All		None		
Old Marina	All		None		
Northern Area	NW-1		None		
	NW-2, Options A&B	Upland to EL +4 ft	None		
	NW-2, Options A&B	Upland to EL +9 ft	20	2 to 5	
	NW-3		90	85.0	<12
	NW-4		None		
Southern Area	SA-2 & 3	Building 15 Area Upland to El. +4 ft	40	15.0	1 to 3
	SA-2 & 3	IRM Area Upland to El. +4 ft	90	85.0	<12
	SA-2 & 3	35 ft Bulkhead Setback Upland to El. +4 ft	None		

Assumptions:
-Average water depth used to calculate length
-5 ft triangular spacing
-4 inch wide drains
-Cv = 0.02 in^2/min
-assume drain can be cut off at new mudline depth
-assume two thirds embedment into marine silt



LEGEND:

● -21 ELEVATION OF DEEPEST PCBs ABOVE 1 PPM (SEE NOTE 2)

NOTES:

1. DRAWING BASED ON NAVD 88 DATUM. TO CONVERT FROM NAVD88 TO NGVD29 DATUM ADD ONE FOOT TO NAVD88 ELEVATIONS.
2. EACH ELEVATION NUMBER ON THIS MAP REPRESENTS THE AVERAGE ELEVATION IN A 10 FT BY 10 FT AREA, LISTED IN FEET BELOW THE MEAN SURFACE WATER LEVEL OF THE RIVER. THE MAP SHOWS THE MAXIMUM MEASURED DEPTH OF PCB'S ABOVE THE 1 PPM PRG, AND WHERE THAT DEPTH IS UNCERTAIN BECAUSE THE DEEPEST SAMPLE WAS ABOVE THE PRG, A DEPTH IS ESTIMATED, BASED ON DATA SHOWING THAT PCBs ARE UNLIKELY TO MIGRATE MORE THAN 3 FEET INTO THE MARINE SILT LAYER.
3. PREDICTED MAXIMUM DEPTH OF PCBs BASED ON RESULTS OF THE AR CONTAMINANT DISTRIBUTION MODEL.

0 30 60 90 120

SCALE IN FEET

HALEY & ALDRICH

UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

HASTINGS OU-2 ENVIRONMENTAL SITE REMEDIATION
HASTINGS-ON-HUDSON, NEW YORK

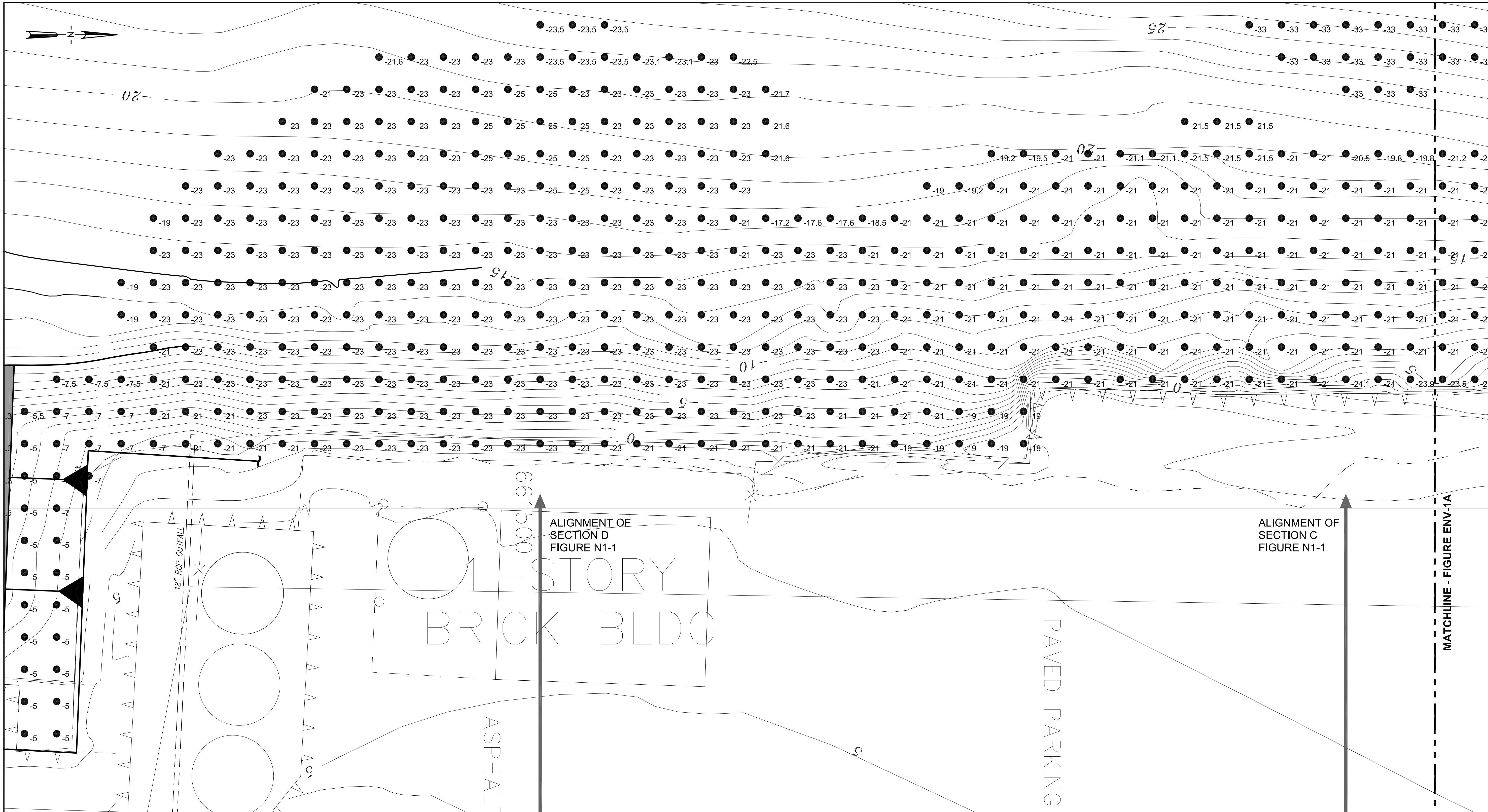
NORTHWEST CORNER AREA PREDICTED MAXIMUM DEPTH OF PCBs IN HASTINGS OU-2 PLAN VIEW

SCALE: AS SHOWN

24 APRIL 2006

28612-010 B141

FIGURE ENV-1A



LEGEND:

● -21 ELEVATION OF DEEPEST PCBs ABOVE 1 PPM (SEE NOTE 2)

NOTES:

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3. PREDICTED MAXIMUM DEPTH OF PCBs BASED ON RESULTS OF THE AR CONTAMINANT DISTRIBUTION MODEL.

0 30 60 90 120
SCALE IN FEET

HALEY & ALDRICH
UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

HASTINGS OU-2 ENVIRONMENTAL SITE REMEDIATION
HASTINGS-ON-HUDSON, NEW YORK

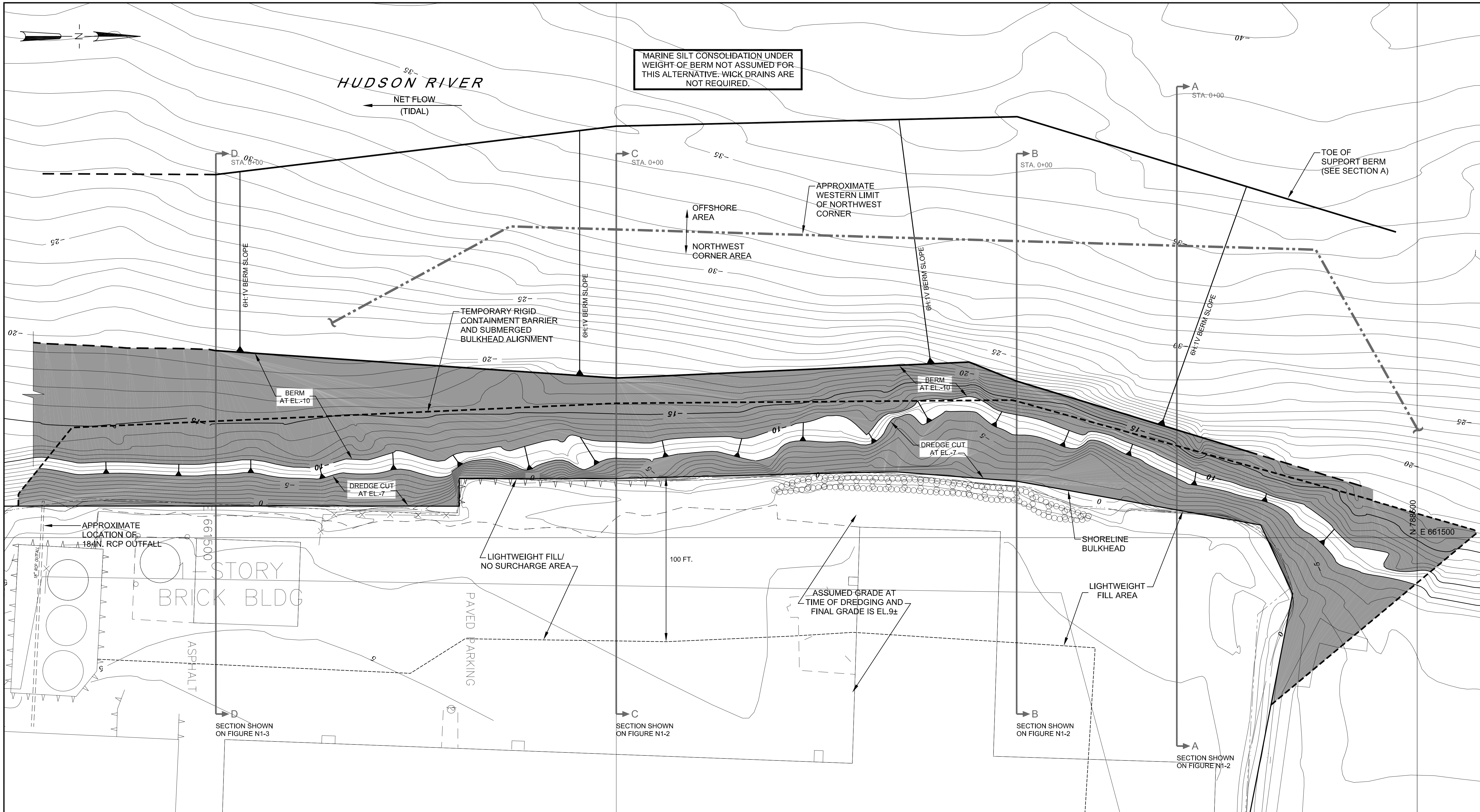
NORTHWEST CORNER AREA
PREDICTED MAXIMUM DEPTH OF PCBs
IN HASTINGS OU-2
PLAN VIEW

SCALE: AS SHOWN

24 APRIL 2006

28612-010 B142 (B141)

FIGURE ENV-1B



NOTES:

1. DRAWING BASED ON NAVD 88 DATUM. TO CONVERT FROM NAVD88 TO NGVD29 DATUM ADD ONE FOOT TO NAVD88 ELEVATIONS. PLAN BASED ON NEW YORK 1988 STATE PLANE COORDINATE SYSTEM.
2. SOIL PROFILES SHOWN IN SECTION VIEW REFLECT TYPICAL CONDITIONS IN THE VICINITY OF THE SECTION CUT. THE SOIL PROFILES ARE SIMPLIFIED AS NECESSARY FOR USE IN THE ENGINEERING ASSESSMENT OF REMEDIAL ACTION ALTERNATIVES.
3. CALCULATIONS FOR NW-1 WERE PERFORMED ON A LIMITED NUMBER OF DESIGN CROSS SECTIONS AS DISCUSSED IN APPENDIX B. BERM CONDITIONS DEPICTED AT AND BETWEEN SECTIONS SHOWN ON THESE DRAWINGS ARE INFERRED FROM THE DESIGN SECTION CALCULATIONS USING ENGINEERING JUDGMENT AND WILL HAVE TO BE CONFIRMED DURING SUBSEQUENT EVALUATION STEPS.
4. MARINE SILT CONSOLIDATION UNDER WEIGHT OF BERM NOT ASSUMED FOR THIS ALTERNATIVE. WICK DRAINS ARE NOT REQUIRED.
5. ALL ENGINEERING ELEMENTS PROVIDED ON THIS PLAN WERE DEVELOPED BASED ON EXISTING INFORMATION FOR THE PURPOSE OF EVALUATING REMEDIAL ALTERNATIVES AT THE SUBJECT SITE. THE ACTUAL DESIGN ELEVATIONS, DIMENSIONS, AND OTHER ENGINEERING ASPECTS OF THE SELECTED REMEDY WILL BE DEVELOPED DURING REMEDIAL DESIGN.

HALEY & ALDRICH

UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

HARBOR AT HASTINGS SITE
SUPPLEMENTAL FEASIBILITY STUDY FOR OU-2
HASTINGS-ON-HUDSON, NEW YORK

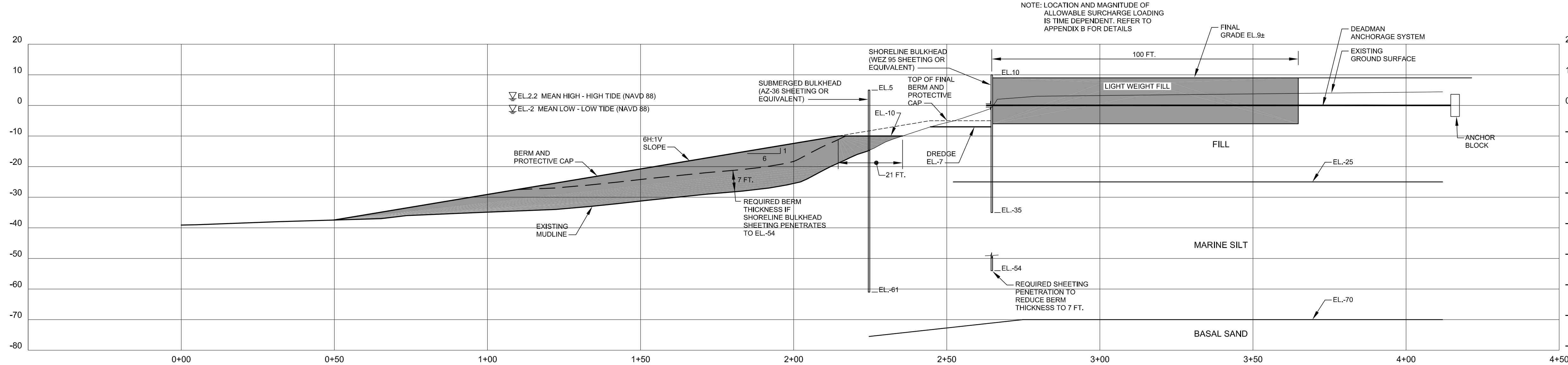
NORTHWEST CORNER AREA
ALTERNATIVE NW-1
FINAL UPLAND GRADE EL.9

SCALE: AS SHOWN

18 APRIL 2006

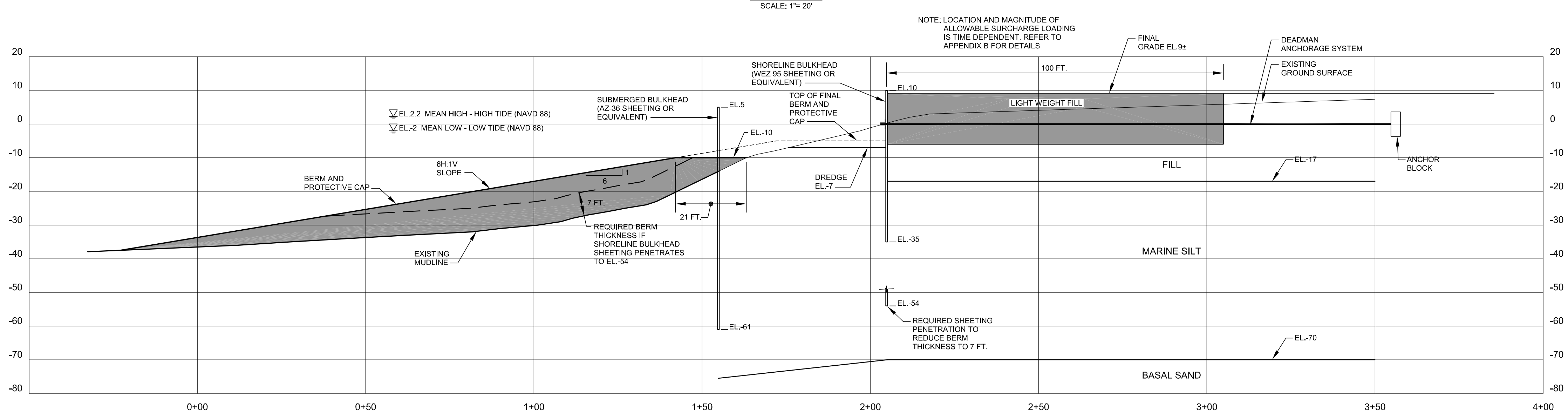
28612-010 D103

FIGURE N1-1



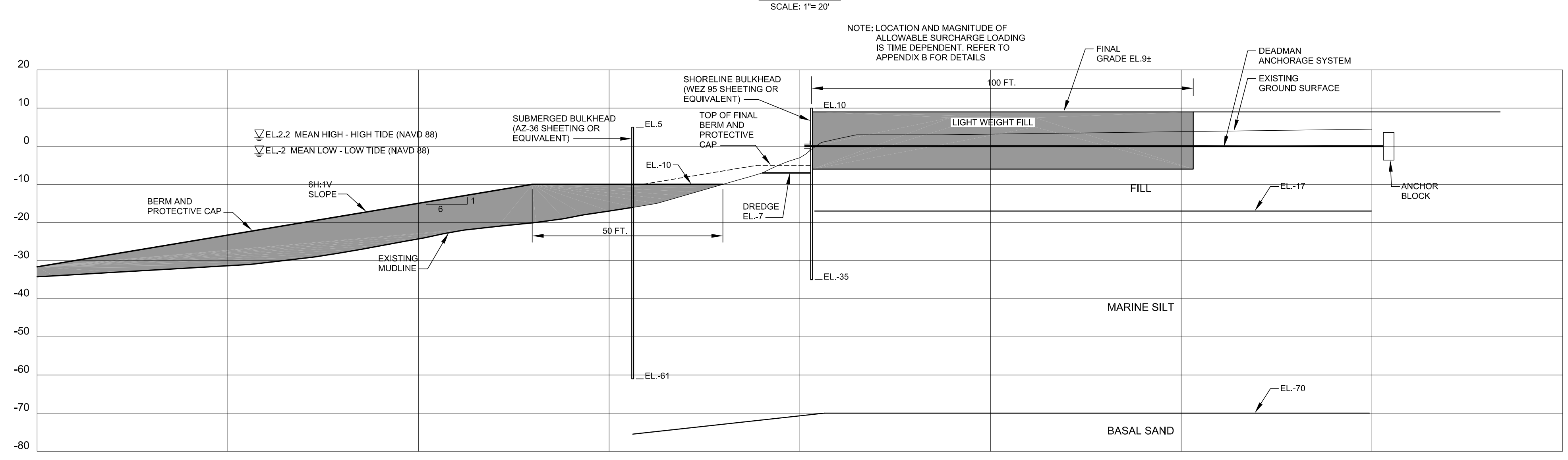
SECTION A-A

SCALE: 1"= 20'



SECTION B-B

SCALE: 1"= 20'



SECTION C-C

SCALE: 1"= 20'

NOTES:

1. MARINE SILT CONSOLIDATION UNDER WEIGHT OF BERM NOT ASSUMED FOR THIS ALTERNATIVE. WICK DRAINS ARE NOT REQUIRED.
2. ALL ENGINEERING ELEMENTS PROVIDED ON THIS PLAN WERE DEVELOPED BASED ON EXISTING INFORMATION FOR THE PURPOSE OF EVALUATING REMEDIAL ALTERNATIVES AT THE SUBJECT SITE. THE ACTUAL DESIGN ELEVATIONS, DIMENSIONS, AND OTHER ENGINEERING ASPECTS OF THE SELECTED REMEDY WILL BE DEVELOPED DURING REMEDIAL DESIGN.

0 20 40 60 80

SCALE IN FEET

HALEY & ALDRICH

UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

HARBOR AT HASTINGS SITE
SUPPLEMENTAL FEASIBILITY STUDY FOR OU-2
HASTINGS-ON-HUDSON, NEW YORK

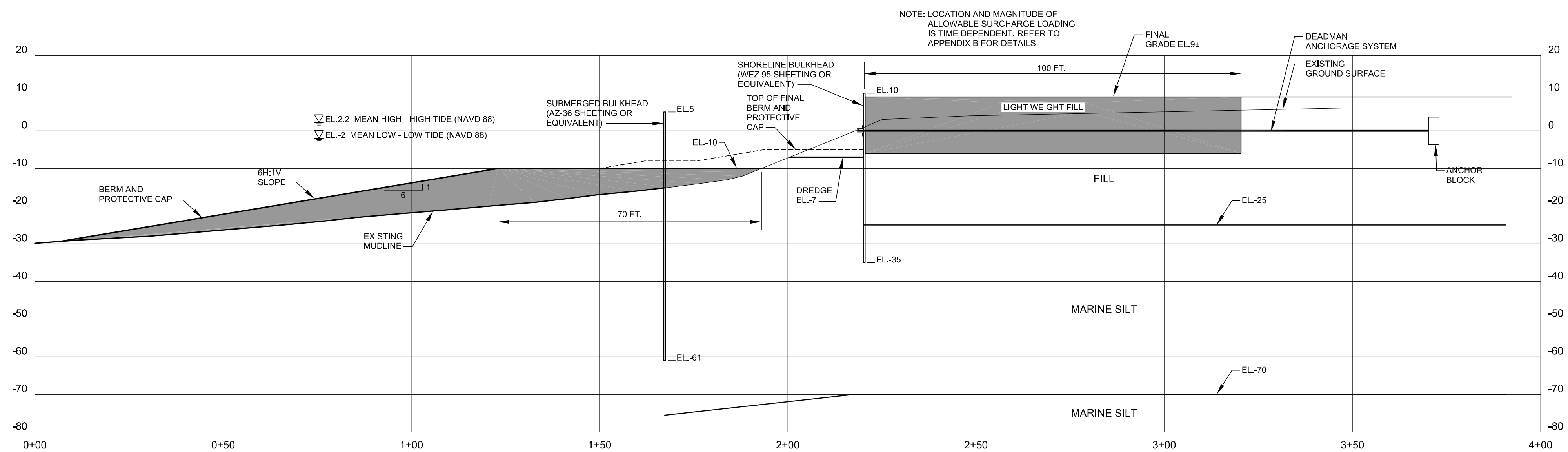
NORTHWEST CORNER AREA
ALTERNATIVE NW-1
SECTIONS

SCALE: AS SHOWN

18 APRIL 2006

28612-010 D104 (D103)

FIGURE N1-2



SECTION D-D

SCALE: 1"= 20'

NOTES:

1. MARINE SILT CONSOLIDATION UNDER WEIGHT OF BERM NOT ASSUMED FOR THIS ALTERNATIVE. WICK DRAINS ARE NOT REQUIRED.
2. ALL ENGINEERING ELEMENTS PROVIDED ON THIS PLAN WERE DEVELOPED BASED ON EXISTING INFORMATION FOR THE PURPOSE OF EVALUATING REMEDIAL ALTERNATIVES AT THE SUBJECT SITE. THE ACTUAL DESIGN ELEVATIONS, DIMENSIONS, AND OTHER ENGINEERING ASPECTS OF THE SELECTED REMEDY WILL BE DEVELOPED DURING REMEDIAL DESIGN.

0 20 40 60 80

SCALE IN FEET

HALEY & ALDRICH

UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

HARBOR AT HASTINGS SITE
SUPPLEMENTAL FEASIBILITY STUDY FOR OU-2
HASTINGS-ON-HUDSON, NEW YORK

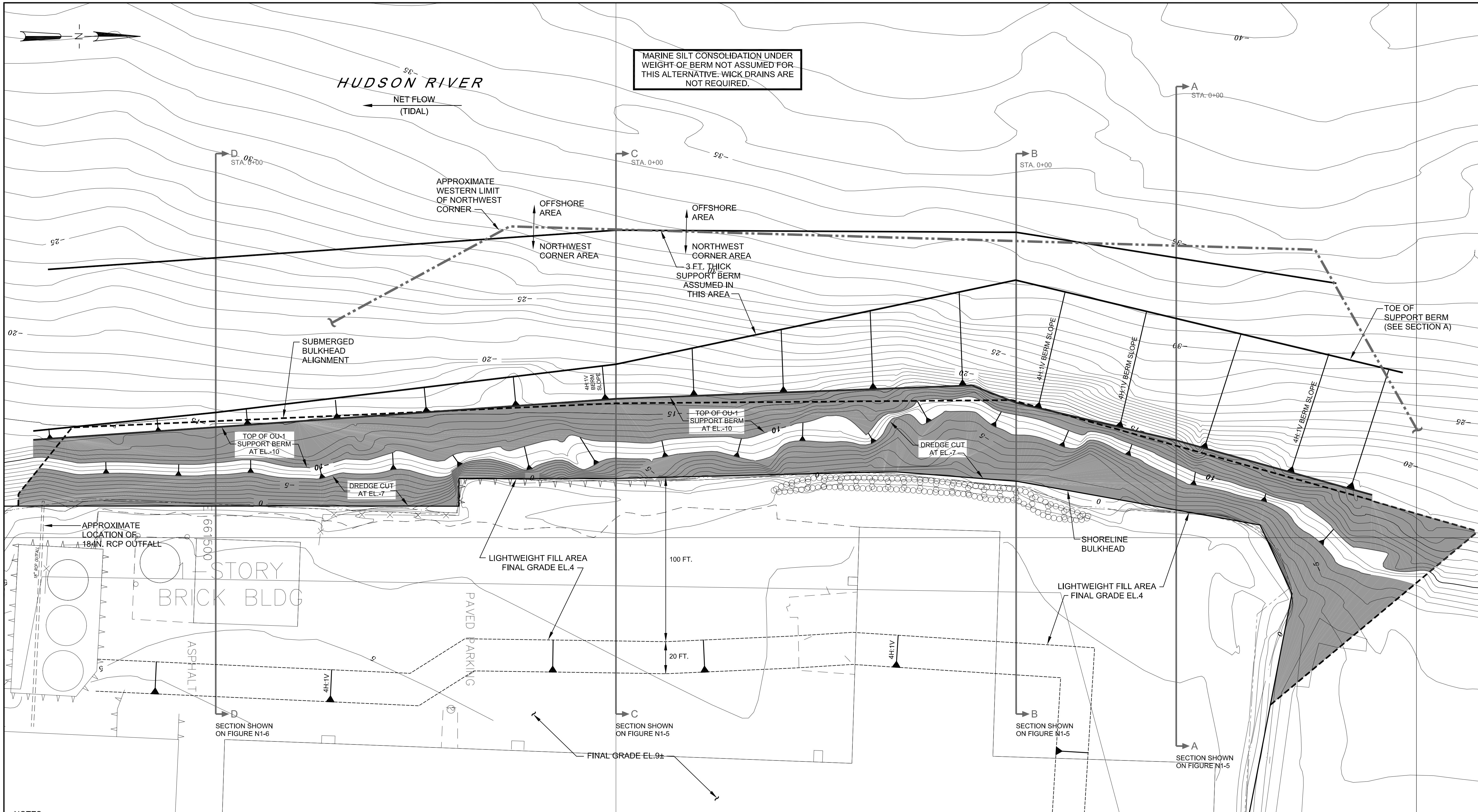
NORTHWEST CORNER AREA
ALTERNATIVE NW-1
SECTIONS

SCALE: AS SHOWN

18 APRIL 2006

28612-010 D105 (D103)

FIGURE N1-3



NOTES:

1. DRAWING BASED ON NAVD 88 DATUM. TO CONVERT FROM NAVD88 TO NGVD29 DATUM ADD ONE FOOT TO NAVD88 ELEVATIONS. PLAN BASED ON NEW YORK 1988 STATE PLANE COORDINATE SYSTEM.
2. SOIL PROFILES SHOWN IN SECTION VIEW REFLECT TYPICAL CONDITIONS IN THE VICINITY OF THE SECTION CUT. THE SOIL PROFILES ARE SIMPLIFIED AS NECESSARY FOR USE IN THE ENGINEERING ASSESSMENT OF REMEDIAL ACTION ALTERNATIVES.
3. CALCULATIONS FOR NW-1 WERE PERFORMED ON A LIMITED NUMBER OF DESIGN CROSS SECTIONS AS DISCUSSED IN APPENDIX B. BERM CONDITIONS DEPICTED AT AND BETWEEN SECTIONS SHOWN ON THESE DRAWINGS ARE INFERRED FROM THE DESIGN SECTION CALCULATIONS USING ENGINEERING JUDGMENT AND WILL HAVE TO BE CONFIRMED DURING SUBSEQUENT EVALUATION STEPS.
4. MARINE SILT CONSOLIDATION UNDER WEIGHT OF BERM NOT ASSUMED FOR THIS ALTERNATIVE. WICK DRAINS ARE NOT REQUIRED.
5. ALL ENGINEERING ELEMENTS PROVIDED ON THIS PLAN WERE DEVELOPED BASED ON EXISTING INFORMATION FOR THE PURPOSE OF EVALUATING REMEDIAL ALTERNATIVES AT THE SUBJECT SITE. THE ACTUAL DESIGN ELEVATIONS, DIMENSIONS, AND OTHER ENGINEERING ASPECTS OF THE SELECTED REMEDY WILL BE DEVELOPED DURING REMEDIAL DESIGN.

HALEY & ALDRICH
UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

HARBOR AT HASTINGS SITE
SUPPLEMENTAL FEASIBILITY STUDY FOR OU-2
HASTINGS-ON-HUDSON, NEW YORK

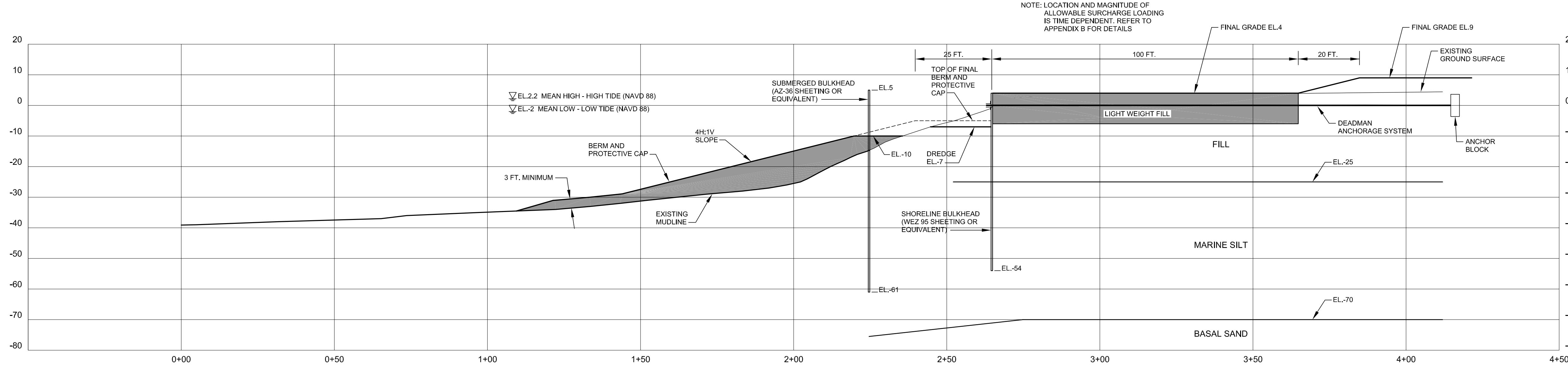
NORTHWEST CORNER AREA
ALTERNATIVE NW-1
FINAL UPLAND GRADE EL.4

SCALE: AS SHOWN

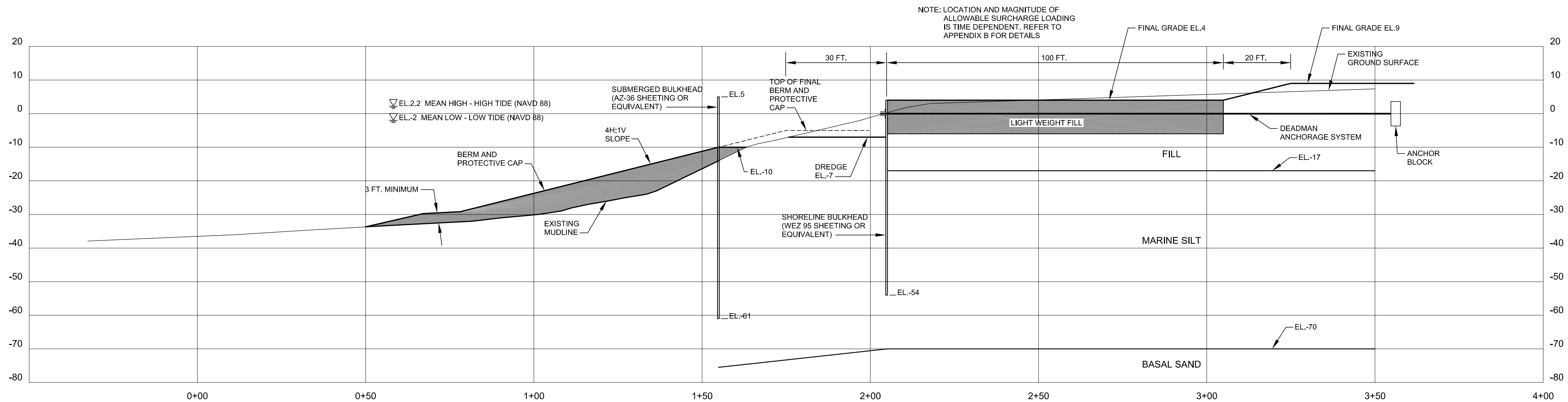
18 APRIL 2006

28612-010 D106

FIGURE N1-4



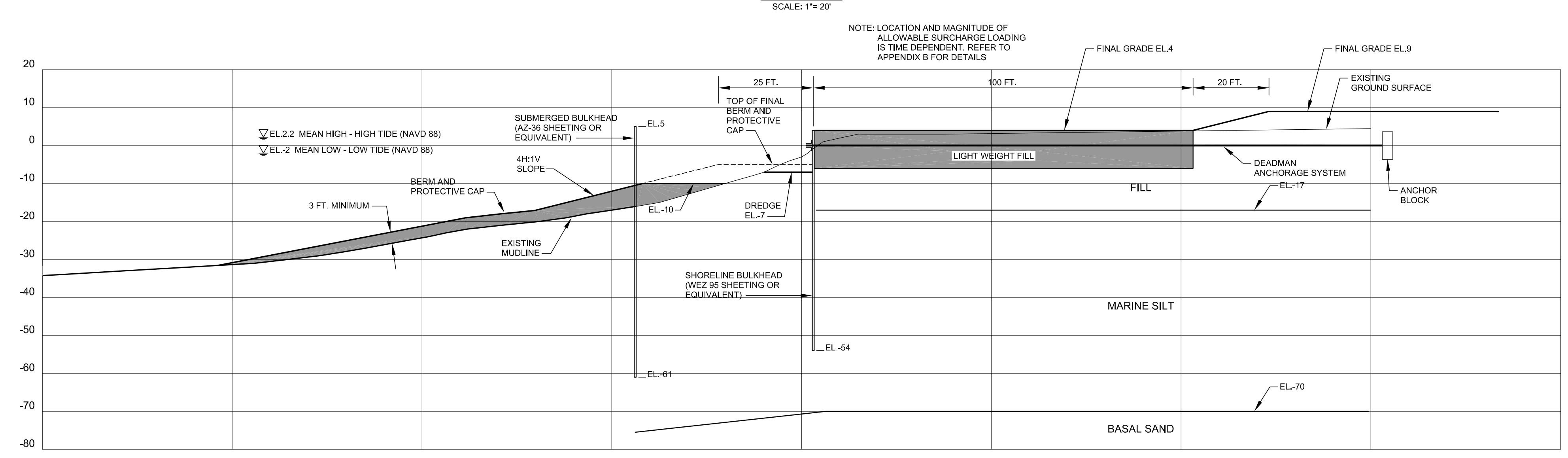
SECTION A-A
SCALE: 1"= 20'



SECTION B-B
SCALE: 1"= 20'

NOTES:

1. MARINE SILT CONSOLIDATION UNDER WEIGHT OF BERM NOT ASSUMED FOR THIS ALTERNATIVE. WICK DRAINS ARE NOT REQUIRED.
2. ALL ENGINEERING ELEMENTS PROVIDED ON THIS PLAN WERE DEVELOPED BASED ON EXISTING INFORMATION FOR THE PURPOSE OF EVALUATING REMEDIAL ALTERNATIVES AT THE SUBJECT SITE. THE ACTUAL DESIGN ELEVATIONS, DIMENSIONS, AND OTHER ENGINEERING ASPECTS OF THE SELECTED REMEDY WILL BE DEVELOPED DURING REMEDIAL DESIGN.



SECTION C-C
SCALE: 1"= 20'

0 20 40 60 80
SCALE IN FEET

28612-010 D107 (D106)

HALEY & ALDRICH
UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

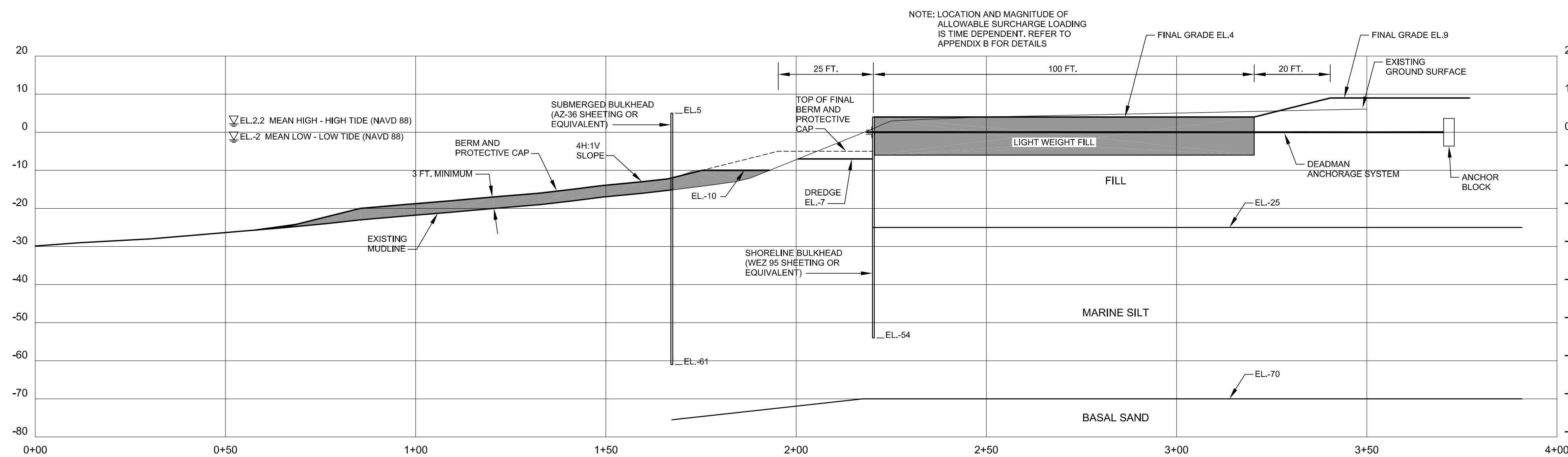
HARBOR AT HASTINGS SITE
SUPPLEMENTAL FEASIBILITY STUDY FOR OU-2
HASTINGS-ON-HUDSON, NEW YORK

NORTHWEST CORNER AREA ALTERNATIVE NW-1, FINAL UPLAND GRADE EL.4 SECTIONS

SCALE: AS SHOWN

18 APRIL 2006

FIGURE N1-5



SECTION D-D

SCALE: 1"= 20'

NOTES:

1. MARINE SILT CONSOLIDATION UNDER WEIGHT OF BERM NOT ASSUMED FOR THIS ALTERNATIVE. WICK DRAINS ARE NOT REQUIRED.
2. ALL ENGINEERING ELEMENTS PROVIDED ON THIS PLAN WERE DEVELOPED BASED ON EXISTING INFORMATION FOR THE PURPOSE OF EVALUATING REMEDIAL ALTERNATIVES AT THE SUBJECT SITE. THE ACTUAL DESIGN ELEVATIONS, DIMENSIONS, AND OTHER ENGINEERING ASPECTS OF THE SELECTED REMEDY WILL BE DEVELOPED DURING REMEDIAL DESIGN.

0 20 40 60 80

SCALE IN FEET

HALEY & ALDRICH

UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

HARBOR AT HASTINGS SITE
SUPPLEMENTAL FEASIBILITY STUDY FOR OU-2
HASTINGS-ON-HUDSON, NEW YORK

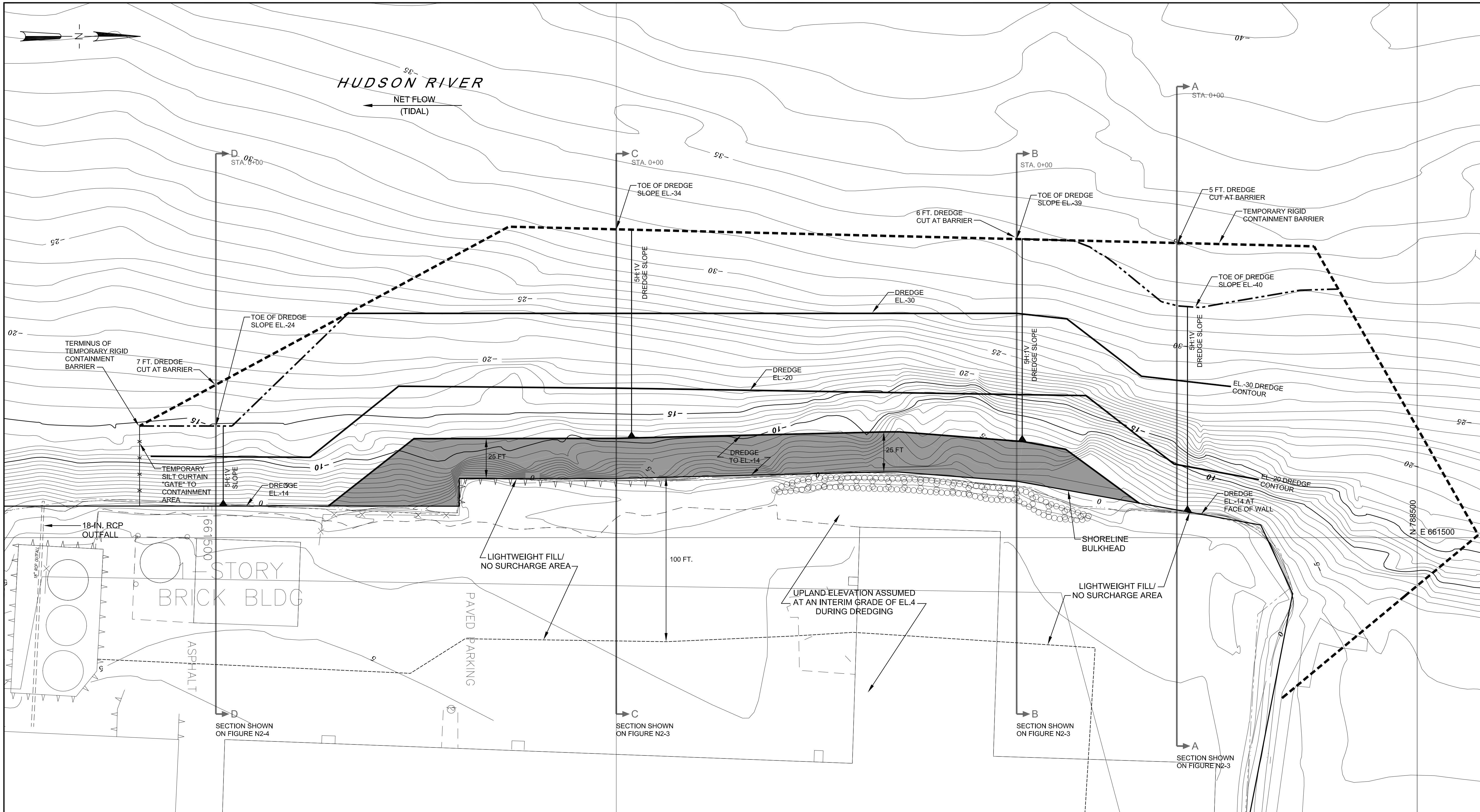
NORTHWEST CORNER AREA
ALTERNATIVE NW-1,
FINAL UPLAND GRADE EL.4
SECTIONS

SCALE: AS SHOWN

18 APRIL 2006

FIGURE N1-6

28612-010 D108 (D106)



NOTES:

1. DRAWING BASED ON NAVD 88 DATUM. TO CONVERT FROM NAVD88 TO NGVD29 DATUM ADD ONE FOOT TO NAVD88 ELEVATIONS. PLAN BASED ON NEW YORK 1988 STATE PLANE COORDINATE SYSTEM.
2. SOIL PROFILES SHOWN IN SECTION VIEW REFLECT TYPICAL CONDITIONS IN THE VICINITY OF THE SECTION CUT. THE SOIL PROFILES ARE SIMPLIFIED AS NECESSARY FOR USE IN THE ENGINEERING ASSESSMENT OF REMEDIAL ACTION ALTERNATIVES.
3. DREDGE CUT ASSUMED FOR GEOTECHNICAL CALCULATIONS IS SHOWN ON BOTH THE PLAN AND SECTION VIEW DRAWINGS FOR THIS ALTERNATIVE. WHERE THE DREDGE CUT BASED ON ENVIRONMENTAL DATA (FIGURES 1.3 AND 1.4) WOULD BE LESS THAN THE DREDGE CUT ASSUMED IN THE GEOTECHNICAL CALCULATIONS, THE ENVIRONMENTAL DREDGE CUT IS ALSO SHOWN ON THE SECTION VIEW DRAWINGS FOR THIS ALTERNATIVE.
4. CALCULATIONS WERE PERFORMED AT SELECT SECTIONS AND EXTRAPOLATED TO OTHER SECTIONS.
5. ALL ENGINEERING ELEMENTS PROVIDED ON THIS PLAN WERE DEVELOPED BASED ON EXISTING INFORMATION FOR THE PURPOSE OF EVALUATING REMEDIAL ALTERNATIVES AT THE SUBJECT SITE. THE ACTUAL DESIGN ELEVATIONS, DIMENSIONS, AND OTHER ENGINEERING ASPECTS OF THE SELECTED REMEDY WILL BE DEVELOPED DURING REMEDIAL DESIGN.

0 30 60 90 120
SCALE IN FEET

HALEY & ALDRICH

UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

HARBOR AT HASTINGS SITE
SUPPLEMENTAL FEASIBILITY STUDY FOR OU-2
HASTINGS-ON-HUDSON, NEW YORK

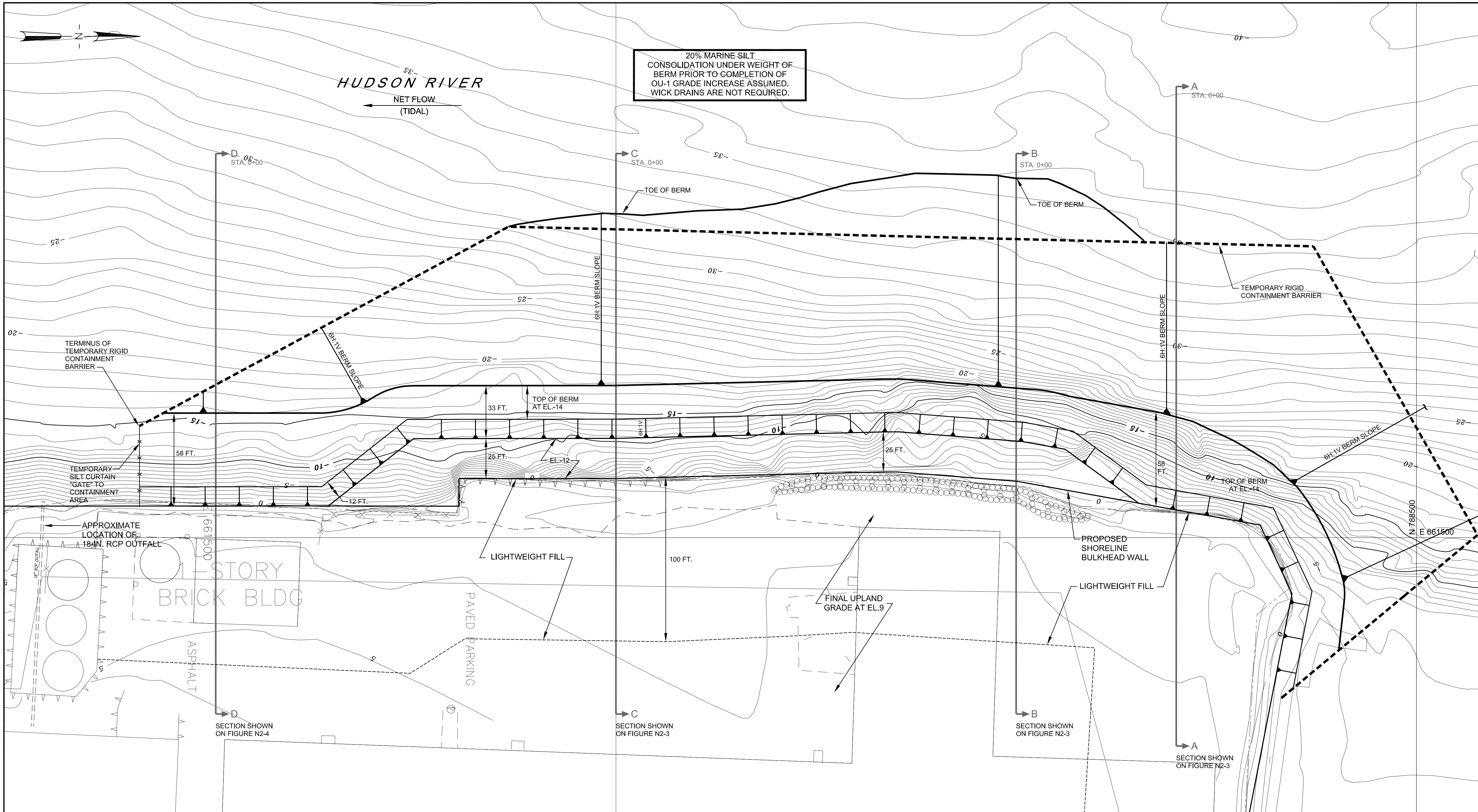
DREDGE CUT
NORTHWEST CORNER AREA
ALTERNATIVE NW-2, OPTION B

SCALE: AS SHOWN

18 APRIL 2006

28612-010 D109

FIGURE N2-1



NOTES:

1. DRAWING BASED ON NAVD 88 DATUM. TO CONVERT FROM NAVD88 TO NGVD29 DATUM ADD ONE FOOT TO NAVD88 ELEVATIONS. PLAN BASED ON NEW YORK 1988 STATE PLANE COORDINATE SYSTEM.
2. SOIL PROFILES SHOWN IN SECTION VIEW REFLECT TYPICAL CONDITIONS IN THE VICINITY OF THE SECTION CUT. THE SOIL PROFILES ARE SIMPLIFIED AS NECESSARY FOR USE IN THE ENGINEERING ASSESSMENT OF REMEDIAL ACTION ALTERNATIVES.
3. APPROXIMATE FINAL BERM CONFIGURATION FOR THIS ALTERNATIVE IS SHOWN ON THIS FIGURE. THE DREDGE CUT IS NOT SHOWN.
4. CALCULATIONS WERE PERFORMED AT SELECT SECTIONS AND EXTRAPOLATED TO OTHER SECTIONS.
5. 20% MARINE SILT CONSOLIDATION UNDER WEIGHT OF BERM PRIOR TO COMPLETION OF OU-1 GRADE INCREASE ASSUMED. WICK DRAINS ARE NOT REQUIRED.
6. ALL ENGINEERING ELEMENTS PROVIDED ON THIS PLAN WERE DEVELOPED BASED ON EXISTING INFORMATION FOR THE PURPOSE OF EVALUATING REMEDIAL ALTERNATIVES AT THE SUBJECT SITE. THE ACTUAL DESIGN ELEVATIONS, DIMENSIONS, AND OTHER ENGINEERING ASPECTS OF THE SELECTED REMEDY WILL BE DEVELOPED DURING REMEDIAL DESIGN.

0 30 60 90 120
SCALE IN FEET

HALEY & ALDRICH
UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

HARBOR AT HASTINGS SITE
SUPPLEMENTAL FEASIBILITY STUDY FOR OU-2
HASTINGS-ON-HUDSON, NEW YORK

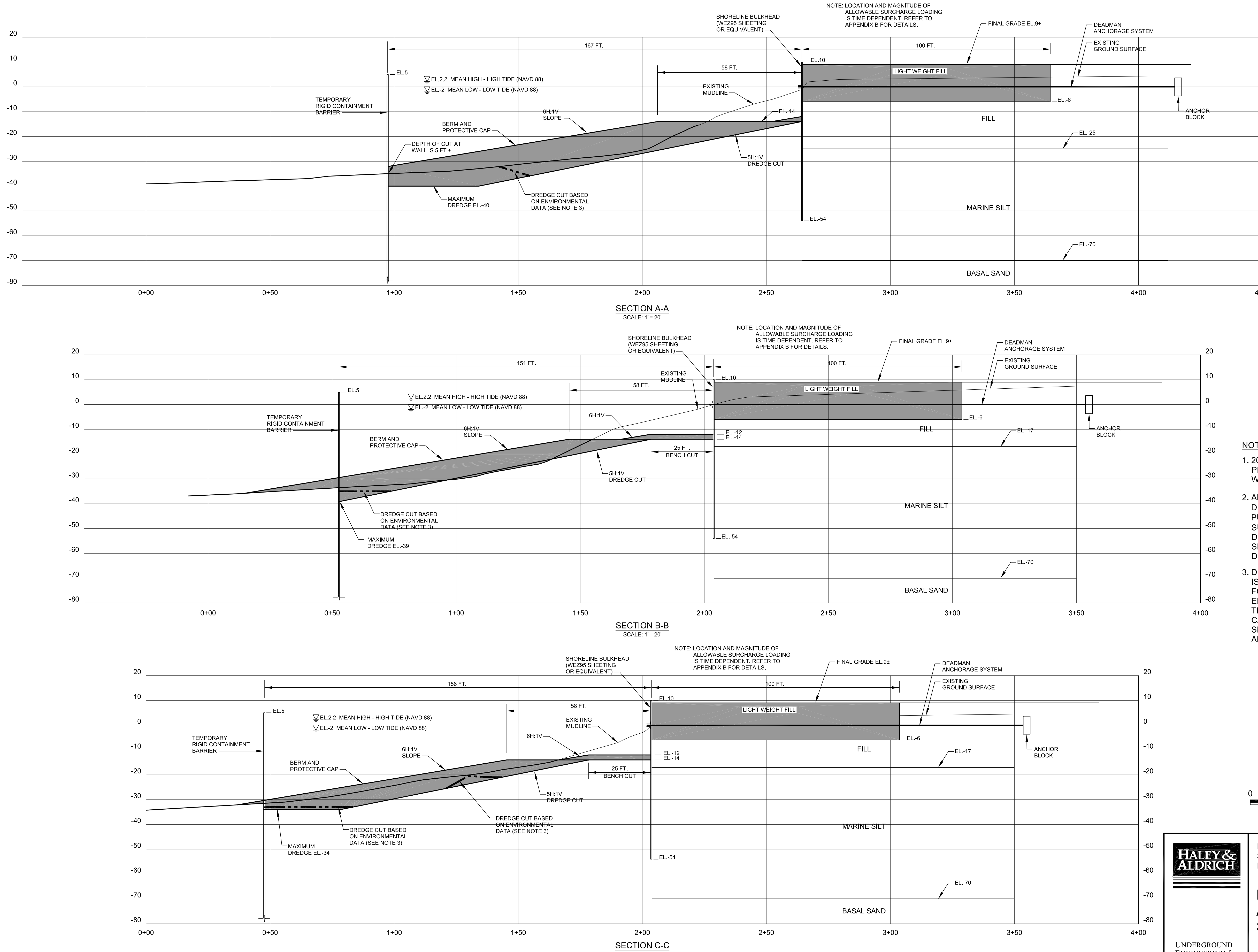
NORTHWEST CORNER AREA
ALTERNATIVE NW-2, OPTION B
FINAL UPLAND GRADE EL.9

SCALE: AS SHOWN

18 APRIL 2006

28612-010 D110

FIGURE N2-2



NOTES:

1. 20% MARINE SILT CONSOLIDATION UNDER WEIGHT OF BERM PRIOR TO COMPLETION OF OU-1 GRADE INCREASE ASSUMED. WICK DRAINS ARE NOT REQUIRED.
2. ALL ENGINEERING ELEMENTS PROVIDED ON THIS PLAN WERE DEVELOPED BASED ON EXISTING INFORMATION FOR THE PURPOSE OF EVALUATING REMEDIAL ALTERNATIVES AT THE SUBJECT SITE. THE ACTUAL DESIGN ELEVATIONS, DIMENSIONS, AND OTHER ENGINEERING ASPECTS OF THE SELECTED REMEDY WILL BE DEVELOPED DURING REMEDIAL DESIGN.
3. DREDGE CUT ASSUMED FOR GEOTECHNICAL CALCULATIONS IS SHOWN ON BOTH THE PLAN AND SECTION VIEW DRAWINGS FOR THIS ALTERNATIVE. WHERE THE DREDGE CUT BASED ON ENVIRONMENTAL DATA (FIGURES 1.3 AND 1.4) WOULD BE LESS THAN THE DREDGE CUT ASSUMED IN THE GEOTECHNICAL CALCULATIONS, THE ENVIRONMENTAL DREDGE CUT IS ALSO SHOWN ON THE SECTION VIEW DRAWINGS FOR THIS ALTERNATIVE.

0 20 40 60 80
SCALE IN FEET

HALEY & ALDRICH
UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

HARBOR AT HASTINGS SITE
SUPPLEMENTAL FEASIBILITY STUDY FOR OU-2
HASTINGS-ON-HUDSON, NEW YORK

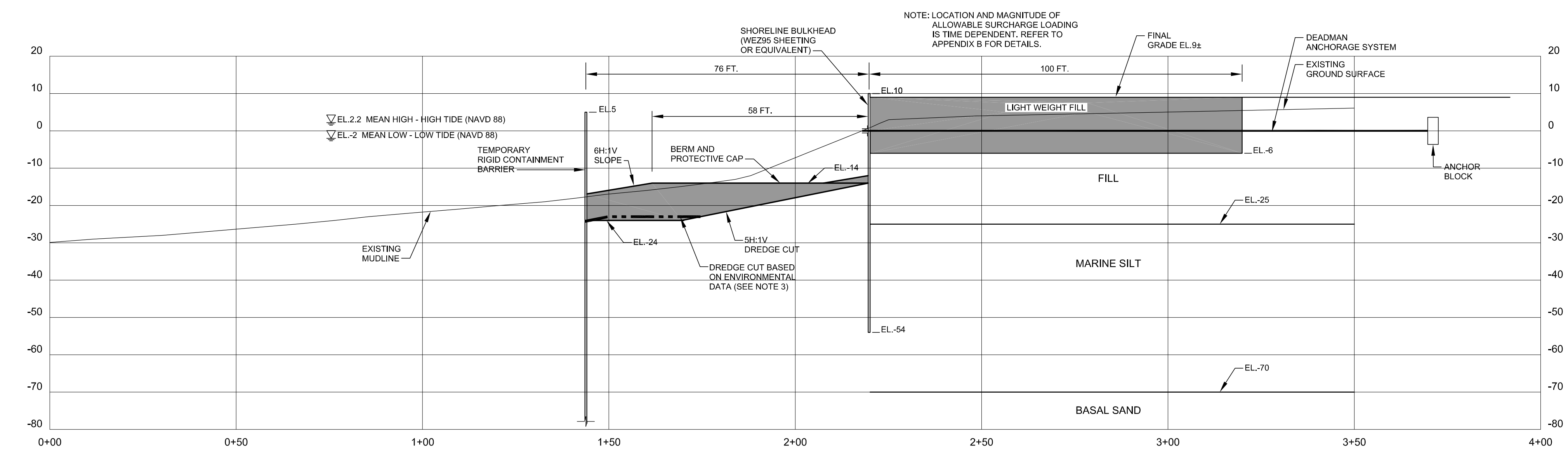
NORTHWEST CORNER AREA ALTERNATIVE NW-2, OPTION B SECTIONS

SCALE: AS SHOWN

18 APRIL 2006

28612-010 D111

FIGURE N2-3



SECTION D-D

SCALE: 1"= 20'

NOTES:

1. 20% MARINE SILT CONSOLIDATION UNDER WEIGHT OF BERM PRIOR TO COMPLETION OF OU-1 GRADE INCREASE ASSUMED. WICK DRAINS ARE NOT REQUIRED.
2. ALL ENGINEERING ELEMENTS PROVIDED ON THIS PLAN WERE DEVELOPED BASED ON EXISTING INFORMATION FOR THE PURPOSE OF EVALUATING REMEDIAL ALTERNATIVES AT THE SUBJECT SITE. THE ACTUAL DESIGN ELEVATIONS, DIMENSIONS, AND OTHER ENGINEERING ASPECTS OF THE SELECTED REMEDY WILL BE DEVELOPED DURING REMEDIAL DESIGN.
3. DREDGE CUT ASSUMED FOR GEOTECHNICAL CALCULATIONS IS SHOWN ON BOTH THE PLAN AND SECTION VIEW DRAWINGS FOR THIS ALTERNATIVE. WHERE THE DREDGE CUT BASED ON ENVIRONMENTAL DATA (FIGURES 1.3 AND 1.4) WOULD BE LESS THAN THE DREDGE CUT ASSUMED IN THE GEOTECHNICAL CALCULATIONS, THIS CUT IS ALSO SHOWN ON THE SECTION VIEW DRAWINGS FOR THIS ALTERNATIVE.

0 20 40 60 80

SCALE IN FEET

HALEY & ALDRICH

UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

HARBOR AT HASTINGS SITE
SUPPLEMENTAL FEASIBILITY STUDY FOR OU-2
HASTINGS-ON-HUDSON, NEW YORK

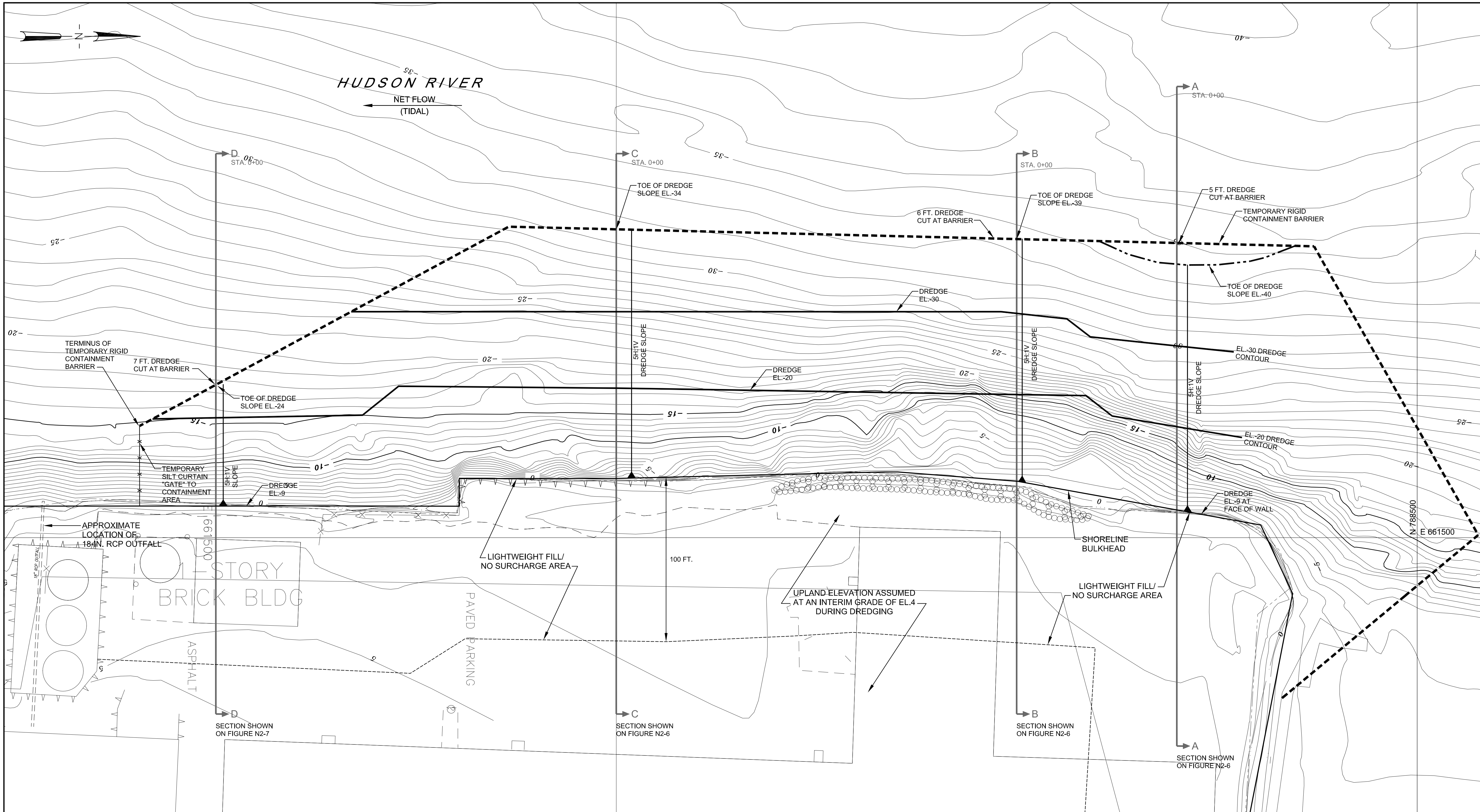
NORTHWEST CORNER AREA
ALTERNATIVE NW-2, OPTION B
SECTIONS

SCALE: AS SHOWN

18 APRIL 2006

28612-010 D112 (D111)

FIGURE N2-4



NOTES:

1. DRAWING BASED ON NAVD 88 DATUM. TO CONVERT FROM NAVD88 TO NGVD29 DATUM ADD ONE FOOT TO NAVD88 ELEVATIONS. PLAN BASED ON NEW YORK 1988 STATE PLANE COORDINATE SYSTEM.
2. SOIL PROFILES SHOWN IN SECTION VIEW REFLECT TYPICAL CONDITIONS IN THE VICINITY OF THE SECTION CUT. THE SOIL PROFILES ARE SIMPLIFIED AS NECESSARY FOR USE IN THE ENGINEERING ASSESSMENT OF REMEDIAL ACTION ALTERNATIVES.
3. DREDGE CUT ASSUMED FOR GEOTECHNICAL CALCULATIONS IS SHOWN ON BOTH THE PLAN AND SECTION VIEW DRAWINGS FOR THIS ALTERNATIVE. WHERE THE DREDGE CUT BASED ON ENVIRONMENTAL DATA (FIGURES 1.3 AND 1.4) WOULD BE LESS THAN THE DREDGE CUT ASSUMED IN THE GEOTECHNICAL CALCULATIONS, THE ENVIRONMENTAL DREDGE CUT IS ALSO SHOWN ON THE SECTION VIEW DRAWINGS FOR THIS ALTERNATIVE.
4. CALCULATIONS WERE PERFORMED AT SELECT SECTIONS AND EXTRAPOLATED TO OTHER SECTIONS.
5. ALL ENGINEERING ELEMENTS PROVIDED ON THIS PLAN WERE DEVELOPED BASED ON EXISTING INFORMATION FOR THE PURPOSE OF EVALUATING REMEDIAL ALTERNATIVES AT THE SUBJECT SITE. THE ACTUAL DESIGN ELEVATIONS, DIMENSIONS, AND OTHER ENGINEERING ASPECTS OF THE SELECTED REMEDY WILL BE DEVELOPED DURING REMEDIAL DESIGN.

HALEY & ALDRICH

UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

HARBOR AT HASTINGS SITE
SUPPLEMENTAL FEASIBILITY STUDY FOR OU-2
HASTINGS-ON-HUDSON, NEW YORK

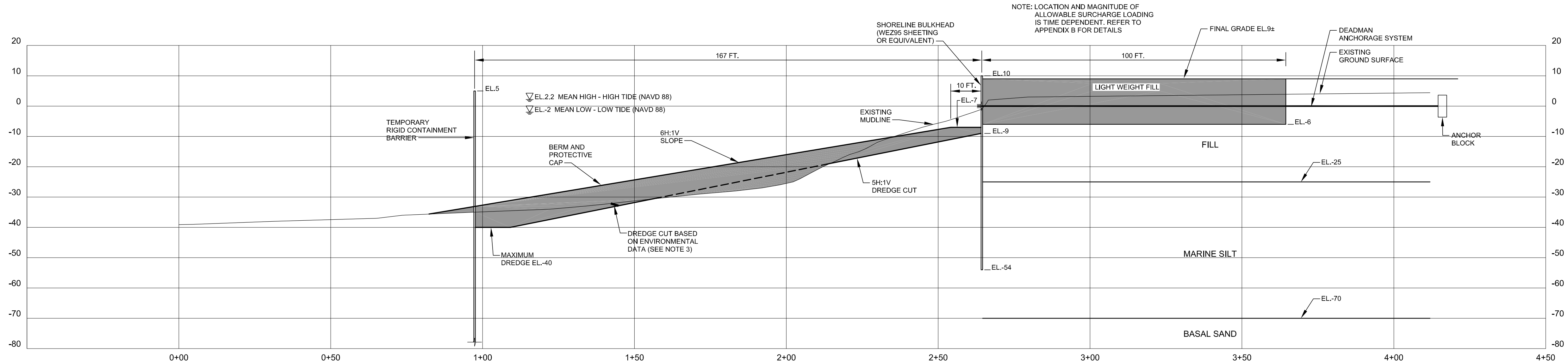
DREDGE CUT
NORTHWEST CORNER AREA
ALTERNATIVE NW-2, OPTION A

SCALE: AS SHOWN

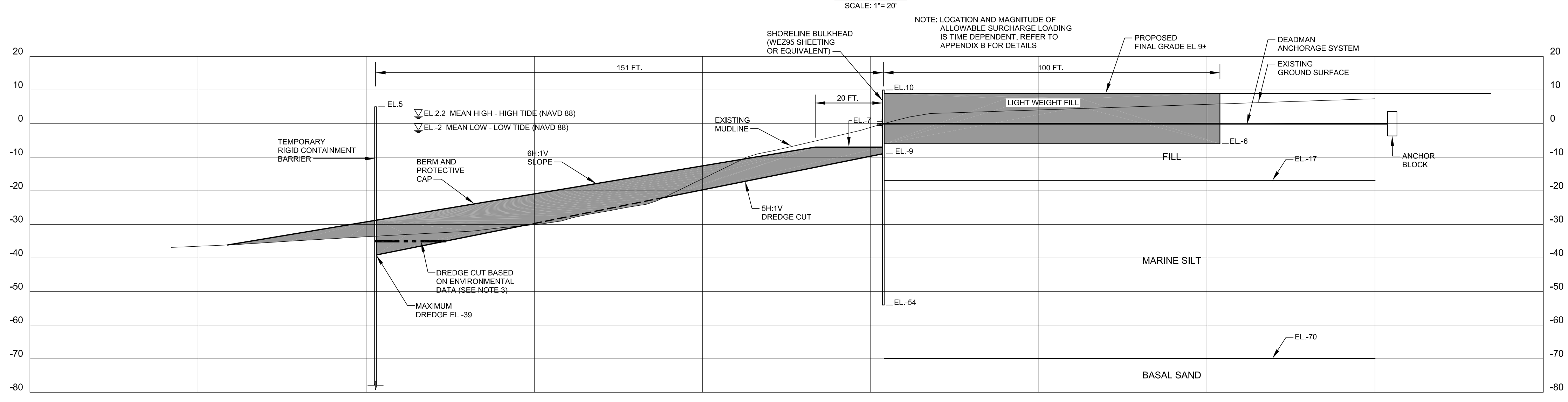
18 APRIL 2006

28612-010 D113

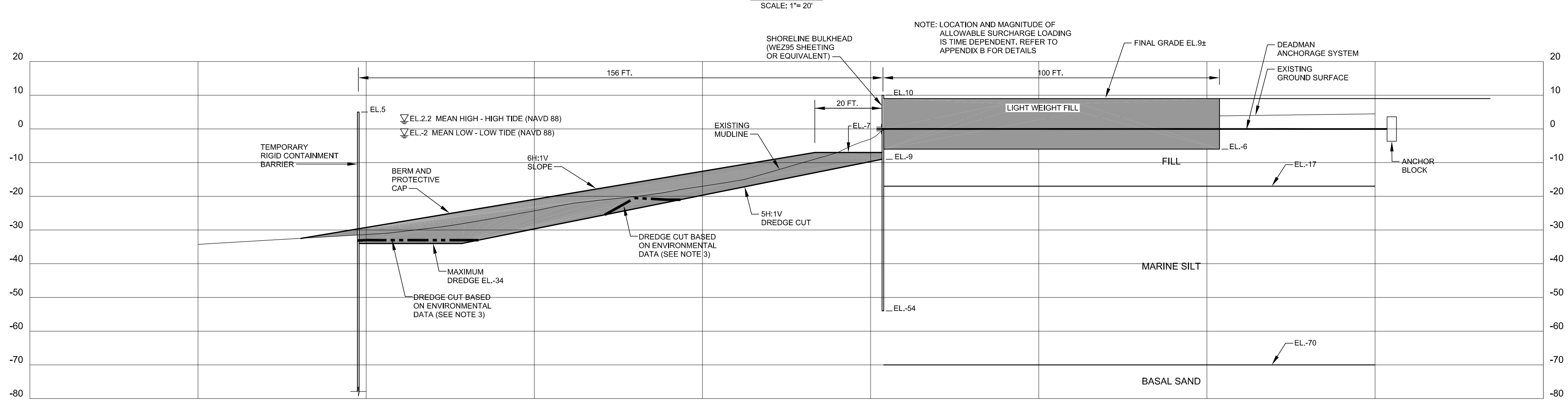
FIGURE N2-5



SECTION A-A
SCALE: 1"= 20'



SECTION B-B
SCALE: 1"= 20'



SECTION C-C
SCALE: 1"= 20'

NOTES:

1. 20% MARINE SILT CONSOLIDATION UNDER WEIGHT OF BERM PRIOR TO COMPLETION OF OU-1 GRADE INCREASE ASSUMED. WICK DRAINS ARE NOT REQUIRED.
2. ALL ENGINEERING ELEMENTS PROVIDED ON THIS PLAN WERE DEVELOPED BASED ON EXISTING INFORMATION FOR THE PURPOSE OF EVALUATING REMEDIAL ALTERNATIVES AT THE SUBJECT SITE. THE ACTUAL DESIGN ELEVATIONS, DIMENSIONS, AND OTHER ENGINEERING ASPECTS OF THE SELECTED REMEDY WILL BE DEVELOPED DURING REMEDIAL DESIGN.
3. DREDGE CUT ASSUMED FOR GEOTECHNICAL CALCULATIONS IS SHOWN ON BOTH THE PLAN AND SECTION VIEW DRAWINGS FOR THIS ALTERNATIVE. WHERE THE DREDGE CUT BASED ON ENVIRONMENTAL DATA (FIGURES 1.3 AND 1.4) WOULD BE LESS THAN THE DREDGE CUT ASSUMED IN THE GEOTECHNICAL CALCULATIONS, THE ENVIRONMENTAL DREDGE CUT IS ALSO SHOWN ON THE SECTION VIEW DRAWINGS FOR THIS ALTERNATIVE.

0 20 40 60 80
SCALE IN FEET

HALEY & ALDRICH
UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

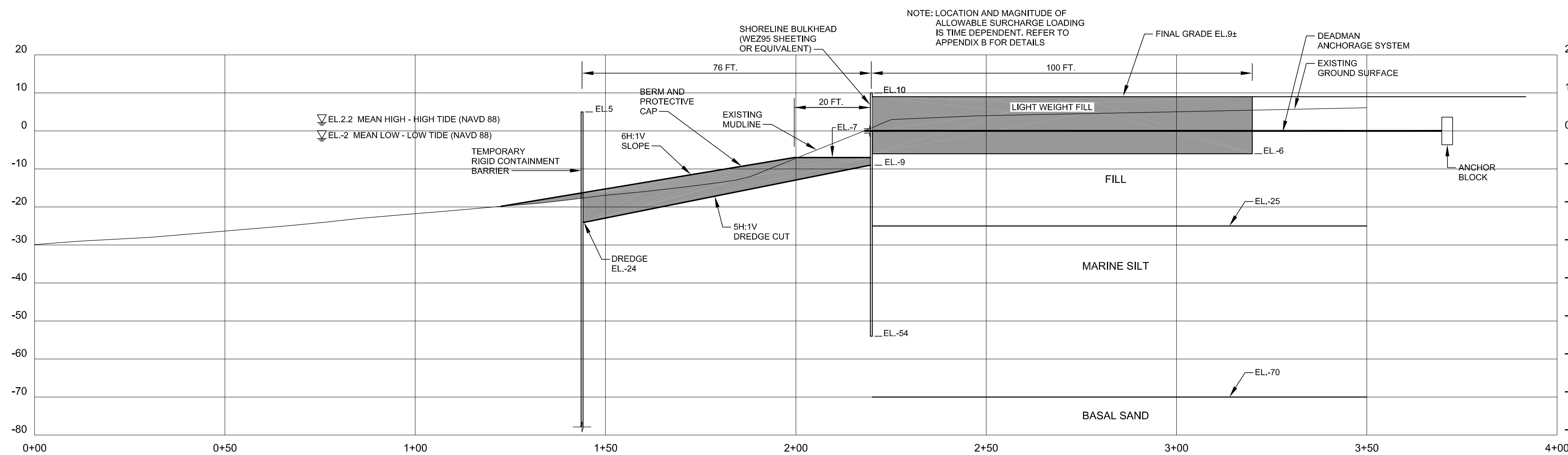
HARBOR AT HASTINGS SITE
SUPPLEMENTAL FEASIBILITY STUDY FOR OU-2
HASTINGS-ON-HUDSON, NEW YORK

NORTHWEST CORNER AREA
ALTERNATIVE NW-2, OPTION A
SECTIONS

SCALE: AS SHOWN
18 APRIL 2006

FIGURE N2-6

28612-010 D114 (D113)



SECTION D-D
SCALE: 1"= 20'

NOTES:

1. 20% MARINE SILT CONSOLIDATION UNDER WEIGHT OF BERM PRIOR TO COMPLETION OF OU-1 GRADE INCREASE ASSUMED. WICK DRAINS ARE NOT REQUIRED.

2. ALL ENGINEERING ELEMENTS PROVIDED ON THIS PLAN WERE DEVELOPED BASED ON EXISTING INFORMATION FOR THE PURPOSE OF EVALUATING REMEDIAL ALTERNATIVES AT THE SUBJECT SITE. THE ACTUAL DESIGN ELEVATIONS, DIMENSIONS, AND OTHER ENGINEERING ASPECTS OF THE SELECTED REMEDY WILL BE DEVELOPED DURING REMEDIAL DESIGN.

3. DREDGE CUT ASSUMED FOR GEOTECHNICAL CALCULATIONS IS SHOWN ON BOTH THE PLAN AND SECTION VIEW DRAWINGS FOR THIS ALTERNATIVE. WHERE THE DREDGE CUT BASED ON ENVIRONMENTAL DATA (FIGURES 1.3 AND 1.4) WOULD BE LESS THAN THE DREDGE CUT ASSUMED IN THE GEOTECHNICAL CALCULATIONS, THE ENVIRONMENTAL DREDGE CUT IS ALSO SHOWN ON THE SECTION VIEW DRAWINGS FOR THIS ALTERNATIVE.

0 20 40 60 80
SCALE IN FEET

HALEY & ALDRICH
UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

HARBOR AT HASTINGS SITE
SUPPLEMENTAL FEASIBILITY STUDY FOR OU-2
HASTINGS-ON-HUDSON, NEW YORK

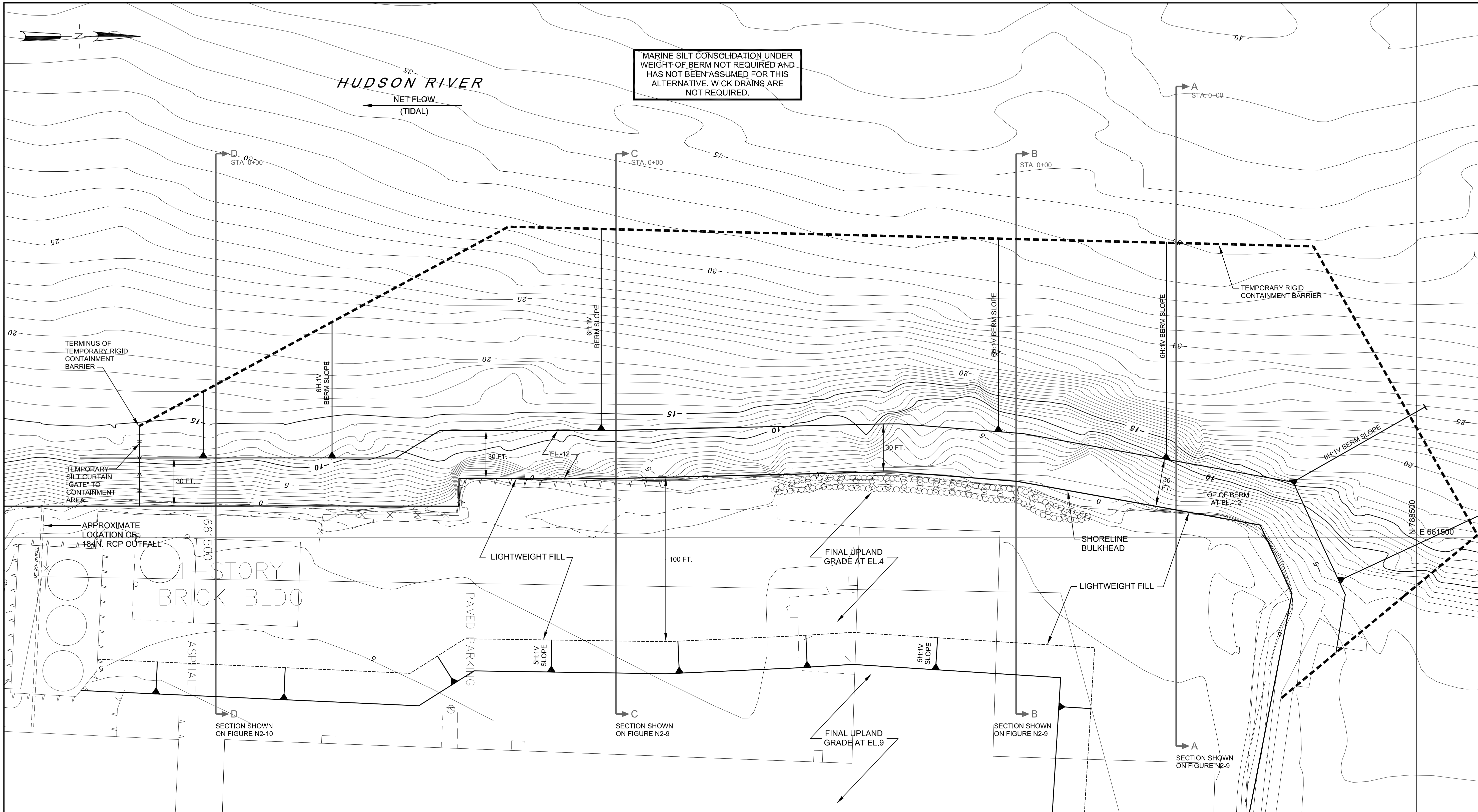
NORTHWEST CORNER AREA
ALTERNATIVE NW-2, OPTION A
SECTIONS

SCALE: AS SHOWN

18 APRIL 2006

28612-010 D115 (D113)

FIGURE N2-7



NOTES:

1. DRAWING BASED ON NAVD 88 DATUM. TO CONVERT FROM NAVD88 TO NGVD29 DATUM ADD ONE FOOT TO NAVD88 ELEVATIONS. PLAN BASED ON NEW YORK 1988 STATE PLANE COORDINATE SYSTEM.
2. SOIL PROFILES SHOWN IN SECTION VIEW REFLECT TYPICAL CONDITIONS IN THE VICINITY OF THE SECTION CUT. THE SOIL PROFILES ARE SIMPLIFIED AS NECESSARY FOR USE IN THE ENGINEERING ASSESSMENT OF REMEDIAL ACTION ALTERNATIVES.
3. APPROXIMATE FINAL BERM CONFIGURATION FOR THIS ALTERNATIVE IS SHOWN ON THIS FIGURE. THE DREDGE CUT IS NOT SHOWN.
4. CALCULATIONS WERE PERFORMED AT SELECT SECTIONS AND EXTRAPOLATED TO OTHER SECTIONS.
5. MARINE SILT CONSOLIDATION UNDER WEIGHT OF BERM NOT REQUIRED AND HAS NOT BEEN ASSUMED FOR THIS ALTERNATIVE. WICK DRAINS ARE NOT REQUIRED.
6. ALL ENGINEERING ELEMENTS PROVIDED ON THIS PLAN WERE DEVELOPED BASED ON EXISTING INFORMATION FOR THE PURPOSE OF EVALUATING REMEDIAL ALTERNATIVES AT THE SUBJECT SITE. THE ACTUAL DESIGN ELEVATIONS, DIMENSIONS, AND OTHER ENGINEERING ASPECTS OF THE SELECTED REMEDY WILL BE DEVELOPED DURING REMEDIAL DESIGN.

0 30 60 90 120
SCALE IN FEET

HALEY & ALDRICH
UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

HARBOR AT HASTINGS SITE
SUPPLEMENTAL FEASIBILITY STUDY FOR OU-2
HASTINGS-ON-HUDSON, NEW YORK

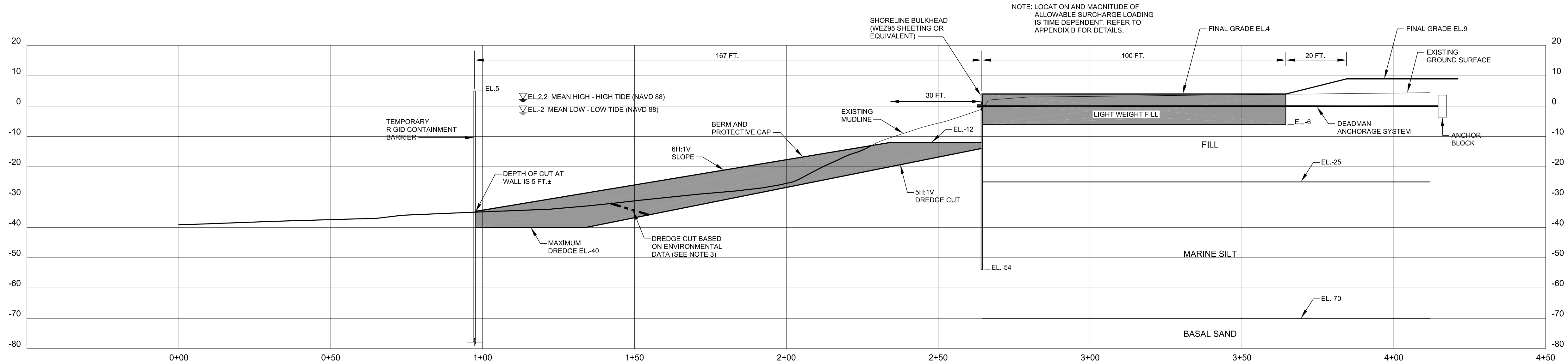
NORTHWEST CORNER AREA
ALTERNATIVE NW-2, OPTION B
FINAL UPLAND GRADE EL.4

SCALE: AS SHOWN

18 APRIL 2006

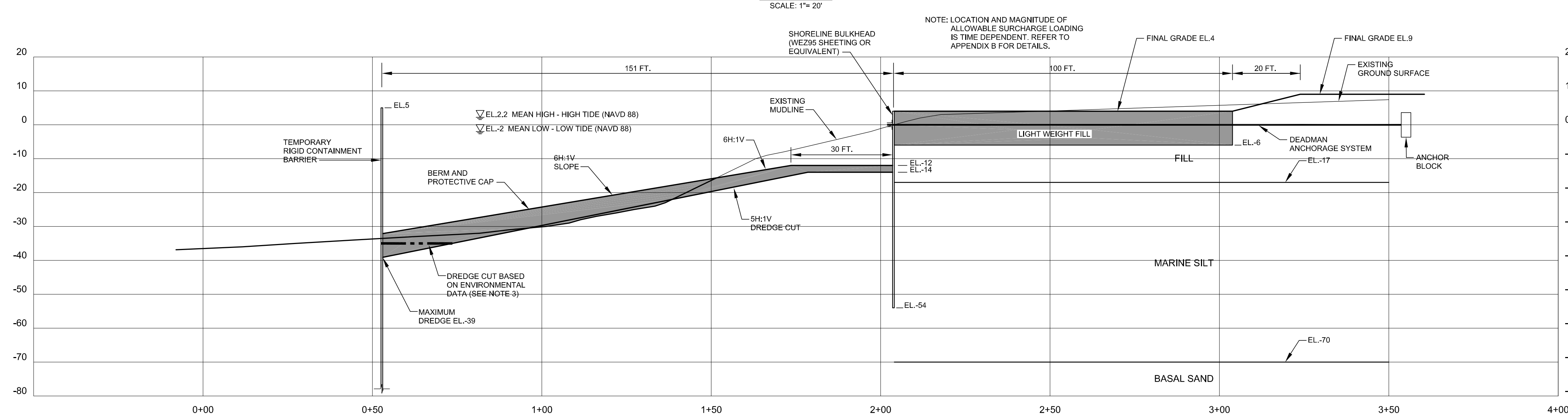
28612-010 D116

FIGURE N2-8



SECTION A-A

SCALE: 1"= 20'

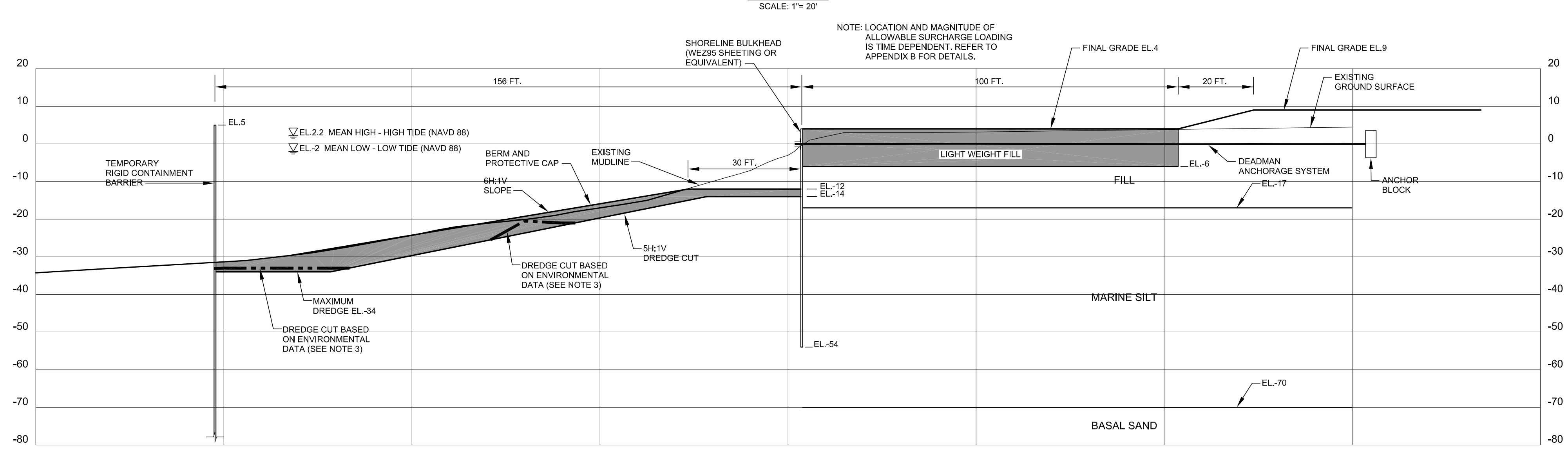


SECTION B-B

SCALE: 1"= 20'

NOTES:

1. MARINE SILT CONSOLIDATION UNDER WEIGHT OF BERM NOT REQUIRED AND HAS NOT BEEN ASSUMED FOR THIS ALTERNATIVE. WICK DRAINS ARE NOT REQUIRED.
2. ALL ENGINEERING ELEMENTS PROVIDED ON THIS PLAN WERE DEVELOPED BASED ON EXISTING INFORMATION FOR THE PURPOSE OF EVALUATING REMEDIAL ALTERNATIVES AT THE SUBJECT SITE. THE ACTUAL DESIGN ELEVATIONS, DIMENSIONS, AND OTHER ENGINEERING ASPECTS OF THE SELECTED REMEDY WILL BE DEVELOPED DURING REMEDIAL DESIGN.
3. DREDGE CUT ASSUMED FOR GEOTECHNICAL CALCULATIONS IS SHOWN ON BOTH THE PLAN AND SECTION VIEW DRAWINGS FOR THIS ALTERNATIVE. WHERE THE DREDGE CUT BASED ON ENVIRONMENTAL DATA (FIGURES 1.3 AND 1.4) WOULD BE LESS THAN THE DREDGE CUT ASSUMED IN THE GEOTECHNICAL CALCULATIONS, THE ENVIRONMENTAL DREDGE CUT IS ALSO SHOWN ON THE SECTION VIEW DRAWINGS FOR THIS ALTERNATIVE.



SECTION C-C

SCALE: 1"= 20'

0 20 40 60 80

SCALE IN FEET

HALEY & ALDRICH

UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

HARBOR AT HASTINGS SITE
SUPPLEMENTAL FEASIBILITY STUDY FOR OU-2
HASTINGS-ON-HUDSON, NEW YORK

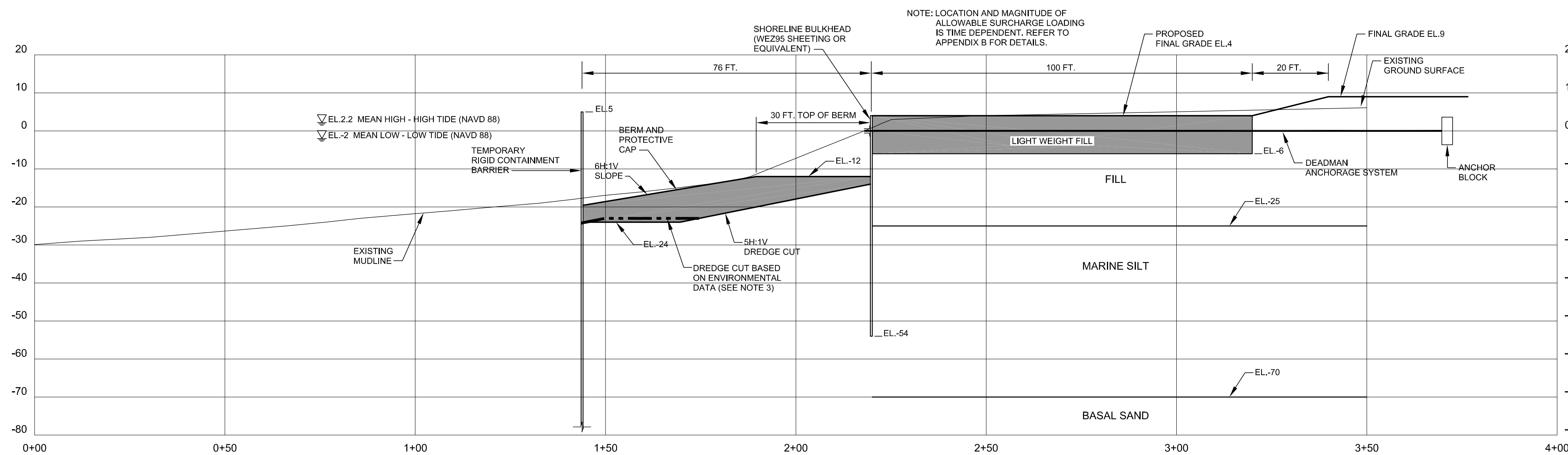
NORTHWEST CORNER AREA ALTERNATIVE NW-2, OPTION B FINAL UPLAND GRADE EL.4 SECTIONS

SCALE: AS SHOWN

18 APRIL 2006

28612-010 D117

FIGURE N2-9



SECTION D-D

SCALE: 1"= 20'

NOTES:

1. MARINE SILT CONSOLIDATION UNDER WEIGHT OF BERM NOT REQUIRED AND HAS NOT BEEN ASSUMED FOR THIS ALTERNATIVE. WICK DRAINS ARE NOT REQUIRED.

2. ALL ENGINEERING ELEMENTS PROVIDED ON THIS PLAN WERE DEVELOPED BASED ON EXISTING INFORMATION FOR THE PURPOSE OF EVALUATING REMEDIAL ALTERNATIVES AT THE SUBJECT SITE. THE ACTUAL DESIGN ELEVATIONS, DIMENSIONS, AND OTHER ENGINEERING ASPECTS OF THE SELECTED REMEDY WILL BE DEVELOPED DURING REMEDIAL DESIGN.

3. DREDGE CUT ASSUMED FOR GEOTECHNICAL CALCULATIONS IS SHOWN ON BOTH THE PLAN AND SECTION VIEW DRAWINGS FOR THIS ALTERNATIVE. WHERE THE DREDGE CUT BASED ON ENVIRONMENTAL DATA (FIGURES 1.3 AND 1.4) WOULD BE LESS THAN THE DREDGE CUT ASSUMED IN THE GEOTECHNICAL CALCULATIONS, THE ENVIRONMENTAL DREDGE CUT IS ALSO SHOWN ON THE SECTION VIEW DRAWINGS FOR THIS ALTERNATIVE.

0 20 40 60 80

SCALE IN FEET

HALEY & ALDRICH

UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

HARBOR AT HASTINGS SITE
SUPPLEMENTAL FEASIBILITY STUDY FOR OU-2
HASTINGS-ON-HUDSON, NEW YORK

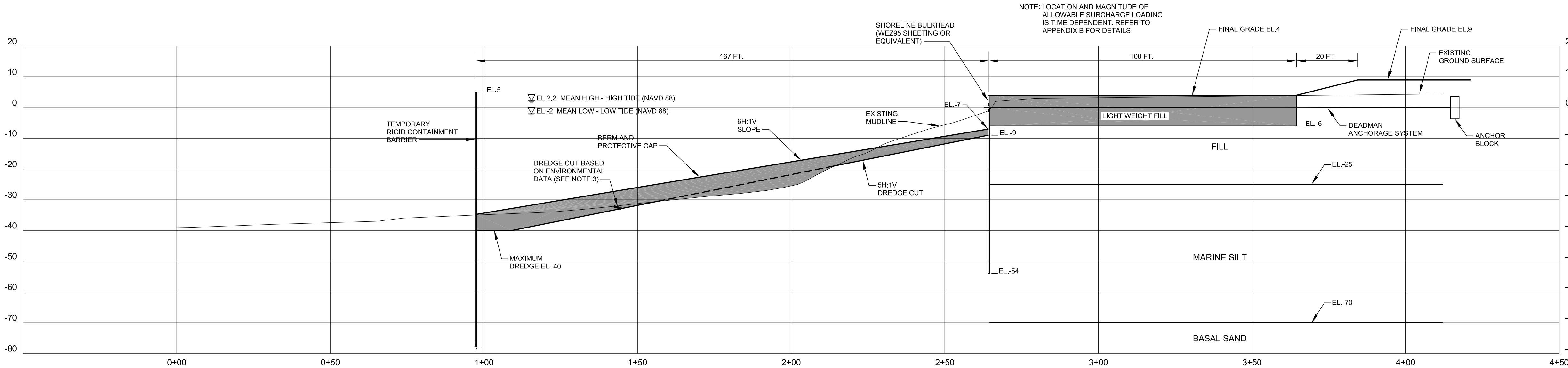
NORTHWEST CORNER AREA ALTERNATIVE NW-2, OPTION B FINAL UPLAND GRADE EL.4 SECTIONS

SCALE: AS SHOWN

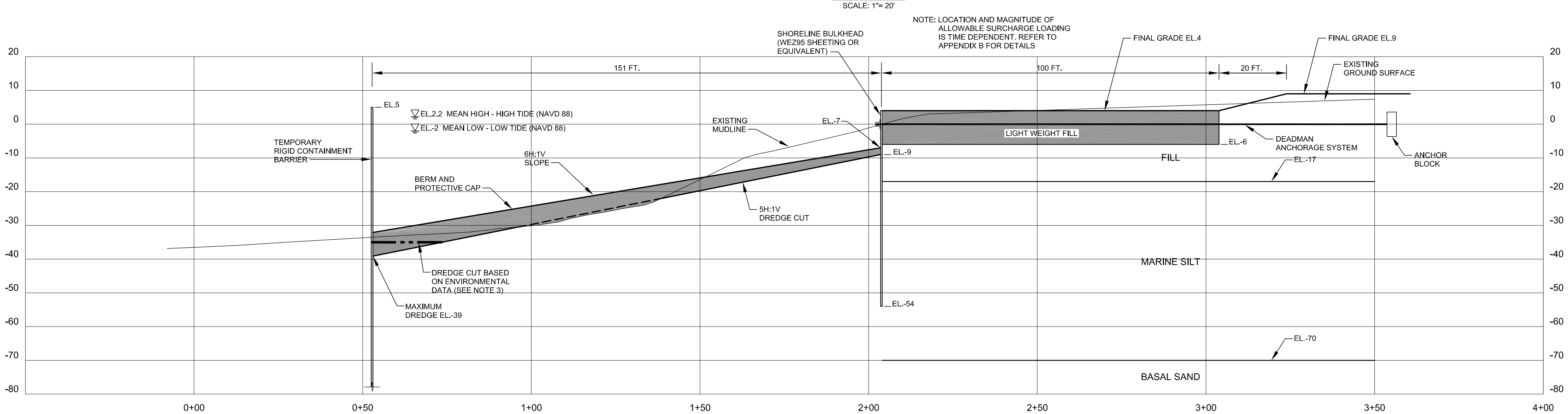
18 APRIL 2006

28612-010 D118 (D117)

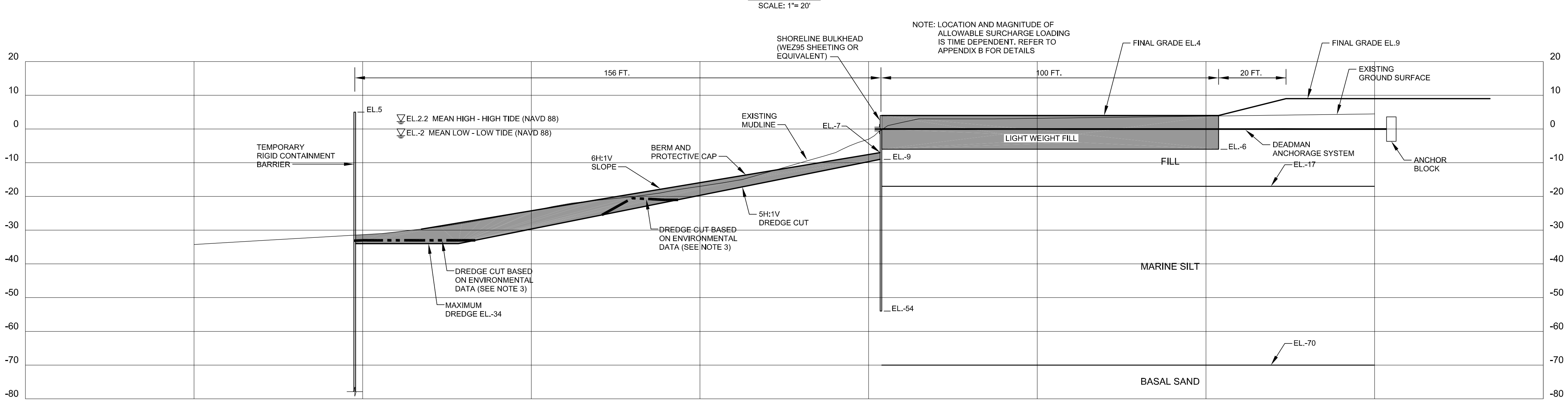
FIGURE N2-10



SECTION A-A
SCALE: 1"= 20'



SECTION B-B
SCALE: 1"= 20'



SECTION C-C
SCALE: 1"= 20'

NOTES:

1. MARINE SILT CONSOLIDATION UNDER WEIGHT OF BERM NOT REQUIRED AND HAS NOT BEEN ASSUMED FOR THIS ALTERNATIVE. WICK DRAINS ARE NOT REQUIRED.
2. ALL ENGINEERING ELEMENTS PROVIDED ON THIS PLAN WERE DEVELOPED BASED ON EXISTING INFORMATION FOR THE PURPOSE OF EVALUATING REMEDIAL ALTERNATIVES AT THE SUBJECT SITE. THE ACTUAL DESIGN ELEVATIONS, DIMENSIONS, AND OTHER ENGINEERING ASPECTS OF THE SELECTED REMEDY WILL BE DEVELOPED DURING REMEDIAL DESIGN.
3. DREDGE CUT ASSUMED FOR GEOTECHNICAL CALCULATIONS IS SHOWN ON BOTH THE PLAN AND SECTION VIEW DRAWINGS FOR THIS ALTERNATIVE. WHERE THE DREDGE CUT BASED ON ENVIRONMENTAL DATA (FIGURES 1.3 AND 1.4) WOULD BE LESS THAN THE DREDGE CUT ASSUMED IN THE GEOTECHNICAL CALCULATIONS, THE ENVIRONMENTAL DREDGE CUT IS ALSO SHOWN ON THE SECTION VIEW DRAWINGS FOR THIS ALTERNATIVE.

0 20 40 60 80
SCALE IN FEET

HALEY & ALDRICH
UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

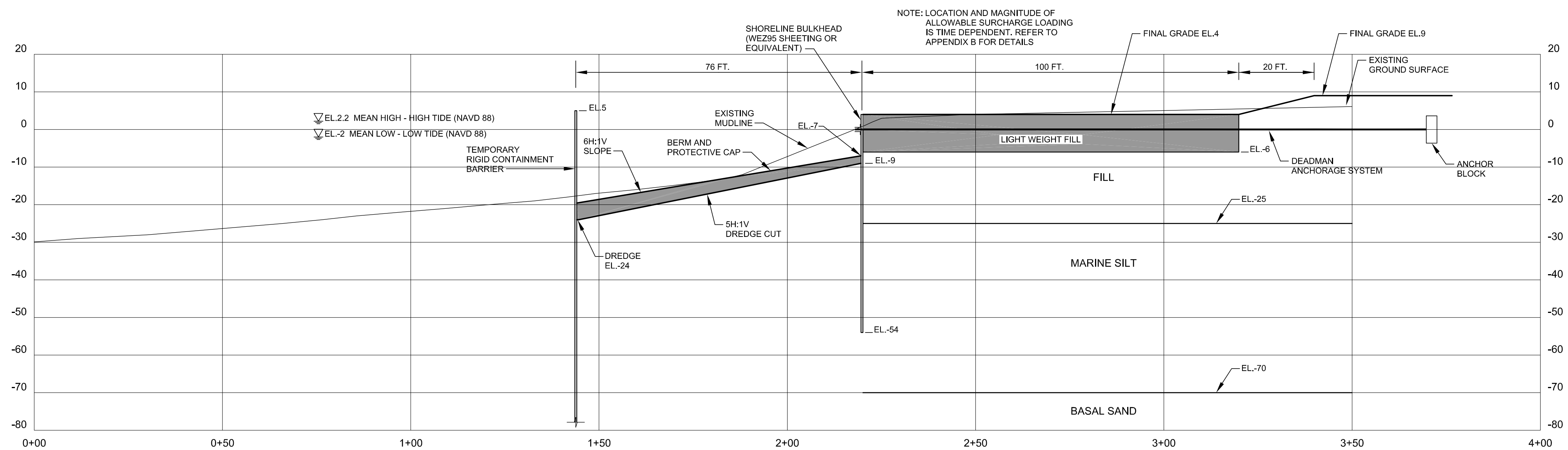
HARBOR AT HASTINGS SITE
SUPPLEMENTAL FEASIBILITY STUDY FOR OU-2
HASTINGS-ON-HUDSON, NEW YORK

NORTHWEST CORNER AREA ALTERNATIVE NW-2, OPTION A FINAL UPLAND GRADE EL.4 SECTIONS

SCALE: AS SHOWN
18 APRIL 2006

28612-010 D119

FIGURE N2-11



SECTION D-D

SCALE: 1"= 20'

NOTES:

1. MARINE SILT CONSOLIDATION UNDER WEIGHT OF BERM NOT REQUIRED AND HAS NOT BEEN ASSUMED FOR THIS ALTERNATIVE. WICK DRAINS ARE NOT REQUIRED.
2. ALL ENGINEERING ELEMENTS PROVIDED ON THIS PLAN WERE DEVELOPED BASED ON EXISTING INFORMATION FOR THE PURPOSE OF EVALUATING REMEDIAL ALTERNATIVES AT THE SUBJECT SITE. THE ACTUAL DESIGN ELEVATIONS, DIMENSIONS, AND OTHER ENGINEERING ASPECTS OF THE SELECTED REMEDY WILL BE DEVELOPED DURING REMEDIAL DESIGN.
3. DREDGE CUT ASSUMED FOR GEOTECHNICAL CALCULATIONS IS SHOWN ON BOTH THE PLAN AND SECTION VIEW DRAWINGS FOR THIS ALTERNATIVE. WHERE THE DREDGE CUT BASED ON ENVIRONMENTAL DATA (FIGURES 1.3 AND 1.4) WOULD BE LESS THAN THE DREDGE CUT ASSUMED IN THE GEOTECHNICAL CALCULATIONS, THE ENVIRONMENTAL DREDGE CUT IS ALSO SHOWN ON THE SECTION VIEW DRAWINGS FOR THIS ALTERNATIVE.

0 20 40 60 80

SCALE IN FEET

HALEY & ALDRICH

UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

HARBOR AT HASTINGS SITE
SUPPLEMENTAL FEASIBILITY STUDY FOR OU-2
HASTINGS-ON-HUDSON, NEW YORK

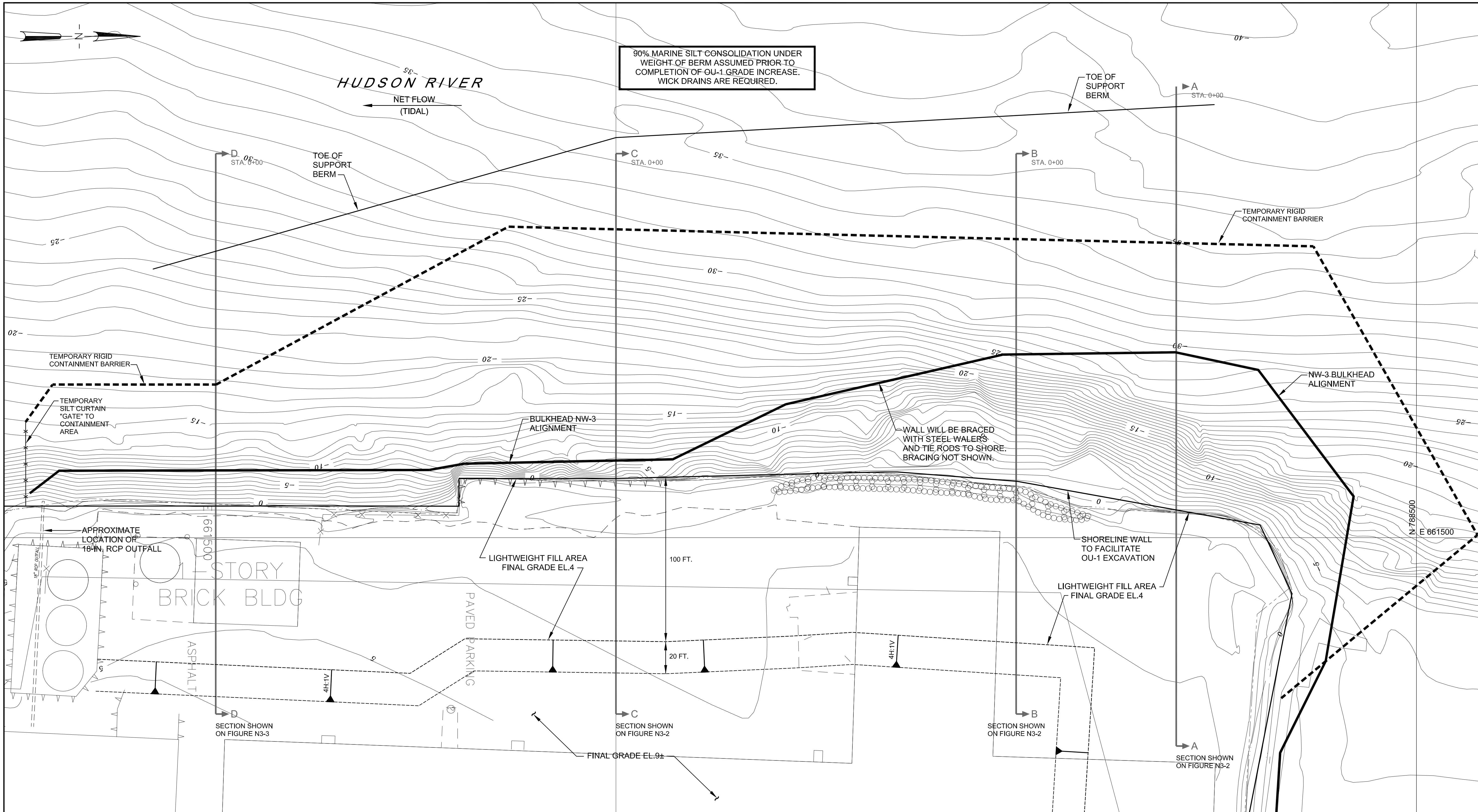
NORTHWEST CORNER AREA
ALTERNATIVE NW-2, OPTION A
FINAL UPLAND GRADE EL.4
SECTIONS

SCALE: AS SHOWN

18 APRIL 2006

28612-010 D120 (D119)

FIGURE N2-12



NOTES:

1. DRAWING BASED ON NAVD 88 DATUM. TO CONVERT FROM NAVD88 TO NGVD29 DATUM ADD ONE FOOT TO NAVD88 ELEVATIONS. PLAN BASED ON NEW YORK 1988 STATE PLANE COORDINATE SYSTEM.
2. SOIL PROFILES SHOWN IN SECTION VIEW REFLECT TYPICAL CONDITIONS IN THE VICINITY OF THE SECTION CUT. THE SOIL PROFILES ARE SIMPLIFIED AS NECESSARY FOR USE IN THE ENGINEERING ASSESSMENT OF REMEDIAL ACTION ALTERNATIVES.
3. CALCULATIONS WERE PERFORMED AT SELECT SECTIONS AND EXTRAPOLATED TO OTHER SECTIONS.
4. 90% MARINE SILT CONSOLIDATION UNDER WEIGHT OF BERM ASSUMED PRIOR TO COMPLETION OF OU-1 GRADE INCREASE. WICK DRAINS ARE REQUIRED.
5. DREDGE CUT ASSUMED FOR GEOTECHNICAL CALCULATIONS IS SHOWN ON BOTH THE PLAN AND SECTION VIEW DRAWINGS FOR THIS ALTERNATIVE. WHERE THE DREDGE CUT BASED ON ENVIRONMENTAL DATA (FIGURES 1.3 AND 1.4) WOULD BE LESS THAN THE DREDGE CUT ASSUMED IN THE GEOTECHNICAL CALCULATIONS, THE ENVIRONMENTAL DREDGE CUT IS ALSO SHOWN ON THE SECTION VIEW DRAWINGS FOR THIS ALTERNATIVE.
6. ALL ENGINEERING ELEMENTS PROVIDED ON THIS PLAN WERE DEVELOPED BASED ON EXISTING INFORMATION FOR THE PURPOSE OF EVALUATING REMEDIAL ALTERNATIVES AT THE SUBJECT SITE. THE ACTUAL DESIGN ELEVATIONS, DIMENSIONS, AND OTHER ENGINEERING ASPECTS OF THE SELECTED REMEDY WILL BE DEVELOPED DURING REMEDIAL DESIGN.

0 30 60 90 120
SCALE IN FEET

HALEY & ALDRICH
UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

HARBOR AT HASTINGS SITE
SUPPLEMENTAL FEASIBILITY STUDY FOR OU-2
HASTINGS-ON-HUDSON, NEW YORK

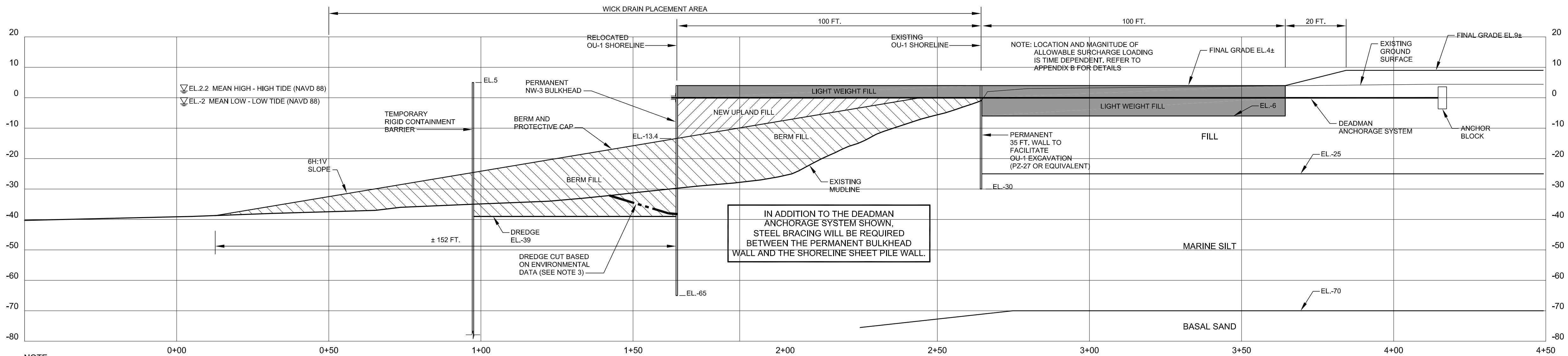
NORTHWEST CORNER AREA
ALTERNATIVE NW-3
ALIGNMENT OF STRUCTURAL WALLS

SCALE: AS SHOWN

18 APRIL 2006

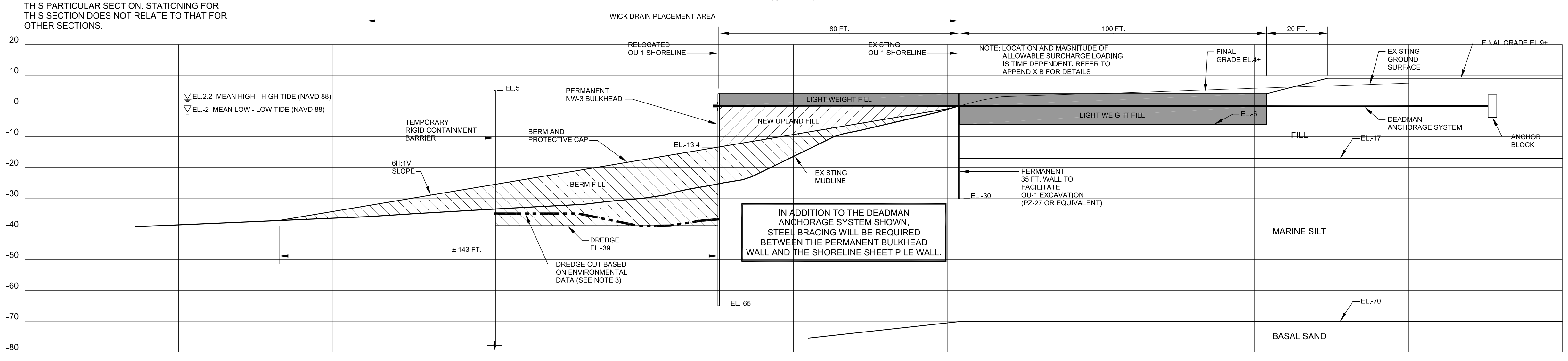
28612-010 D127

FIGURE N3-1



NOTE:
STATIONING IS REFERENCED TO SECTION CUT ON FIGURE N3-1 AND IS UNIQUE TO THIS PARTICULAR SECTION. STATIONING FOR THIS SECTION DOES NOT RELATE TO THAT FOR OTHER SECTIONS.

SECTION A-A
SCALE: 1"= 20'

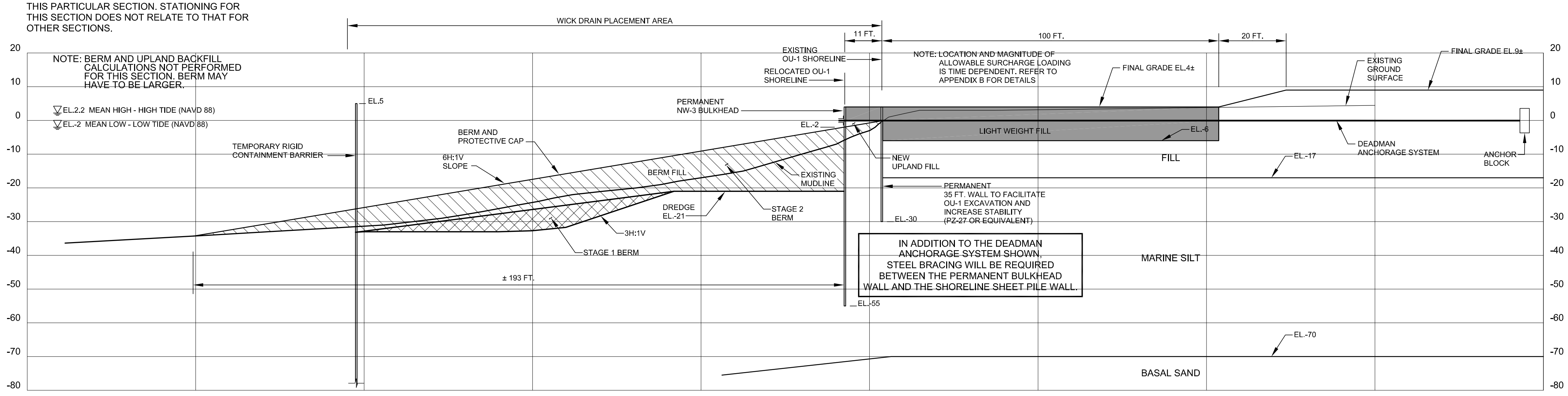


NOTE:
STATIONING IS REFERENCED TO SECTION CUT ON FIGURE N3-1 AND IS UNIQUE TO THIS PARTICULAR SECTION. STATIONING FOR THIS SECTION DOES NOT RELATE TO THAT FOR OTHER SECTIONS.

SECTION B-B
SCALE: 1"= 20'

NOTES:

1. 90% MARINE SILT CONSOLIDATION UNDER WEIGHT OF BERM ASSUMED PRIOR TO COMPLETION OF OU-1 GRADE INCREASE. WICK DRAINS ARE REQUIRED.
2. ALL ENGINEERING ELEMENTS PROVIDED ON THIS PLAN WERE DEVELOPED BASED ON EXISTING INFORMATION FOR THE PURPOSE OF EVALUATING REMEDIAL ALTERNATIVES AT THE SUBJECT SITE. THE ACTUAL DESIGN ELEVATIONS, DIMENSIONS, AND OTHER ENGINEERING ASPECTS OF THE SELECTED REMEDY WILL BE DEVELOPED DURING REMEDIAL DESIGN.
3. DREDGE CUT ASSUMED FOR GEOTECHNICAL CALCULATIONS IS SHOWN ON BOTH THE PLAN AND SECTION VIEW DRAWINGS FOR THIS ALTERNATIVE. WHERE THE DREDGE CUT BASED ON ENVIRONMENTAL DATA (FIGURES 1.3 AND 1.4) WOULD BE LESS THAN THE DREDGE CUT ASSUMED IN THE GEOTECHNICAL CALCULATIONS, THE ENVIRONMENTAL DREDGE CUT IS ALSO SHOWN ON THE SECTION VIEW DRAWINGS FOR THIS ALTERNATIVE.



NOTE:
STATIONING IS REFERENCED TO SECTION CUT ON FIGURE N3-1 AND IS UNIQUE TO THIS PARTICULAR SECTION. STATIONING FOR THIS SECTION DOES NOT RELATE TO THAT FOR OTHER SECTIONS.

SECTION C-C
SCALE: 1"= 20'

0 20 40 60 80
SCALE IN FEET

HALEY & ALDRICH
UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

HARBOR AT HASTINGS SITE
SUPPLEMENTAL FEASIBILITY STUDY FOR OU-2
HASTINGS-ON-HUDSON, NEW YORK

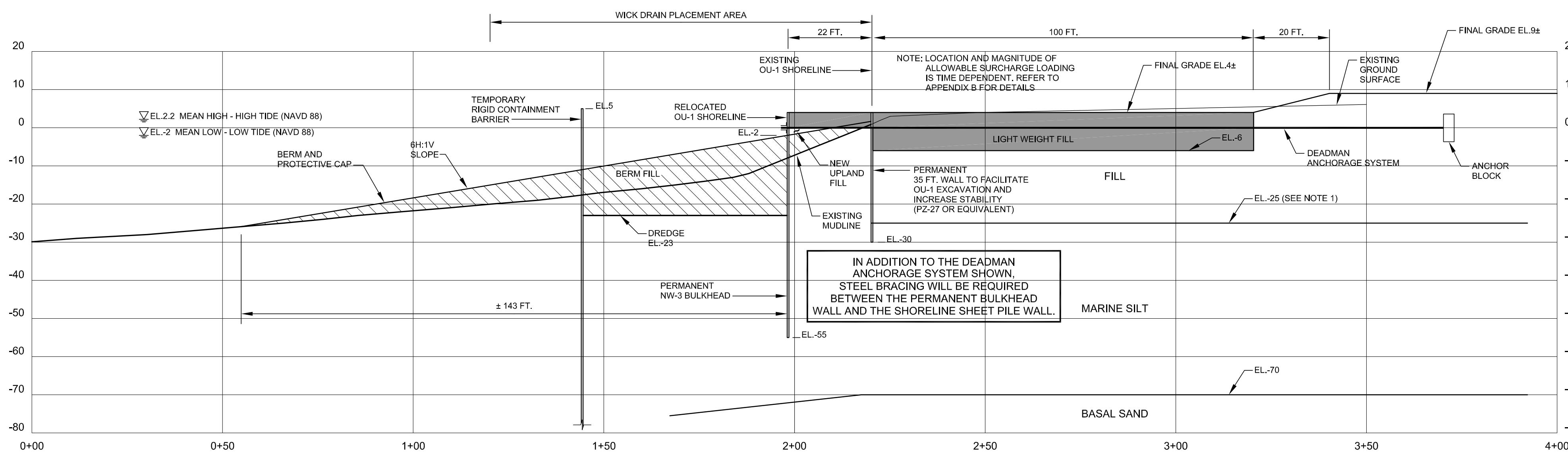
NORTHWEST CORNER AREA
ALTERNATIVE NW-3
SECTIONS

SCALE: AS SHOWN

18 APRIL 2006

28612-010 D128 (D127)

FIGURE N3-2



NOTE:
STATIONING IS REFERENCED TO SECTION CUT ON FIGURE N3-1 AND IS UNIQUE TO THIS PARTICULAR SECTION. STATIONING FOR THIS SECTION DOES NOT RELATE TO THAT FOR OTHER SECTIONS.

SECTION D-D
SCALE: 1"= 20'

NOTES:

1. 90% MARINE SILT CONSOLIDATION UNDER WEIGHT OF BERM ASSUMED PRIOR TO COMPLETION OF OU-1 GRADE INCREASE. WICK DRAINS ARE REQUIRED.
2. ALL ENGINEERING ELEMENTS PROVIDED ON THIS PLAN WERE DEVELOPED BASED ON EXISTING INFORMATION FOR THE PURPOSE OF EVALUATING REMEDIAL ALTERNATIVES AT THE SUBJECT SITE. THE ACTUAL DESIGN ELEVATIONS, DIMENSIONS, AND OTHER ENGINEERING ASPECTS OF THE SELECTED REMEDY WILL BE DEVELOPED DURING REMEDIAL DESIGN.
3. DREDGE CUT ASSUMED FOR GEOTECHNICAL CALCULATIONS IS SHOWN ON BOTH THE PLAN AND SECTION VIEW DRAWINGS FOR THIS ALTERNATIVE. WHERE THE DREDGE CUT BASED ON ENVIRONMENTAL DATA (FIGURES 1.3 AND 1.4) WOULD BE LESS THAN THE DREDGE CUT ASSUMED IN THE GEOTECHNICAL CALCULATIONS, THE ENVIRONMENTAL DREDGE CUT IS ALSO SHOWN ON THE SECTION VIEW DRAWINGS FOR THIS ALTERNATIVE.

0 20 40 60 80
SCALE IN FEET

HALEY & ALDRICH
UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

HARBOR AT HASTINGS SITE
SUPPLEMENTAL FEASIBILITY STUDY FOR OU-2
HASTINGS-ON-HUDSON, NEW YORK

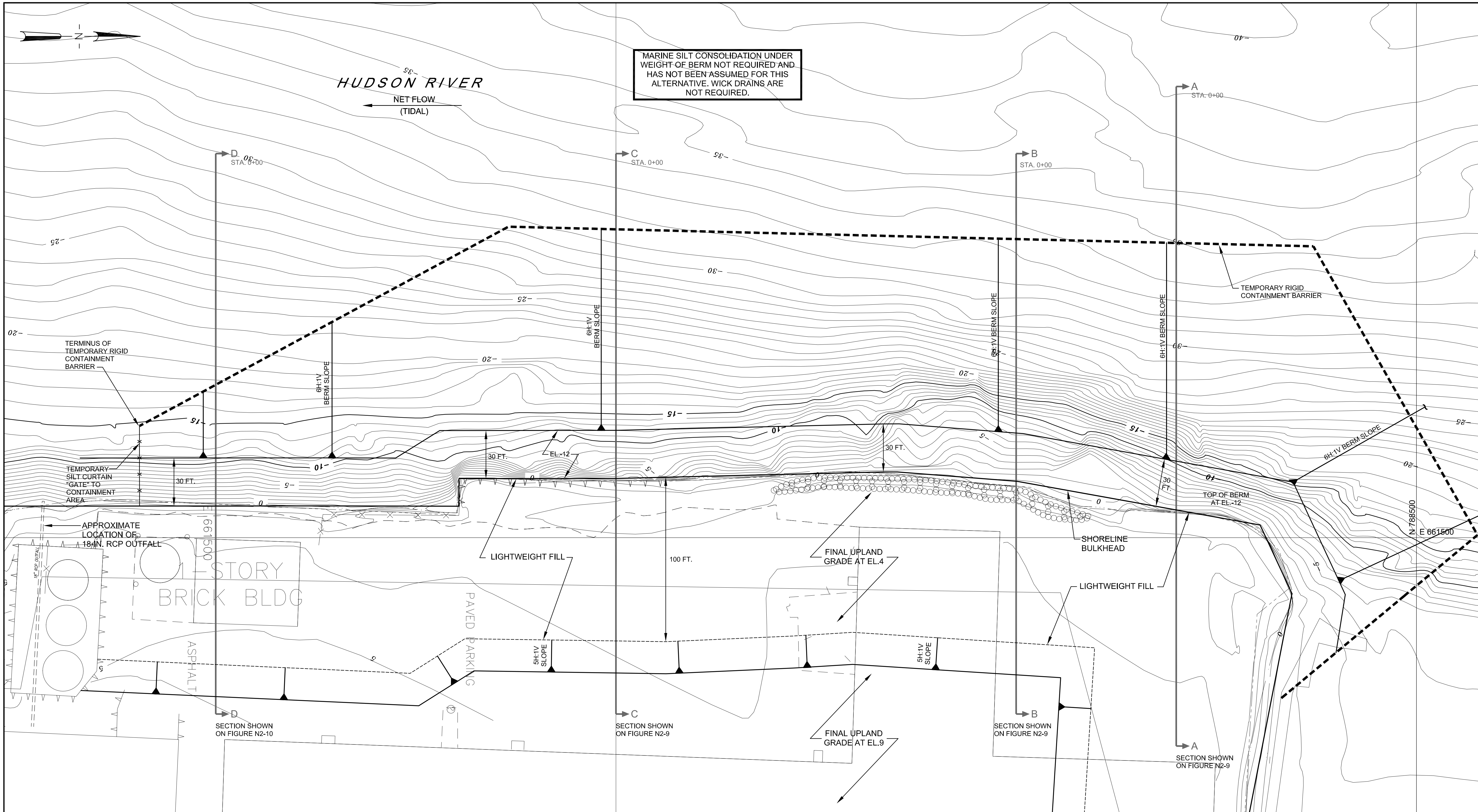
NORTHWEST CORNER AREA
ALTERNATIVE NW-3
SECTIONS

SCALE: AS SHOWN

18 APRIL 2006

28612-010 D129 (D127)

FIGURE N3-3



NOTES:

1. DRAWING BASED ON NAVD 88 DATUM. TO CONVERT FROM NAVD88 TO NGVD29 DATUM ADD ONE FOOT TO NAVD88 ELEVATIONS. PLAN BASED ON NEW YORK 1988 STATE PLANE COORDINATE SYSTEM.
2. SOIL PROFILES SHOWN IN SECTION VIEW REFLECT TYPICAL CONDITIONS IN THE VICINITY OF THE SECTION CUT. THE SOIL PROFILES ARE SIMPLIFIED AS NECESSARY FOR USE IN THE ENGINEERING ASSESSMENT OF REMEDIAL ACTION ALTERNATIVES.
3. APPROXIMATE FINAL BERM CONFIGURATION FOR THIS ALTERNATIVE IS SHOWN ON THIS FIGURE. THE DREDGE CUT IS NOT SHOWN.
4. CALCULATIONS WERE PERFORMED AT SELECT SECTIONS AND EXTRAPOLATED TO OTHER SECTIONS.
5. MARINE SILT CONSOLIDATION UNDER WEIGHT OF BERM NOT REQUIRED AND HAS NOT BEEN ASSUMED FOR THIS ALTERNATIVE. WICK DRAINS ARE NOT REQUIRED.
6. ALL ENGINEERING ELEMENTS PROVIDED ON THIS PLAN WERE DEVELOPED BASED ON EXISTING INFORMATION FOR THE PURPOSE OF EVALUATING REMEDIAL ALTERNATIVES AT THE SUBJECT SITE. THE ACTUAL DESIGN ELEVATIONS, DIMENSIONS, AND OTHER ENGINEERING ASPECTS OF THE SELECTED REMEDY WILL BE DEVELOPED DURING REMEDIAL DESIGN.

HALEY & ALDRICH

UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

HARBOR AT HASTINGS SITE
SUPPLEMENTAL FEASIBILITY STUDY FOR OU-2
HASTINGS-ON-HUDSON, NEW YORK

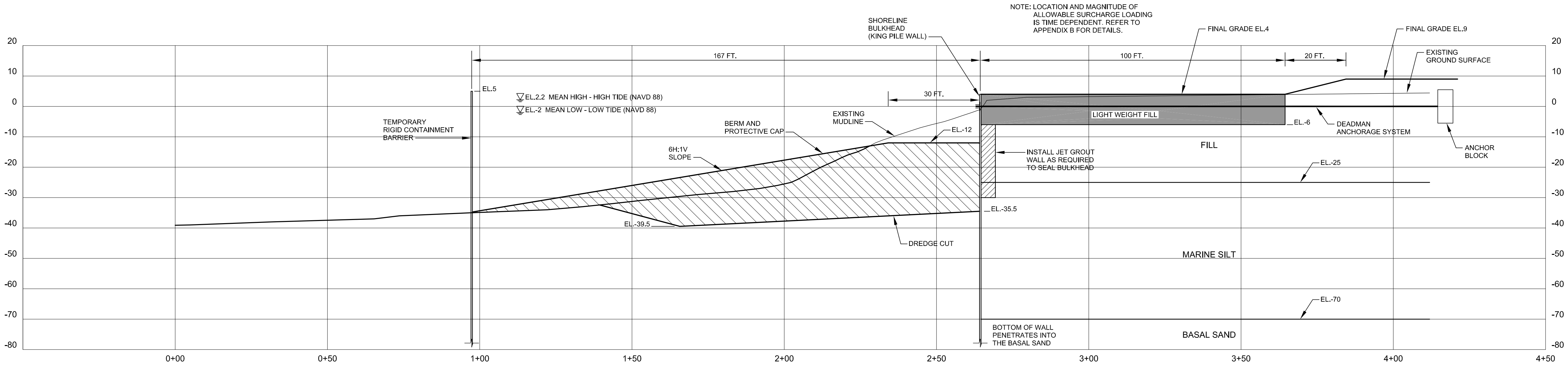
NORTHWEST CORNER AREA ALTERNATIVE NW-4 PLAN VIEW

SCALE: AS SHOWN

18 APRIL 2006

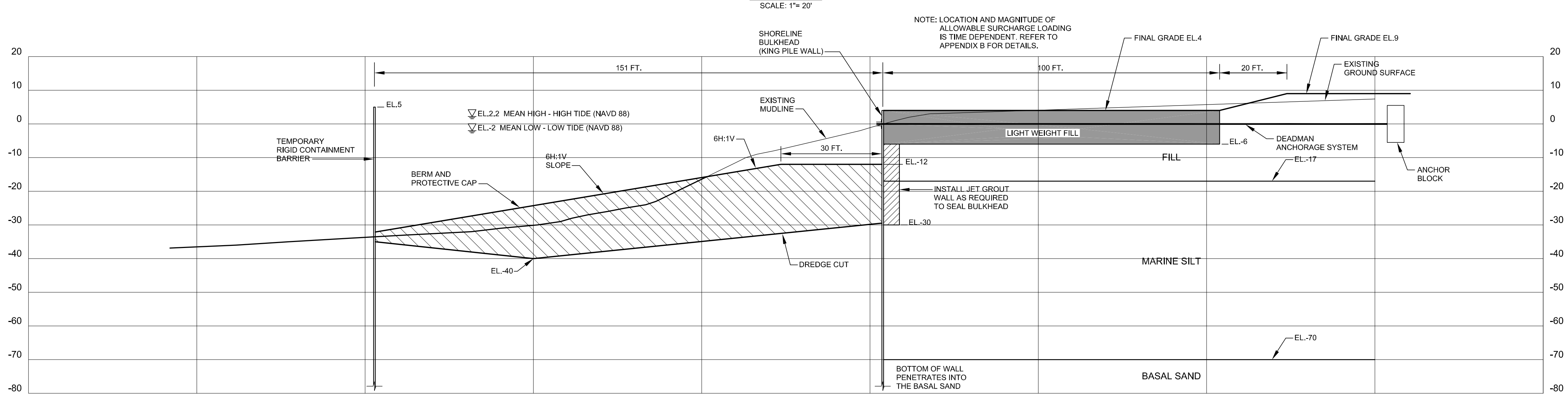
28612-010 D138

FIGURE N4-1



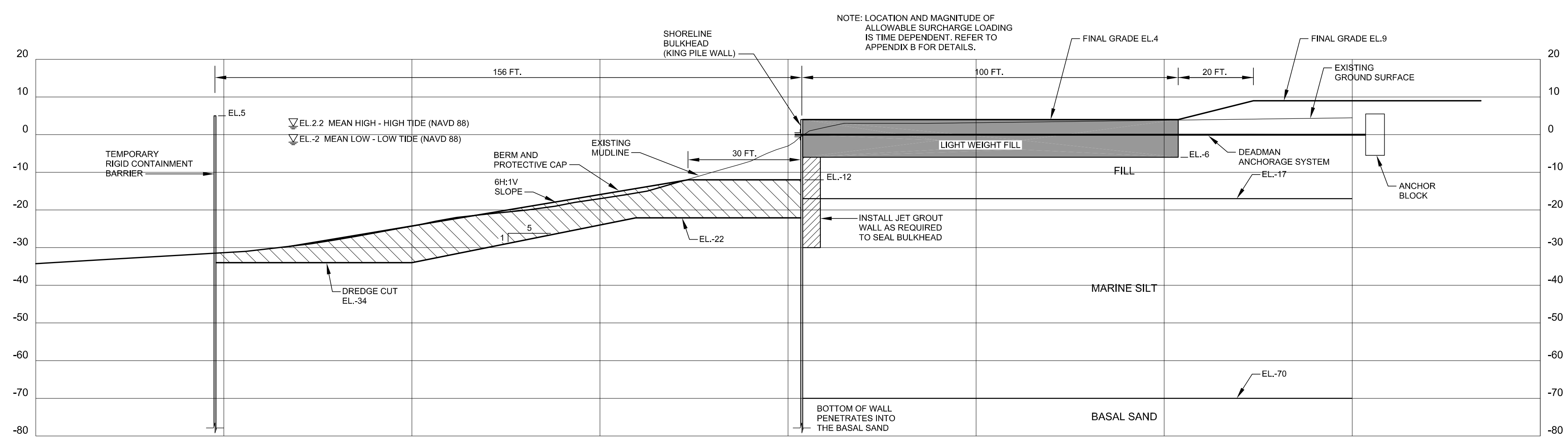
SECTION A-A

SCALE: 1"= 20'



SECTION B-B

SCALE: 1"= 20'



SECTION C-C

SCALE: 1"= 20'

NOTES:

1. CALCULATIONS SPECIFIC TO THIS ALTERNATIVE WERE NOT PERFORMED SO A SPECIFIC WALL SIZE IS NOT SHOWN. WALL ASSUMED IS A HZ-975D-24/AZ26 OR EQUIVALENT.
2. PLAN VIEW OF UPLAND AREA SIMILIAR TO FIGURE N2-8.
3. MARINE SILT CONSOLIDATION UNDER WEIGHT OF BERM NOT REQUIRED AND HAS NOT BEEN ASSUMED FOR THIS ALTERNATIVE. WICK DRAINS ARE NOT REQUIRED.
4. ALL ENGINEERING ELEMENTS PROVIDED ON THIS PLAN WERE DEVELOPED BASED ON EXISTING INFORMATION FOR THE PURPOSE OF EVALUATING REMEDIAL ALTERNATIVES AT THE SUBJECT SITE. THE ACTUAL DESIGN ELEVATIONS, DIMENSIONS, AND OTHER ENGINEERING ASPECTS OF THE SELECTED REMEDY WILL BE DEVELOPED DURING REMEDIAL DESIGN.
5. DREDGE CUT ASSUMED FOR GEOTECHNICAL CALCULATIONS IS SHOWN ON BOTH THE PLAN AND SECTION VIEW DRAWINGS FOR THIS ALTERNATIVE. WHERE THE DREDGE CUT BASED ON ENVIRONMENTAL DATA (FIGURES 1.3 AND 1.4) WOULD BE LESS THAN THE DREDGE CUT ASSUMED IN THE GEOTECHNICAL CALCULATIONS, THE ENVIRONMENTAL DREDGE CUT IS ALSO SHOWN ON THE SECTION VIEW DRAWINGS FOR THIS ALTERNATIVE.

0 20 40 60 80

SCALE IN FEET

HALEY & ALDRICH

UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

HARBOR AT HASTINGS SITE
SUPPLEMENTAL FEASIBILITY STUDY FOR OU-2
HASTINGS-ON-HUDSON, NEW YORK

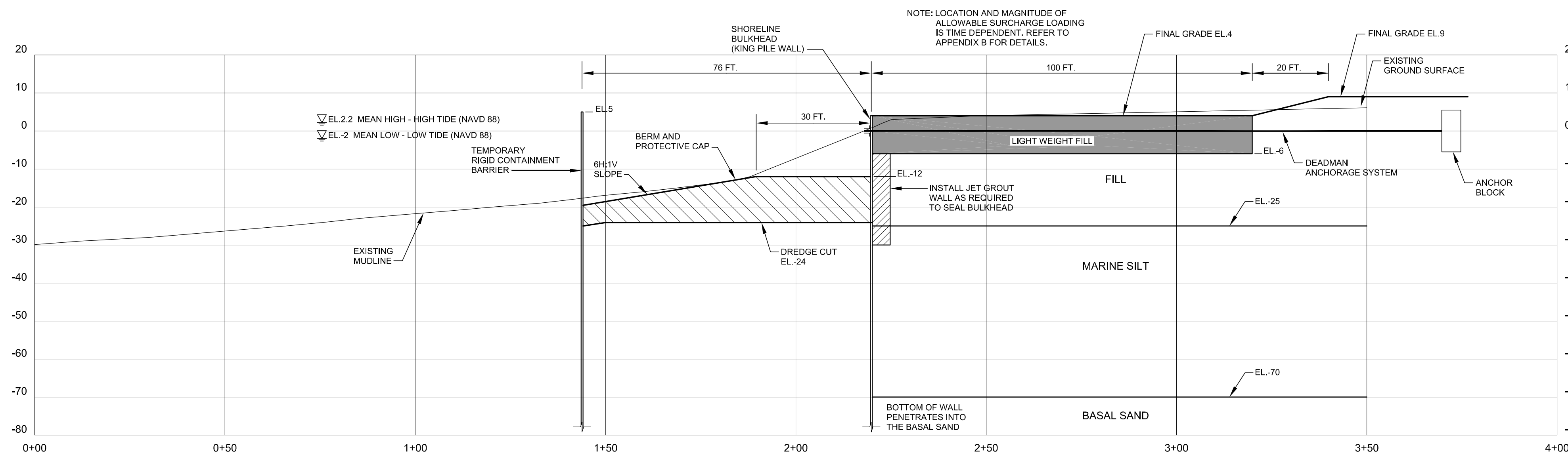
NORTHWEST CORNER AREA ALTERNATIVE NW-4 SECTIONS

SCALE: AS SHOWN

18 APRIL 2006

28612-010 D130

FIGURE N4-2



SECTION D-D

SCALE: 1"= 20'

NOTES:

1. CALCULATIONS SPECIFIC TO THIS ALTERNATIVE WERE NOT PERFORMED SO A SPECIFIC WALL SIZE IS NOT SHOWN. WALL ASSUMED IS A HZ-975D-24/AZ26 OR EQUIVALENT.
2. PLAN VIEW OF UPLAND AREA SIMILIAR TO FIGURE N2-8.
3. MARINE SILT CONSOLIDATION UNDER WEIGHT OF BERM NOT REQUIRED AND HAS NOT BEEN ASSUMED FOR THIS ALTERNATIVE. WICK DRAINS ARE NOT REQUIRED.
4. ALL ENGINEERING ELEMENTS PROVIDED ON THIS PLAN WERE DEVELOPED BASED ON EXISTING INFORMATION FOR THE PURPOSE OF EVALUATING REMEDIAL ALTERNATIVES AT THE SUBJECT SITE. THE ACTUAL DESIGN ELEVATIONS, DIMENSIONS, AND OTHER ENGINEERING ASPECTS OF THE SELECTED REMEDY WILL BE DEVELOPED DURING REMEDIAL DESIGN.
5. DREDGE CUT ASSUMED FOR GEOTECHNICAL CALCULATIONS IS SHOWN ON BOTH THE PLAN AND SECTION VIEW DRAWINGS FOR THIS ALTERNATIVE. WHERE THE DREDGE CUT BASED ON ENVIRONMENTAL DATA (FIGURES 1.3 AND 1.4) WOULD BE LESS THAN THE DREDGE CUT ASSUMED IN THE GEOTECHNICAL CALCULATIONS, THE ENVIRONMENTAL DREDGE CUT IS ALSO SHOWN ON THE SECTION VIEW DRAWINGS FOR THIS ALTERNATIVE.

0 20 40 60 80

SCALE IN FEET

HALEY & ALDRICH

UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

HARBOR AT HASTINGS SITE
SUPPLEMENTAL FEASIBILITY STUDY FOR OU-2
HASTINGS-ON-HUDSON, NEW YORK

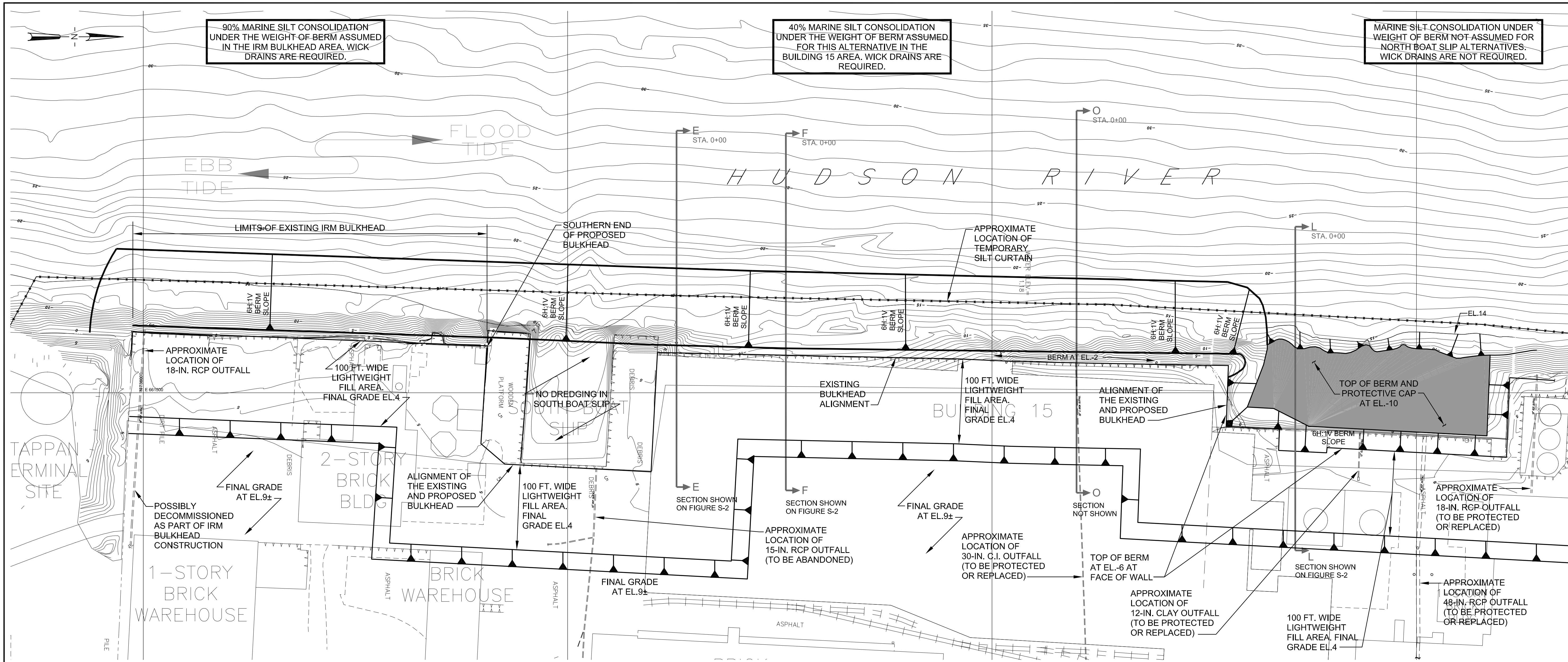
NORTHWEST CORNER AREA
ALTERNATIVE NW-4
SECTIONS

SCALE: AS SHOWN

18 APRIL 2006

FIGURE N4-3

28612-010 D131 (D130)



SOUTHERN BULKHEAD AND BOAT SLIP AREA NOTES:

1. DRAWING BASED ON NAVD 88 DATUM. TO CONVERT FROM NAVD88 TO NGVD29 DATUM ADD ONE FOOT TO NAVD88 ELEVATIONS. PLAN BASED ON NEW YORK 1988 STATE PLANE COORDINATE SYSTEM.
2. SOIL PROFILES SHOWN IN SECTION VIEW REFLECT TYPICAL CONDITIONS IN THE VICINITY OF THE SECTION CUT. THE SOIL PROFILES ARE SIMPLIFIED AS NECESSARY FOR USE IN THE ENGINEERING ASSESSMENT OF REMEDIAL ACTION ALTERNATIVES.
3. DREDGE CUT ASSUMED FOR GEOTECHNICAL CALCULATIONS IS SHOWN ON BOTH THE PLAN AND SECTION VIEW DRAWINGS FOR THIS ALTERNATIVE. WHERE THE DREDGE CUT BASED ON ENVIRONMENTAL DATA (FIGURES 1.3 AND 1.4) WOULD BE LESS THAN THE DREDGE CUT ASSUMED IN THE GEOTECHNICAL CALCULATIONS, THE ENVIRONMENTAL DREDGE CUT IS ALSO SHOWN ON THE SECTION VIEW DRAWINGS FOR THIS ALTERNATIVE.
4. CALCULATIONS WERE PERFORMED AT THE SECTIONS SHOWN. THE RESULTS OF THESE CALCULATIONS WERE THEN EXTRAPOLATED TO OTHER APPARENTLY SIMILAR AREAS OF THE SITE.
5. ALL ENGINEERING ELEMENTS PROVIDED ON THIS PLAN WERE DEVELOPED BASED ON EXISTING INFORMATION FOR THE PURPOSE OF EVALUATING REMEDIAL ALTERNATIVES AT THE SUBJECT SITE. THE ACTUAL DESIGN ELEVATIONS, DIMENSIONS, AND OTHER ENGINEERING ASPECTS OF THE SELECTED REMEDY WILL BE DEVELOPED DURING REMEDIAL DESIGN.

0 60 120 180 240
SCALE IN FEET

HALEY & ALDRICH
UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

HARBOR AT HASTINGS SITE
SUPPLEMENTAL FEASIBILITY STUDY FOR OU-2
HASTINGS-ON-HUDSON, NEW YORK

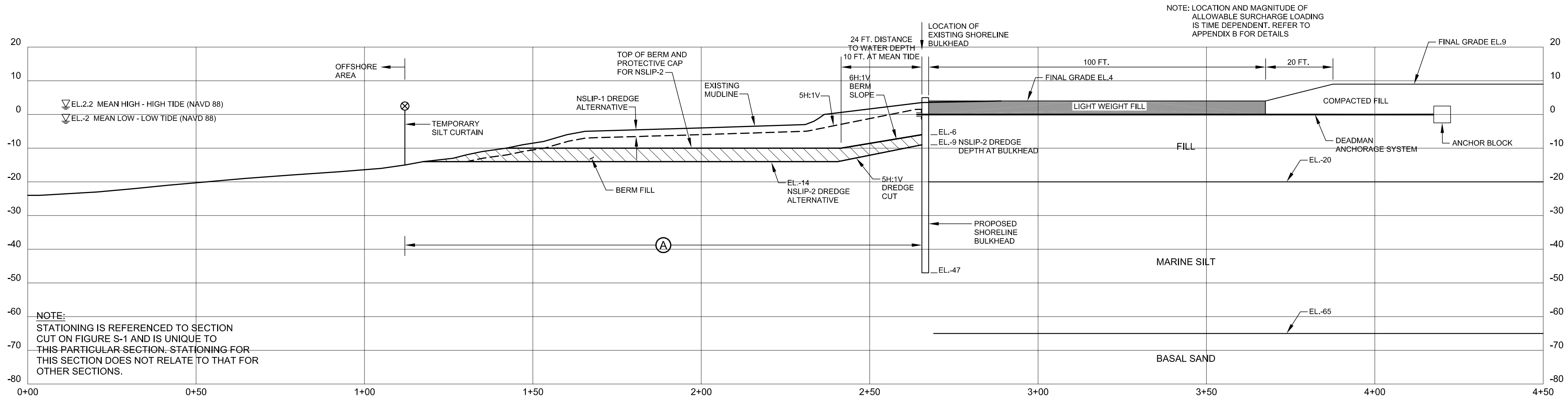
SOUTHERN BULKHEAD AND BOAT SLIP AREAS
EXISTING SHORELINE ALIGNMENT
PLAN VIEW

SCALE: AS SHOWN

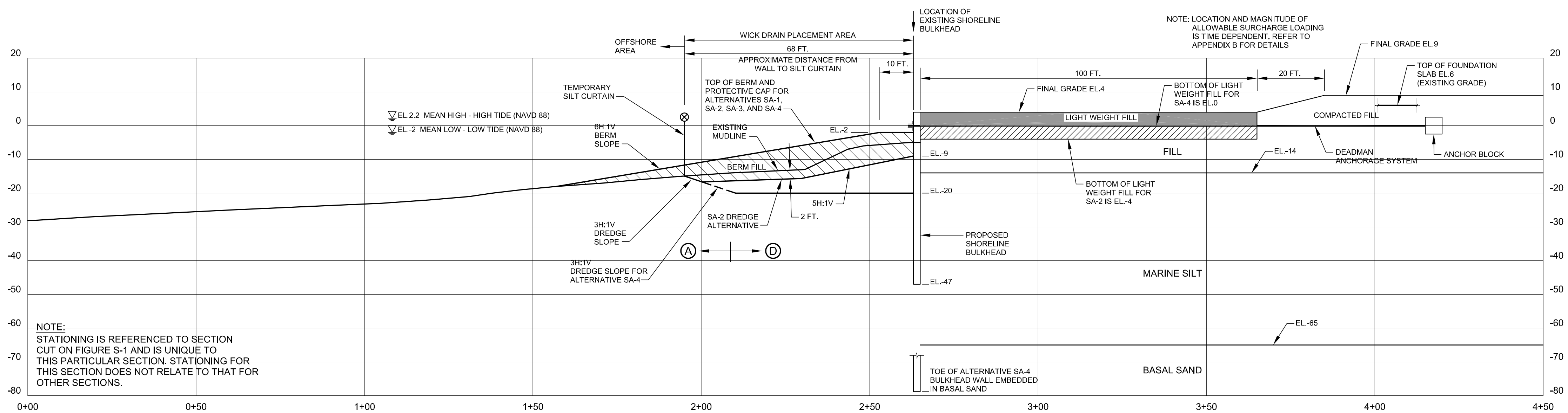
18 APRIL 2006

28612-010 D121

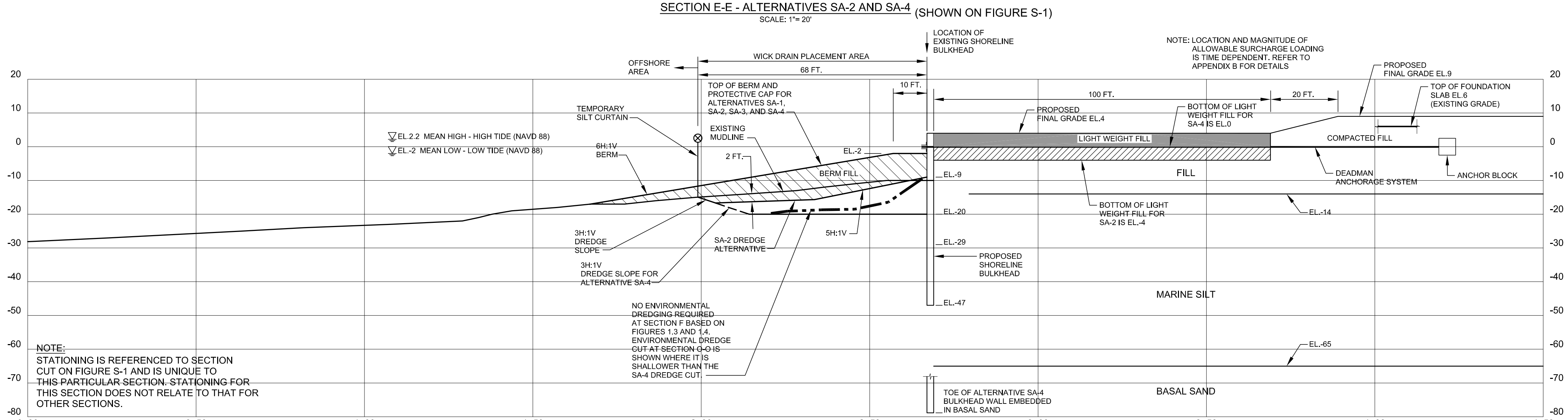
FIGURE S-1



SECTION L-L (NORTHERN BOAT SLIP AREA) (SHOWN ON FIGURE S-1)
SCALE: 1"= 20'



SECTION E-E - ALTERNATIVES SA-2 AND SA-4 (SHOWN ON FIGURE S-1)
SCALE: 1"= 20'



SECTION F-F - ALTERNATIVES SA-2 AND SA-4 (SHOWN ON FIGURE S-1)
SCALE: 1"= 20'

LEGEND:

- (A) DREDGE CUT BASED ON ENVIRONMENTAL DATA (FIGURES 1.3 AND 1.4) IS DEEPER THAN DREDGE CUT ASSUMED IN GEOTECHNICAL CALCULATIONS
- (B) DREDGE CUT BASED ON ENVIRONMENTAL DATA (FIGURES 1.3 AND 1.4) IS THE SAME AS ASSUMED IN GEOTECHNICAL CALCULATIONS
- (C) DREDGE CUT BASED ON ENVIRONMENTAL DATA (FIGURES 1.3 AND 1.4) IS LESS THAN ASSUMED IN GEOTECHNICAL CALCULATIONS
- (D) PRGs ARE NOT EXCEEDED SO DREDGING TO REMOVE CONTAMINATION IS NOT NEEDED IN THIS AREA

NOTES:

1. MARINE SILT CONSOLIDATION UNDER WEIGHT OF BERM ASSUMED PRIOR TO COMPLETION OF OU-1 GRADE INCREASE FOR SECTIONS E-E AND F-F. WICK DRAINS ARE REQUIRED FOR ALTERNATIVE SA-2.
2. ALL ENGINEERING ELEMENTS PROVIDED ON THIS PLAN WERE DEVELOPED BASED ON EXISTING INFORMATION FOR THE PURPOSE OF EVALUATING REMEDIAL ALTERNATIVES AT THE SUBJECT SITE. THE ACTUAL DESIGN ELEVATIONS, DIMENSIONS, AND OTHER ENGINEERING ASPECTS OF THE SELECTED REMEDY WILL BE DEVELOPED DURING REMEDIAL DESIGN.
3. DREDGE CUT ASSUMED FOR GEOTECHNICAL CALCULATIONS IS SHOWN ON BOTH THE PLAN AND SECTION VIEW DRAWINGS FOR THIS ALTERNATIVE. WHERE THE DREDGE CUT BASED ON ENVIRONMENTAL DATA (FIGURES 1.3 AND 1.4) WOULD BE LESS THAN THE DREDGE CUT ASSUMED IN THE GEOTECHNICAL CALCULATIONS, THE ENVIRONMENTAL DREDGE CUT IS ALSO SHOWN ON THE SECTION VIEW DRAWINGS FOR THIS ALTERNATIVE.

0 20 40 60 80
SCALE IN FEET

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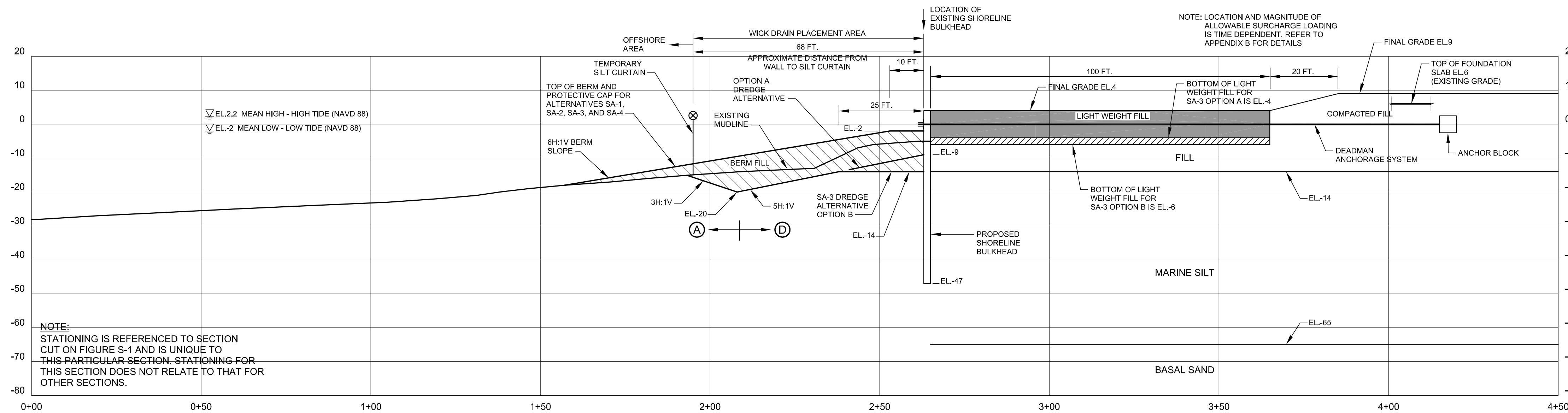
SUPPLEMENTAL FEASIBILITY STUDY FOR OU-2
HASTINGS-ON-HUDSON, NEW YORK

SOUTHERN BULKHEAD AND BOAT SLIP AREAS EXISTING SHORELINE ALIGNMENT ALTERNATIVES SA-2 AND SA-4

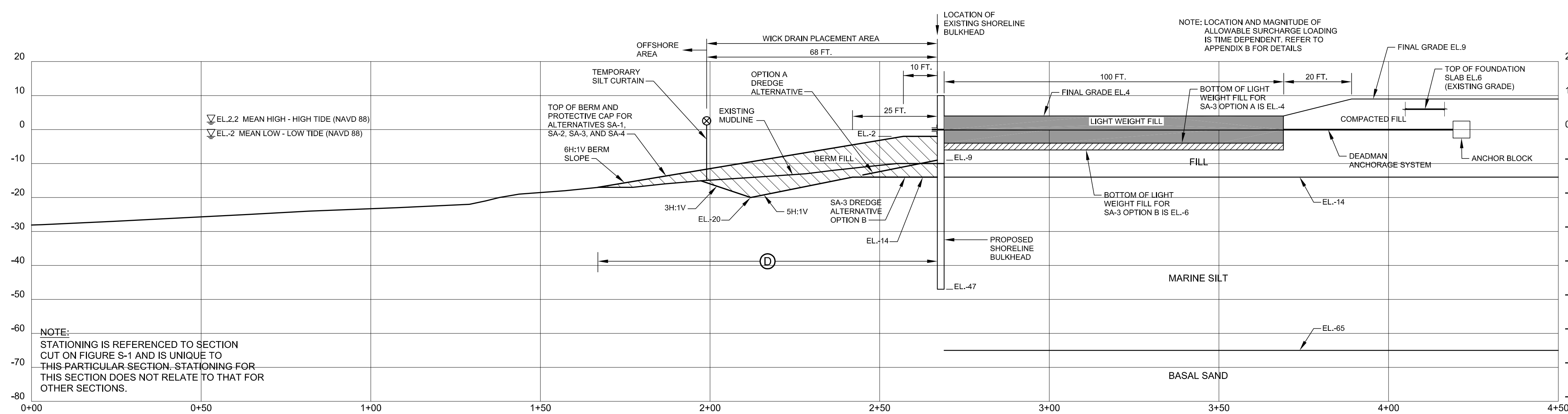
SCALE: AS SHOWN
18 APRIL 2006

FIGURE S-2

28612-010 D122 (D121)



SECTION E-E - ALTERNATIVES SA-3 OPTIONS A AND B (SHOWN ON FIGURE S-1)
SCALE: 1"= 20'



SECTION F-F - ALTERNATIVES SA-3 OPTIONS A AND B (SHOWN ON FIGURE S-1)
SCALE: 1"= 20'

LEGEND:

- (A) DREDGE CUT BASED ON ENVIRONMENTAL DATA (FIGURES 1.3 AND 1.4) IS DEEPER THAN DREDGE CUT ASSUMED IN GEOTECHNICAL CALCULATIONS
- (B) DREDGE CUT BASED ON ENVIRONMENTAL DATA (FIGURES 1.3 AND 1.4) IS THE SAME AS ASSUMED IN GEOTECHNICAL CALCULATIONS
- (C) DREDGE CUT BASED ON ENVIRONMENTAL DATA (FIGURES 1.3 AND 1.4) IS LESS THAN ASSUMED IN GEOTECHNICAL CALCULATIONS
- (D) PRGs ARE NOT EXCEEDED SO DREDGING TO REMOVE CONTAMINATION IS NOT NEEDED IN THIS AREA

NOTES:

1. MARINE SILT CONSOLIDATION UNDER WEIGHT OF BERM ASSUMED PRIOR TO COMPLETION OF OU-1 GRADE INCREASE FOR SECTIONS E-E AND F-F. WICK DRAINS ARE REQUIRED FOR ALTERNATIVE SA-3.
2. ALL ENGINEERING ELEMENTS PROVIDED ON THIS PLAN WERE DEVELOPED BASED ON EXISTING INFORMATION FOR THE PURPOSE OF EVALUATING REMEDIAL ALTERNATIVES AT THE SUBJECT SITE. THE ACTUAL DESIGN ELEVATIONS, DIMENSIONS, AND OTHER ENGINEERING ASPECTS OF THE SELECTED REMEDY WILL BE DEVELOPED DURING REMEDIAL DESIGN.
3. DREDGE CUT ASSUMED FOR GEOTECHNICAL CALCULATIONS IS SHOWN ON BOTH THE PLAN AND SECTION VIEW DRAWINGS FOR THIS ALTERNATIVE. WHERE THE DREDGE CUT BASED ON ENVIRONMENTAL DATA (FIGURES 1.3 AND 1.4) WOULD BE LESS THAN THE DREDGE CUT ASSUMED IN THE GEOTECHNICAL CALCULATIONS, THE ENVIRONMENTAL DREDGE CUT IS ALSO SHOWN ON THE SECTION VIEW DRAWINGS FOR THIS ALTERNATIVE.

0 20 40 60 80
SCALE IN FEET

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HASTINGS-ON-HUDSON, NEW YORK

SOUTHERN BULKHEAD AND BOAT SLIP AREAS EXISTING SHORELINE ALIGNMENT ALTERNATIVE SA-3 SECTION

SCALE: AS SHOWN
18 APRIL 2006

FIGURE S-3

28612-010 D123 (D121)

LEGEND:

ALLOWABLE DREDGE CUT BASED ON ASSUMPTIONS OUTLINED IN APPENDIX B

NOTES:

1. PLAN PREPARED FROM AN ELECTRONIC BASE PLAN PROVIDED BY PARSONS.
2. DRAWING BASED ON NAVD 88 DATUM. TO CONVERT FROM NAVD88 TO NGVD29 DATUM ADD ONE FOOT TO NAVD88 ELEVATIONS. PLAN BASED ON NEW YORK 1988 STATE PLANE COORDINATE SYSTEM.
3. NO BERMS PLACED IN OLD MARINA AREA. NO CONSOLIDATION OF MARINE SILT ASSUMED.
4. ALL ENGINEERING ELEMENTS PROVIDED ON THIS PLAN WERE DEVELOPED BASED ON EXISTING INFORMATION FOR THE PURPOSE OF EVALUATING REMEDIAL ALTERNATIVES AT THE SUBJECT SITE. THE ACTUAL DESIGN ELEVATIONS, DIMENSIONS, AND OTHER ENGINEERING ASPECTS OF THE SELECTED REMEDY WILL BE DEVELOPED DURING REMEDIAL DESIGN.
5. DREDGE CUT ASSUMED FOR GEOTECHNICAL CALCULATIONS IS SHOWN ON BOTH THE PLAN AND SECTION VIEW DRAWINGS FOR THIS ALTERNATIVE. WHERE THE DREDGE CUT BASED ON ENVIRONMENTAL DATA (FIGURES 1.3 AND 1.4) WOULD BE LESS THAN THE DREDGE CUT ASSUMED IN THE GEOTECHNICAL CALCULATIONS, THE ENVIRONMENTAL DREDGE CUT IS ALSO SHOWN ON THE SECTION VIEW DRAWINGS FOR ALTERNATIVE OM-2.

0 30 60 90 120

SCALE IN FEET

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HARBOR AT HASTINGS SITE
SUPPLEMENTAL FEASIBILITY STUDY FOR OU-2
HASTINGS-ON-HUDSON, NEW YORK

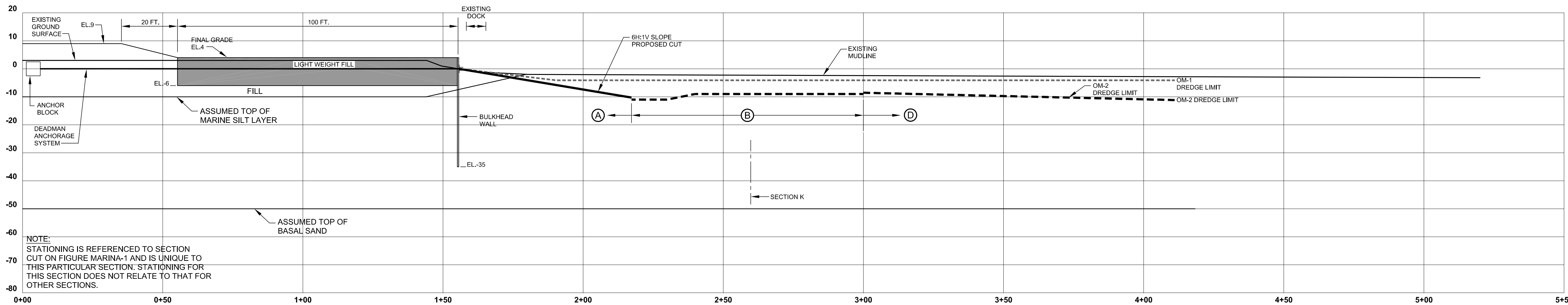
PLAN VIEW OF OLD MARINA AREA ALTERNATIVE OM-2

SCALE: AS SHOWN

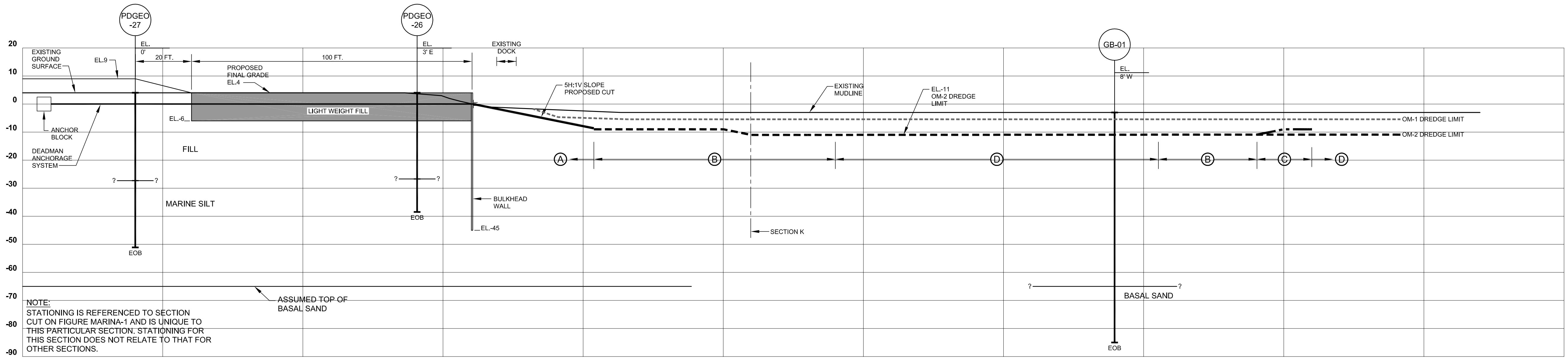
18 APRIL 2006

28612-010 D124

FIGURE MARINA-1



SECTION H-H (SECTION H-H SHOWN ON FIGURE MARINA-1)
SCALE: 1"= 20'



SECTION I-I (SECTION I-I SHOWN ON FIGURE MARINA-1)
SCALE: 1"= 20'

LEGEND:

- Ⓐ DREDGE CUT BASED ON ENVIRONMENTAL DATA (FIGURES 1.3 AND 1.4) IS DEEPER THAN DREDGE CUT ASSUMED IN GEOTECHNICAL CALCULATIONS
- Ⓑ DREDGE CUT BASED ON ENVIRONMENTAL DATA (FIGURES 1.3 AND 1.4) IS THE SAME AS ASSUMED IN GEOTECHNICAL CALCULATIONS
- Ⓒ DREDGE CUT BASED ON ENVIRONMENTAL DATA (FIGURES 1.3 AND 1.4) IS LESS THAN ASSUMED IN GEOTECHNICAL CALCULATIONS
- Ⓓ PRGs ARE NOT EXCEEDED SO DREDGING TO REMOVE CONTAMINATION IS NOT NEEDED IN THIS AREA

NOTES:

1. ALLOWABLE DREDGE CUT BASED ON ASSUMPTIONS OUTLINED IN APPENDIX B.
2. OM-1 DREDGE LIMIT: DREDGE TO 2 FT BELOW EXISTING MUDLINE AND CAP WHERE SEDIMENT EXCEEDS PRGs AND THEN PLACE PROTECTIVE CAP.
3. OM-2 DREDGE LIMIT: DREDGE WHERE SEDIMENT EXCEEDS PRGs TO LIMITS OF BULKHEAD STABILITY.
4. ALL ENGINEERING ELEMENTS PROVIDED ON THIS PLAN WERE DEVELOPED BASED ON EXISTING INFORMATION FOR THE PURPOSE OF EVALUATING REMEDIAL ALTERNATIVES AT THE SUBJECT SITE. THE ACTUAL DESIGN ELEVATIONS, DIMENSIONS, AND OTHER ENGINEERING ASPECTS OF THE SELECTED REMEDY WILL BE DEVELOPED DURING REMEDIAL DESIGN.
5. DREDGE CUT ASSUMED FOR GEOTECHNICAL CALCULATIONS IS SHOWN ON BOTH THE PLAN AND SECTION VIEW DRAWINGS FOR THIS ALTERNATIVE. WHERE THE DREDGE CUT BASED ON ENVIRONMENTAL DATA (FIGURES 1.3 AND 1.4) WOULD BE LESS THAN THE DREDGE CUT ASSUMED IN THE GEOTECHNICAL CALCULATIONS, THE ENVIRONMENTAL DREDGE CUT IS ALSO SHOWN ON THE SECTION VIEW DRAWINGS FOR ALTERNATIVE OM-2.

0 20 40 60 80
SCALE IN FEET

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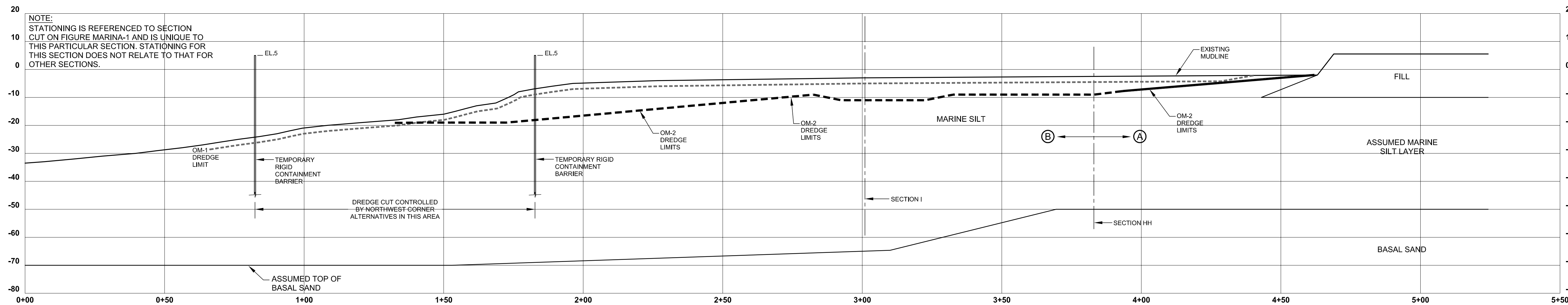
HASTINGS-ON-HUDSON, NEW YORK

OLD MARINA AREA ALTERNATIVES OM-1 AND OM-2 SECTIONS

SCALE: AS SHOWN
18 APRIL 2006

FIGURE MARINA-2

28612-010 D125



SECTION K-K (SECTION K-K SHOWN ON FIGURE MARINA-1)
SCALE: 1"= 20'

LEGEND:

Ⓐ DREDGE CUT BASED ON ENVIRONMENTAL DATA (FIGURES 1.3 AND 1.4) IS DEEPER THAN DREDGE CUT ASSUMED IN GEOTECHNICAL CALCULATIONS

Ⓑ DREDGE CUT BASED ON ENVIRONMENTAL DATA (FIGURES 1.3 AND 1.4) IS THE SAME AS ASSUMED IN GEOTECHNICAL CALCULATIONS

Ⓒ DREDGE CUT BASED ON ENVIRONMENTAL DATA (FIGURES 1.3 AND 1.4) IS LESS THAN ASSUMED IN GEOTECHNICAL CALCULATIONS

Ⓓ PRGs ARE NOT EXCEEDED SO DREDGING TO REMOVE CONTAMINATION IS NOT NEEDED IN THIS AREA

NOTES:

1. ALLOWABLE DREDGE CUT BASED ON ASSUMPTIONS OUTLINED IN APPENDIX B.
2. OM-1 DREDGE LIMIT: DREDGE TO 2 FT BELOW EXISTING MUDLINE AND CAP WHERE SEDIMENT EXCEEDS PRGs AND THEN PLACE PROTECTIVE CAP.
3. OM-2 DREDGE LIMIT: DREDGE WHERE SEDIMENT EXCEEDS PRGs TO LIMITS OF BULKHEAD STABILITY.
4. ALL ENGINEERING ELEMENTS PROVIDED ON THIS PLAN WERE DEVELOPED BASED ON EXISTING INFORMATION FOR THE PURPOSE OF EVALUATING REMEDIAL ALTERNATIVES AT THE SUBJECT SITE. THE ACTUAL DESIGN ELEVATIONS, DIMENSIONS, AND OTHER ENGINEERING ASPECTS OF THE SELECTED REMEDY WILL BE DEVELOPED DURING REMEDIAL DESIGN.
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0 20 40 60 80
SCALE IN FEET

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HARBOR AT HASTINGS SITE
SUPPLEMENTAL FEASIBILITY STUDY FOR OU-2
HASTINGS-ON-HUDSON, NEW YORK

OLD MARINA AREA
ALTERNATIVES OM-1 AND OM-2
SECTIONS

SCALE: AS SHOWN

18 APRIL 2006

FIGURE MARINA-3

28612-010 D126 (D125)

APPENDIX C

BIOAVAILABILITY AND TOXICITY OF METALS IN LOWER HUDSON RIVER SEDIMENTS AT HARBOR AT HASTINGS OPERABLE UNIT 2

PREPARED BY BLASLAND, BOUCK & LEE

APRIL 2006

TABLE OF CONTENTS

Page

TABLE OF CONTENTS
(CONTINUED)

Page

LIST OF TABLES

LIST OF FIGURES

BIOAVAILABILITY AND TOXICITY OF METALS IN LOWER HUDSON RIVER SEDIMENTS AT HARBOR AT HASTINGS OPERABLE UNIT 2

C1 INTRODUCTION

In March 2003, Earth Tech issued to the New York State Department of Environmental Conservation (NYSDEC) the *Final Feasibility Study Report* (FS) for the Harbor at Hastings Site (Site) Operable Unit 2 (OU-2). The FS identified six remedial action objectives (RAOs). One of these objectives was to "reduce the mass of contaminants that are bioavailable" (Earth Tech 2003). However, the sediment data that were relied upon in the FS did not provide a sufficient basis for evaluating the bioavailability of metals in sediments of this Site. Consequently, the Preliminary Remedial Goals (PRGs) and Modified Remedial Goals (MRGs) presented in the FS did not account for site-specific bioavailability or toxicity of metals in sediments of OU-2. Instead, the FS relies upon generic sediment screening criteria (ER-Ls and ER-Ms)[1] and background concentrations in sediments for the Lower Hudson River as a basis for selecting remedial alternatives[2].

Comparisons of site-specific data with background concentrations provide a basis for determining if metal concentrations are elevated in sediments adjacent to the Site, which may suggest further site-specific evaluation is needed, but they provide insufficient information regarding the potential bioavailability or toxicity of those metals. Similarly, the ER-L and ER-M are generic screening-level benchmarks that are based on measures of bulk metals in sediments and do not consider site-related factors that limit metal bioavailability and toxicity.

As the USEPA indicates in the *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites* (USEPA, 2005a, Page 2-6):

> "Concentrations of bulk (total dry weight basis) metals in sediment alone are typically not good measures of metal toxicity. However, in addition to direct measurement of toxicity, EPA has developed a recommended approach for estimating metal toxicity based on the bioavailable metal fraction, which can be measured in pore water and/or predicted based on the relative sediment concentrations of acid volatile sulfide (AVS), simultaneously extracted metals (SEM), and total organic carbon (TOC) (U.S. EPA 2005c). Both AVS and TOC are capable of sequestering and immobilizing a range of metals in sediment."

---

[1] ER-L is defined at the "effects range low" which corresponds to the lower 10th percentile of the effects data distribution. ER-M is defined as the "effects range medium" which corresponds to the 50th percentile of the effects data distribution (Long et al. 1995a).

[2] The NYSDEC (1993) "*Technical Guidance for Screening Contaminated Sediments*" acknowledges that the ER-L and ER-M values developed by NOAA make use of the screening level approach. Long et al. (1995a) specifically state, "The numerical guidelines should be used as informal screening tools in environmental assessments. They are not intended to preclude the use of toxicity tests or other measures of biological effects."

These methods are described in the USEPA's *Procedures for Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: Metal Mixtures (Cadmium, Copper, Lead, Nickel, Silver, and Zinc)* (USEPA, 2005b). The ESB Guidance provides a rigorous methodology for assessing the factors that limit the bioavailability and toxicity of metals. The ESB Guidance recognizes the importance of AVS and organic carbon in sequestering metals in sediments thereby limiting their introduction into porewater, which is the primary route of exposure for benthic organisms (USEPA, 2005b). The ESB Guidance establishes the scientific basis for evaluating the bioavailability and toxicity of metals in sediments, and provides detailed methodology for quantitatively assessing the metal binding capacity of sediments.

Neither AVS nor porewater data were collected during the Remedial Investigation (RI) for OU-2. However, data collected during the RI indicated that shallow OU-2 sediments are anoxic (Earth Tech 2000), and thus are likely to contain sufficient AVS to significantly reduce metal bioavailability and toxicity in OU-2 sediments. TOC data were collected during the RI, but were not considered in the evaluation of metal toxicity.

Site-specific AVS, TOC, and metal porewater data have since been obtained during supplemental sediment investigations of OU-2 conducted in Fall of 2004 and 2005. These data fill previous data gaps and allow the site-specific bioavailability and toxicity of metals to be evaluated based on the methods presented in the ESB Guidance. The results of these studies are described in the following sections.

In conjunction with the results of the Fall 2004 and Fall 2005 studies, sediment benchmark comparisons, bulk sediment bioassays, and benthic community surveys previously conducted at OU-2 were further evaluated using a Sediment Quality Triad Analysis, as described by Chapman (1996), to provide a comprehensive evaluation of the potential bioavailability and toxicity of metals in OU-2 sediments. This Sediment Quality Triad Analysis is discussed in Appendix D.

C2 AR FALL 2004 SEDIMENT INVESTIGATION

One objective of AR's Fall 2004 sediment investigation was to collect the appropriate data needed to evaluate the site-specific bioavailability and toxicity of metals in OU-2 sediments based on USEPA (2005b) ESB Guidance. To address this objective, a total of 17 samples were collected during November 2004 using box core sampling methods. Special techniques were used during sampling and analysis to prevent the oxidation of AVS. Samples were analyzed for AVS, SEM, total metals, TOC, redox, porewater metals, and porewater dissolved organic carbon (DOC). The specific sampling and analysis protocols are described in the Work Plan (Parsons 2004). Results for the Fall 2004 sediment investigation are presented in the Field Work Summary Report (Parsons 2005a), and results relevant to metals bioavailability and toxicity are discussed below in Section C2.1 (∑SEM-AVS) and Section C2.2 (Organic Carbon). Porewater metals results are discussed in Section C2.3. Additional discussion of the methods employed and the results of this investigation were provided in AR's August 4, 2005 letter to NYSDEC (AR 2005).

C2.1 ∑SEM-AVS

As indicated in Section C1, the toxicity of metals in sediments is highly correlated with concentrations of metals in porewater rather than in bulk sediments. AVS represent a significant sink for metals in the solid phase of sediments and can significantly limit partitioning of metals into porewater. When the molar concentration of AVS exceeds the sum of the molar concentrations of simultaneously extracted metals (∑SEM) (e.g., ∑SEM - AVS < 0 µmol/g), metals remain bound in the solid phase and metal toxicity is not observed. However, when the concentrations of SEM exceed those of AVS (e.g., ∑SEM - AVS > 0 µmol/g), the concentrations of metals in porewater may increase and further site-specific evaluation may be desirable to determine whether toxicity may be observed (Ankley et al, 1993; Berry et al., 1996; Di Toro et al., 1999; and USEPA, 2005b).

During the Fall 2004 sediment investigation, SEM concentrations were measured for five of the six metals for which the USEPA (2005b) ESB methodology is applicable (e.g., cadmium, copper, lead, nickel, and zinc). It should be noted that cadmium and silver were not considered site-related chemicals of concern in the FS (Earth Tech 2003). Nonetheless, cadmium was included in the SEM calculations as it competes with the other metals for AVS and could theoretically affect the ∑SEM-AVS calculation. Silver was not included in the 2004 study because it was not thought to contribute significantly to the ∑SEM calculation due to its low concentrations in sediments and its requirement for only half as much AVS because it is a monovalent ion (Ag^{+}) unlike the other metals which are divalent (e.g., Cu^{2+}). Silver was included in the Fall 2005 study and it was concluded that it did not contribute significantly to the ∑SEM (see Section C3).

The molar concentrations of ∑SEM and AVS for sediments from the 17 sampling locations are summarized in Table C.1, as presented in Section C2.2. Concentrations of AVS exceeded those of ∑SEM at all 17 locations. ∑SEM-AVS ranged from -7.7 µmol/g at SD-26 to -72 µmol/g at SD-20 with a mean ∑SEM-AVS of -27 µmol/g. These results indicate that there is sufficient AVS to sequester the concentrations of cadmium, copper, lead, nickel, and zinc at these locations, preventing their release into porewater, thus controlling their bioavailability and toxicity to aquatic organisms (Table C.1, column 4). Moreover, the magnitude of the ∑SEM-AVS values indicates capacity to sequester additional metals. As an example, the SEM-AVS value at SD-22, which had the highest concentrations of each of the metals in bulk sediments, was -8.4 µmol/g, which indicates substantial additional capacity of AVS to bind metals.

C2.2 Organic Carbon

As indicated in the introduction, organic carbon can provide metal sequestering capacity above and beyond that provided by AVS (Di Toro et al. 1986, 1996; Mahony et al., 1996; Besser et al., 2003). Based on these and other studies, the USEPA (2005b) has incorporated the additional complexation capacity of organic carbon in the ESB analysis. This is accomplished by normalizing the ∑SEM-AVS to the fraction of organic carbon as described in the following equation:

$$\frac{\sum SEM - AVS}{f_{oc}}$$

where,

$\sum SEM$ = sum of simultaneously extracted metals (µmol/g)
AVS = acid volatile sulfides (µmol/g)
f_{oc} = fraction of total organic carbon (unitless; e.g., 2.3 percent is 0.023 as a fraction)

As shown in Figure 3-8 of the ESB Guidance, the effect of normalizing ∑SEM-AVS to the fraction of total organic carbon is to expand the range of conditions over which the ESB evaluation of metal toxicity to benthic invertebrates can be employed. When the (∑SEM-AVS)/f_{oc} is less than 130 µmol/g, toxicity to benthic organisms is not observed and no additional biological testing is necessary (USEPA, 2005b, Figures 3-9, Page 3-22). Those sediments with (∑SEM-AVS)/f_{oc} > 3,000 µmol/g are likely to be toxic. In cases where (∑SEM-AVS)/f_{oc} > 130 µmol/g but < 3,000 µmol/g the potential toxicity of the sediments is less certain. Chronic bioassays and/or benthic community studies may be employed to address uncertainties in this 130 to 3,000 µmol/g range (USEPA, 2005b).

Table C.1. Calculation of ∑SEM-AVS and (∑SEM-AVS)/f_{oc} for OU-2 Sediments Collected in the Fall of 2004

Sample	∑SEM (µmoles/g)	AVS (µmoles/g)	∑SEM-AVS (µmoles/g)	TOC (percent)	(∑SEM-AVS)/f_{oc} (µmoles/g)	Excess[a] Capacity (µmoles/g)
Average	***2.2***	***29***	***-27***	***2.3***	***-1,185***	***1,315***
Minimum	***1.6***	***9.8***	***-72***	***1.6***	***-2,571***	***401***
Maximum	***4.1***	***75***	***-7.7***	***2.9***	***-271***	***2,701***
SD-20	2.7	75	-72	2.8	-2,571	2,701
SD-17	1.8	43	-41	2.2	-1,899	2,029
SD-14	3.1	41	-38	2.2	-1,768	1,898
SD-25	1.8	40	-39	2.2	-1,753	1,883
SD-12	1.9	30	-28	1.6	-1,708	1,838
SD-18	2.1	40	-37	2.3	-1,658	1,788
SD-16	1.9	25	-23	2.0	-1,178	1,308
SD-23	2.3	31	-29	2.5	-1,154	1,284
SD-24	2.2	34	-31	2.7	-1,142	1,272
SD-21	1.6	30	-28	2.5	-1,138	1,268
SD-19	1.9	20	-18	1.7	-1,064	1,194
SD-11	2.2	22	-19	2.4	-807	937
SD-15	1.6	14	-13	2.2	-565	695
SD-10	1.9	16	-13	2.6	-530	660
SD-22	4.1	13	-8.4	1.7	-487	617
SD-13	1.7	11	-9.1	2.0	-460	590
SD-26	2.1	9.8	-7.7	2.9	-271	401

a. Excess capacity was calculated as [absolute value of *(∑SEM-AVS)/* f_{oc}*] + 130*.

The inclusion of organic carbon in the ESB calculation demonstrates that the sediment samples collected from OU-2 during the Fall 2004 supplemental study have additional capacity to sequester metals. As shown in Table C.1, sample SD-26, with the lowest concentration of AVS, has 7.7 µmol/g of excess binding capacity associated with AVS alone (e.g. ∑SEM-AVS). Accounting for the fraction of TOC as well as AVS in this sample results in 401 µmol/g excess metal binding capacity, or 52 times that provided by AVS alone. For all 17 samples, the excess binding capacity provided by AVS and TOC together averages 1,315 µmol/g and ranges from 401 to 2,701 µmol/g. With organic carbon typically found at percent levels in sediments as compared to AVS, which is generally present at only part per million levels, it is clear that organic carbon substantially increases binding capacity above and beyond that provided by AVS alone.

As shown in Table C.1, the excess binding capacity provided by AVS and TOC exceeds the ∑SEM concentrations for each of the 17 sampling locations by two to three orders of magnitude (100-fold or more). By comparison, the highest metal concentrations identified in the RI and FS are only four to five times those of the Fall 2004 sampling.

C2.3 Porewater Metal Concentrations vs. New York Water Quality Standards

The effectiveness of AVS, TOC, and other factors in the solid phase to complex metals was evaluated independently by quantifying the concentrations of dissolved metals directly in porewater (Ankley et al., 1991, 1993, and 1994; Berry et al., 1996; and USEPA, 2005b). Concentrations of metals in porewater collected during the Fall 2004 investigation were then compared against the NYSDEC (1998, 1999) chronic saltwater water quality standards (WQS) for each metal.

This approach provides an independent line of evidence for evaluating the potential toxicity of those metals considered with the (∑SEM-AVS)/f_{oc} approach (e.g., cadmium, copper, lead, nickel, and zinc). It also provides a basis for evaluating the potential toxicity of metals such as arsenic, chromium, mercury, and silver which were not considered in the (∑SEM-AVS)/f_{oc} analysis of Fall 2004 data. Table C.2 presents a comparison of OU-2 porewater metals concentrations for the 17 OU-2 sediment samples to NYSDEC chronic saltwater WQS.

As shown in Table C.2, the maximum dissolved concentrations for the three metals that were detected in OU-2 sediment porewater (arsenic, copper, and lead) are each below their respective NYSDEC chronic saltwater WQS at all 17 sampling locations. The maximum detection limits for four of the six metals that were not detected in porewater samples (cadmium, chromium, nickel, and zinc) are also well below the NYSDEC chronic saltwater WQS. NYSDEC does not have chronic saltwater WQS for total mercury or for silver. Mercury was not detected in any of the 17 porewater samples, and the maximum detection limit of 0.071 µg/L was well below the USEPA (2005c) chronic saltwater ambient water quality criterion (AWQC) of 0.94 µg/L. Silver was also not detected in any of the porewater samples, and the maximum detection limit of 0.25 µg/L was below the USEPA (2005c) acute saltwater AWQC of 1.9 µg/L; USEPA (2005c) has not developed chronic AWQC for silver

Table C.2. Comparison of OU-2 Sediment Porewater Metals Concentrations with NYSDEC Water Quality Standards

Metal	Detection Frequency (percent)	Sediment Porewater Concentration Min (µg/L)	Max (µg/L)	Arithmetic Mean (µg/L)	Geometric Mean (µg/L)	NYSDEC[a,b] Chronic Saltwater WQS (µg/L)	Ratio of Geometric Mean Concentration to WQS (unitless)
Arsenic	71	7.5 U	18.6	11.7	11.3	63	0.18
Cadmium	0	0.34 U	0.34 U	0.34	0.34	7.7	0.044
Chromium	0	2.8 U	2.8 U	2.8	2.8	54	0.052
Copper	33	2.5 U	3.3	2.6	2.6	5.6[b]	0.46
Lead	12	0.24 U	1.9	0.48	0.37	8.0	0.046
Mercury	0	0.071 U	0.071 U	0.071	0.071	NA	NA
Nickel	0	1.5 U	3.4 U	2.1	2.1	8.2	0.26
Silver	0	0.25 U	0.25 U	0.25	0.25	NA	NA
Zinc	0	3.9 U	9.9 U	5.49	5.26	66	0.080

a. NYSDEC 1999.

b. The chronic saltwater WQS for copper is a region-specific value applicable to NY/NJ Harbor saltwater as defined by NYSDEC (1998) extending upstream of the Lower Hudson River to the vicinity of Bear Mountain Bridge.

NA – not applicable (see discussion below)

U – not detected; value shown is the analytical detection limit

WQS – water quality standards

The low concentrations of cadmium, copper, lead, nickel, and zinc in porewater are consistent with the results of the ESB evaluation which demonstrates that these metals are sequestered by AVS and organic carbon as discussed in Sections C2.1 and C2.2. Thus, two independent lines of evidence demonstrate that cadmium, copper, lead, nickel, and zinc are not toxic to benthic organisms over the range of concentrations observed in the Fall 2004 supplemental investigation.

Four of the metals evaluated in porewater (arsenic, chromium, mercury, and silver) are not considered in the ESB analysis (USEPA, 2005b). The maximum concentrations (or detection limits) of these metals and metalloids in porewater were well below WQS indicating they are not toxic to benthic organisms over the range of concentrations observed in the Fall 2004 supplemental investigation.

C3 FALL 2005 SEDIMENT INVESTIGATION

AR undertook a second supplemental investigation in the Fall of 2005 to further characterize the effects of AVS and TOC on metals bioavailability and toxicity in sediments of OU-2. The numeric range of total metal concentrations in bulk sediments from the 17 locations sampled in the Fall 2004 for ESB evaluation did not reflect the full range of metal concentrations in surface sediments that had been documented in prior studies of OU-2. The Fall 2004 copper concentrations encompassed 96 percent of the range of data found in the larger RI data set and the numeric distribution of the copper concentrations from the Fall 2004 study is not statistically different from the sediment copper concentrations reported in the RI (AR, 2005). Nonetheless, the highest concentration of copper in the 2004 sediment investigation was 603 mg/kg, while copper concentrations reported in the RI ranged up to 2,560 mg/kg in surface sediments (Earth Tech 2000). Therefore, one objective of the Fall 2005 study was to sample locations within

OU-2 where higher metals concentrations would be expected based on the distribution of metals data reported in the RI.

The Fall 2005 study also evaluated variations in ∑SEM, AVS, and TOC within the 0 to 12-inch depth range employed in the 2004 study. Studies at other locations had demonstrated reduced AVS concentrations in shallow oxic sediments (Boothman and Helmstetter, 1992). However, AVS and TOC concentrations measured in the 0 to 12 inch sediment cores in the Fall 2004 sediment investigation are consistent with AVS and TOC concentrations in much shallower sediments (0 to 2 cm) throughout the Lower Hudson River and the Hudson-Raritan Estuary (Long et al. 1995b; USEPA 2005b). Average AVS concentrations in OU-2, Lower Hudson River, and Hudson-Raritan Estuary sediments were 29, 28, and 25 µmol/g, respectively. Average TOC concentrations in OU-2, Lower Hudson River, and Hudson-Raritan Estuary sediments were 2.3, 2.6, and 2.2 percent, respectively (AR 2005). These data indicate that surface sediments from the Lower Hudson River, as shallow as 0 to 2 cm have substantial concentrations of AVS and TOC. However, there were no data on AVS concentrations in the shallower sediments (e.g., 0 to 3 inches) of OU-2 to directly resolve this issue.

To address these issues, AR conducted a supplemental sediment investigation in November 2005 to focus AVS and SEM analysis on the 0 to 3 inch depth range and to resample locations where sediment copper concentrations were likely higher (as reported in the RI) than those measured in the Fall 2004 investigation. The results of the Fall 2005 investigation are presented in Section C3.1.

C3.1 Results of the Fall 2005 Sediment Investigation

AR conducted a focused investigation of surface sediments in OU-2 in November 2005 to resample sediments previously reported to exhibit the highest sediment copper concentrations, and to further characterize the concentrations of AVS and TOC in surface sediments. The Fall 2005 investigation was conducted during the weeks of November 7 and 14, 2005 and followed the protocols specified in the NYSDEC-approved Work Plan for the Fall 2004 sediment investigation (Parsons 2004). The specific details of the Fall 2005 investigation were documented in the Focused Sediment Sampling Plan letter dated October 22, 2005 (Parsons 2005b). Thirty-three sediment cores were collected using either a box corer or a Ted Young grab sampler in the southern portion of OU-2, south of the North Boat Slip. The box corer was damaged during the investigation requiring the use of the alternative Ted Young grab sampler. As described in the Parsons (2006) Field Work Summary Report for the Fall 2005 investigation, the use of the Ted Young grab sampler was modified to ensure a 1 to 2 inch blanket of river water over sediments thus maintaining natural redox conditions.

C3.1.1 Focus on Areas of Higher Concentrations

As discussed in Section C3, one of the limitations of the Fall 2004 study was that the numerical distribution of metals did not reflect the full range documented in the historic RI data set. To address this issue, the Fall 2005 sampling focused on areas offshore of the sluice and the SPDES outfall beneath former Building 15, where some of the highest metal concentrations had been found historically (sample locations are presented in Figure C.1 – south of the North Boat Slip; Figure C.2 – south of the South Boat Slip). Concentrations of metals in bulk sediments from all sampling locations in the Fall 2005 study are presented in Table C.3. Ranges and geometric means of bulk metal concentrations from the most recent Fall 2005 study are presented in Table C.4 along with those of the Fall 2004 study and the RI.

Table C.3. Fall of 2005 Total Bulk Metal Concentrations

Sample	Depth (inches)	Copper (mg/kg)	Lead (mg/kg)	Nickel (mg/kg)	Zinc (mg/kg)
SD60A	0 – 3	155	76.2	23.4 J	145 J
SD60A	3 – 6	144	89.0	27.1 J	166 J
SD60B	0 – 3	96.5 J	79.7	25.1 J	133 J
SD60C	0 – 3	86.5 J	70.5	24.4 J	128 J
SD61A	0 – 3	138 J	83.3 J	84.0 J	199 J
SD61A Dup	0 – 3	199 J	74.2 J	77.6 J	178 J
SD61B	0 – 3	104 J	72.9 J	23.8 J	133 J
SD61C	0 – 3	108 J	80.4 J	23.9 J	139 J
SD62A	0 – 3	472 J	**379 J**	**160 J**	**1,050 J**
SD62B	0 – 3	116 J	110 J	28.5 J	182 J
SD62C	0 – 3	139	63.7	22.8	166 J
SD63A	0 – 3	65.9 J	60.3 J	26.8 J	151 J
SD63A	3 – 6	72.1 J	66.5 J	28.1 J	157 J
SD63A	6 – 9	77.1 J	78.8 J	28.1 J	155 J
SD63A	9 – 12	76.6 J	63.5 J	23.9 J	158 J
SD63B	0 – 3	127 J	65.1 J	27.1 J	151 J
SD63C	0 – 3	65.6 J	61.4 J	26.0 J	142 J
SD64A	0 – 3	75.4 J	77.2 J	29.6 J	154 J
SD64B	0 – 3	91.6 J	97.3 J	30.4 J	165 J
SD64C	0 – 3	74.1 J	70.6 J	26.2 J	142 J
SD65A	0 – 3	270 J	50.9 J	20.1 J	209 J
SD65B	0 – 3	143 J	82.4	25.9 J	146 J
SD65C	0 – 3	982 J	164	23.2 J	937 J
SD66A	0 – 3	67.7 J	69.2 J	26.1 J	138 J
SD66B	0 – 3	81.9 J	70.1 J	26.2 J	146 J
SD67A	0 – 3	**1,440 J**	73.1	18.8 J	464 J
SD68A	0 – 3	69.6 J	64.2 J	23.5 J	137 J
SD68B	0 – 3	82.9 J	73.6 J	29.4 J	156 J
SD68C	0 – 3	84.4 J	72.3 J	26.5 J	156 J
SD69A	0 – 3	79.5 J	53.3 J	21.7	127 J
SD69 Dup	0 – 3	100 J	69.5 J	25.0 J	147 J
SD69B	0 – 3	1,230 J	164 J	15.2 J	147 J
SD69C	0 – 3	955 J	169 J	22.2 J	152 J

Note: Bolded values represent the highest measured concentration for each metal

As shown in Table C.4, the concentrations of metals are two- to five-fold higher in the Fall 2005 samples than in the Fall 2004 samples. As an example, the highest concentration of copper in Fall 2005 is 1,440 mg/kg (SD67A) and the geometric mean is 140 mg/kg (see Tables 3 and 4). These compare with a maximum concentration of 603 mg/kg for copper and a geometric mean concentration of 85 mg/kg in Fall 2004. Similarly the highest concentrations of lead, nickel, and zinc in Fall of 2005 were 379, 160, and 1,050 mg/kg, respectively. In comparison, the maximum concentrations for the same metals for the Fall 2004 study were 110, 28, and 262 mg/kg, respectively (Table C.4).

Although metal concentrations in the Fall 2005 study are significantly higher than in the Fall 2004 study, the maximum concentrations are still lower than the those documented in the RI (Table C.4). Differences in maximum concentrations of metals in recent sampling events and older historic data sets reflect the patchy distribution of elevated metal concentrations in shallow sediments of OU-2 (Table C.4). The concentrations of copper from 2004 and 2005 data sets combined encompass 98.5 percent of the historic copper data and only two data points from the historic data set exceed the maximum value measured in the 2005 sampling event. Moreover, the geometric mean copper concentration in the 2005 data set was 50 percent greater than that for the historic RI data set (Table C.4), indicating that the overall distribution of copper concentrations in the Fall 2005 data set exceeds that of the RI data set. While the two highest data points in the upper tail of the RI copper data set is not represented in the Fall 2005 data set, the probability of reacquiring one of these isolated spots with higher metal concentrations is exceedingly low.

Table C.4. Summary of Bulk Metal Concentrations in Surface Sediments from the RI and AR 2004 and AR 2005 Studies

Metal	RI 2000 Geometric Mean (Range)	AR 2004 Geometric Mean (Range)	AR 2005 Geometric Mean (Range)
Copper	93 (12 – 2,560)	85 (51 – 603)	140 (65.6 – 1,440)
Lead	70 (6.0 – 1,390)	74 (62 – 110)	82 (50.9 – 379)
Nickel	25 (6.6 – 1,390)	22 (19 – 28)	28 (15.2 – 160)
Zinc	170 (56 – 5,710)	133 (109 – 262)	177 (127 – 1,050)

All concentrations are in units of mg/kg.

a. RI data reflect 92 samples collected from a depth of 0 to 6 inches, 62 samples collected from depths within the 6 – 29 inch depth range, one sample from a depth of 0 to 9 inches, one sample from a depth of 7 to 14 inches, and one sample from a depth of 10 to 16 inches (Earth Tech, 2000).
b. AR 2004 data reflect sediment depths of 0 to 12 inches.
c. AR 2005 data reflect sediment depths of 0 to 3 inches with the exception of two samples collected from 3 to 6 inches, one sample collected from 6 to 9 inches, and one sample collected from 9 to 12 inches.

C3.1.2 Variations in AVS and TOC Concentrations with Depth

Significant concentrations of AVS were observed in the 0 to 3 inch depth for all sampling locations in the Fall of 2005 study. Concentrations of AVS for these samples averaged 17 µmoles/g and ranged from 1.6 to 69 µmoles/g (Table C.6 – discussed in Section C3.1.3). These averages and ranges are lower than those observed for the 0 to 12 inch depth range collected in the Fall of 2004 where AVS concentrations averaged 29 µmoles/g and ranged from 9.8 to 75 µmoles/g (Table C.1). As these data were collected at different locations and times, it is difficult to determine the degree to which these variations in AVS concentrations between the 2004 and 2005 sampling events are a consequence of depth or other variables.

Two sediment cores were collected in Fall 2005 to specifically assess AVS and TOC trends with depth (Table C.5). In core SD63A, AVS concentrations increased with depth ranging from 5.8 µmol/g in near-surface sediment to 15 µmol/g in the deepest section at 9 to 12 inches below the mudline. Data from SD63A indicate that AVS levels in near-surface sediments may average about 50 percent of those in subsurface sediments. These results are consistent with the 41 percent reduction in average AVS concentrations in the 0 to 3 inch depth range relative to that in the 0 to 12 inch range (17 and 29 µmoles/g for Fall 2004 and Fall 2005 data, respectively). In contrast, AVS data for location SD60A show little difference in AVS between the 0 to 3 and 0 to 6 inch depth intervals.

Table C.5. Summary of Results for OU-2 Sediments Collected from Subsurface Sediments in the Fall of 2005

Sample	Depth (inches)	∑SEM (µmoles/g)	AVS (µmoles/g)	∑SEM-AVS (µmoles/g)	TOC (percent)	(∑SEM-AVS)/foc (µmoles/g)
SD60A	0 – 3	5.1	22	-17	2.2	-774
SD60A	3 – 6	5.6	18	-13	2.8	-457
SD63A	0 – 3	3.4	5.8	-2.4	3.0	-82
SD63A	3 – 6	3.5	6.2	-2.7	3.2	-84
SD63A	6 – 9	3.2	14	-11	3.1	-344
SD63A	9 - 12	3.0	15	-12	2.6	-478

The percent TOC in the 0 to 3 inch samples taken in 2005 averaged 2.9 percent and ranged from 1.8 to 4.3 percent (Table C.6 – see Section C3.1.3). This is slightly higher than was observed in the 0 to 12 inch range in Fall 2004 when TOC averaged 2.3 percent and ranged from 1.6 to 2.9 percent (Table C.1). No clear patterns in TOC variability were observed with depth for two cores taken in Fall 2005 to evaluate changes with depth (Table C.5).

Taken together, these data show that substantial levels of AVS are present throughout the top 12 inches of sediments, but suggest that concentrations of AVS in sediment at depths less than 3 inches may be reduced somewhat relative to those at greater depths at some locations. However, concentrations of AVS in 0 to 3 inch sediments are still significant ranging as high as 69 µmoles/g. Moreover, these data demonstrate that concentrations of TOC in shallow sediments (0 to 3 inches) are at least as high as those in the 0 to 12 inch depth range.

C3.1.3 Fall 2005 ∑SEM-AVS/f_{oc} Results

The AVS, ∑SEM, and TOC results for OU-2 sediments collected from the 0 – 3 inch depth interval at each sample location during the Fall 2005 sediment investigation are presented in Table C.6. Associated ESB calculations for each sampling location are also presented. These calculations demonstrate there is sufficient AVS present to sequester metals in most but not all samples. ∑SEM-AVS was less than 0 µmoles/g in 24 of 29 near-surface sediment samples. Five near-surface sediment samples had ∑SEM-AVS greater than zero µmoles/g (SD63C, SD65C, SD66B, SD67A, and SD69B). The concentrations TOC were sufficiently high in three of these samples (SD63C, SD65C, SD66B) so that the (∑SEM-AVS)/f_{oc} fell below the 130 µmoles/g USEPA ESB threshold of uncertainty (USEPA 2005b). Metals at these locations are thus considered non-toxic. At the two remaining locations (SD67A and SD69B), the (∑SEM-AVS)/f_{oc} exceeds 130 µmoles/g, indicating some uncertainty in the prediction of potential metals-related toxicity. Neither of these samples approached 3,000 µmoles/g, which is the USEPA ESB threshold for metal toxicity (USEPA, 2005b).

Table C.6. Summary of Results for 0 to 3 Inch Depth Interval OU-2 Sediments Collected in the Fall of 2005

Sample	∑SEM (µmoles/g)	AVS (µmoles/g)	∑SEM-AVS (µmoles/g)	TOC (percent)	(∑SEM-AVS)/foc (µmoles/g)
Average	***5.9***	***17***	***-11***	***2.9***	***-339***
Minimum	***2.3***	***1.6***	***-66***	***1.8***	***-1,521***
Maximum	***29***	***69***	***22***	***4.3***	***1,220***
SD60A	5.1	22	-17	2.2	-774
SD60B	3.2	18	-15	3.1	-476
SD60C	3.3	14	-11	2.2	-514
SD61A	3.4	13	-10	3.6	-274
SD61A Dup	2.3	8.1	-5.8	3.4	-173
SD61B	3.8	21	-17	2.9	-604
SD61C	3.4	24	-20	3.2	-636
SD62A	27	41	-15	2.7	-549
SD62B	4.7	11	-6.6	2.9	-229
SD62C	3.7	13	-8.9	2.4	-369
SD63A	3.4	5.8	-2.4	3.0	-82
SD63B	2.9	9.7	-6.8	2.7	-254
SD63C	3.3	2.9	**0.39**	2.6	15
SD64A	4.0	30	-26	3.2	-789
SD64B	3.4	69	-66	4.3	-1,521
SD64C	4.2	4.3	-0.15	3.1	-4.8
SD65A	3.4	5.6	-2.2	2.1	-107
SD65B	3.2	13	-9.9	2.6	-384
SD65C	7.9	6.2	**1.7**	2.4	69
SD66A	2.5	4.1	-1.6	2.5	-64
SD66B	2.5	1.6	**0.85**	3.3	26
SD67A	13	2.0	**11**	3.0	**368**
SD68A	4.0	38	-34	4.0	-851
SD68B	3.5	24	-21	3.5	-604
SD68C	3.4	42	-38	3.3	-1,150
SD69A	3.5	16	-12	2.5	-475
SD69 Dup	3.3	13	-10	2.2	-464
SD69B	29	7.0	**22**	1.8	**1,220**
SD69C	10	15	-5.0	2.6	-196

Values in bold indicate exceedance of USEPA's ESB threshold of toxicity for SEM-AVS > 0 µmoles/g or threshold of uncertainty for (∑SEM-AVS)/f_{oc} > 130 µmoles/g.

The two locations that exceeded the 130 µmol/g ESB threshold of uncertainty had the highest concentrations of total copper observed in the Fall 2004 and Fall 2005 sampling events. The highest ESB value of 1,220 µmoles/g was found at SD69B, which is located immediately offshore of the sluice (see Figures C.1 and C.2). The concentration of total copper at SD69B was 1,230 mg/kg. The second ESB exceedance, at 368 µmoles/g, was found at SD67A, which is located offshore of the SPDES discharge pipe at former Building 15. The concentration of total copper at SD67A was 1,440 mg/kg, the highest concentration recorded in the 2004 and 2005 sampling events. The next highest concentrations of copper were found at SD65C and SD69C with 982 and 955 mg/kg, respectively (Table C.3). These samples were again located offshore of the SPDES discharge pipe at former Building 15. The (∑SEM-AVS)/f_{oc} levels for these locations are below the 130 µmoles/g ESB threshold of uncertainty with values of 69 µmoles/g and -196 µmoles/g, respectively.

These results indicate that exceedance of the 130 µmole/g ESB threshold of uncertainty for total copper toxicity in sediments of OU-2 lies between 982 and 1,230 mg/kg. Based on the ESB guidance, 982 mg/kg is the highest concentration of total copper in sediments of OU-2 falling in the no-effect range. This value is the functional equivalent of the no observed adverse effect concentration (NOAEC) in standard toxicity testing. The 1,230 mg/kg value, however, represents the lowest concentration of total copper in the uncertainty range. This value is well below the 3,000 µmole/g threshold of toxicity and is thus **not** the equivalent of the lowest observed adverse effect concentration (LOAEC).

The highest concentrations of lead, nickel, and zinc in bulk sediments were all found at a single location, SD62A (see Table C.3). Concentrations of lead, nickel, and zinc at this location were 379, 160, and 1,050 mg/kg, respectively. This sample is located offshore of the SPDES discharge pipe at former Building 15 in the same vicinity as SD67A where the highest copper concentration (1,440 mg/kg) was observed (Figure C.1). Even though this single sample had the highest concentrations of all three of these metals, the $\sum$SEM-AVS/f_{oc} for this location was -549 µmoles/g, which is well below the 130 µmoles/g ESB threshold of uncertainty. These data indicate that the concentrations of these metals in bulk sediments required to exceed the 130 µmole/g ESB threshold of uncertainty for toxicity are substantially higher than those measured at SD67A.

Based on these analyses, the NOAECs for total lead, nickel, and zinc in bulk sediments of OU-2 are 379, 160, and 1,050 mg/kg, respectively. These values are the highest concentrations measured in the ESB studies for each metal for which $\sum$SEM-AVS/f_{oc} did not exceed the 130 µmoles/g ESB threshold of uncertainty. The upper-bound thresholds of uncertainty for these metals in sediments of OU-2 are not known.

C3.2 Conclusions Regarding the Fall 2005 Study

One of the objectives of the Fall 2005 sediment study was to expand the range of metal concentrations by focusing on areas where higher metal concentrations had been reported in the RI. As shown in Tables 3 and 4, copper concentrations for the Fall 2005 study ranged up to 1,440 mg/kg (SD67A). This maximum copper concentration from the Fall 2004 and Fall 2005 supplemental investigations corresponds to the 98.5 percentile copper concentration from the RI and FS data sets indicating that these supplemental studies have captured nearly the full range of historic RI data. Moreover, the geometric mean of 140 mg/kg for the Fall 2005 data set is 1.5 times that for the historic RI data set indicating that the data used in the ESB analysis are biased high and thus likely to overestimate the distribution of elevated metal concentrations in sediments of OU-2. Concentrations of total lead, nickel, and zinc in bulk sediments are similarly increased relative to the Fall 2004 data set.

SEM metals are fully bound by AVS and TOC and thus non toxic at all sampling locations but two, for which there is some uncertainty. These locations are SD67A and SD69B. These locations had the highest total copper concentrations measured in the Fall 2004 and Fall 2005 Supplemental Investigations, at 1,440 and 1,230 mg/kg, respectively. The ($\sum$SEM-AVS)/f_{oc} values for these two locations are 368 and 1,220 µmol/g, respectively. While these two data point fall within the range for which there is uncertainty regarding metal toxicity, their ESB results also are well below the (∑SEM-AVS)/f_{oc} value of 3,000 µmol/g which is considered the USEPA (2005b) ESB threshold for metal toxicity. In combination, the Fall 2004 and Fall 2005 (∑SEM-AVS)/f_{oc} estimates show that 96 percent of the 50 samples (48/50) collected during these two studies fall below the 130 µmol/g ESB threshold for toxicity. While 4 percent (2/50) of the samples fall within the 130 to 3,000 µmol/g range of uncertainty, none of the data collected during these 2004 and 2005 Supplemental Investigations approach or exceed the ESB threshold of 3,000 µmol/g for predicted toxicity (Figure C.3).

C3.3 Proposed ESB-Based Remedial Goals for OU-2

Based on the analysis presented above, we propose that the site-specific ESB-based NOAECs for copper, lead, nickel, and zinc represent appropriately conservative remedial goals for sediments of OU-2.

In the case of copper, the threshold for exceeding the 130 µmoles/g ESB benchmark lies between a bulk copper concentration of 982 and 1,230 mg/kg total copper in bulk sediments. The 982 mg/kg copper NOAEC, which corresponds to an (∑SEM-AVS)/f_{oc} value of 69 µmoles/g, is the highest concentration to not exceed the 130 µmoles/g ESB benchmark above which there is some uncertainty. Importantly, the (∑SEM-AVS)/f_{oc} value of 69 µmoles/g is over 40-fold lower than the 3,000 umoles/g ESB benchmark that indicates predicted toxicity. Based on these data, the 982 mg/kg NOAEC represents an appropriately conservative ESB-based copper remedial goal for OU-2.

The NOAECs for lead, nickel, and zinc of 379, 160, and 1,050 mg/kg, respectively, are equally conservative remedial goals. These NOAEC values represent the highest concentrations measured in bulk sediments for each metal in the ESB studies. As indicated previously, the highest concentrations of all three metals were found at a single location. Even though this single sample had the highest concentrations of all three of these metals, the ∑SEM-AVS/f_{oc} for this location was -549 µmoles/g, which is well below the 130 µmoles/g USEPA (2005b) ESB threshold of uncertainty and several orders of magnitude below the 3,000 µmoles/g ESB threshold for toxicity.

The proposed site-specific ESB-based remedial goals for each metal are summarized in Table C.7. Areas of OU-2 where modeled concentrations of total copper, lead, nickel, and zinc exceed their respective remediation goals are presented in Figures C.4 through C.7 respectively. These modeled distributions are based on all available data for each metal in bulk sediments of OU-2, including data from the RI and FS and from the Fall 2004 and 2005 investigations (modeling methods are described in Appendix A). Actual data for each metal at each sampling location are also presented each figure for comparison with the modeled data.

Table C.7. Summary of Proposed ESB-Based Remedial Goals

Metal	Remedial Goal (mg/kg)
Copper	982
Lead	379
Nickel	160
Zinc	1,050

C4 COPPER AS A PRIMARY METAL OF CONCERN AND SURROGATE FOR OTHER METALS

The RI identified copper as the primary metal of concern in OU-2 sediments (Earth Tech 2000, Page 6-13). Copper was the primary metal used by Anaconda Wire and Cable in the production of copper wire and cable. Lead was used onsite and the spatial distribution of elevated concentrations of lead in OU-2 sediments is consistent with that of copper with the highest concentrations found: 1) offshore of the sluice discharge; 2) offshore of the former Building 15 SPDES discharge pipe; and 3) in the northwest area over the Fill Unit. The distribution of elevated concentrations of nickel and zinc in sediments are similar to those of copper and lead, suggesting common sources and/or pathways to OU-2.

C4.1 Results from Supplemental ESB Studies

Data presented above from the Fall 2004 and 2005 supplemental studies provide further insight as to the relative importance of each of the four metals in evaluating potential metal-related impacts and associated remedies. Together these studies provide data on copper, lead, nickel, and zinc in surface sediments at 50 sampling locations in areas of OU-2 where the highest concentrations of metals have been documented. Data for each of these four metals are discussed separately below.

C4.1.1 Copper

Concentrations of total copper in surface sediment samples collected from these locations during the Fall 2004 and Fall 2005 studies ranged from 50.9 to 1,440 mg/kg. Thirty-eight percent of the samples (19 of 50) exceeded the 88.7 mg/kg PRG which reflects the maximum background copper concentration identified in the RI. This background-based PRG was derived in the FS using data reported in the RI (Earth Tech 2003). As indicated in Section C3.1.2 above, the two locations with the highest concentrations of copper, SD69B and SD67A, also exceeded the 130 µmoles/g ESB threshold of uncertainty. The highest (∑SEM-AVS)/f_{oc} value of 1,220 µmoles/g was found at SD69B, which is located immediately offshore of the sluice. The concentration of total copper in bulk sediments at SD69B was 1,230 mg/kg. Copper accounted for 87 percent of the ∑SEM for this sample. The second ESB exceedance, with a (SEM-AVS)/f_{oc} value of 368 µmoles/g, was found at SD67A which is located offshore of the SPDES discharge pipe at former Building 15. The concentration of total copper at SD67A was 1,440 mg/kg, the highest concentration of total copper recorded in the Fall 2004 and Fall 2005 sampling events. Copper accounted for 40 percent of the ∑SEM in this sample.

Even at these comparatively high bulk copper concentrations, none of the 50 samples from the Fall 2004 and the Fall 2005 studies exceeded the (∑SEM-AVS)/f_{oc} threshold of 3,000 µmoles/g indicative of toxicity. The absence of toxicity in OU-2 sediments is further supported by comparison of porewater data to NYSDEC WQS as discussed in Section C2.3. As shown in Table C.2, the ratio of the geometric mean porewater copper concentration to the NYSDEC WQS for copper is 0.46 demonstrating that porewater copper concentrations are not sufficiently elevated to result in toxicity to benthos at bulk sediment copper concentrations ranging up to 603 mg/kg and suggest that concentrations approximately 2-fold higher also would not result in toxicity. These findings are consistent with the ESB results from the Fall 2005 study, which indicate sufficient AVS and TOC binding capacity to limit the bioavailability and toxicity of copper at concentrations as high as the copper NOAEC of 982 mg/kg. Potential toxicity of total copper concentrations in excess 982 mg/kg is uncertain based on ESB guidance

Areas of OU-2 where modeled concentrations of total copper are in excess of the 982 mg/kg NOAEC are presented in Figure C.4. Copper exceeds the 982 mg/kg NOAEC in three areas. The most extensive area is located offshore of former Building 15 centered at the SPDES outfall and extending north away from shore just below the southern portion of the North Boat Slip. The second area is in the southern end of OU-2 and is much less extensive being limited to an area immediately off of the sluice and just south of the sluice. The third area is immediately adjacent to the bulkhead in Northwest Corner within the fill.

C4.1.2 Zinc

Zinc had the second highest range of concentrations in the two supplemental sampling events, after copper (Table C.4). Total zinc concentrations ranged from 109 to 1,050 mg/kg, and 8 percent of the sample locations (4 of 50) exceeded the background-based zinc PRG of 260 mg/kg. The samples with the highest zinc concentrations were SD62A and SD65C, with concentrations of 1,050 and 937 mg/kg, respectively. These samples were located off the SPDES discharge pipe at former Building 15. Neither of these locations exceeded the ESB threshold of uncertainty of 130 µmoles/g. The (SEM-AVS)/f_{oc} values for these locations were -549 µmoles/g and 69 µmoles/g, respectively. The elevated concentration of zinc at SD67A (464 mg/kg) did contribute to the exceedance of the ESB threshold of uncertainty at that location. However, the concentration of zinc at that location was only one-third that of copper (1,440 mg/kg).

Areas of OU-2 where modeled concentrations of total zinc are in excess of the 1,050 mg/kg NOAEC are presented in Figure C.7. Zinc exceeds the 1,050 mg/kg NOAEC in three areas. As with copper, the most extensive area of zinc is located off former Building 15. The second area is much less extensive, being limited to an area immediately south of the sluice where copper also exceeds its NOAEC. The third area is located offshore just north of the North Boat Slip. Exceedance of the zinc NOAEC at this location is driven by elevated concentrations of zinc in a single sample (GB-09) at a depth of 6 to 10 feet below the mudline.

C4.1.3 Lead

Concentrations of total lead in the Fall 2004 and Fall 2005 studies were substantially lower than those of copper or zinc, ranging from 50.9 to 379 mg/kg. The concentrations of lead in 6 percent of these sample locations (3 of 50) exceeded the background-based PRG of 97.7 mg/kg. As with zinc, the highest concentration of lead was found at SD62A, where the (∑SEM-AVS)/f_{oc} value of -549 µmoles/g fell well below ESB threshold of uncertainty of 130 µmoles/g. The highest concentration of total lead measured in this study, 379 mg/kg, thus represents an extremely conservative NOAEC. As shown in Table C.2, the ratio of the geometric mean porewater lead concentration to the NYSDEC WQS for lead is 0.046 indicating that there is more than a 20-fold margin of protection for benthos in OU-2 sediments with bulk lead concentration ranging up to 74 mg/kg (geometric mean for Fall 2004 data).

Areas of OU-2 where modeled concentrations of total lead exceed the 379 mg/kg NOAEC are presented in Figure C.5. Lead exceeds the 379 mg/kg NOAEC in two areas. The first is limited to a highly localized area immediately just south of the sluice where copper and zinc also exceeded their respective NOAECs. The second area is immediately adjacent to the bulkhead in the Northwest Corner within the fill.

C4.1.3 Nickel

The concentrations of nickel in the supplemental sampling events were the lowest of the four metals, ranging from 15.2 to 160 mg/kg. Only 2 percent of the sample locations (1 of 50) exceeded the 37.3 mg/kg background-based PRG for nickel. As with zinc and lead, the highest concentration of nickel was found at SD62A, which had an $(\sum\text{SEM-AVS})/f_{oc}$ value well below the ESB threshold of uncertainty. The highest concentration of total nickel measured in this study, 160 mg/kg, thus represents an extremely conservative NOAEC. Nickel was not detected in pore water and the maximum detection limit was well below the NYSDEC WQS for nickel (Table C.2).

Areas of OU-2 where modeled concentrations of total nickel exceed the 160 mg/kg NOAEC are presented in Figure C.6. Nickel exceeds the 160 mg/kg NOAEC at a single location, immediately south of the sluice, where copper, zinc, and lead also exceeded their respective NOAECs.

C4.2 Lines of Evidence Supporting Use of Copper for Selecting a Metals Remedy

Of all of the metals and metalloids evaluated in porewater, only four were considered to likely be site-related (Earth Tech 2003). Copper and lead were used in the former manufacturing operations at the facility, while the industrial nature of the fill material used on the Site is considered a possible source of nickel and zinc. All four metals were present at elevated concentrations in OU-2 sediments and their spatial distributions are consistent with known pathways from OU-1 (e.g., the sluice and an SPDES pipe beneath former Building 15).

Data from the supplemental investigations strongly support the use of copper as the primary metal of concern in the Southern Portion of OU-2 and as a surrogate for the other three metals. Lines of evidence in support of this include:

- Copper was the primary metal used at the Site (OU-1).
- Concentrations of copper in bulk sediments are generally higher than those of other metals in relation to background-based PRGs, particularly lead and nickel.
- Copper had by far the highest frequency of PRG exceedances, as defined by the background-based PRGs (38 percent for copper vs. 1 to 8 percent for the other metals).
- The ratio of copper concentrations in pore water to the NYSDEC WQS was higher than those for other metals (Table C.2).
- The sample locations with the two highest concentrations of copper were the only ones to exceed the ESB threshold of uncertainty.
- Sample SD62A, which had the highest concentrations of lead, nickel, and zinc combined and moderately elevated copper, did not exceed the ESB benchmark.

Based on these lines of evidence, copper is clearly the primary metal of concern in sediments of OU-2. In addition, modeling results demonstrate that copper serves as an excellent surrogate for the other metals in OU-2 sediments. As can be seen in Figures C.4 through C.7, the spatial distribution of total copper concentrations in excess of the copper NOAEC captures exceedance of respective NOAECs for the other three metals in almost every instance. The one exception is the localized area, immediately north of the North Boat Slip, where zinc exceeds its 1,050 mg/kg NOAEC. However, exceedance of the zinc NOAEC at this location occurs at a depth of 6 – 10 feet below the mudline and is thus not relevant to benthic organisms. Moreover, this location falls in an area where the remediation will be driven by PCBs rather than metals and will be addressed in the proposed remedy. Therefore, focusing the metals remedy on areas with copper concentrations in excess of the 982 mg/kg copper NOAEC would also address areas where zinc, lead, and nickel exceed there respective NOAECs.

C5 EVALUATION OF THE UTILITY OF CONDUCTING ADDITIONAL BIOLOGICAL STUDIES

The ESB guidance defines three clear ranges for evaluating potential toxicity of metals based on $(\sum SEM\text{-}AVS)/f_{oc}$ values: 1) the non toxic range which falls below 130 µmol/g; 2). The toxic range which falls above 3,000 µmol/g; and 3) the range of uncertainty which falls between 130 and 3,000 µmol/g (USEPA 2005b). The ESB guidance indicates that sediment toxicity testing (e.g., bioassays and benthic community studies) may be required to address the uncertainty when the $(\sum SEM\text{-}AVS)/f_{oc}$ falls in the 130 and 3,000 µmol/g range (USEPA 2005b, Section C3.4.5).

As discussed in Section C3, the proposed remedial goals for copper, lead, nickel, and zinc are each based on site-specific NOAECs. The NOAECs represent the highest concentrations of each metal that fall in the non-toxic range established in the ESB guidance (USEPA 2005b). The $(\sum SEM\text{-}AVS)/f_{oc}$ values associated with each of these remedial goals fall well below the 130 µmol/g threshold of uncertainty. Given that the proposed remedial goals fall well below the ESB range of uncertainty and are orders of magnitude below the 3,000 µmol/g USEPA (2005b) ESB threshold for toxicity, there is no need or justification for conducting additional sediment toxicity tests.

AR has additional concerns regarding additional bioassays and benthic community studies. Benthic community studies provide a measure of overall health in terms of species diversity and population density but provide no insight into the factors that may be related to degradation of the benthic community structure. These testing methods respond to a wide variety of contaminants and non-contaminant factors (e.g., grain size, organic carbon content, ammonia, redox potential) that are unrelated to the Hastings Site. It is thus extremely difficult to differentiate whether small study differences may be attributable to site-related chemicals of concern, from non-site related chemicals, or from non-chemical stressors. This is of particular concern in the Lower Hudson River with multiple sources of contaminants (e.g., CSOs and SSOs) independent of the Hastings Site and the difficulty with locating appropriate reference sites that would be considered representative of OU-2 but for site-related releases. This problem is reflected in the classification of the mesohaline benthic habitat on the entire eastern shore of the Lower Hudson River above Yonkers as degraded (NYSDEC 2003).

NYSDEC acknowledges in the RI that benthic communities respond to many factors that are unrelated to chemicals attributable to the Site (Earth Tech, 2000). The NYSDEC has raised these same issues regarding reference sites in previous comments regarding existing studies sediment toxicity studies conducted as part of the RI (Earth Tech, 2000). In addition, the NYSDEC has raised concerns regarding the selection of appropriate species to be used in sediment bioassays, given the variable salinity in the estuarine environment of OU-2. These issues exemplify the uncertainty associated with the implementation of any additional sediment toxicity testing in OU-2.

The proposed remedial goals for copper, lead, nickel, and zinc are each based on a site-specific application of the methods delineated in the ESB guidance document (USEPA 2005b). The ($\sum$SEM-AVS)/f_{oc} values associated with each of these remedial goals falls well within the non toxic range specified in this ESB guidance. Given that the proposed remedial goals fall well below the ESB range of uncertainty and are orders of magnitude below the 3,000 µmol/g USEPA (2005b) ESB threshold for toxicity, there is no need or justification for conducting additional sediment toxicity tests.

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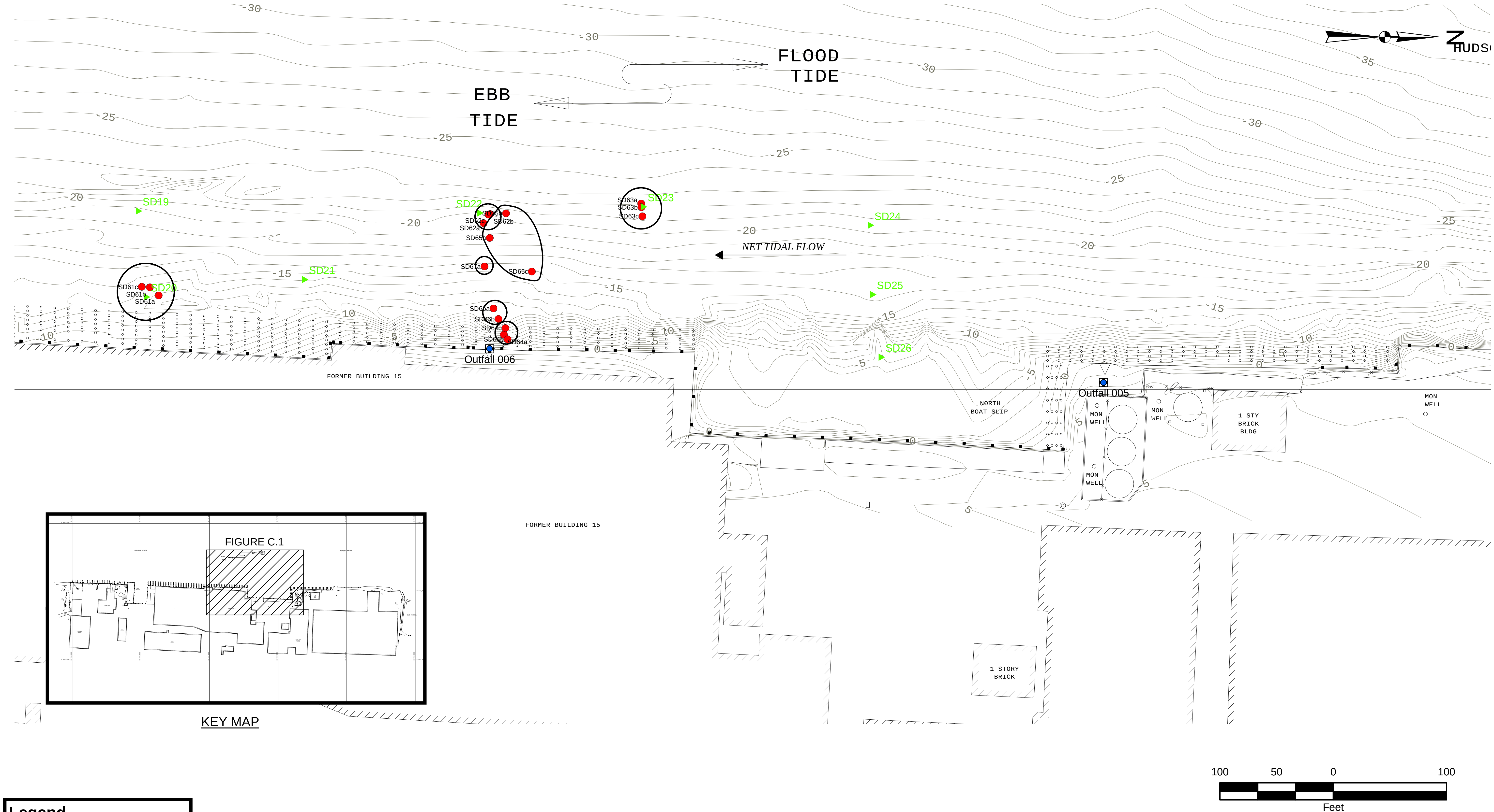


Legend

- ▲ 2004 Sample Locations
- ● 2005 Sample Locations
- ◼ SPDES Outfalls

PARSONS
180 LAWRENCE BELL DRIVE, SUITE 104
WILLIAMSVILLE, NEW YORK 14221
716-633-7074

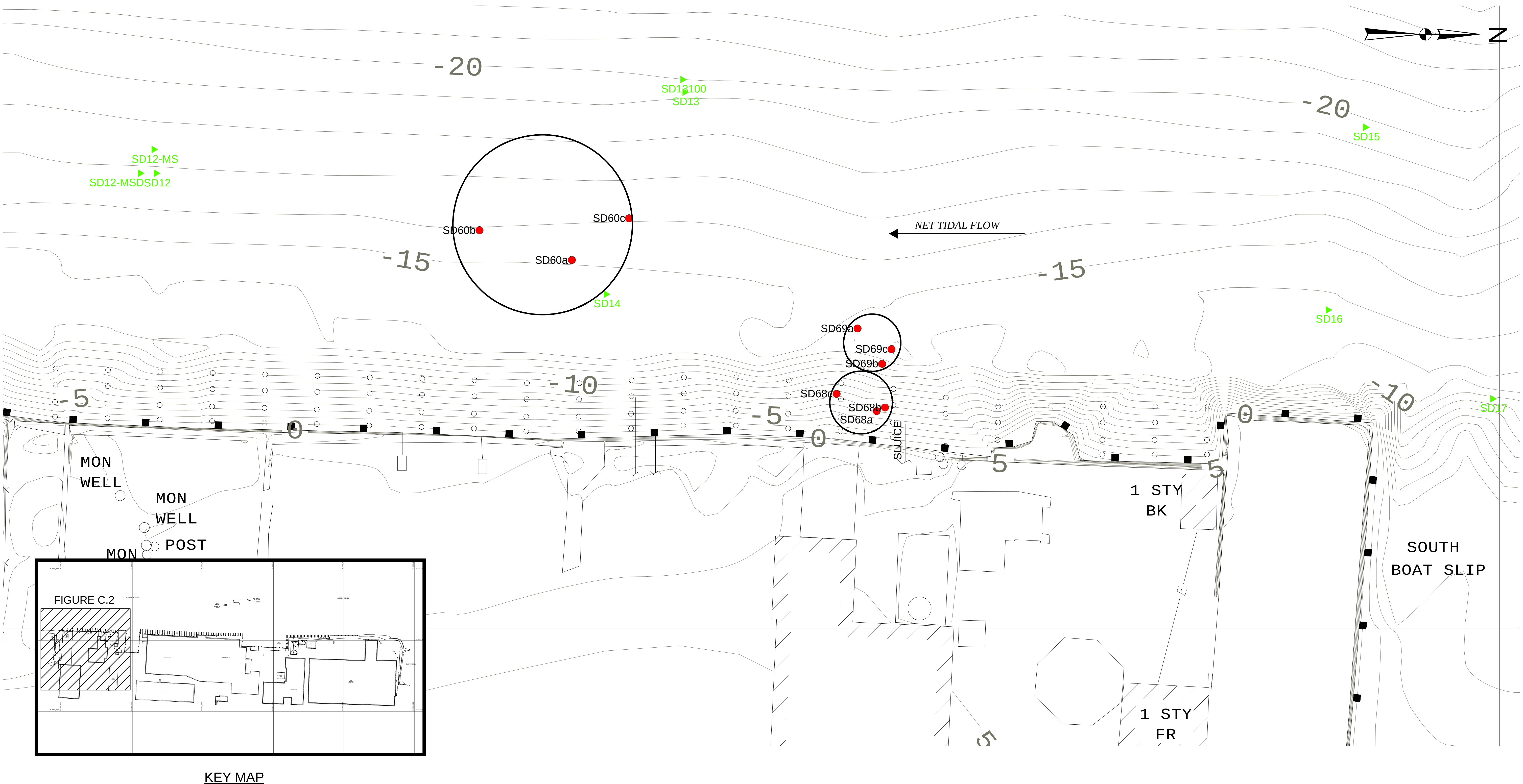
FIGURE C.1

AR and AERL

AVS-SEM Sample Locations

(South of the North Boat Slip)
FORMER AWC PLANT SITE
OU-2
HASTINGS-ON-HUDSON, NEW YORK

F:\440552\GIS\MXD_FILES\FIGURE-C.1.MXD 04-24-06



Legend

▲ 2004 Sample Locations

● 2005 Sample Locations

PARSONS
180 LAWRENCE BELL DRIVE, SUITE 104
WILLIAMSVILLE, NEW YORK 14221
716-633-7074

FIGURE C.2

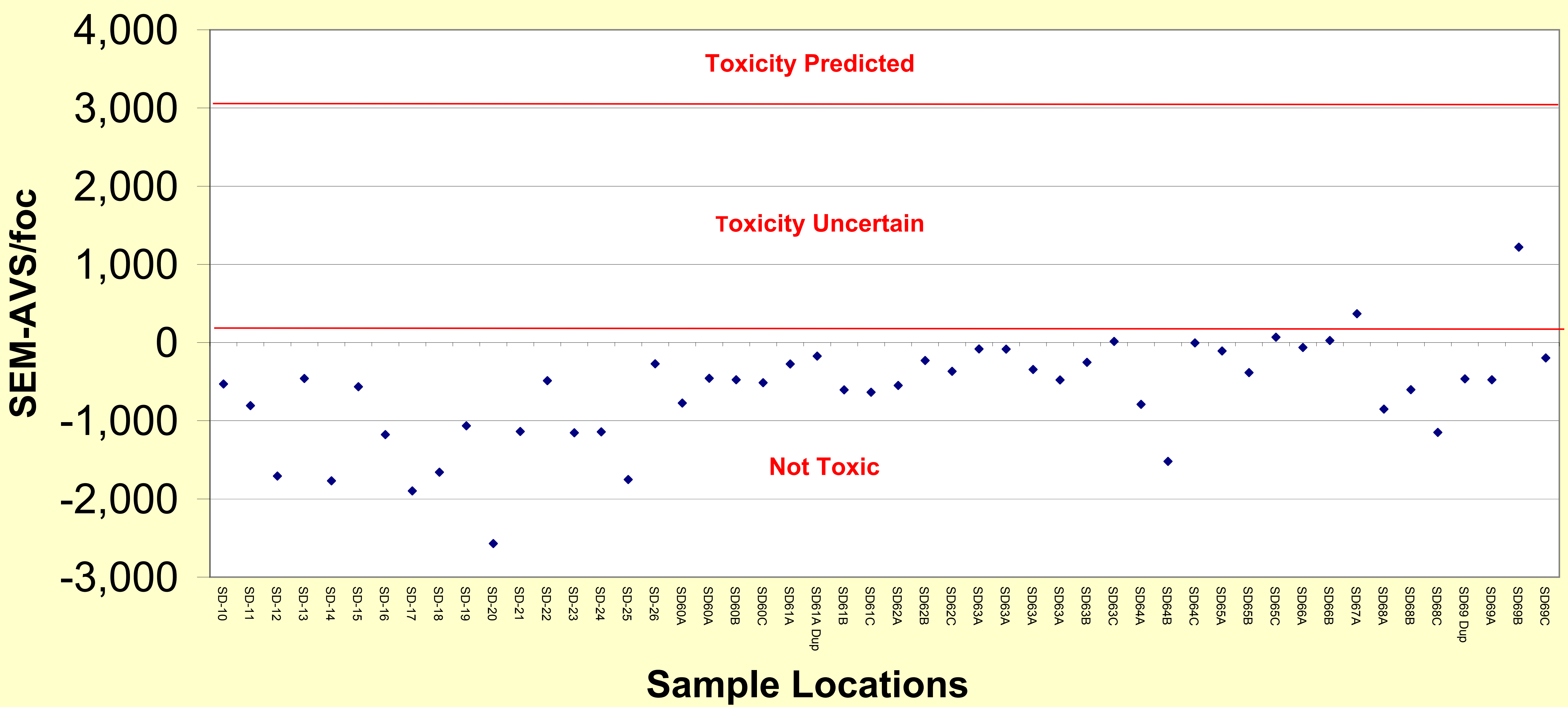
AR and AERL

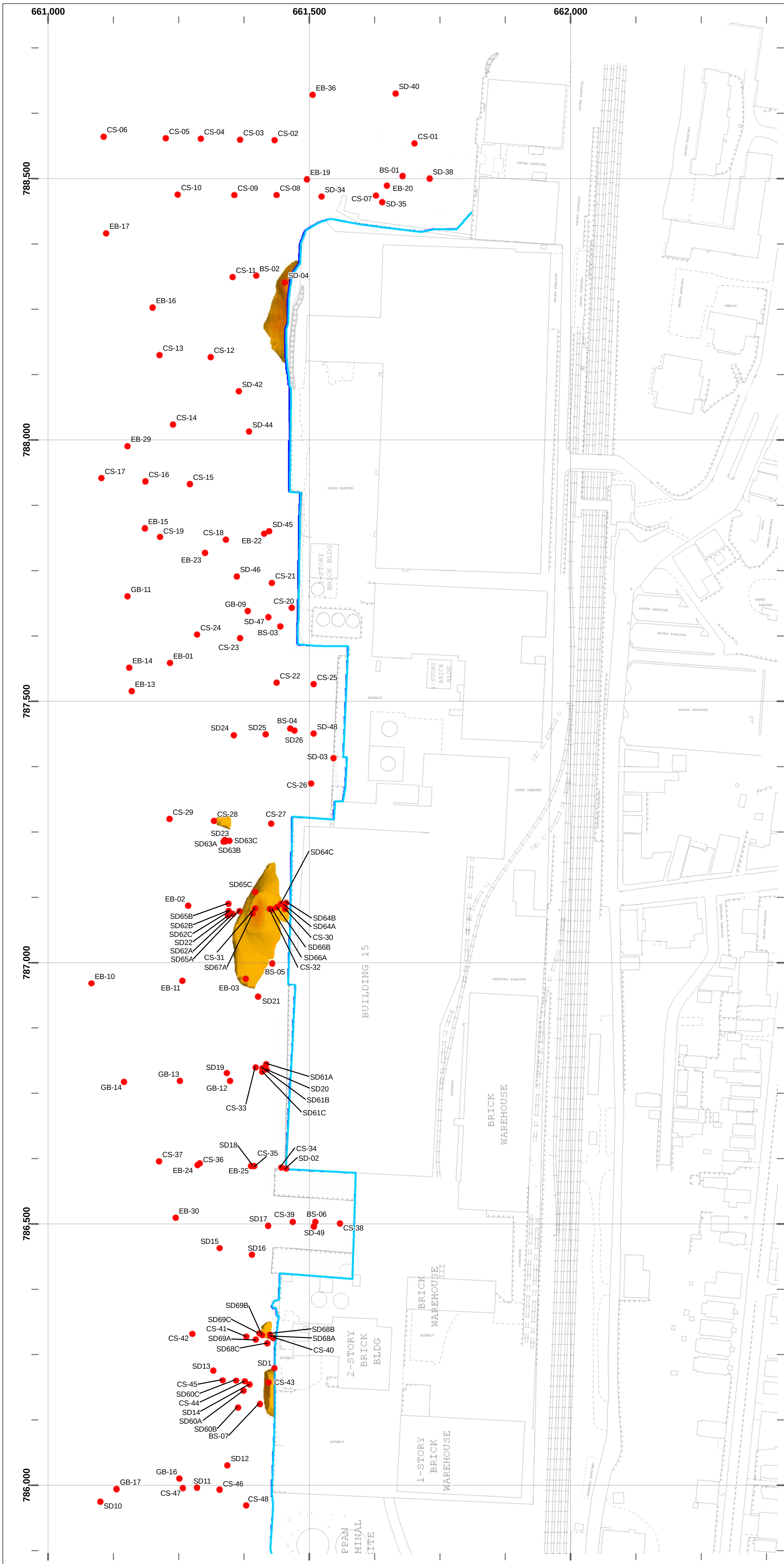
AVS-SEM SAMPLE LOCATIONS

(South of the South Boat Slip)
FORMER AWC PLANT SITE
OU-2
HASTINGS-ON-HUDSON, NEW YORK

F:\440552\GIS\MXD_FILES\FIGURE-C2.MXD 04-24-06

Figure C.3. SEM-AVS/foc for OU-2 Sediments





FORMER ANACONDA PLANT SITE
OPERABLE UNIT No. 2

Atlantic Richfield Company and
ARCO Environmental Remediation, LLC

Village of Hastings on Hudson
Westchester County, New York

N

Legend

- SHORELINE
- PILING LINE
- PILING
- COPPER SAMPLE LOCATIONS

Copper Concentration

982 mg/kg — 1,000 mg/kg

FIGURE C.4 SPATIAL DISTRIBUTION OF COPPER EXCEEDING PROPOSED ESB-BASED COPPER PRG OF 982 MG/KG(PPM)

0 90 180 270 360 450 540
Feet

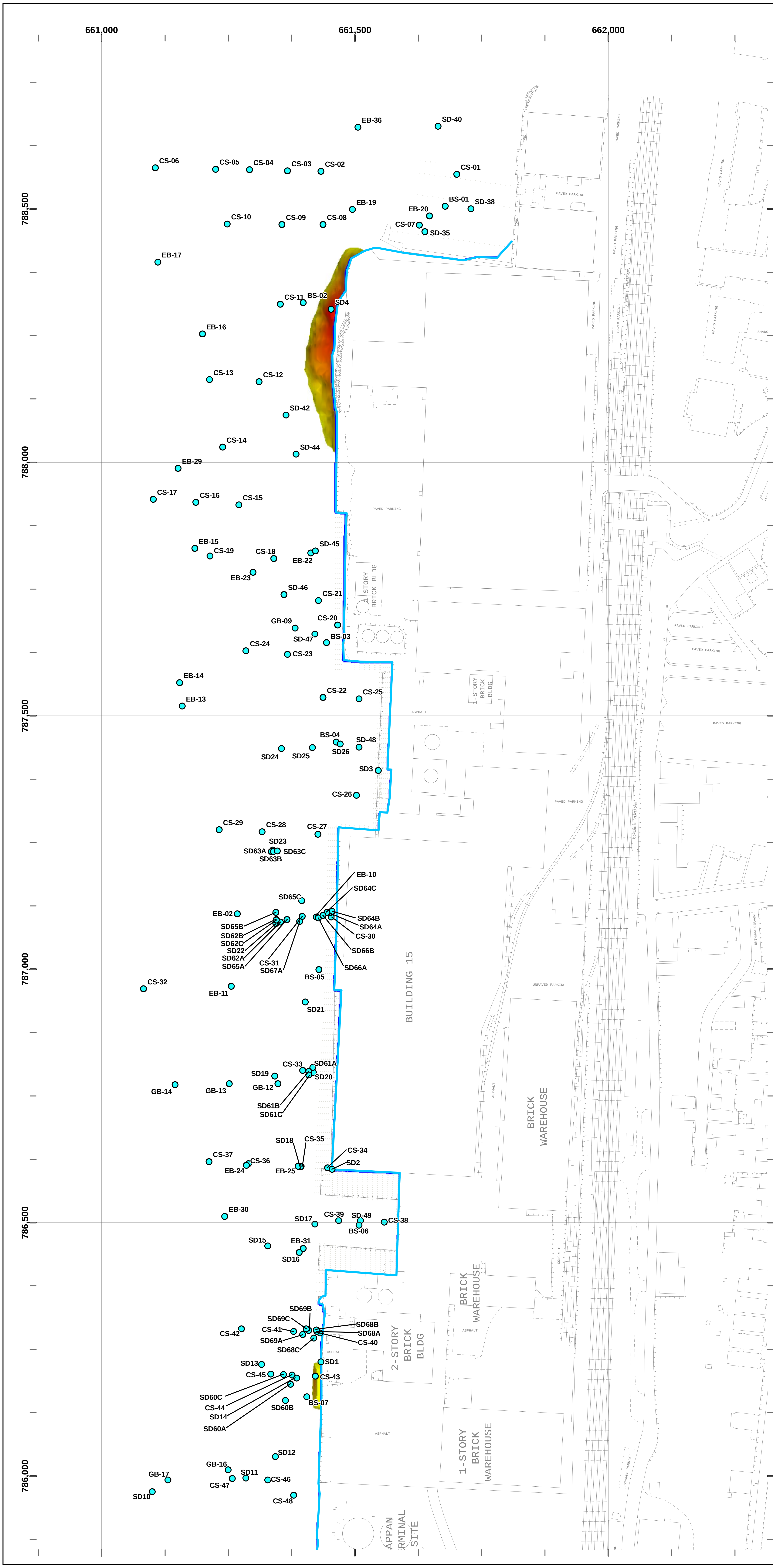
APRIL 7, 2006 rev. 2

ENVIRONMENTAL STANDARDS

FORMER ANACONDA PLANT SITE
OPERABLE UNIT No. 2

Atlantic Richfield Company and
ARCO Environmental Remediation, LLC

Village of Hastings on Hudson
Westchester County, New York



N

Legend

- Shoreline
- Piling Line
- Piling
- LEAD SAMPLE LOCATIONS

LEAD CONCENTRATION

1,000 mg/kg

379 mg/kg

FIGURE C.5 SPATIAL DISTRIBUTION OF LEAD EXCEEDING PROPOSED ESB-BASED LEAD PRG OF 379 MG/KG (PPM)

0 100 200 300 400 500 600

SCALE IN FEET

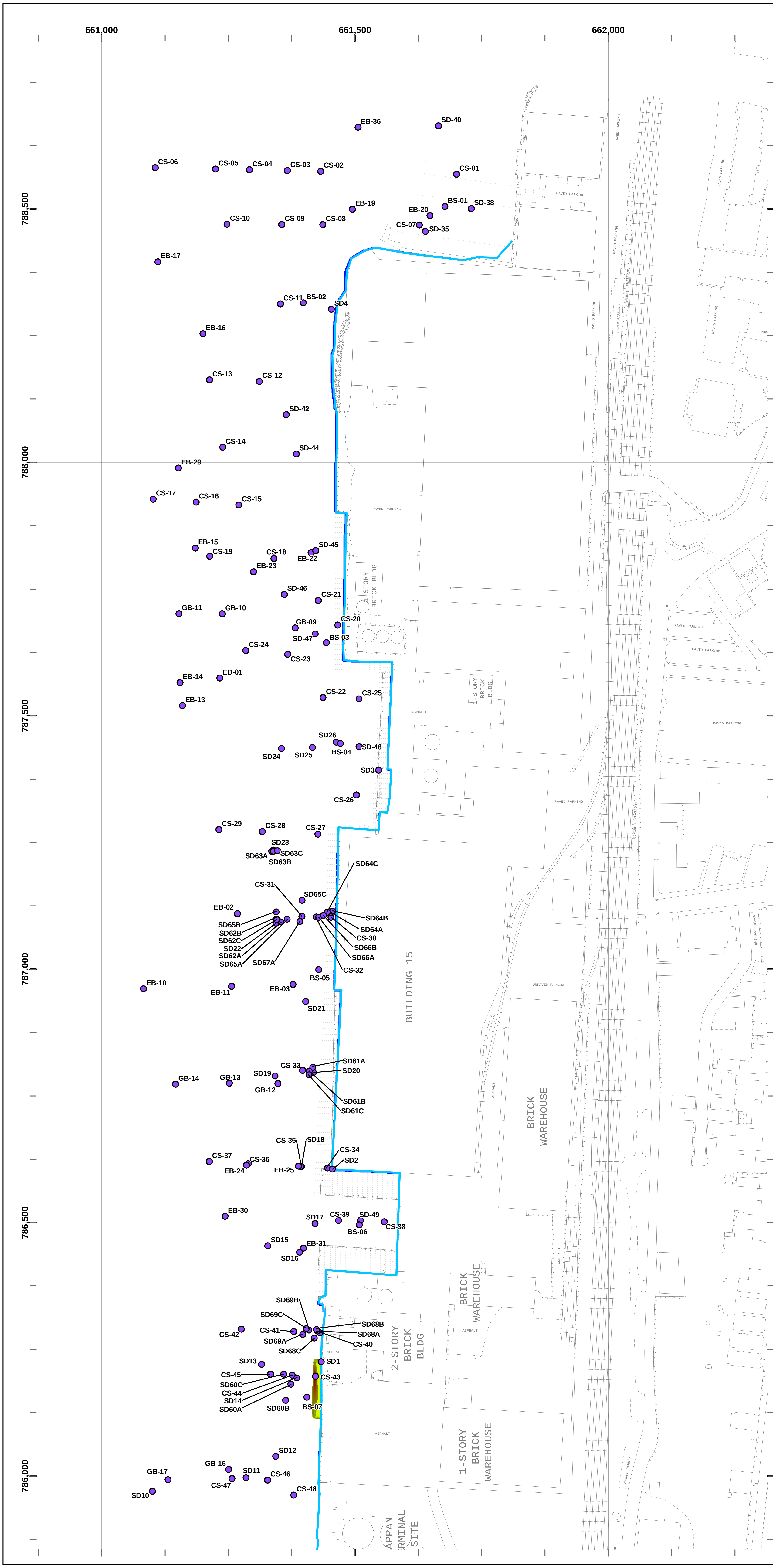
APRIL 7, 2006 rev.2

ENVIRONMENTAL STANDARDS

FORMER ANACONDA PLANT SITE
OPERABLE UNIT No. 2

Atlantic Richfield Company and
ARCO Environmental Remediation, LLC

Village of Hastings on Hudson
Westchester County, New York



Legend

Shoreline

Piling Line

Piling

NICKEL SAMPLE LOCATIONS

NICKEL CONCENTRATION

1,000 mg/kg

300 mg/kg

160 mg/kg

FIGURE C.6 SPATIAL DISTRIBUTION OF NICKEL EXCEEDING PROPOSED ESB-BASED NICKEL PRG OF 160 MG/KG(PPM)

0 100 200 300 400 500 600

SCALE IN FEET

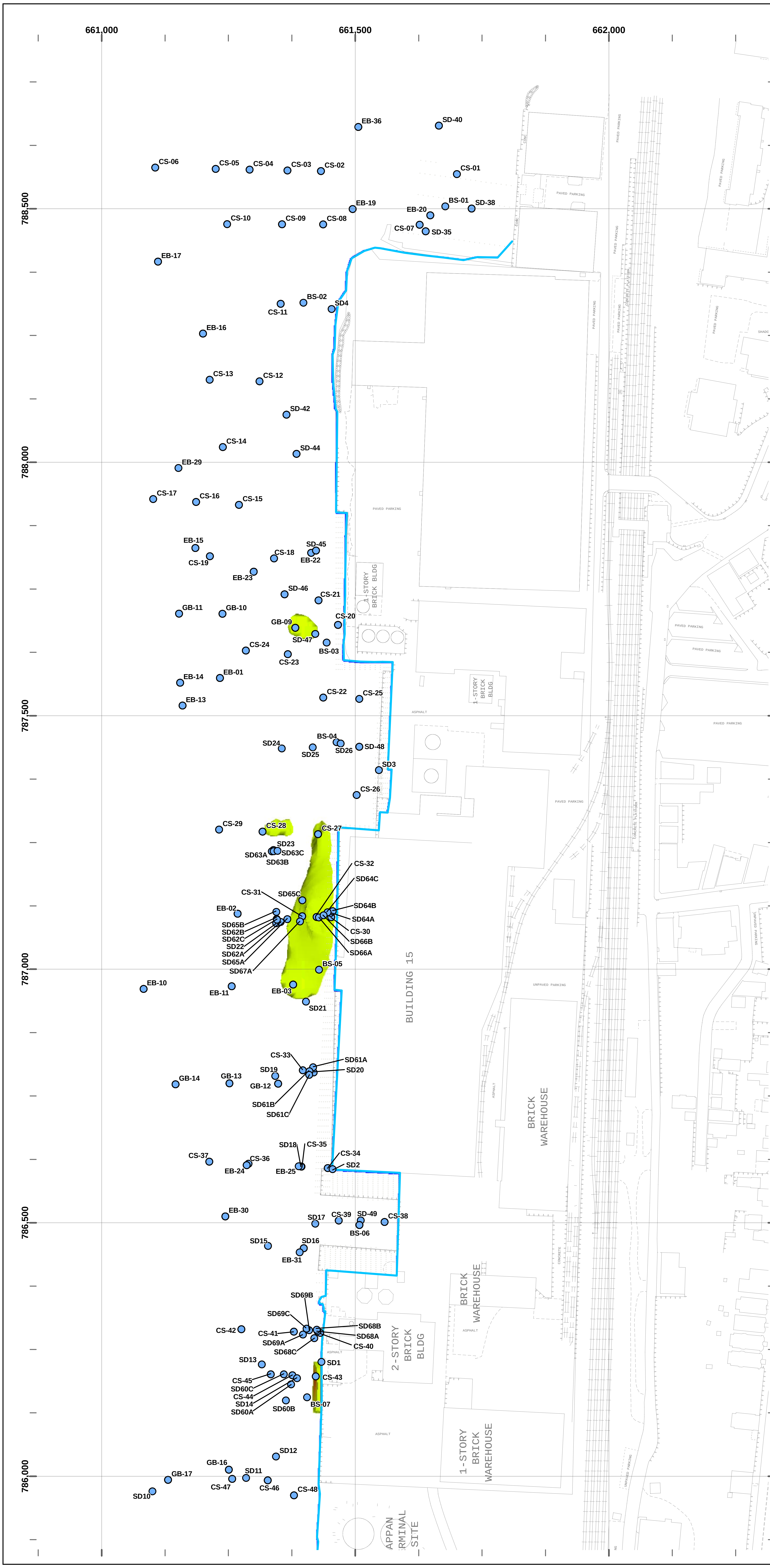
APRIL 7, 2006 rev. 2

ENVIRONMENTAL STANDARDS

FORMER ANACONDA PLANT SITE
OPERABLE UNIT No. 2

Atlantic Richfield Company and
ARCO Environmental Remediation, LLC

Village of Hastings on Hudson
Westchester County, New York



Legend

- Shoreline
- Piling Line
- Piling
- ZINC SAMPLE LOCATIONS

ZINC CONCENTRATION

3,000 mg/kg

1,050 mg/kg

FIGURE C.7 SPATIAL DISTRIBUTION OF ZINC EXCEEDING PROPOSED ESB-BASED ZINC PRG OF 1050 MG/KG(PPM)

0 100 200 300 400 500 600

SCALE IN FEET

APRIL 7, 2006 rev. 2

ENVIRONMENTAL STANDARDS

APPENDIX D

USE OF THE SEDIMENT QUALITY TRIAD ANALYSIS TO EVALUATE POTENTIAL TOXICITY OF METALS IN SEDIMENTS OF OU-2 TO BENTHIC ORGANISMS

PREPARED BY BLASLAND, BOUCK & LEE

MARCH 2006

TABLE OF CONTENTS

TABLE OF CONTENTS

APPENDIX D

USE OF THE SEDIMENT QUALITY TRIAD ANALYSIS TO EVALUATE POTENTIAL TOXICITY OF METALS IN SEDIMENTS OF OU-2 TO BENTHIC ORGANISMS

MARCH 2006

D1 INTRODUCTION

The Sediment Quality Triad Analysis uses three independent lines of evidence to evaluate the potential effects of chemicals of concern in sediments on benthic organisms. These lines of evidence are: 1) a comparison of concentrations of chemicals of concern in sediments against published benchmarks for those chemicals; 2) bioassays in which test organisms are exposed to bulk sediments from the site of interest and appropriate reference sites; and 3) benthic community surveys from locations at the site of interest and reference sites (Chapman 1996).

Each of these individual lines of evidence has strengths and weaknesses. As an example, published sediment benchmarks provide a convenient basis for screening-level evaluations of sediment chemistry but these benchmarks often do not take into account site specific factors that can effect contaminant bioavailability and toxicity. In contrast, benthic community studies provide a direct measure of the site-specific status of the benthic community in the study area, but may respond to many factors unrelated to chemicals of concern in sediments for the site in question, including temperature, redox potential, grain size, organic carbon content, and ammonia. Bioassays provide information on the relative toxicity of sediment samples but, as with benthic community surveys, the results of bioassays can be affected by many factors independent of chemicals of concern. The underlying assumption of the Sediment Quality Triad Analysis is that these lines of evidence with differing strengths and weaknesses, can in combination, provide more insight into causal factors resulting in sediment toxicity.

The 2003 Feasibility Study (FS) for OU-2 considered two sediment benchmarks when evaluating potential remedial action goals, the ER-L and ER-M (Earth Tech, 2003). These benchmarks are based on concentrations of metals in bulk sediments (Long et al., 1995). However, the recently released *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites* (USEPA 2005a, Page 2-6) makes it clear that:

> "Concentrations of bulk (total dry weight basis) metals in sediment alone are typically not good measures of metal toxicity. However, in addition to direct measurement of toxicity, EPA has developed a recommended approach for estimating metal toxicity based on the bioavailable metal fraction, which can be measured in pore water and/or predicted based on the relative sediment concentrations of acid volatile sulfide (AVS), simultaneously extracted metals (SEM), and total organic carbon (TOC) (U.S. EPA 2005c). Both AVS and TOC are capable of sequestering and immobilizing a range of metals in sediment."

Therefore, AR has used the USEPA's recommended methods in the sediment benchmark component of this triad analysis. These methods are described in the USEPA's *Procedures for Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: Metal Mixture (Cadmium, Copper, Lead, Nickel, Sliver, and Zinc)* (USEPA, 2005b). The ESB Guidance provides a rigorous methodology for assessing the factors that limit the bioavailability and toxicity of metals. The ESB Guidance recognizes the importance of AVS and organic carbon in sequestering metals in sediments thereby limiting their introduction into porewater, which is the primary route of exposure for benthic organisms (USEPA, 2005b). The ESB Guidance establishes the scientific basis for evaluating the bioavailability and toxicity of metals in sediments, and provides detailed methodology for quantitatively assessing the metal binding capacity of sediments.

The results of the ESB evaluation of the potential bioavailability and toxicity of metals in sediments of OU-2 are described in detail in Appendix C. These data were used in conjunction with bulk sediment toxicity tests and benthic community surveys presented in the Remedial Investigation (RI) (Earth Tech, 2000) in the Sediment Quality Triad Analysis. The results of each line of evidence are first discussed independently and then reviewed in combination as part of the triad analysis.

D2 SEDIMENT BIOASSAY RESULTS

The bulk sediment bioassays were conducted on sediments collected from seven stations within OU-2 and from two reference sites located beyond the influence of the Site. One reference site was located along the western shore of the Lower Hudson River across from the Site. The other reference site was located approximately 1.1 miles upstream of the Site along the eastern shore of the River. Sediment samples collected from these nine locations were used for both toxicity tests and benthic community characterization.

Sediment bioassays consisted of 10-day acute toxicity tests using the marine amphipod *Leptocheirus plumulosus* and 28-day chronic toxicity tests using the marine polychaete *Neanthes arenaceodentata*. Both the 10-day acute and 28-day chronic tests comprised five replicate tests each for OU-2 and reference sediments and ten replicates for laboratory control sediments. The 10-day acute toxicity test evaluates organism survival, and the 28-day chronic toxicity test evaluates both survival and growth. The results of these bioassays are summarized below in Table D.1.

TABLE D.1

ACUTE AND CHRONIC TOXICITY TEST RESULTS

Sample ID	10-Day Acute Mean Percent Survival	28-Day Chronic Mean Percent Survival	28-Day Chronic Mean Growth Rate (mg/day)
Control	97	98	0.09
BS-8 Reference	90	52[a]	0.03[b]
BS-9 Reference	94	84	0.03[b]
BS-1	93	100	0.04
BS-2	93	84	0.03
BS-3	94	92	0.03
BS-4	98	96	0.04
BS-5	87[a]	88	0.03
BS-6	97	72	0.03
BS-7	95	64[a]	0.02

a. Statistically significant decrease in survival as compared to control sediments.
b. Statistically significant difference in growth weight as compared to control sediments.

In the 10-day acute toxicity test, no statistically significant differences in survival were observed when results for OU-2 sediments were compared to reference site sediments. In the 28-day chronic toxicity test, no statistically significant difference in survival or growth was observed when results for OU-2 sediments were compared to reference site sediments.

The only statistically significant differences observed for the OU-2 toxicity tests were based on comparisons with laboratory control sediments. In the 10-day acute toxicity test, survival was significantly reduced in one sample (BS-5) as compared to controls. In the 28-day chronic toxicity test, survival was significantly reduced in one OU-2 sediment sample (BS-7) and in one reference site sample (BS-8) as compared to controls. In addition, mean growth rates were significantly lower in the two reference site samples as compared to controls.

It is important to note that observations of differences between laboratory control results and results from field collected samples should not be used or interpreted alone as evidence of toxicity. Laboratory control sediments do not provide an appropriate reference for sediments from the Lower Hudson River. Laboratory control sediments are not comparable to those of the Lower Hudson River in terms of grain size, organic carbon content, or contaminant chemicals unrelated to the Hastings Site. The purpose of the laboratory controls is not to judge site toxicity, but rather to establish test validity based on very stringent acceptability criteria which assume optimal exposure conditions for laboratory organisms (e.g., conditions which mimic the environment from which bioassay test organisms were collected). Determinations of toxicity should be based on comparisons to appropriate reference site results (e.g., Lower Hudson River reference sites), which reflect the same sediment characteristics as OU-2 but for site-related releases.

It is also important to consider the biological significance of any observation, regardless of whether it is statistically significant. For example, the USEPA (2005b) ESB Guidance considers samples with survival rates of 76 percent or greater to be non-toxic (see Page 3-5 and Figure 3-3, explaining that mortality rates greater than 24 percent are considered toxic, and thus survival rates greater than 76 percent are considered non-toxic). The acute survival result of 87 percent for BS-5 is well above the toxicity threshold and would thus be considered non-toxic according to methods employed in the ESB Guidance. This is completely consistent with the lack of any significant difference in toxicity between BS-5 and reference sites from the Lower Hudson River, which were located beyond the possible influence of the Harbor at Hastings Site.

D3 BENTHIC COMMUNITY SURVEY RESULTS

Samples for benthic community analyses were collected from the same stations used in the sediment bioassays. They included seven locations in OU-2 and two reference locations. Concentrations of metals and benthic community indices are summarized in Table D.2 for all nine sampling locations. The community indices data show a moderate degree of variability in species diversity and population density within OU-2 sediment and for the two reference site samples. The RI acknowledges that these parameters respond to many factors independent of site-related contaminants such as differences in substrate (Earth Tech, 2000, Section 6.2.6). It is thus important to distinguish metal-related variations in benthic community structure from variations due other factors.

TABLE D.2

SUMMARY OF METAL CONCENTRATIONS AND BENTHIC COMMUNITY INDICES

Station	Metal			Benthic Community Indices				
	Copper (mg/kg)	Lead (mg/kg)	Nickel (mg/kg)	Zinc (mg/kg)	Number of Species	Density (count/m^2)	Simpson's Index (unitless)	Shannon-Weiner Diversity Index (unitless)
BS-1	58.3 J	54.3	20.4	134	14	1,558	0.77	1.83
BS-2	108 J	105	33.3	217	10	884	0.72	1.56
BS-3	72.9 J	61.7	21.1	138	16	1,324	0.81	2.01
BS-4	61 J	57.7	21.0	156	11	1,166	0.71	1.45
BS-5	198 J	68.9	23.3	169	12	1,061	0.75	1.67
BS-6	71.2 J	63.7	22.4	148	19	2,600	0.82	1.98
BS-7	192 J	75.5	36.5	190	11	965	0.77	1.75
BS-8-ref	78.3 J	76.3	25.7	166	15	1,094	0.79	1.85
BS-9-ref	77.8 J	76.5	28.1	175	16	2,265	0.80	1.84

Variations in benthic community structure that are metal-related should show an exposure-related response in which the change in community structure increases with increasing metal concentrations. The results from the benthic community survey have been evaluated for potential exposure-response relationships using correlation analyses (Table D.3). No significant exposure-response relationships were found between copper, lead, nickel, or zinc concentrations in sediments and the Shannon-Weiner Diversity Index, Simpson's Index, the number of species, or the density of individual organisms over the seven OU-2 locations and two reference site locations. In the absence of any exposure-response trend, it is clear that these metals, including copper, are not significant factors in the observed variability in benthic community parameters among the nine sampling locations (seven within OU-2 and two reference locations).

TABLE D.3

STATISTICAL CORRELATIONS BETWEEN METAL CONCENTRATIONS AND BENTHIC COMMUNITY INDICES

Metal	Statistic	Number of Species	Density (count/m^2)	Simpson's Index (unitless)	Shannon-Weiner Diversity Index (unitless)
Copper	*p-value*	*0.18*	*0.22*	*0.57*	*0.54*
	R^2 value	0.25	0.21	0.05	0.06
Lead	*p-value*	*0.29*	*0.41*	*0.46*	*0.43*
	R^2 value	0.16	0.10	0.08	0.09
Nickel	*p-value*	*0.20*	*0.39*	*0.64*	*0.54*
	R^2 value	0.21	0.11	0.034	0.055
Zinc	*p-value*	*0.08*	*0.27*	*0.21*	*0.15*
	R^2 value	0.37	0.17	0.22	0.27

D4 ESB RESULTS

The results of the ESB studies are discussed in detail in Appendix C of this Supplemental Feasibility Study (Parsons, 2006). The data from the ESB studies demonstrated that simultaneously extracted metals (SEM) are fully bound by AVS and TOC and thus non toxic at 48 of 50 locations evaluated in OU-2. Based on these analyses, conservative site-specific ESB-based no observable adverse effects concentrations (NOAEC) were developed for copper, lead, nickel, and zinc (Table D.4). These NOAEC values represent the highest concentrations measured in bulk sediments for each metal that fall within the non-toxic range specified in the ESB Guidance. Moreover, they are several orders of magnitude below the regulatory threshold of toxicity specified in the ESB Guidance (USEPA, 2005b).

TABLE D.4

SUMMARY OF ESB-BASED NOAECs

Metal	Remedial Goal (mg/kg)
Copper	982
Lead	379
Nickel	160
Zinc	1,050

D5 INTEGRATION OF THE THREE LINES OF EVIDENCE

The ESB data, acute and chronic sediment bioassays, and the benthic community studies provide the three independent lines of evidence used in the Sediment Quality Triad Analysis

(Chapman, 1996). The strengths of these lines of evidence vary substantially. The acute and chronic bioassays and the benthic community survey provide no evidence of metal-related toxicity at the seven stations sampled in OU-2. However, these data are somewhat limited by the low concentrations of metals in sediments from the seven OU-2 stations sampled in these studies.

The PRGs presented in the 2003 OU-2 FS for copper, lead, nickel, and zinc are 88.7, 98.7, 37.3, and 260 mg/kg, respectively (Earth Tech, 2003). These PRGs represent estimates of maximum background concentrations for these metals in sediments of OU-2. Concentrations of copper exceeded the copper PRG in two of the seven stations from OU-2 with the highest concentration (192 mg/kg) about twice the PRG (Table D.2). Lead concentrations exceeded the lead PRG in one of seven stations and nickel and zinc were below their respective PRGs at all seven sampling locations (Earth Tech, 2003). Thus, although the bioassays and benthic community surveys show no evidence of toxicity, the concentrations of metals in these studies are at or only slightly above background.

The 50 locations sampled in the 2004 and 2005 supplemental investigations conducted by AR encompassed a much broader range of metal concentrations. These studies confirm that concentrations of metals used in the bioassays and benthic community surveys are not toxic. Moreover, they demonstrated that concentrations of metals as much an order of magnitude higher than those from the bioassays and benthic community surveys are not toxic to benthic organisms. The resulting site-specific ESB-based NOAECs (or PRGs) for copper, lead, nickel, and zinc are presented in Table D.4. These NOAEC values represent the highest concentrations measured in bulk sediments that fall within the non-toxic range specified in the USEPA ESB Guidance and are several orders of magnitude below the regulatory threshold for toxicity.

D.6.0 REFERENCES

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APPENDIX E

BASIS FOR COST ESTIMATES AND TASK DURATIONS FOR HARBOR AT HASTINGS OU-2

PREPARED BY PARSONS

APRIL 2006

TABLE OF CONTENTS

LIST OF TABLES

of remediation depend on many site variables, including quantity of contaminated sediments and debris, interaction of the remedial actions for OU-1 and OU-2, sediment handling procedures, labor and equipment costs, and the final project scope. As a result, the final project costs will vary from the estimates presented herein. These cost estimates are expected to be within the minus 30 percent to plus 50 percent range of accuracy that is typical for feasibility studies.

Table E.1 presents non-fixed and fixed costs. Non-fixed costs are costs that vary from one alternative to another. Fixed costs, presented at the end of Table E.1, are costs that would not vary from one alternative to another for a particular portion of OU-2. Fixed costs would be higher for Year 1 of construction when permitting, institutional controls, and site services would be established. Fixed costs for years following Year 1 of construction include costs to prepare to start up construction for that particular year. Based on the construction durations for the recommended remedial action alternatives presented in Sections 3, 5, 7, and 9 of this Supplemental FS, the Northwest Corner would take approximately one construction year to complete, the Southern Area and North Boat Slip could together be remediated within a single construction year, and the Old Marina and offshore could together be remediated within one construction year. The order in which these areas of OU-2 would be remediated can be determined at a later time. For this Supplemental FS, the total fixed costs of $5.0 million (i.e., $3.2 million + $0.9 million + $0.9 million from Table E.1) are assumed to be apportioned evenly (at $1.0 million each) amongst the Northwest Corner, Southern Area, North Boat Slip, Old Marina, and offshore.

E1.1 Conditions Common to All Dredging Alternatives

The costs presented in this report are based on the alternatives described in this Supplemental Feasibility Study Report. In order to prepare cost estimates that best reflect the differences between alternatives and are the most accurate relative costs, it is necessary to make a number of assumptions on the project scope. The key assumptions for construction costs that apply to all alternatives are listed below. Specific assumptions for each area and each alternative are given in subsequent sections.

- Construction costs include overhead and profit as part of the subcontractor and labor unit costs. Overhead and profit are assumed to be 30 percent of total construction costs (from USACE/USEPA, 2000).
- The labor rates are based on New York City area union wage rates and are adjusted to 2006 rates based on an annual inflation rate of 3 percent. Equipment rates are based on RS Means' standard cost estimating guide (Means, 2004) and experience with past dredging projects. Material costs are based (in order of preference) on personnel communications from local vendors, experience with past projects, or using Means costs adjusted for New York City using Means city cost indices.
- Construction production rates based on equipment rated capacity modified for work at OU-2. For cost estimating purposes only, production work is assumed to proceed at a pace of 50 hours per week.

E1.1.1 Dredging and Debris Removal

There is extensive debris and old timber pilings in the areas of OU-2 being evaluated for dredging. Mechanical dredging is therefore the only practical method for removing debris and sediment at OU-2. It is assumed that dredging and debris removal would be done with a barge-mounted crane and a clamshell bucket. A small bucket would not have the weight to penetrate into the debris and sediment, and a small crane would not have the lifting capacity to remove debris materials. Therefore, a bucket size of 6 cubic yards (cy), or larger, is assumed to be used. A loaded 6-cy bucket would weigh 20 to 25 tons. In order to safely lift a bucket this size at a radius of 60 ft, a 150-ton, or larger, crane would be needed. A typical dredge barge would be 150 ft long by 50 ft wide by 11 ft high and would have a water draft of 3 to 4 ft.

Dredged material would have to be loaded into hopper barges and transported to a sediment processing area. A typical hopper barge would be the same length but narrower than a dredge barge (150 ft long, 35 to 40 ft wide and 12 ft high). Each hopper barge would have a water draft of 2 to 4 ft empty, but would require 10 ft of water draft when loaded with a capacity of 1,000 to 1,500 tons (sediment and associated water).

Because of limited space available within these response areas, only one dredge will be able to be used at a time. The costs are based on using a combination of the following major equipment, which are typical for an environmental dredging project:

- Dredge barge with a 150-ton crane,
- Debris barge with a 150-ton crane,
- 1,500-ton capacity hopper barges,
- Deck barges,
- Tug boats,
- Long-stick excavator on land or on a fixed barge
- Crane with clamshell bucket on land or on a fixed barge, and
- Front-end loaders on land.

E1.1.2 Dredged Material Unloading and Processing

Prior to starting dredging, fender piles and barge mooring structures are assumed to be installed in the southern portion of the site. It is expected that fender piles and mooring structures would be installed at the same time that a new shoreline bulkhead would be installed. The specific location for the unloading area would be selected during remedial design and would have to be coordinated with the OU-1 remediation work and upland site redevelopment.

The dredged material is assumed to be drained, dewatered as needed, sampled, stockpiled, and loaded for transport offsite by truck, rail or barge. For feasibility study cost estimating purposes, it is assumed that after pumping off “free” water overlying the dredged material, lime or cement could be added to the dredged material to reduce the free water content to the levels required to allow transport and disposal off-site. On recent projects in the southeastern New York and New Jersey area, cement has been mixed into dredged material in hopper barges prior to unloading. Given the limited upland area at this site, it is assumed that adding lime or cement would be the preferred method for removing enough water from sediment dredged from OU-2 to allow the sediment to be effectively transported offsite.

The loaded hopper barges would be moved to a temporary wharf at OU-1 for offloading and sediment preparation. It would most likely not be practical to unload the barges along the

APPENDIX E

BASIS FOR COST ESTIMATES AND TASK DURATIONS FOR HARBOR AT HASTINGS OU-2

Costs included in this Supplemental Feasibility Study Report for OU-2 at the Harbor at Hastings site include capital costs, the present worth costs for post-construction monitoring, and an allowance for cap repair.

E1 CAPITAL COSTS

Capital costs include the following:

- Estimated construction costs;
- Estimated design costs, which include pre-design sampling and analysis, as well as design submittals;
- Estimated construction oversight and quality control costs; and
- Contingency set at 25 percent of construction costs in accordance with recent USEPA cost estimating guidance (USEPA/USACE, 2000).

The cost tables presented in this appendix are organized as follows:

- Summary Cost Table – Table E.1 presents total net present worth costs for alternatives on a one page summary for each portion of OU-2. The table includes key cost input quantities (such as dredge volume, cap area, temporary rigid containment barrier length, shoreline bulkhead length, and volume percentages of TSCA and non-TSCA disposal) and costs for major work elements (placement of the temporary rigid containment barrier and shoreline bulkhead, dredging, capping, and dredged sediment processing). This table provides non-fixed costs for each alternative, at the bottom of the table the fixed costs for construction (with a duration of 1 to 3 years depending on alternatives selected) are provided and the net present value cost for post construction monitoring is shown as well. These costs apply sitewide. Cap repair is included as a net present value operation and maintenance (O&M) cost under the non-fixed costs for each alternative.
- Unit Costs Tables – Tables E.2 through E.5 provide unit costs used in this Supplemental FS to develop the detailed cost estimates. These unit costs are presented as costs for specialty subcontractors, labor, equipment, and materials, respectively.
- Cost Estimate Tables for Each Remedial Action Alternative – Tables E.11 through E.27 provide the cost estimates for each remedial action alternative based on the quantities discussed in this Supplemental FS Report. Cost percentages for engineering, administration, and contingency are taken from USEPA/USACE, 2000.

Cost estimates presented in this appendix have been prepared for the purpose of assisting in the evaluation of remedial action alternatives for OU-2. These cost estimates are based on quantities and unit costs available in late 2005 and early 2006 from various sources. Actual costs northwest shoreline, because: (a) the water is too shallow for loaded barges; (b) the new shoreline bulkhead would not have fender piles and energy adsorbing features to be protected from damage by the barges; (c) the weight of equipment and dredged material would decrease bulkhead stability; (d) there is limited room inside the containment; and (e) under some conceptual approaches, the upland ground surface along the bulkhead would be lowered during dredging.

On average, each barge would have capacity to hold all the dredged material from one to two days of dredging, which would be approximately 600 in-situ cubic yards (50 ft by 75 ft at the base by 4.5 ft high). Since the dredged material would be very soft and have low shear strength, each OU-1 stockpile area is assumed to be surrounded by temporary concrete blocks to contain the dredged material. A typical sequence for dredge operations could be as follows:

- Day 1 – Place material into a hopper barge. Concurrently with dredging, the debris barge would remove obstructions from the bottom or remove large debris from the hopper barge and load a deck barge.
- Day 2 – Pump water that separated from the sediment within the hopper barge to a water treatment plant and mix lime or cement into the dredged material using a long-stick excavator, and deliver a representative sample to a laboratory.
- Day 3 – Unload hopper barge and place dredged material into temporary stockpiles on land.
- Day 4 – Receive the sample results, designate dredged material, prepare manifests or shipping documents and arrange for transport.
- Day 5 – Load trucks, railcars, or barges for transport off site to a permitted facility.

For cost estimating purposes, dredging is assumed to be limited at OU-2 to 10 hours per day primarily due to Village Code requirements associated with night work (see Section 1.4). It is anticipated barges could be moved in and out of the containment area when the dredge is not operating.

E1.1.3 Dredging Rate

The average dredging rate depends on many factors, including the size of equipment and number of crew members.

Based on dredge production rates achieved at the Grasse River (2005), Fox River SMU 56/57, Cumberland Bay, GM Massena, Reynolds Massena, and other sites, it is assumed that the average dredge production rate would be 250 cubic yards per day. Peak daily dredge production rates are likely to be 500 cubic yards per day or greater during favorable dredging periods, but debris removal activities, weather restrictions, and equipment efficiency limitations will likely constrain the overall project dredge rate.

E1.1.4 Sealed Shoreline Bulkhead

Cost estimates presented herein for OU-2 do not include the costs for a new sealed shoreline bulkhead that is required as part of the OU-1 remediation. The costs for OU-2 include only the incremental, or added costs for the sealed shoreline bulkhead which would be required to allow dredging near the shoreline.

Based on the OU-1 FS cost estimate (Shaw and Haley & Aldrich, 2002), the shoreline bulkhead is assumed to consist of a single row of steel sheet piles 35 ft long with a weight of 24 pounds per square ft (such as WEZ 95 sheets), which gives a weight of 840 pounds of steel per ft of bulkhead length. The shoreline bulkhead would include a single horizontal steel whaler on the sheet piles and steel anchor rods connected to concrete "deadman" anchors installed about 100 to 150 ft inland of the bulkhead location. The OU-1 shoreline bulkhead would have sealed joints and cathodic protection.

For those alternatives where a stronger, more costly shoreline bulkhead is needed in order to dredge, the incremental costs are based on analyses prepared by Haley & Aldrich, as described in Appendix B. A stronger bulkhead would be needed under each of the OU-2 remedial action alternatives except SA-1 and BS-1.

The sealed shoreline bulkhead must sufficiently reinforce existing conditions and support new load requirements resulting from sediment remediation actives on the river side. To accommodate the OU-2 alternatives, portions of OU-1 need to be unloaded using light weight fill. The required lightweights fill volumes for each alternative were calculated and 50 percent of the costs ($75 per cubic yard includes subcontractor overhead and profit) were included under the sealed shoreline bulkhead category, it is assumed that the remaining 50 percent is a component of the OU-1 remedy.

E1.1.5 Temporary Rigid Containment Barrier

A temporary rigid containment barrier would most likely be required around the Northwest Corner dredging area. This temporary rigid containment barrier is assumed to consist of an Arbed "King-pile" or equivalent, which consists of pairs of 36-inch wide H-piles installed about 7.5 ft apart with steel sheet piles in between the H-piles (see Appendix B).

The material costs for the fabricated steel delivered to the site on barges is $1,400 per ton, or 70 cents per pound based on information provided in late 2005 by Skyline Steel. Costs estimated herein for installing a temporary rigid containment barrier are based on information from an experienced pile driving contractor and, for more general construction steps, on installation costs in the Means cost guide.

For alternatives NW-2 through NW-4, the temporary barrier is sized to resist the lateral load due to ice flows down the river in case the temporary barrier needs to remain in place over a winter season. More details on the conceptual analysis for the temporary barrier are presented in Appendix B.

E1.1.6 Temporary Dredged Material Processing

The cost estimates for OU-2 include costs for the temporary facilities required to process, stockpile and load dredged material; for debris processing and for water treatment. At this time, no design for these facilities has been performed. For cost estimating purposes, it is assumed that the following temporary facilities would be constructed within OU-1.

- Mooring dolphins, consisting of groups of three steel piles, would be required to provide secure moorage for the sediment and debris barges. Existing timber docks and bulkhead structures are not considered to be useable.

- No equipment or materials can be placed at OU-1 within 100 ft of the existing shoreline or new shoreline bulkhead. The cranes or excavators used to unload and transfer sediment and debris would have to be supported on stationary barges tied up to dolphin piles adjacent to the new bulkhead.
- The dredged materials are assumed to be transferred at OU-1 from the barges to trucks to stockpiles. Trucks within 100 ft of the shoreline would be restricted to existing pile-supported areas or to new pile-supported concrete slabs.
- Five stockpile areas are assumed to be needed for drained dredged material. Each stockpile area is assumed to be about 50 ft by 75 ft with temporary concrete block wall 6 ft high on three sides.
- A temporary shed-type structure is assumed to be placed over the stockpile area to reduce rainfall infiltration.
- The upland sediment and debris processing and stockpile area is assumed to be paved with asphalt to prevent contamination of existing concrete or soils. It is assumed that the paved area would be 90,000 square ft in area.
- Rainwater that falls within the processing area while OU-2 sediment is being stored would be collected in sumps, as needed, and pumped to a water treatment system prior to being discharged to the Hudson River.
- The cost for extending a rail spur onto the site is included in the costs for remediating OU-1 rather than in this estimate for OU-2.
- A water treatment system would treat water pumped out of the sediment barges and water collected from the processing area.

E1.2 Assumptions for Alternative Construction Cost Estimates

Northwest Corner

- The estimated dredge volumes are based on the sediment dredge volumes provided by ESI from its contaminant distribution model (see Appendix A) plus additional sediment volume based on an over-dredge allowance and dredging side slopes required for slope stability.
- It is assumed that the percentages of dredged sediment regulated under TSCA (50 ppm PCBs and above) and regulated under RCRA Subtitle D (less than 50 ppm PCBs) would vary depending on the alternative as follows:
  - For Alternative NW-1, all of the dredged sediment is assumed to be regulated under TSCA.
  - For Alternatives NW-2 and NW-4, 50 percent of the dredged sediment is assumed to be regulated under TSCA and the remaining 50 percent is assumed to be regulated under RCRA Subtitle D.
  - For Alternative NW-3, 25 percent of the dredged sediment is assumed to be regulated under TSCA and the remaining 75 percent is assumed to be regulated under RCRA Subtitle D.

– The nearest offsite TSCA facility with available capacity and rail access is in Wayne, Michigan. The nearest RCRA Subtitle D facility with rail access is the Pine Avenue facility in Niagara Falls, NY.

Sediment dredge volumes provided by ESI for the Northwest Corner remedial action alternatives and sediment dredge volumes added to account for over-dredging and transition slopes necessary during dredging are presented in Table E.6. As discussed in Appendix B, wick drains are needed in Alternative NW-3 to facilitate settling. The wick drain costs were included with the berm costs provided for Alternative NW-3.

Southern Area

- As for the Northwest Corner, estimated dredge volumes are based on sediment dredge volumes from model output provided by ESI, an over-dredge allowance, and additional dredge volume to provide stable slopes around the dredge area. It is assumed that the dredge slope would be five horizontal to one vertical along the bulkhead and three horizontal to one vertical on the river side of the dredge area based on the geotechnical analysis presented in Appendix B.
- All of the sediment to be dredged from the Southern Area is assumed for this cost estimate to be managed offsite. It is assumed that all of the dredged sediment would be regulated under RCRA Subtitle D. None of the sediment PCB concentrations measured in the Southern Area exceed 50 ppm.
- Sediment from the Southern Area containing less than 10 ppm PCBs could possibly be reused at OU-1. However, reuse of OU-2 sediment at OU-1 has not been included in these cost estimates.

Sediment dredge volumes provided by ESI for the Southern Area remedial action alternatives and the dredge volumes added to account for over-dredging and transition slopes necessary during dredging are presented in Table E.7. As discussed in Appendix B, wick drains are needed in Alternative SA-2, SA-3a and SA-3b to facilitate settling. The wick drain costs were included with the berm costs as appropriate.

North Boat Slip

- Like for the other portions of OU-2, estimated dredge volumes are based on the sediment dredge volumes provided by ESI from model output, an over-dredge allowance and additional dredge volume required to provide stable slopes around the dredge area. It is assumed that the dredge slope would be 5 horizontal to 1 vertical along the bulkhead.
- All of the sediment to be dredged from the North Boat Slip is assumed for this cost estimate to be managed offsite. Twenty-five percent of the dredged sediment is assumed to be regulated under TSCA and the remaining 75 percent is assumed to be regulated under RCRA Subtitle D.

Sediment dredge volumes provided by ESI for the North Boat Slip remedial action alternatives and the dredge volumes added to account for over-dredging and transition slopes necessary during dredging are presented in Table E.8.

Old Marina

- Estimated dredge volumes are based on the sediment dredge volumes from model output provided by ESI, an over-dredge allowance, and additional dredge volume required to provide stable slopes around the dredge area. It is assumed that the dredge slope would be 5 horizontal to 1 vertical along the shoreline and existing docks and 3 horizontal to 1 vertical on the river side of the dredge area.
- All of the dredged sediment is assumed for this cost estimate to be managed offsite and regulated under RCRA Subtitle D.
- Sediment from the Old Marina containing less than 10 ppm PCBs could possibly be reused at OU-1. However, reuse of OU-2 sediment at OU-1 has not been included in these cost estimates.

Sediment dredge volumes provided by ESI for the Old Marina remedial action alternatives and the dredge volumes added to account for over-dredging and transition slopes necessary during dredging are presented in Table E.9.

E2 BASIS OF CONSTRUCTION DURATION ESTIMATES

E2.1 Shoreline Bulkhead

Construction durations estimated for installing the shoreline bulkhead and deadman anchor system are based on the Southwest Corner Bulkhead installed on the site as an interim remedial measure (IRM) in 2000. Table E.10 shows the estimated durations for installation of the new shoreline bulkhead. Sheet piles placed as part of the IRM bulkhead were 40 ft long.

The installation rate for steel sheet piles based on the Means Building cost reference is 120 liner ft per week. This compares to the production rates of 60 and 100 linear ft (lf) per week for the shoreline and interior walls, respectively, for constructing the IRM bulkhead. Therefore, use of the rates from the IRM bulkhead project appears to be reasonable and slightly less than average.

The length of piles for the Northwest Corner is estimated to vary from 40 to 60 ft along the existing shoreline. The estimated placement rate for the shoreline bulkhead is adjusted based on bulkhead characteristics presented in Appendix B.

With one crew, it would take approximately 35 weeks to install a new shoreline bulkhead and interior sheet pile wall along 800 ft of the Northwest Corner shoreline. For a project of this size, it is more likely that there would be a separate crew to install the whalers and anchors because that work could be done concurrently with pile driving. There is room on the site for two pile driving crews with one installing the sheets along the shoreline and the second working on the interior wall. However, for the evaluation of conceptual approaches, it is assumed that there would be one crew driving the sheet piles and a second crew to install the whalers and anchors and a third crew for sealing the joints and installing cathodic protection. Even with only one pile driving crew, the time to install the bulkhead is estimated to be 27 weeks.

E2.2 Temporary Rigid Containment Barrier

The estimated duration for installing the temporary rigid containment barrier is based on three items: (1) recent experience with a similar wall in Portsmouth, VA; (2) product estimating guides for steel H-piles; and (3) experience installing sheet piles in marine conditions. The analysis to date for the temporary rigid containment barrier includes installing pairs of H-piles or equivalent 7.5 ft apart with sheet piles in between. This type of barrier is called a "King-pile" system and the H-pile are also referred to as "king piles" (see Appendix B). In order to install the temporary barrier, a temporary steel truss supported by temporary vertical piles would be placed along the alignment to guide the H-piles and sheet piles (called a "template"). The temporary truss would typically be long enough to guide 5 to 9 pairs of piles.

At the Portsmouth project, Weeks Marine use a template that guided 8 H piles per set and the H piles were spaced 6 ft apart. They used one crew to set the template and install the H piles, then a second crew to install the sheet piles between the H piles. They set the template and installed 8 H piles per work day, or 240 linear ft (lf) per week. For the overall project, they installed 3,750 linear ft (lf) of barrier over a period of 5 months, which equals an average of about 170 lf per week.

For OU-2, it is estimated that the installation would take twice as long as the Portsmouth project because of the deeper water depths and higher current velocities. It is assumed that one crew could install 6 pairs of H-piles, which are spaced 8 ft apart, every 2 1/2 days, which is a production rate of 90 linear ft per week. The temporary rigid containment barrier for the alignment 140 ft from the shoreline is approximately 1,250 ft long based on the original alignment presented in the 2003 OU-2 FS Report. The estimated duration for installing the H-piles would be 14 weeks after mobilization and material delivery, with a 1 week lag for the sheet piles. The duration for installing the temporary rigid containment barrier would be approximately 15 weeks following mobilization and delivery of barrier materials.

E2.3 Dredging and Capping Durations

For OU-2, estimated remediation costs are based on an average dredging rate of 250 cy per 10-hour shift (see Section E.1).

The berm and cap in the river would also be placed using a clamshell with a 4- to 8-cy buckets. The production rate for placing berm fill placement would be similar to the rates for dredging without debris. Using a 6-cy bucket, the average placement rate would be 95-cy per hour, or 950-cy per day for one 10-hour shift. The production rate for placing cap material would be slower since each layer has to be placed separately and the layers are only 6 inches to 12 inches thick. For cap placement, the production rate was assumed to be 50 tons per hour.

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Hastings-on-Hudson OU-2
Remedial Action Alternative Cost Estimate Summary
Table E.1

		INPUTS								COSTS											
		Dredge Volume (cy)	Cap Area (ac)	Berm Volume (excluding portion that will be Cap) (cy)	Temporary Containment (ft)	Sealed Shoreline Bulkhead (ft)	Submerged Bulkhead (ft)	Offsite TSCA Disposal (%)	Offsite RCRA Disposal (%)	Submerged Bulkhead ($)	Temporary Containment ($)	Sealed Shoreline Bulkhead ($)	Dredging ($)	Capping (includes berm) ($)	Non-Construction Costs	Transport and Disposal ($)	O&M ($)	Contingency ($)	Total Non-fixed ($)	Estimated Total Capital Costs[1] ($)	Estimated Net Present Worth[2] ($)
	Northwest Corner																				
NW-1	Dredge for Cap Stability	5,900	2.3	2,600	0	900	980	100%	0%	4.8	0.0	2.1	4.6	1.1	2.5	2.0	0.5	4.0	21.5	21.9	23.0
NW-2a	Dredge to Limits of Bulkhead Stability (elev -9)	19,000	2.2	5,700	1,200	900	0	50%	50%	0.0	14.6	4.1	10.6	1.3	5.5	4.4	0.5	9.8	50.8	51.2	52.3
NW-2b	Dredge to Limits of Bulkhead Stability (elev -14)	27,000	2.3	6,200	1,200	900	0	50%	50%	0.0	14.6	4.1	14.2	1.3	6.1	6.3	0.5	11.3	58.4	58.8	59.9
NW-3	Redivide OU-1 and OU-2	18,000	1.2	26,000	1,200	1,060	0	25%	75%	0.0	14.6	7.2	10.2	2.9	6.2	3.2	0.5	10.7	55.6	56.0	57.1
NW-4	Penetrate Shoreline Bulkhead into Basal Sands	51,000	2.3	27,700	1,200	900	0	50%	50%	0.0	14.6	11.7	24.8	3.2	9.5	11.9	0.5	18.5	94.7	95.1	96.2
	Southern Area																				
SA-1	Place a Protective Cap	0	1.8	0	2,000	1,100	0	0%	100%	0.0	0.0	0.0	0.0	2.0	0.6	0.0	0.5	0.5	3.6	4.0	5.1
SA-2	Dredge 2 ft and Place Protective Cap	6,900	1.8	23,200	2,000	1,100	0	0%	100%	0.0	0.4	2.8	4.7	2.9	2.2	0.9	0.5	3.2	17.5	17.9	19.0
SA-3a	Dredge to Limit of Bulkhead Stability (elev -9)	8,300	1.8	24,200	2,000	1,100	0	0%	100%	0.0	0.4	3.2	5.3	3.0	2.3	1.0	0.5	3.5	19.3	19.7	20.8
SA-3b	Dredge to Limit of Bulkhead Stability (elev -14)	8,800	1.8	25,200	2,000	1,100	0	0%	100%	0.0	0.4	3.2	5.6	3.1	2.4	1.1	0.5	3.6	19.8	20.2	21.3
SA-4	Penetrate Shoreline Bulkhead into Basal Sands	16,000	1.8	26,200	2,000	1,100	0	0%	100%	0.0	0.4	8.7	8.7	2.9	3.8	2.0	0.5	6.3	33.4	33.8	34.9
	Boat Slips																				
NSLIP-1	Dredge 2 ft and Place Protective Cap	2,100	0.7	0	330	470	0	25%	75%	0.0	0.1	0.0	1.0	0.3	0.6	0.4	0.5	0.5	3.3	3.7	4.8
NSLIP-2	Dredge to Limit of Bulkhead Stability	8,400	0.7	11,700	330	470	0	25%	75%	0.0	0.1	1.4	3.8	0.9	1.4	1.5	0.5	2.0	11.6	12.0	13.1
	Old Marina																				
OM-1	Dredge 2 ft and Place Protective Cap	6,800	1.2	700	620	200	0	0%	100%	0.0	0.1	0.3	3.1	0.5	1.0	0.9	0.5	1.3	7.8	8.2	9.3
OM-2	Dredge to Limit of Bulkhead Stability	15,000	1.2	700	620	200	0	0%	100%	0.0	0.1	0.7	6.7	0.6	1.7	1.9	0.5	2.7	14.8	15.2	16.3
	Offshore																				
Offshore-1	Monitoring of Natural Recovery	0	0.0	0	0	0	0	0%	0%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	1.3	0.0	1.3
Offshore-2a	Cap PCBs > 1ppm and copper > 982 ppm off shore	0	5.8	0	0	0	0	0%	0%	0.0	0.0	0.0	0.0	2.3	0.6	0.0	0.5	0.6	4.1	4.5	5.6
Offshore-2b	Cap PRAP PCBs > 1ppm and copper > 982 ppm off shore	0	13.6	0	0	0	0	0%	0%	0.0	0.0	0.0	0.0	4.0	0.9	0.0	0.6	1.0	6.5	6.8	8.0
Offshore-2c	Cap PCBs > 1ppm and copper > 88.7 ppm off shore	0	11.3	0	0	0	0	0%	0%	0.0	0.0	0.0	0.0	3.5	0.8	0.0	0.6	0.9	5.8	6.1	7.3
	Fixed Costs Year 1																				
	institutional controls, site prep, utilities, other site services, water treatment, decon, dredge demonstration, bathymetric surveys																		3.2		
	Fixed Costs Year 2 and 3																				
	site prep, utilities, other site services, water treatment, decon, bathymetric surveys																		0.9		
	NPV of Post Construction Monitoring																				
	Assumes 30 years of post construction monitoring (annual cost sitewide of $160,000)																		2.5		

1. Assumes that construction costs from Years 1, 2, and 3 will be summed and evenly divided and distributed between 5 areas. O&M costs are not included.

2. Assumes that construction costs from Years 1, 2, and 3 will be summed and evenly divided and distributed between 5 areas. Both fixed and not-fixed O&M costs are included, the post construction monitoring cost has been divided and distributed evenly between the five areas for purposes of this calculation.

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Table E.2
Subcontractor Unit Costs

Item	Unit	Unit Cost ($)[1]	Reference
Cut/fill	CY	$ 12	Parsons
Unloading Piles and Dolphins	LS	$ 246,456	Means[2]/Parsons calc
Geomembrane	SF	$ 1	GSE, 3/13/06
Electrical Hookup	LS	$ 25,000	Parsons
Water Hookup	LS	$ 25,000	Parsons
Bathymetry Survey	LS	$ 20,000	CREnvironmental
TSS	EA	$ 7	CES, Syracuse
PCB Test	EA	$ 105	STL BP Contract Rate, 13 March 2006
PCB Test Air	EA	$ 200	Air Toxics, 13 March 2006
Asphalt Paving	SY	$ 6	Means
Asphalt Berms	LF	$ 2	Parsons
Debris Disposal	TN	$ 15	Parsons
Water Monitoring	MO	$ 6,000	FS[3]
Total Post-Construction Monitoring	YR	$ 123,516	FS
Dredging Demonstration Project	LS	$ 378,072	FS
T&D to TSCA	TN	$ 150	Parsons/Broker Estimate
T&D to RCRA	TN	$ 55	Parsons/Broker Estimate
Operate Solids Separation System	CY	$ 20	Parsons
Install Mooring Dolphins	LS	$ 364,266	H&A Containment Barrier Quantities Calc
Cut sheet piles at waterline	LF	$ 130	Pelligrino Marine
Sealed Shoreline Bulkhead Costs (By Alternative)			
NW-1			
Wall at Shoreline_NW-1	LS	$ 1,658,880	Quantities and unit costs by Parsons based on analysis and recommendations by H&A available upon request
Deduction[4] for OU-1 Bulkhead_NW-1	LS	$ (900,000)	Quantities by H&A, unit costs by Parsons available upon request
NW-2a			
Wall at Shoreline_NW-2a	LS	$ 1,684,800	Quantities and unit costs by Parsons based on analysis and recommendations by H&A available upon request
Additional Anchor System_NW-2a	LS	$ 400,000	Quantities by H&A, unit costs by Parsons available upon request
Additional Upland Excavation_NW-2a	LS	$ 540,000	Quantities by H&A, unit costs by Parsons available upon request
Additional Upland Mobilization_NW-2a	LS	$ 500,000	Quantities by H&A, unit costs by Parsons available upon request
Deduction for OU-1 Bulkhead_NW-2a	LS	$ (900,000)	Quantities by H&A, unit costs by Parsons available upon request
NW-2b			
Wall at Shoreline_NW-2b	LS	$ 1,684,800	Quantities and unit costs by Parsons based on analysis and recommendations by H&A available upon request
Additional Anchor System_NW-2b	LS	$ 400,000	Quantities by H&A, unit costs by Parsons available upon request
Additional Upland Excavation_NW-2b	LS	$ 540,000	Quantities by H&A, unit costs by Parsons available upon request
Additional Upland Mobilization_NW-2b	LS	$ 500,000	Quantities by H&A, unit costs by Parsons available upon request
Deduction for OU-1 Bulkhead_NW-2b	LS	$ (900,000)	Quantities by H&A, unit costs by Parsons available upon request
NW-3			
Wall at Shoreline_NW-3	LS	$ 2,289,600	Quantities and unit costs by Parsons based on analysis and recommendations by H&A available upon request
Interior Wall_NW-3	LS	$ 1,221,120	Quantities by H&A, unit costs by Parsons available upon request
Additional Anchor System_NW-3	LS	$ 400,000	Quantities by H&A, unit costs by Parsons available upon request

Table E.2
Subcontractor Unit Costs

Item	Unit	Unit Cost ($)[1]	Reference
Bracing_NW-3	LS	$ 500,000	Quantities by H&A, unit costs by Parsons available upon request
Additional Upland Excavation_NW-3	LS	$ 540,000	Quantities by H&A, unit costs by Parsons available upon request
Additional Upland Mobilization_NW-3	LS	$ 500,000	Quantities by H&A, unit costs by Parsons available upon request
Deduction for OU-1 Bulkhead_NW-3	LS	$ (1,060,000)	Quantities by H&A, unit costs by Parsons available upon request
NW-4			
Wall at Shoreline_NW-4	LS	$ 6,418,913	Quantities and unit costs by Parsons based on analysis and recommendations by H&A available upon request
Interior Wall_NW-4	LS	$ 737,100	Quantities by H&A, unit costs by Parsons available upon request
Additional Anchor System_NW-4	LS	$ 450,000	Quantities by H&A, unit costs by Parsons available upon request
Grouting bulkhead_NW-4	LS	$ 600,000	Quantities by H&A, unit costs by Parsons available upon request
Additional Upland Excavation_NW-4	LS	$ 400,000	Quantities by H&A, unit costs by Parsons available upon request
Additional Upland Mobilization_NW-4	LS	$ 300,000	Quantities by H&A, unit costs by Parsons available upon request
Deduction for OU-1 Bulkhead_NW-4	LS	$ (900,000)	Quantities by H&A, unit costs by Parsons available upon request
SA-1			
Wall at Shoreline	LS	$ 1,108,800	Quantities and unit costs by Parsons based on analysis and recommendations by H&A available upon request
Deduction for OU-1 Bulkhead	LS	$ (1,100,000)	Quantities by H&A, unit costs by Parsons available upon request
SA-2			
Wall at Shoreline	LS	$ 1,805,760	Quantities and unit costs by Parsons based on analysis and recommendations by H&A available upon request
Additional Anchor System	LS	$ 500,000	Quantities by H&A, unit costs by Parsons available upon request
Deduction for OU-1 Bulkhead	LS	$ (1,100,000)	Quantities by H&A, unit costs by Parsons available upon request
SA-3a			
Wall at Shoreline	LS	$ 1,805,760	Quantities and unit costs by Parsons based on analysis and recommendations by H&A available upon request
Additional Anchor System	LS	$ 500,000	Quantities by H&A, unit costs by Parsons available upon request
Deduction for OU-1 Bulkhead	LS	$ (1,100,000)	Quantities by H&A, unit costs by Parsons available upon request
SA-3b			
Wall at Shoreline	LS	$ 1,805,760	Quantities and unit costs by Parsons based on analysis and recommendations by H&A available upon request
Additional Anchor System	LS	$ 500,000	Quantities by H&A, unit costs by Parsons available upon request
Deduction for OU-1 Bulkhead	LS	$ (1,100,000)	Quantities by H&A, unit costs by Parsons available upon request
SA-4			
Wall at Shoreline	LS	$ 9,655,800	Quantities and unit costs by Parsons based on analysis and recommendations by H&A available upon request
Interior Wall	LS	$ 1,108,800	Quantities by H&A, unit costs by Parsons available upon request

Table E.2
Subcontractor Unit Costs

Item	Unit	Unit Cost ($)[1]	Reference
Additional Anchor System	LS	$ 1,000,000	Quantities by H&A, unit costs by Parsons available upon request
Grouting bulkhead	LS	$ 1,100,000	Quantities by H&A, unit costs by Parsons available upon request
Deduction for OU-1 Bulkhead	LS	$ (1,100,000)	Quantities by H&A, unit costs by Parsons available upon request
NSLIP-1			
Wall at Shoreline	LS	$ 473,760	Quantities and unit costs by Parsons based on analysis and recommendations by H&A available upon request
Deduction for OU-1 Bulkhead	LS	$ (470,000)	Quantities by H&A, unit costs by Parsons available upon request
NSLIP-2			
Wall at Shoreline	LS	$ 812,160	Quantities and unit costs by Parsons based on analysis and recommendations by H&A available upon request
Additional Anchor System	LS	$ 500,000	Quantities by H&A, unit costs by Parsons available upon request
Deduction for OU-1 Bulkhead	LS	$ (470,000)	Quantities by H&A, unit costs by Parsons available upon request
OM-1			
Wall at Shoreline	LS	$ 259,200	Quantities and unit costs by Parsons based on analysis and recommendations by H&A available upon request
OM-2			
Wall at Shoreline	LS	$ 316,800	Quantities and unit costs by Parsons based on analysis and recommendations by H&A available upon request
Additional Anchor System	LS	$ 200,000	Quantities by H&A, unit costs by Parsons available upon request
Lightweight Fill NW-1	LS	$ 850,000	Unit costs by H&A, Quantities by Parsons available upon request, costs split 50/50 with OU-1
Lightweight Fill NW-2a	LS	$ 850,000	
Lightweight Fill NW-2b	LS	$ 850,000	
Lightweight Fill NW-3	LS	$ 1,050,000	
Lightweight Fill NW-4	LS	$ 850,000	
Lightweight Fill SA-2	LS	$ 925,000	
Lightweight Fill SA-3a	LS	$ 1,200,000	
Lightweight Fill SA-3b	LS	$ 1,200,000	
Lightweight Fill SA-4	LS	$ 925,000	
Lightweight Fill NSlip-2	LS	$ 195,000	
Wick Drains NW-3	LS	$ 175,000	
Wick Drains SA-2	LS	$ 220,000	
Wick Drains SA-3a	LS	$ 220,000	
Wick Drains SA-3b	LS	$ 220,000	

NOTE: (1) All unit costs are 2006 cost for New York, NY. Cost include equipment rental and average operations expenses for fuel and routine maintenace. (2) "Means" costs reference is from RSMeans Building Construction Cost Data, 62nd Annual Addition. RSMeans Construction Publishers, Kingston, RI. 2004. Published average costs multiplied by 1.22 to convert to 2006 New York costs. (3) "FS" refers to March 2003 OU-2 Feasibility Study. (4) A deduction for the OU-1 Bulkhead was made in situations where the OU-1 Remedial Design required a portion of the Sealed Shoreline Bulkhead construction as part of the OU-1 design.

Table E.3
Labor Unit Costs

Item	Unit	Unit Cost[1]	Source
Institutional controls	LS	$ 151,229	FS[2]
Remedial Design	LS	$ 545,865	EPA Superfund Cost Estimating Guidance Document (6%)
Project Management	LS	$ 454,888	EPA Superfund Cost Estimating Guidance Document (5%)
Construction Management	LS	$ 545,865	EPA Superfund Cost Estimating Guidance Document (6%)
Construction Cost Contingency	LS	25%	FS
Foreman	HR	$ 75	1/06 Wage Determination[3]
Pile Driver	HR	$ 57	1/06 Wage Determination
Leverman	HR	$ 68	1/06 Wage Determination
Captain (Tug)	HR	$ 57	1/06 Wage Determination
Deckhand	HR	$ 50	1/06 Wage Determination
Surveyor	HR	$ 53	1/06 Wage Determination, Avg of COP and Rodman
Operator	HR	$ 68	1/06 Wage Determination
Laborer	HR	$ 49	1/06 Wage Determination, Shoreman
Mechanic	HR	$ 60	1/06 Wage Determination, Maintenance Engineer
Project Manager	HR	$ 134	Parsons
Superintendent	HR	$ 100	Parsons
Engineer	HR	$ 68	Parsons
Off-Hour Security	M-Yr	$ 120,000	FS
Certified Industrial Hygienest	HR	$ 98	Parsons
Industrial Hygiene Technician	HR	$ 33	Parsons
Clerk	HR	$ 13	Parsons
Per Diem	DY	$ 45	Parsons
Diver	HR	$ 80	Parsons

NOTE: (1) Labor costs based on a 50 hour work week. (2) "FS" refers to March 2003 OU-2 Feasibility Study. (3) NYS Wage Determination from Operating Engineer - Heavy & Highway - Marine Construction in Westchester County. Hourly unit cost is calculated as: Wages + Supplemental Benefits [both $ and %])'* factor for overtime: assumed OT wage is 1.3 times regular wage and convert to average hourly based on 10-hr days:'(1.3*2+8)/8 = (2 hrs at 1.3 * regular rate + 8 hours at regular rate) divided by 8 hrs to get avg 8-hr rate'* factor of 1.3 for taxes

Table E.4
Equipment Unit Costs

Item	Unit	Unit Cost[1]		Source
Install Work Lighting	EA	$	3,031	FS[3]
Skiff	HR	$	5	Allowance
150 Ton Crane Barge	HR	$	390	Means[2] 165 ton crane and 800 ton barge
250 Ton Crane	HR	$	500	Means 250 ton crane and 800 ton barge
Tender Tug	HR	$	174	Means 380 hp tug
Survey Boat	HR	$	210	March 2006 APEX quote
Booster Pump	HR	$	32	Godwin Pumps,Feb 2004 and $10 operation (OP)
Derrick Barge (Platform Barge)	HR	$	64	Means 800 ton barge
Hopper Barge	HR	$	84	Sevenson
Work Barge	HR	$	42	Means 400 ton barge
Long-stick excavator	HR	$	180	Means 2.5 cy crawler excavator
Front End Loader	HR	$	40	Hertz, Feb 2004 and $10 OP
Water Truck	HR	$	45	Means truck
Trailer	HR	$	3	Allowance
Pickup Truck	HR	$	5	Allowance
Turbidity Meter	HR	$	2	Enviro Equipment 03 Feb 2004
Diver Equipment	HR	$	100	Parsons
Forklift	HR	$	28	Parsons
Diesel Pile Driving Hammer	HR	$	210	Means 141,000 ft-lb hammer

NOTE: (1) All unit costs are 2006 cost for New York, NY. Cost include equipment rental and average operations expenses for fuel and routine maintenace. Published average costs multiplied by 1.22 to convert to 2006 New York costs.(2) "Means" costs reference is from RSMeans Building Construction Cost Data, 62nd Annual Addition. RSMeans Construction Publishers, Kingston, RI. 2004. (3) "FS" refers to March 2003 OU-2 Feasibility Study.

Table E.5
Material Unit Costs

Item[4]	Unit	Unit Cost[1]		Source
Silt Curtain	LF	$	132.00	Elastec Inc. and River Marine Supply.
Asphalt Pavement	SF	$	0.82	Means[2]
Building	SF	$	11.57	Means
Block Bin Walls	LS	$	26,400.00	Means
Gravel	TN	$	15.00	Parsons
Crushed Stone	TN	$	35.00	Parsons
Water Treatment Facility	LS	$	396,975.43	FS[3]
Lime	TN	$	102.84	Graymont
Fence	LF	$	28.00	Hudson FS
Contaminated Water Control Syste	LS	$	100,000.00	Parsons
Sand	TN	$	10.00	Parsons
Fuel	GA	$	2.00	Parsons
GPS Equipment	LS	$	40,000.00	Parsons
Hard Hats	EA	$	12.00	Parsons
Safety Glasses	EA	$	6.00	Parsons
Face Shields	EA	$	11.00	Parsons
Coveralls, Tyvek, Case of 25	EA	$	150.00	Parsons
Boot Covers, Tyvek, Bag of 10	EA	$	10.00	Parsons
Gloves, Latex, Box of 100	EA	$	15.00	Parsons
Gloves, PVC, Pack of 12	EA	$	12.00	Parsons
Misc. Pipe and Fittings	LS	$	500.00	Parsons
Riprap	TN	$	35.00	Parsons
Small Tools	day	$	100.00	Parsons
Arbed double	tn	$	1,400.00	Parsons

NOTE: (1) All unit costs are 2006 cost for New York, NY. Cost include equipment rental and average operations expenses for fuel and routine maintenace. Costs include deliery to site. Published average costs multiplied by 1.22 to convert to 2006 New York costs. (2) "Means" costs reference is from RSMeans Building Construction Cost Data, 62nd Annual Addition. RSMeans Construction Publishers, Kingston, RI. 2004. (3) "FS" refers to March 2003 OU-2 Feasibility Study. (4) Other material costs not shown have been acounted for under lump sum costs and subcontractor costs.

Table E.6 Dredge Volumes for the Northwest Corner Alternatives

Alternative	Sediment Dredge Volume Exceeding PRGs (cy)	Over-dredge Allowance (cy) for 1.0 ft	Side Slope Volume (cy)	Estimated Total Sediment Dredge Volume (cy)
NW-1	4,400	1,500	0	5,900
NW-2 Option A	13,000	3,600	2,000	19,000
NW-2 Option B	21,000	3,600	2,000	27,000
NW-3	15,000	2,000	1,000	18,000
NW-4	45,000	3,600	2,000	51,000

Table E.7 Dredge Volumes for the Southern Area Alternatives

Alternative	Sediment Dredge Volume Exceeding PRGs (cy)	Over-dredge Allowance (cy) for 1.0 ft	Side Slope Volume (cy)	Estimated Total Sediment Dredge Volume (cy)
SA-1	0	0	0	0
SA-2	3,200	3,700	0	6,900
SA-3a	4,600	3,700	0	8,300
SA-3b	5,100	3,700	0	8,800
SA-4	13,000	3,700	0	17,000

Table E.8 Dredge Volumes for the North Boat Slip Alternatives

Alternative	Sediment Dredge Volume Exceeding PRGs (cy)	Over-dredge Allowance (cy) for 1.0 ft	Side Slope Volume (cy)	Estimated Total Sediment Dredge Volume (cy)
NSLIP-1	890	1,200	0	2,100
NSLIP-2	7,200	1,200	0	8,400

Table E.9 Dredge Volumes for the Old Marina Alternatives

Alternative	Sediment Dredge Volume Exceeding PRGs (cy)	Over-dredge Allowance (cy) for 1.0 ft	Side Slope Volume (cy)	Estimated Total Sediment Dredge Volume (cy)
OM-1	2,800	3,800	200	6,800
OM-2	9,600	3,800	1,200	15,000

Table E.10 Estimated Shoreline Bulkhead Construction Duration (Lf Is Linear Ft)

Work Element	IRM Bulkhead Actual Construction Pace	Estimated Pace for Shoreline Bulkhead	Quantity for Shoreline Bulkhead	Estimated Duration (work weeks)
Install sheet pile	72 lf/week	60 lf/week	800 lf	13 weeks
Install anchor wall	110 lf/week	100 lf/week	800 lf	8 weeks
Install whalers and anchors	82 lf/week	80 lf/week	800 lf	10 weeks
Seal joints	165 lf/week	825 lf/week	800 lf	1 week
Cathodic protection	275 lf/week	275 lf/week	800 lf	3 weeks

Task	Qty	Unit	Cost					NPV	NPV	TOTAL	Not Fixed
			Labor	Equipment	Materials	Subcont	TOTAL	Factor		UNIT $	Total
Dredging Costs											
Mobilization and Site Preparation											
Mobilization	1	LS	452,469	462,505	0	0	914,973	1	914,973	914,973	914,973
Install/ Remove Fence	1,500	LF	0	0	55,545	0	55,545	1	55,545	37	0
Repair Road/ Work Area	10,000	SY	0	0	0	78,689	78,689	1	78,689	8	0
Install Work Lighting	10	EA	0	40,085	0	0	40,085	1	40,085	4,008	0
Unloading Piles and Dolphins	1	EA	0	0	0	325,938	325,938	1	325,938	325,938	0
Building over Stock Piles	1	LS	0	0	493,954	0	493,954	1	493,954	493,954	0
Asphalt Paving	90,000	SF	0	0	97,601	0	97,601	1	97,601	1	0
Demobilization	1	LS	452,469	462,505	0	0	914,973	1	914,973	914,973	914,973
Site Services and Health and Safety											
Electrical Power Hookup	1	LS	0	0	0	33,063	33,063	1	33,063	33,063	0
Water Line Hookup	1	LS	0	0	0	33,063	33,063	1	33,063	33,063	0
Contaminated Water Control System	1	LS	0	0	132,250	0	132,250	1	132,250	132,250	0
Decon Facility	1	LS	2,616	0	661	11,109	14,386	1	14,386	14,386	0
Health and Safety	2	MO	70,584	0	6,903	0	77,487	1	77,487	38,744	77,487
Solids Separation System											
Construct Process Area	1,500	LF	0	0	0	3,968	3,968	1	3,968	3	0
Solidification	5,900	CY	232,182	157,616	88,268	0	478,065	1	478,065	81	478,065
Water Treatment System											
Water Treatment Facility	1	LS	0	0	525,000	0	525,000	1	525,000	525,000	0
Dredging Costs											
Bathymetry Survey - Pre-Dredging	1	LS	0	0	0	26,450	26,450	1	26,450	26,450	0
Debris Removal	5,900	CY	599,392	414,170	15,606	46,817	1,075,984	1	1,075,984	182	1,075,984
Dredging	5,900	CY	340,960	425,874	74,748	0	841,582	1	841,582	143	841,582
Bathymetry Survey - Post Dredging	1	LS	0	0	0	26,450	26,450	1	26,450	26,450	0.0
Total Monitoring Costs											
PCB analysis on dewatered sediment	59.00	EA	17,594	0	0	8,193	25,787	1	25,787	437	25,787
Performance and discharge monitoring	34	Day	68,403	92,236	529	14,299	175,467	1	175,467	5,161	175,467
Environmental monitoring											
Air monitoring	1	LS	52,095	1,561	0	6,242	59,897	1	59,897	59,897	59,897
Water monitoring	1.0	MO	0	0	0	7,935	7,935	1	7,935	7,935	7,935
Total Dredging Direct Costs									**6,458,592**		**4,572,152**
Submerged Bulkhead											
Submerged Bulkhead	980	LF	672,920	938,946	2,531,616	650,228	4,793,711	1	**4,793,711**	4,892	**4,793,711**
Temporary Containment											
Temporary Containment Barrier	0	LF	0	0	0	0	0	1	0	na	0.0
Silt Curtain	0	LF	0	0	0	0	0	1	0	na	0.0
Total Temporary Containmen									**0**		**0**
Sealed Bulkhead											
Sealed Shoreline Bulkhead	900	LF	0	0	0	2,127,744	2,127,744	1	**2,127,744**	2,364	**2,127,743.8**
Capping Costs											
Cap Construction											
Erosion Protection Layer Gravel	2,041	CY	56,071	58,058	52,631	0	166,760	1	166,760	82	166,760
Erosion Protection Layer Sand	2,041	CY	56,071	58,058	35,088	0	149,216	1	149,216	73	149,216
Chemical Isolation Layer	4,082	CY	123,356	127,727	123,075	0	374,159	1	374,159	92	374,159
Berm	2,579	CY	30,278	31,351	155,168	0	216,798	1	216,798	84	216,798
Mixing Layer	1,855	CY	56,071	66,522	31,898	0	154,491	1	154,491	83	154,491
Total Capping Direct Costs									**1,061,424**		**1,061,424**
Markups on Capital Cost Estimate											
Engineering and Admin. Costs (5% of Capital Costs)											
Institutional Controls	1	LS	200,000	0	0	0	200,000	1	200,000	200,000	0
Remedial Design (6%)	1	LS	865,997	0	0	0	865,997	1	865,997	865,997	865,997
Project Management (5%)	1	LS	721,664	0	0	0	721,664	1	721,664	721,664	721,664
Construction Related Services (6%)	1	LS	865,997	0	0	0	865,997	1	865,997	865,997	865,997
Dredging Demonstration Project	1	LS	0	0	0	500,000	500,000	1	500,000	500,000	0
Total Markup Costs									**3,153,657**		**2,453,657**
Disposal Costs											
Off-site transport/disposal at TSCA haz waste landfill	10,178	TN	0	0	0	2,018,962	2,018,962	1	2,018,962	198	2,018,962
Off-site transport/disposal to RCRA Part 360 Solid Wast	0	TN	0	0	0	0	0	1	0	na	0
Total Disposal Costs									**2,018,962**		**2,018,962**
Monitoring and Maintenance	1	YR	84,354	94,639	55,830	0	234,823	1	234,823	234,823	
Post-Construction Inspection and Maintenance											
Cap Maintenance (every 5 yrs)	1	YR	84,354	94,639	55,830	0	234,823	2.16	506,277	506,277	506,277
Total Post-Construction Monitoring (for 30 yrs)	1	YR	0	0	0	163,350	163,350	12.41	2,027,010	2,027,010	0
Total Monitoring and Maintenance									**2,533,287**		**506,277**
Contingency											
Construction Contingency Costs (25% of Capital Costs)	1	LS	5,001,017	0	0	0	5,001,017	1	5,001,017	5,001,017	3,959,271
Total Cost			11,022,560	3,431,851	4,476,369	6,082,497	25,013,278		27,148,393		21,493,197
											TOTAL
								check:	27,148,393		21,493,197

Hastings-on-Hudson OU-2
Cost Estimate Summary for Alternative NW-2a
Table E.12

Task	Qty	Unit			Cost			NPV	NPV	TOTAL	Not Fixed
			Labor	Equipment	Materials	Subcont	TOTAL	Factor		UNIT $	Total
Dredging Costs											
Mobilization and Site Preparation											
Mobilization	1	LS	481,460	568,728	0	0	1,050,188	1	1,050,188	1,050,188	1,050,188
Install/ Remove Fence	1,500	LF	0	0	55,545	0	55,545	1	55,545	37	0
Repair Road/ Work Area	10,000	SY	0	0	0	78,689	78,689	1	78,689	8	0
Install Work Lighting	10	EA	0	40,085	0	0	40,085	1	40,085	4,008	0
Unloading Piles and Dolphins	1	LS	0	0	0	325,938	325,938	1	325,938	325,938	0
Building over Stock Piles	1	LS	0	0	493,954	0	493,954	1	493,954	493,954	0
Asphalt Paving	90,000	SF	0	0	97,601	0	97,601	1	97,601	1	0
Demobilization	1	LS	481,460	568,728	0	0	1,050,188	1	1,050,188	1,050,188	1,050,188
Site Services and Health and Safety											
Electrical Power Hookup	1	LS	0	0	0	33,063	33,063	1	33,063	33,063	0
Water Line Hookup	1	LS	0	0	0	33,063	33,063	1	33,063	33,063	0
Contaminated Water Control System	1	LS	0	0	132,250	0	132,250	1	132,250	132,250	0
Decon Facility	1	LS	2,616	0	661	11,109	14,386	1	14,386	14,386	0
Health and Safety	4	MO	180,513	0	13,807	0	194,320	1	194,320	48,580	194,320
Solids Separation System											
Construct Process Area	1,500	LF	0	0	0	3,968	3,968	1	3,968	3	0
Solidification	19,000	CY	747,703	507,576	284,252	0	1,539,531	1	1,539,531	81	1,539,531
Water Treatment System											
Water Treatment Facility	1	LS	0	0	525,000	0	525,000	1	525,000	525,000	0
Dredging											
Bathymetry Survey - Pre-Dredging	1	LS	0	0	0	26,450	26,450	1	26,450	26,450	0
Debris Removal	19,000	CY	1,928,099	1,333,768	50,255	150,765	3,462,886	1	3,462,886	182	3,462,886
Dredging	19,000	CY	1,096,291	1,371,459	123,257	0	2,591,007	1	2,591,007	136	2,591,007
Bathymetry Survey - Post Dredging	1	LS	0	0	0	26,450	26,450	1	26,450	26,450	0.0
Total Monitoring Costs											
PCB analysis on dewatered sediment	190.00	EA	56,542	0	0	26,384	82,926	1	82,926	436	82,926
Performance and discharge monitoring	86	Days	171,220	240,300	529	29,635	441,684	1	441,684	5,136	441,684
Environmental monitoring											
Air monitoring	1	LS	167,762	5,026	0	20,102	192,890	1	192,890	192,890	192,890
Water monitoring	3	MO	0	0	0	23,805	23,805	1	23,805	7,935	23,805
Total Dredging Direct Costs									**12,515,865**		**10,629,425**
Submerged Bulkhead											
Submerged Bulkhead	0	LF	0	0	0	0	0	1	0	na	0
Temporary Containment											
Temporary Containment Barrier	1,200	LF	1,388,396	2,488,099	9,891,401	796,198	14,564,093	1	14,564,093	12,137	14,564,093.3
Silt Curtain	0	LF	0	0	0	0	0	1	0	na	0.0
Total Temporary Containment									**14,564,093**		**14,564,093**
Sealed Bulkhead											
Sealed Shoreline Bulkhead	900	LF	0	0	0	4,066,423	4,066,423	1	4,066,423	4,518	**4,066,423**
Capping Costs											
Cap Construction											
Erosion Protection Layer Gravel	1,996	CY	56,071	58,058	51,482	0	165,611	1	165,611	83	165,611
Erosion Protection Layer Sand	1,996	CY	56,071	58,058	34,321	0	148,450	1	148,450	74	148,450
Chemical Isolation Layer	3,993	CY	112,142	116,116	121,543	0	349,800	1	349,800	88	349,800
Berm	5,741	CY	67,285	69,669	345,442	0	482,397	1	482,397	84	482,397
Mixing Layer	1,815	CY	56,071	66,522	31,201	0	153,794	1	153,794	85	153,794
Total Capping Direct Costs									**1,300,052**		**1,300,052**
Markups on Capital Cost Estimate											
Engineering and Admin. Costs (5% of Capital Costs)											
Institutional Controls	1	LS	200,000	0	0	0	200,000	1	200,000	200,000	0
Remedial Design (6%)	1	LS	1,945,203	0	0	0	1,945,203	1	1,945,203	1,945,203	1,945,203
Project Management (5%)	1	LS	1,621,002	0	0	0	1,621,002	1	1,621,002	1,621,002	1,621,002
Construction Related Services (6%)	1	LS	1,945,203	0	0	0	1,945,203	1	1,945,203	1,945,203	1,945,203
Dredging Demonstration Project	1	LS	0	0	0	500,000	500,000	1	500,000	500,000	0
Total Markup Costs									**6,211,408**		**5,511,408**
Disposal Costs											
Off-site transport/disposal at TSCA haz waste	16,388	TN	0	0	0	3,250,870	3,250,870	1	3,250,870	198	3,250,870
Off-site transport/disposal to RCRA Part 360	16,388	TN	0	0	0	1,191,986	1,191,986	1	1,191,986	73	1,191,986
Total Disposal Costs									**4,442,856**		**4,442,856**
Monitoring and Maintenance											
Post-Construction Inspection and Maintenance											
Cap Maintenance (every five years)	1	YR	84,331	94,611	55,769	0	234,711	2.16	506,036	506,036	506,036
Total Post-Construction Monitoring (for 30 ye	1	YR	0	0	0	163,350	163,350	12.41	2,027,010	2,027,010	0
Total Monitoring and Maintenance									**2,533,046**		**506,036**
Contingency											
Construction Contingency Costs (25% of Cap	1	LS	10,868,094	0	0	0	10,868,094	1	10,868,094	10,868,094	9,769,358
Total Cost			23,713,538	7,586,800	12,308,269	10,758,246	54,366,853		56,501,839		50,789,653

TOTAL
NOT FIXED

check: 56,501,839 50,789,653

Hastings-on-Hudson OU-2
Cost Estimate Summary for Alternative NW-2b
Table E.13

Task	Qty	Unit	Cost					NPV	NPV	TOTAL	Not Fixed
			Labor	Equipment	Materials	Subcont	TOTAL	Factor		UNIT $	Total
Dredging Costs											
Mobilization and Site Preparation											
Mobilization	1	LS	481,460	568,728	0	0	1,050,188	1	1,050,188	1,050,188	1,050,188
Install/ Remove Fence	1,500	LF	0	0	55,545	0	55,545	1	55,545	37	0
Repair Road/ Work Area	10,000	SY	0	0	0	78,689	78,689	1	78,689	8	0
Install Work Lighting	10	EA	0	40,085	0	0	40,085	1	40,085	4,008	0
Unloading Piles and Dolphins	1	LS	0	0	0	325,938	325,938	1	325,938	325,938	0
Building over Stock Piles	1	LS	0	0	493,954	0	493,954	1	493,954	493,954	0
Asphalt Paving	90,000	SF	0	0	97,601	0	97,601	1	97,601	1	0
Demobilization	1	LS	481,460	568,728	0	0	1,050,188	1	1,050,188	1,050,188	1,050,188
Site Services and Health and Safety											
Electrical Power Hookup	1	LS	0	0	0	33,063	33,063	1	33,063	33,063	0
Water Line Hookup	1	LS	0	0	0	33,063	33,063	1	33,063	33,063	0
Contaminated Water Control System	1	LS	0	0	132,250	0	132,250	1	132,250	132,250	0
Decon Facility	1	LS	2,616	0	661	11,109	14,386	1	14,386	14,386	0
Health and Safety	6	MO	244,770	0	20,710	0	265,480	1	265,480	44,247	265,480
Solids Separation System											
Construct Process Area	1,500	LF	0	0	0	3,968	3,968	1	3,968	3	0
Solidification	27,000	CY	1,062,526	721,292	403,938	0	2,187,755	1	2,187,755	81	2,187,755
Water Treatment System											
Water Treatment Facility	1	LS	0	0	525,000	0	525,000	1	525,000	525,000	0
Dredging											
Bathymetry Survey - Pre-Dredging	1	LS	0	0	0	26,450	26,450	1	26,450	26,450	0
Debris Removal	27,000	CY	2,739,930	1,895,354	71,415	214,245	4,920,944	1	4,920,944	182	4,920,944
Dredging	27,000	CY	1,557,887	1,948,915	152,881	0	3,659,684	1	3,659,684	136	3,659,684
Bathymetry Survey - Post Dredging	1	LS	0	0	0	26,450	26,450	1	26,450	26,450	0.0
Total Monitoring Costs											
PCB analysis on dewatered sediment	270.00	EA	80,350	0	0	37,493	117,843	1	117,843	436	117,843
Performance and discharge monitoring	118	DAY	234,009	330,721	529	39,072	604,331	1	604,331	5,121	604,331
Environmental monitoring											
Air monitoring	1	LS	238,399	7,142	0	28,566	274,107	1	274,107	274,107	274,107
Water monitoring	5	MO	0	0	0	39,675	39,675	1	39,675	7,935	39,675
Total Dredging Direct Costs									**16,056,634**		**14,170,194**
Submerged Bulkhead											
Submerged Bulkhead	0	LF	0	0	0	0	0	1	**0**	na	**0**
Temporary Containment											
Temporary Containment Barrier	1,200	LF	1,388,396	2,488,099	9,891,401	796,198	14,564,093	1	14,564,093	12,137	14,564,093.3
Silt Curtain	0	LF	0	0	0	0	0	1	0	na	0.0
Total Temporary Containment									**14,564,093**		**14,564,093**
Sealed Bulkhead											
Sealed Shoreline Bulkhead	900	LF	0	0	0	4,066,423	4,066,423	1	**4,066,423**	4,518	**4,066,423.0**
Capping Costs											
Cap Construction											
Erosion Protection Layer Gravel	1,997	CY	56,071	58,058	51,487	0	165,616	1	165,616	83	165,616
Erosion Protection Layer Sand	1,997	CY	56,071	58,058	34,325	0	148,454	1	148,454	74	148,454
Chemical Isolation Layer	3,993	CY	112,142	116,116	121,550	0	349,807	1	349,807	88	349,807
Berm	6,240	CY	74,014	76,636	375,484	0	526,134	1	526,134	84	526,134
Mixing Layer	1,815	CY	56,071	66,522	31,204	0	153,797	1	153,797	85	153,797
Total Capping Direct Costs									**1,343,809**		**1,343,809**
Markups on Capital Cost Estimate											
Engineering and Admin. Costs (5% of Capital Costs)											
Institutional Controls	1	LS	200,000	0	0	0	200,000	1	200,000	200,000	0
Remedial Design (6%)	1	LS	2,159,608	0	0	0	2,159,608	1	2,159,608	2,159,608	2,159,608
Project Management (5%)	1	LS	1,799,673	0	0	0	1,799,673	1	1,799,673	1,799,673	1,799,673
Construction Related Services (6%)	1	LS	2,159,608	0	0	0	2,159,608	1	2,159,608	2,159,608	2,159,608
Dredging Demonstration Project	1	LS	0	0	0	500,000	500,000	1	500,000	500,000	0
Total Markup Costs									**6,818,889**		**6,118,889**
Disposal Costs											
Off-site transport/disposal at TSCA haz waste	23,288	TN	0	0	0	4,619,658	4,619,658	1	4,619,658	198	4,619,658
Off-site transport/disposal to RCRA Part 360 S	23,288	TN	0	0	0	1,693,875	1,693,875	1	1,693,875	73	1,693,875
Total Disposal Costs									**6,313,532**		**6,313,532**
Monitoring and Maintenance											
Post-Construction Inspection and Maintenance											
Cap Maintenance (every five years)	1	YR	84,331	94,611	55,769	0	234,711	2.16	506,036	506,036	506,036
Total Post-Construction Monitoring (for 30 yea	1	YR	0	0	0	163,350	163,350	12.41	2,027,010	2,027,010	0
Total Monitoring and Maintenance									**2,533,046**		**506,036**
Contingency											
Construction Contingency Costs (25% of Capi	1	LS	12,380,987	0	0	0	12,380,987	1	**12,380,987**	12,380,987	**11,276,093**
Total Cost			27,650,380	9,039,063	12,515,703	12,737,282	61,942,428		64,077,414		58,359,070

TOTAL
NOT FIXED

check: 64,077,414 58,359,070

Hastings-on-Hudson OU-2
Cost Estimate Summary for Alternative NW-3
Table E.14

Task	Qty	Unit	Cost					NPV	NPV	TOTAL	Not Fixed
			Labor	Equipment	Materials	Subcont	TOTAL	Factor		UNIT $	Total
Dredging Costs											
Mobilization and Site Preparation											
Mobilization	1	LS	481,460	568,728	0	0	1,050,188	1	1,050,188	1,050,188	1,050,188
Install/ Remove Fence	1,500	LF	0	0	55,545	0	55,545	1	55,545	37	0
Repair Road/ Work Area	10,000	SY	0	0	0	78,689	78,689	1	78,689	8	0
Install Work Lighting	10	EA	0	40,085	0	0	40,085	1	40,085	4,008	0
Unloading Piles and Dolphins	1	EA	0	0	0	325,938	325,938	1	325,938	325,938	0
Building over Stock Piles	30,000	SF	0	0	493,954	0	493,954	1	493,954	16	0
Asphalt Paving	90,000	SF	0	0	97,601	0	97,601	1	97,601	1	0
Demobilization	1	LS	481,460	568,728	0	0	1,050,188	1	1,050,188	1,050,188	1,050,188
Site Services and Health and Safety											
Electrical Power Hookup	1	LS	0	0	0	33,063	33,063	1	33,063	33,063	0
Water Line Hookup	1	LS	0	0	0	33,063	33,063	1	33,063	33,063	0
Contaminated Water Control System	1	LS	0	0	132,250	0	132,250	1	132,250	132,250	0
Decon Facility	1	LS	2,616	0	661	11,109	14,386	1	14,386	14,386	0
Health and Safety	5	MO	206,413	0	17,259	0	223,672	1	223,672	44,734	223,672
Solids Separation System											
Construct Process Area	1,500	LF	0	0	0	3,968	3,968	1	3,968	3	0
Solidification	18,000	CY	708,350	480,861	269,292	0	1,458,503	1	1,458,503	81	1,458,503
Water Treatment System											
Water Treatment Facility	1	LS	0	0	525,000	0	525,000	1	525,000	525,000	0
Dredging											
Bathymetry Survey - Pre-Dredging	1	LS	0	0	0	26,450	26,450	1	26,450	26,450	0
Debris Removal	18,000	CY	1,826,620	1,263,569	47,610	142,830	3,280,629	1	3,280,629	182	3,280,629
Dredging	18,000	CY	1,038,592	1,299,277	119,554	0	2,457,423	1	2,457,423	137	2,457,423
Bathymetry Survey - Post Dredging	1	LS	0	0	0	26,450	26,450	1	26,450	26,450	0.0
Total Monitoring Costs											
PCB analysis on dewatered sediment	180.00	EA	53,567	0	0	24,995	78,562	1	78,562	436	78,562
Performance and discharge monitoring	78	DAY	153,764	217,889	0	25,400	397,053	1	397,053	5,090	397,053
Environmental monitoring											
Air monitoring	1	LS	158,933	4,761	0	19,044	182,738	1	182,738	182,738	182,738
Water monitoring	3	MO	0	0	0	23,805	23,805	1	23,805	7,935	23,805
Total Dredging Direct Costs									**12,089,200**		**10,202,760**
Submerged Bulkhead											
Submerged Bulkhead	0	LF	0	0	0	0	0	1	0	na	0
Temporary Containment											
Temporary Containment Barrier	1,200	LF	1,388,396	2,488,099	9,891,401	796,198	14,564,093	1	14,564,093	12,137	14,564,093.3
Silt Curtain	0	LF	0	0	0	0	0	1	0	na	0.0
Total Temporary Containment									**14,564,093**		**14,564,093**
Sealed Bulkhead											
Sealed Shoreline Bulkhead	1,060	LF	0	0	0	7,195,352	7,195,352	1	**7,195,352**	6,788	**7,195,352.2**
Capping Costs											
Cap Construction											
Erosion Protection Layer Gravel	1,100	CY	33,643	34,835	28,368	0	96,845	1	96,845	88	96,845
Erosion Protection Layer Sand	1,100	CY	33,643	34,835	18,912	0	87,389	1	87,389	79	87,389
Chemical Isolation Layer	2,200	CY	67,285	69,669	90,724	0	227,678	1	227,678	103	227,678
Berm and Wick Drains	26,000	CY	307,270	318,156	1,564,518	231,438	2,421,381	1	2,421,381	93	2,421,381
Backfill	1,000	CY	33,643	39,913	17,193	0	90,748	1	90,748	91	90,748
Total Capping Direct Costs									**2,924,042**		**2,924,042**
Markups on Capital Cost Estimate											
Engineering and Admin. Costs (5% of Capital Costs)											
Institutional Controls	1	LS	200,000	0	0	0	200,000	1	200,000	200,000	0
Remedial Design (6%)	1	LS	2,204,862	0	0	0	2,204,862	1	2,204,862	2,204,862	2,204,862
Project Management (5%)	1	LS	1,837,385	0	0	0	1,837,385	1	1,837,385	1,837,385	1,837,385
Construction Related Services (6%)	1	LS	2,204,862	0	0	0	2,204,862	1	2,204,862	2,204,862	2,204,862
Dredging Demonstration Project	1	LS	0	0	0	500,000	500,000	1	500,000	500,000	0
Total Markup Costs									**6,947,108**		**6,247,108**
Disposal Costs											
Off-site transport/disposal at TSCA haz waste	7,763	TN	0	0	0	1,539,886	1,539,886	1	1,539,886	198	1,539,886
Off-site transport/disposal to RCRA Part 360	23,288	TN	0	0	0	1,693,875	1,693,875	1	1,693,875	73	1,693,875
Total Disposal Costs									**3,233,760**		**3,233,760**
Monitoring and Maintenance											
Post-Construction Inspection and Maintenance											
Cap Maintenance (every five years)	1	YR	83,646	93,816	54,479	0	231,941	2.16	500,065	500,065	500,065
Total Post-Construction Monitoring (for 30 ye	1	YR	0	0	0	163,350	163,350	12.41	2,027,010	2,027,010	0
Total Monitoring and Maintenance									**2,527,075**		**500,065**
Contingency											
Construction Contingency Costs (25% of Cap	1	LS	11,830,963	0	0	0	11,830,963	1	**11,830,963**	11,830,963	**10,727,873**
Total Cost			25,337,371	7,523,220	13,424,317	12,894,901	59,179,809		61,311,593		55,595,054

		TOTAL NOT FIXED
check:	61,311,593	55,595,054

Hastings-on-Hudson OU-2
Cost Estimate Summary for Alternative NW-4
Table E.15

Task	Qty	Unit	Cost Labor	Equipment	Materials	Subcont	TOTAL	NPV Factor	NPV	TOTAL UNIT $	Not Fixed Total
Dredging Costs											
Mobilization and Site Preparation											
Mobilization	1	LS	481,460	568,728	0	0	1,050,188	1	1,050,188	1,050,188	1,050,188
Install/ Remove Fence	1,500	LF	0	0	55,545	0	55,545	1	55,545	37	0
Repair Road/ Work Area	10,000	SY	0	0	0	78,689	78,689	1	78,689	8	0
Install Work Lighting	10	EA	0	40,085	0	0	40,085	1	40,085	4,008	0
Unloading Piles and Dolphins	1	LS	0	0	0	325,938	325,938	1	325,938	325,938	0
Building over Stock Piles	1	LS	0	0	493,954	0	493,954	1	493,954	493,954	0
Asphalt Paving	90,000	SF	0	0	97,601	0	97,601	1	97,601	1	0
Demobilization	1	LS	481,460	568,728	0	0	1,050,188	1	1,050,188	1,050,188	1,050,188
Site Services and Health and Safety											
Electrical Power Hookup	1	LS	0	0	0	33,063	33,063	1	33,063	33,063	0
Water Line Hookup	1	LS	0	0	0	33,063	33,063	1	33,063	33,063	0
Contaminated Water Control System	1	LS	0	0	132,250	0	132,250	1	132,250	132,250	0
Decon Facility	1	LS	2,616	0	661	11,109	14,386	1	14,386	14,386	0
Health and Safety	11	MO	479,258	0	37,969	0	517,227	1	517,227	47,021	517,227
Solids Separation System											
Construct Process Area	1,500	LF	0	0	0	3,968	3,968	1	3,968	3	0
Solidification	51,000	CY	2,006,993	1,362,440	762,993	0	4,132,425	1	4,132,425	81	4,132,425
Water Treatment System											
Water Treatment Facility	1	LS	0	0	525,000	0	525,000	1	525,000	525,000	0
Dredging											
Bathymetry Survey - Pre-Dredging	1	LS	0	0	0	26,450	26,450	1	26,450	26,450	0
Debris Removal	51,000	CY	5,175,422	3,580,113	134,895	404,685	9,295,116	1	9,295,116	182	9,295,116
Dredging	51,000	CY	2,942,676	3,681,285	241,753	0	6,865,714	1	6,865,714	135	6,865,714
Bathymetry Survey - Post Dredging	1	LS	0	0	0	26,450	26,450	1	26,450	26,450	0.0
Total Monitoring Costs											
PCB analysis on dewatered sediment	510.00	EA	151,772	0	0	70,820	222,592	1	222,592	436	222,592
Performance and discharge monitoring	214	DAY	422,375	601,984	529	67,384	1,092,272	1	1,092,272	5,104	1,092,272
Environmental monitoring											
Air monitoring	1	LS	450,310	13,490	0	53,958	517,757	1	517,757	517,757	517,757
Water monitoring	9	MO	0	0	0	71,415	71,415	1	71,415	7,935	71,415
Total Dredging Direct Costs									**26,701,334**		**24,814,894**
Submerged Bulkhead											
Submerged Bulkhead	0	LF	0	0	0	0	0	1	0	na	0
Temporary Containment											
Temporary Containment Barrier	1,200	LF	1,388,396	2,488,099	9,891,401	796,198	14,564,093	1	14,564,093	12,137	14,564,093.3
Silt Curtain	0	LF	0	0	0	0	0	1	0	na	0.0
Total Temporary Containment									**14,564,093**		**14,564,093**
Sealed Bulkhead											
Sealed Shoreline Bulkhead	900	LF	0	0	0	11,712,077	11,712,077	1	**11,712,077**	13,013	**11,712,076.5**
Capping Costs											
Cap Construction											
Erosion Protection Layer Gravel	1,997	CY	56,071	58,058	51,487	0	165,616	1	165,616	83	165,616
Erosion Protection Layer Sand	1,997	CY	56,071	58,058	34,325	0	148,454	1	148,454	74	148,454
Chemical Isolation Layer	3,993	CY	112,142	116,116	121,550	0	349,807	1	349,807	88	349,807
Berm	27,740	CY	327,455	339,057	1,669,220	0	2,335,732	1	2,335,732	84	2,335,732
Mixing Layer	1,815	CY	56,071	66,522	31,204	0	153,797	1	153,797	85	153,797
Total Capping Direct Costs									**3,153,407**		**3,153,407**
Markups on Capital Cost Estimate											
Engineering and Admin. Costs (5% of Capital Costs)											
Institutional Controls	1	LS	200,000	0	0	0	200,000	1	200,000	200,000	0
Remedial Design (6%)	1	LS	3,363,605	0	0	0	3,363,605	1	3,363,605	3,363,605	3,363,605
Project Management (5%)	1	LS	2,803,005	0	0	0	2,803,005	1	2,803,005	2,803,005	2,803,005
Construction Related Services (6%)	1	LS	3,363,605	0	0	0	3,363,605	1	3,363,605	3,363,605	3,363,605
Dredging Demonstration Project	1	LS	0	0	0	500,000	500,000	1	500,000	500,000	0
Total Markup Costs									**10,230,215**		**9,530,215**
Disposal Costs											
Off-site transport/disposal at TSCA haz waste	43,988	TN	0	0	0	8,726,020	8,726,020	1	8,726,020	198	8,726,020
Off-site transport/disposal to RCRA Part 360	43,988	TN	0	0	0	3,199,541	3,199,541	1	3,199,541	73	3,199,541
Total Disposal Costs									**11,925,561**		**11,925,561**
Monitoring and Maintenance											
Post-Construction Inspection and Maintenance											
Cap Maintenance (every five years)	1	YR	84,331	94,611	55,769	0	234,711	2.16	506,036	506,036	506,036
Total Post-Construction Monitoring (for 30 ye	1	YR	0	0	0	163,350	163,350	12.41	2,027,010	2,027,010	0
Total Monitoring and Maintenance									**2,533,046**		**506,036**
Contingency											
Construction Contingency Costs (25% of Cap	1	LS	19,653,482	0	0	0	19,653,482	1	**19,653,482**	19,653,482	**18,531,598**
Total Cost			44,058,579	13,637,371	14,338,105	26,304,176	98,338,230		100,473,216		94,737,882
											TOTAL NOT FIXED
								check:	100,473,216		94,737,882

Hastings-on-Hudson OU-2
Cost Estimate Summary for Alternative SA-1
Table E.16

Task	Qty	Unit	Cost					NPV	NPV	TOTAL	Not Fixed
			Labor	Equipment	Materials	Subcont	TOTAL	Factor		UNIT $	Total
Dredging or Capping Costs (if no dredging)											
Mobilization and Site Preparation											
Mobilization	1	LS	279,341	222,709	0	0	502,050	1	502,050	502,050	502,050
Install/ Remove Fence	1,500	LF	0	0	55,545	0	55,545	1	55,545	37	0
Repair Road/ Work Area	10,000	SY	0	0	0	78,689	78,689	1	78,689	8	0
Install Work Lighting	10	EA	0	40,085	0	0	40,085	1	40,085	4,008	0
Unloading Piles and Dolphins	1	EA	0	0	0	325,938	325,938	1	325,938	325,938	0
Building over Stock Piles	30,000	SF	0	0	493,954	0	493,954	1	493,954	16	0
Asphalt Paving	90,000	SF	0	0	97,601	0	97,601	1	97,601	1	0
Demobilization	1	LS	279,341	222,709	0	0	502,050	1	502,050	502,050	502,050
Site Services and Health and Safety											
Electrical Power Hookup	1	LS	0	0	0	33,063	33,063	1	33,063	33,063	0
Water Line Hookup	1	LS	0	0	0	33,063	33,063	1	33,063	33,063	0
Contaminated Water Control System	1	LS	0	0	132,250	0	132,250	1	132,250	132,250	0
Decon Facility	1	LS	2,616	0	661	11,109	14,386	1	14,386	14,386	0
Health and Safety	1	MO	14,433	0	3,452	0	17,885	1	17,885	17,885	17,885
Solids Separation System											
Construct Process Area	1,500	LF	0	0	0	3,968	3,968	1	3,968	3	0
Solidification	0	CY	0	0	0	0	0	1	0	na	0
Water Treatment System											
Water Treatment Facility	0	LS	0	0	0	0	0	1	0	na	0
Dredging											
Bathymetry Survey - Pre-Cap	1	LS	0	0	0	26,450	26,450	1	26,450	26,450	0
Debris Removal	0	CY	0	0	0	0	0	1	0	na	0
Dredging	0	CY	0	0	0	0	0	1	0	na	0
Bathymetry Survey - Post Cap	1	LS	0	0	0	26,450	26,450	1	26,450	26,450	0.0
Total Monitoring Costs											
PCB analysis on dewatered sediment	0.00	EA	0	0	0	0	0	1	0	na	0
Performance and discharge monitoring	0	AC	0	0	0	0	0	1	0	na	0
Environmental monitoring											
Air monitoring	0	LS	0	0	0	0	0	1	0	na	0
Water monitoring	0	MO	0	0	0	0	0	1	0	na	0
Total Dredging or Capping Direct Costs									**2,383,424**		**1,021,984**
Submerged Bulkhead											
Submerged Bulkhead	0	LF	0	0	0	0	0	1	**0**	na	**0**
Temporary Containment											
Temporary Containment Barrier	0	LF	0	0	0	0	0	1	0	na	0.0
Silt Curtain	0	LF	0	0	0	0	0	1	0	na	0.0
Total Temporary Containment									**0**		**0**
Sealed Bulkhead											
Sealed Shoreline Bulkhead	1,100	LF	0	0	0	0	0	1	**0**	0	**0.0**
Capping Costs											
Cap Construction											
Debris Removal	73	HR	186,365	128,112	4,827	14,481	333,786	1	333,786	4,572	333,786
Erosion Protection Layer Gravel	1,597	CY	44,857	46,446	41,190	0	132,493	1	132,493	83	132,493
Erosion Protection Layer Sand	1,597	CY	44,857	46,446	27,460	0	118,763	1	118,763	74	118,763
Chemical Isolation Layer	3,194	CY	89,714	92,892	107,820	0	290,426	1	290,426	91	290,426
Berm	0	CY	0	0	0	0	0	1	0	na	0
Mixing Layer	1,452	CY	44,857	53,217	24,964	0	123,038	1	123,038	85	123,038
Total Capping Direct Costs									**998,505**		**998,505**
Markups on Capital Cost Estimate											
Engineering and Admin. Costs (5% of Capital Costs)											
Institutional Controls	1	LS	200,000	0	0	0	200,000	1	200,000	200,000	0
Remedial Design (6%)	1	LS	202,916	0	0	0	202,916	1	202,916	202,916	202,916
Project Management (5%)	1	LS	169,096	0	0	0	169,096	1	169,096	169,096	169,096
Construction Related Services (6%)	1	LS	202,916	0	0	0	202,916	1	202,916	202,916	202,916
Dredging Demonstration Project	1	LS	0	0	0	500,000	500,000	1	500,000	500,000	0
Total Markup Costs									**1,274,928**		**574,928**
Disposal Costs											
Off-site transport/disposal at TSCA haz waste	0	TN	0	0	0	0	0	1	0	na	0
Off-site transport/disposal to RCRA Part 360	0	TN	0	0	0	0	0	1	0	na	0
Total Disposal Costs									**0**		**0**
Monitoring and Maintenance											
Post-Construction Inspection and Maintenance											
Cap Maintenance (every five years)	1	YR	84,014	94,244	55,199	0	233,457	2.16	503,333	503,333	503,333
Total Post-Construction Monitoring (for 30 ye	1	YR	0	0	0	163,350	163,350	12.41	2,027,010	2,027,010	0
Total Monitoring and Maintenance									**2,530,343**		**503,333**
Contingency											
Construction Contingency Costs (25% of Cap	1	LS	1,263,416	0	0	0	1,263,416	1	**1,263,416**	1,263,416	**544,720**
Total Cost			3,108,739	946,861	1,044,921	1,216,560	6,317,081		8,450,617		**3,643,470**

		TOTAL NOT FIXED
check:	8,450,617	3,643,470

Hastings-on-Hudson OU-2
Cost Estimate Summary for Alternative SA-2
Table E.17

Task	Qty	Unit	Cost					NPV	NPV	TOTAL	Not Fixed
			Labor	Equipment	Materials	Subcont	TOTAL	Factor		UNIT $	Total
Dredging Costs											
Mobilization and Site Preparation											
Mobilization	1	LS	384,075	367,073	0	0	751,148	1	751,148	751,148	751,148
Install/ Remove Fence	1,500	LF	0	0	55,545	0	55,545	1	55,545	37	0
Repair Road/ Work Area	10,000	SY	0	0	0	78,689	78,689	1	78,689	8	0
Install Work Lighting	10	EA	0	40,085	0	0	40,085	1	40,085	4,008	0
Unloading Piles and Dolphins	1	EA	0	0	0	325,938	325,938	1	325,938	325,938	0
Building over Stock Piles	30,000	SF	0	0	493,954	0	493,954	1	493,954	16	0
Asphalt Paving	90,000	SF	0	0	97,601	0	97,601	1	97,601	1	0
Demobilization	1	LS	384,075	367,073	0	0	751,148	1	751,148	751,148	751,148
Site Services and Health and Safety											
Electrical Power Hookup	1	LS	0	0	0	33,063	33,063	1	33,063	33,063	0
Water Line Hookup	1	LS	0	0	0	33,063	33,063	1	33,063	33,063	0
Contaminated Water Control System	1	LS	0	0	132,250	0	132,250	1	132,250	132,250	0
Decon Facility	1	LS	2,616	0	661	11,109	14,386	1	14,386	14,386	0
Health and Safety	3	MO	117,244	0	10,355	0	127,599	1	127,599	42,533	127,599
Solids Separation System											
Construct Process Area	1,500	LF	0	0	0	3,968	3,968	1	3,968	3	0
Solidification	6,900	CY	271,534	184,330	103,228	0	559,093	1	559,093	81	559,093
Water Treatment System											
Water Treatment Facility	1	LS	0	0	525,000	0	525,000	1	525,000	525,000	0
Dredging											
Bathymetry Survey - Pre-Dredging	1	LS	0	0	0	26,450	26,450	1	26,450	26,450	0
Debris Removal	6,900	CY	700,871	484,368	18,251	54,752	1,258,241	1	1,258,241	182	1,258,241
Dredging	6,900	CY	398,660	498,056	78,451	0	975,167	1	975,167	141	975,167
Bathymetry Survey - Post Dredging	1	LS	0	0	0	26,450	26,450	1	26,450	26,450	0.0
Total Monitoring Costs											
PCB analysis on dewatered sediment	69.00	EA	20,570	0	0	9,582	30,151	1	30,151	437	30,151
Performance and discharge monitoring	6,900	CY	71,448	97,984	529	13,812	183,774	1	183,774	27	183,774
Environmental monitoring											
Air monitoring	1	LS	60,924	1,825	0	7,300	70,049	1	70,049	70,049	70,049
Water monitoring	1	MO	0	0	0	9,522	9,522	1	9,522	7,935	9,522
Total Dredging Direct Costs									**6,602,333**		**4,715,893**
Submerged Bulkhead											
Submerged Bulkhead	0	LF	0	0	0	0	0	1	0	na	0
Temporary Containment											
Temporary Containment Barrier	0	LF	0	0	0	0	0	1	0	na	0.0
Silt Curtain	2,000	LF	11,773	21,742	349,140	0	382,655	1	382,655	191	382,654.8
Total Temporary Containment									**382,655**		**382,655**
Sealed Bulkhead											
Sealed Shoreline Bulkhead	1,100	LF	0	0	0	2,817,930	2,817,930	1	**2,817,930**	2,562	**2,817,930.1**
Capping Costs											
Cap Construction											
Erosion Protection Layer Gravel	1,597	CY	44,857	46,446	41,190	0	132,493	1	132,493	83	132,493
Erosion Protection Layer Sand	1,597	CY	44,857	46,446	27,460	0	118,763	1	118,763	74	118,763
Chemical Isolation Layer	3,194	CY	89,714	92,892	107,820	0	290,426	1	290,426	91	290,426
Berm and Wick Drains	23,192	CY	273,627	283,322	1,395,550	290,950	2,243,449	1	2,243,449	97	2,243,449
Mixing Layer	1,452	CY	44,857	53,217	24,964	0	123,038	1	123,038	85	123,038
Total Capping Direct Costs									**2,908,168**		**2,908,168**
Markups on Capital Cost Estimate											
Engineering and Admin. Costs (5% of Capital Costs)											
Institutional Controls	1	LS	200,000	0	0	0	200,000	1	200,000	200,000	0
Remedial Design (6%)	1	LS	762,090	0	0	0	762,090	1	762,090	762,090	762,090
Project Management (5%)	1	LS	635,075	0	0	0	635,075	1	635,075	635,075	635,075
Construction Related Services (6%)	1	LS	762,090	0	0	0	762,090	1	762,090	762,090	762,090
Dredging Demonstration Project	1	LS	0	0	0	500,000	500,000	1	500,000	500,000	0
Total Markup Costs									**2,859,256**		**2,159,256**
Disposal Costs											
Off-site transport/disposal at TSCA haz waste	0	TN	0	0	0	0	0	1	0	na	0
Off-site transport/disposal to RCRA Part 360	11,903	TN	0	0	0	865,758	865,758	1	865,758	73	865,758
Total Disposal Costs									**865,758**		**865,758**
Monitoring and Maintenance											
Post-Construction Inspection and Maintenance											
Cap Maintenance (every five years)	1	YR	84,014	94,244	55,199	0	233,457	2.16	503,333	503,333	503,333
Total Post-Construction Monitoring (for 30 ye	1	YR	0	0	0	163,350	163,350	12.41	2,027,010	2,027,010	0
Total Monitoring and Maintenance									**2,530,343**		**503,333**
Contingency											
Construction Contingency Costs (25% of Cap	1	LS	4,205,831	0	0	0	4,205,831	1	**4,205,831**	4,205,831	**3,182,793**
Total Cost			9,570,804	2,679,105	3,517,146	5,271,684	21,038,738		23,172,274		17,535,786

TOTAL
NOT FIXED

check: 23,172,274 17,535,786

Hastings-on-Hudson OU-2
Cost Estimate Summary for Alternative SA-3a
Table E-18

Task	Qty	Unit	Cost					NPV	NPV	TOTAL	Not Fixed
			Labor	Equipment	Materials	Subcont	TOTAL	Factor		UNIT $	Total
Dredging Costs											
Mobilization and Site Preparation											
Mobilization	1	LS	384,075	367,073	0	0	751,148	1	751,148	751,148	751,148
Install/ Remove Fence	1,500	LF	0	0	55,545	0	55,545	1	55,545	37	0
Repair Road/ Work Area	10,000	SY	0	0	0	78,689	78,689	1	78,689	8	0
Install Work Lighting	10	EA	0	40,085	0	0	40,085	1	40,085	4,008	0
Unloading Piles and Dolphins	1	EA	0	0	0	325,938	325,938	1	325,938	325,938	0
Building over Stock Piles	30,000	SF	0	0	493,954	0	493,954	1	493,954	16	0
Asphalt Paving	90,000	SF	0	0	97,601	0	97,601	1	97,601	1	0
Demobilization	1	LS	384,075	367,073	0	0	751,148	1	751,148	751,148	751,148
Site Services and Health and Safety											
Electrical Power Hookup	1	LS	0	0	0	33,063	33,063	1	33,063	33,063	0
Water Line Hookup	1	LS	0	0	0	33,063	33,063	1	33,063	33,063	0
Contaminated Water Control System	1	LS	0	0	132,250	0	132,250	1	132,250	132,250	0
Decon Facility	1	LS	2,616	0	661	11,109	14,386	1	14,386	14,386	0
Health and Safety	3	MO	130,491	0	10,355	0	140,846	1	140,846	46,949	140,846
Solids Separation System											
Construct Process Area	1,500	LF	0	0	0	3,968	3,968	1	3,968	3	0
Solidification	8,300	CY	326,628	221,730	124,173	0	672,532	1	672,532	81	672,532
Water Treatment System											
Water Treatment Facility	1	LS	0	0	525,000	0	525,000	1	525,000	525,000	0
Dredging											
Bathymetry Survey - Pre-Dredging	1	LS	0	0	0	26,450	26,450	1	26,450	26,450	0
Debris Removal	8,300	CY	843,608	582,646	21,954	65,861	1,514,068	1	1,514,068	182	1,514,068
Dredging	8,300	CY	479,973	599,111	83,635	0	1,162,719	1	1,162,719	140	1,162,719
Bathymetry Survey - Post Dredging	1	LS	0	0	0	26,450	26,450	1	26,450	26,450	0.0
Total Monitoring Costs											
PCB analysis on dewatered sediment	83.00	EA	24,682	0	0	11,526	36,208	1	36,208	436	36,208
Performance and discharge monitoring	8,300	CY	82,436	113,808	529	15,582	212,355	1	212,355	26	212,355
Environmental monitoring											
Air monitoring	1	LS	73,286	2,195	0	8,781	84,262	1	84,262	84,262	84,262
Water monitoring	1	MO	0	0	0	11,109	11,109	1	11,109	7,935	11,109
Total Dredging Direct Costs									**7,222,835**		**5,336,395**
Submerged Bulkhead											
Submerged Bulkhead	0	LF	0	0	0	0	0	1	**0**	na	**0**
Temporary Containment											
Temporary Containment Barrier	0	LF	0	0	0	0	0	1	0	na	0.0
Silt Curtain	2,000	LF	11,773	21,742	349,140	0	382,655	1	382,655	191	382,654.8
Total Temporary Containment									**382,655**		**382,655**
Sealed Bulkhead											
Sealed Shoreline Bulkhead	1,100	LF	0	0	0	3,181,618	3,181,618	1	**3,181,618**	2,892	**3,181,617.6**
Capping Costs											
Cap Construction											
Erosion Protection Layer Gravel	1,597	CY	44,857	46,446	41,190	0	132,493	1	132,493	83	132,493
Erosion Protection Layer Sand	1,597	CY	44,857	46,446	27,460	0	118,763	1	118,763	74	118,763
Chemical Isolation Layer	3,194	CY	89,714	92,892	107,820	0	290,426	1	290,426	91	290,426
Berm and Wick Drain	24,192	CY	285,963	296,095	1,455,723	290,950	2,328,731	1	2,328,731	96	2,328,731
Mixing Layer	1,452	CY	44,857	53,217	24,964	0	123,038	1	123,038	85	123,038
Total Capping Direct Costs									**2,993,450**		**2,993,450**
Markups on Capital Cost Estimate											
Engineering and Admin. Costs (5% of Capital Costs)											
Institutional Controls	1	LS	200,000	0	0	0	200,000	1	200,000	200,000	0
Remedial Design (6%)	1	LS	826,142	0	0	0	826,142	1	826,142	826,142	826,142
Project Management (5%)	1	LS	688,452	0	0	0	688,452	1	688,452	688,452	688,452
Construction Related Services (6%)	1	LS	826,142	0	0	0	826,142	1	826,142	826,142	826,142
Dredging Demonstration Project	1	LS	0	0	0	500,000	500,000	1	500,000	500,000	0
Total Markup Costs									**3,040,735**		**2,340,735**
Disposal Costs											
Off-site transport/disposal at TSCA haz waste	0	TN	0	0	0	0	0	1	0	na	0
Off-site transport/disposal to RCRA Part 360	14,318	TN	0	0	0	1,041,419	1,041,419	1	1,041,419	73	1,041,419
Total Disposal Costs									**1,041,419**		**1,041,419**
Monitoring and Maintenance											
Post-Construction Inspection and Maintenance											
Cap Maintenance (every five years)	1	YR	84,014	94,244	55,199	0	233,457	2.16	503,333	503,333	503,333
Total Post-Construction Monitoring (for 30 ye	1	YR	0	0	0	163,350	163,350	12.41	2,027,010	2,027,010	0
Total Monitoring and Maintenance									**2,530,343**		**503,333**
Contingency											
Construction Contingency Costs (25% of Cap	1	LS	4,561,998	0	0	0	4,561,998	1	4,561,998	4,561,998	3,529,953
Total Cost			10,440,638	2,944,804	3,607,151	5,828,923	22,821,517		24,955,053		19,309,558

TOTAL
NOT FIXED

check: 24,955,053 19,309,558

Hastings-on-Hudson OU-2
Cost Estimate Summary for Alternative SA-3b
Table E.19

Task	Qty	Unit	Cost					NPV	NPV	TOTAL	Not Fixed
			Labor	Equipment	Materials	Subcont	TOTAL	Factor		UNIT $	Total
Dredging Costs											
Mobilization and Site Preparation											
Mobilization	1	LS	384,075	367,073	0	0	751,148	1	751,148	751,148	751,148
Install/ Remove Fence	1,500	LF	0	0	55,545	0	55,545	1	55,545	37	0
Repair Road/ Work Area	10,000	SY	0	0	0	78,689	78,689	1	78,689	8	0
Install Work Lighting	10	EA	0	40,085	0	0	40,085	1	40,085	4,008	0
Unloading Piles and Dolphins	1	EA	0	0	0	325,938	325,938	1	325,938	325,938	0
Building over Stock Piles	30,000	SF	0	0	493,954	0	493,954	1	493,954	16	0
Asphalt Paving	90,000	SF	0	0	97,601	0	97,601	1	97,601	1	0
Demobilization	1	LS	384,075	367,073	0	0	751,148	1	751,148	751,148	751,148
Site Services and Health and Safety											
Electrical Power Hookup	1	LS	0	0	0	33,063	33,063	1	33,063	33,063	0
Water Line Hookup	1	LS	0	0	0	33,063	33,063	1	33,063	33,063	0
Contaminated Water Control System	1	LS	0	0	132,250	0	132,250	1	132,250	132,250	0
Decon Facility	1	LS	2,616	0	661	11,109	14,386	1	14,386	14,386	0
Health and Safety	3	MO	136,422	0	10,355	0	146,778	1	146,778	48,926	146,778
Solids Separation System											
Construct Process Area	1,500	LF	0	0	0	3,968	3,968	1	3,968	3	0
Solidification	8,800	CY	346,305	235,088	131,654	0	713,046	1	713,046	81	713,046
Water Treatment System											
Water Treatment Facility	1	LS	0	0	525,000	0	525,000	1	525,000	525,000	0
Dredging											
Bathymetry Survey - Pre-Dredging	1	LS	0	0	0	26,450	26,450	1	26,450	26,450	0
Debris Removal	8,800	CY	894,347	617,745	23,276	69,828	1,605,196	1	1,605,196	182	1,605,196
Dredging	8,800	CY	508,822	635,202	85,486	0	1,229,511	1	1,229,511	140	1,229,511
Bathymetry Survey - Post Dredging	1	LS	0	0	0	26,450	26,450	1	26,450	26,450	0.0
Total Monitoring Costs											
PCB analysis on dewatered sediment	88.00	EA	26,170	0	0	12,220	38,390	1	38,390	436	38,390
Performance and discharge monitoring	8,800	CY	86,361	119,459	529	16,172	222,520	1	222,520	25	222,520
Environmental monitoring											
Air monitoring	1	LS	77,700	2,328	0	9,310	89,338	1	89,338	89,338	89,338
Water monitoring	2	MO	0	0	0	11,903	11,903	1	11,903	7,935	11,903
Total Dredging Direct Costs									**7,445,418**		**5,558,979**
Submerged Bulkhead											
Submerged Bulkhead	0	LF	0	0	0	0	0	1	0	na	0
Temporary Containment											
Temporary Containment Barrier	0	LF	0	0	0	0	0	1	0	na	0.0
Silt Curtain	2,000	LF	11,773	21,742	349,140	0	382,655	1	382,655	191	382,654.8
Total Temporary Containmen									**382,655**		**382,655**
Sealed Bulkhead											
Sealed Shoreline Bulkhead	1,100	LF	0	0	0	3,181,618	3,181,618	1	**3,181,618**	2,892	**3,181,617.6**
Capping Costs											
Cap Construction											
Erosion Protection Layer Gravel	1,597	CY	44,857	46,446	41,190	0	132,493	1	132,493	83	132,493
Erosion Protection Layer Sand	1,597	CY	44,857	46,446	27,460	0	118,763	1	118,763	74	118,763
Chemical Isolation Layer	3,194	CY	89,714	92,892	107,820	0	290,426	1	290,426	91	290,426
Berm and Wick Drains	25,192	CY	297,177	307,706	1,515,897	290,950	2,411,730	1	2,411,730	96	2,411,730
Mixing Layer	1,452	CY	44,857	53,217	24,964	0	123,038	1	123,038	85	123,038
Total Capping Direct Costs									**3,076,450**		**3,076,450**
Markups on Capital Cost Estimate											
Engineering and Admin. Costs (5% of Capital Costs)											
Institutional Controls	1	LS	200,000	0	0	0	200,000	1	200,000	200,000	0
Remedial Design (6%)	1	LS	844,435	0	0	0	844,435	1	844,435	844,435	844,435
Project Management (5%)	1	LS	703,696	0	0	0	703,696	1	703,696	703,696	703,696
Construction Related Services (6%)	1	LS	844,435	0	0	0	844,435	1	844,435	844,435	844,435
Dredging Demonstration Project	1	LS	0	0	0	500,000	500,000	1	500,000	500,000	0
Total Markup Costs									**3,092,567**		**2,392,567**
Disposal Costs											
Off-site transport/disposal at TSCA haz waste	0	TN	0	0	0	0	0	1	0	na	0
Off-site transport/disposal to RCRA Part 360	15,180	TN	0	0	0	1,104,155	1,104,155	1	1,104,155	73	1,104,155
Total Disposal Costs									**1,104,155**		**1,104,155**
Monitoring and Maintenance											
Post-Construction Inspection and Maintenance											
Cap Maintenance (every five years)	1	YR	84,014	94,244	55,199	0	233,457	2.16	503,333	503,333	503,333
Total Post-Construction Monitoring (for 30 ye	1	YR	0	0	0	163,350	163,350	12.41	2,027,010	2,027,010	0
Total Monitoring and Maintenance									**2,530,343**		**503,333**
Contingency											
Construction Contingency Costs (25% of Cap	1	LS	4,666,862	0	0	0	4,666,862	1	4,666,862	4,666,862	3,632,407
Total Cost			10,723,572	3,046,747	3,677,980	5,898,233	23,346,531		25,480,068		**19,832,162**

TOTAL
NOT FIXED
check: 25,480,068 19,832,162

Hastings-on-Hudson OU-2
Cost Estimate Summary for Alternative SA-4
Table E.20

Task	Qty	Unit	Cost					NPV	NPV	TOTAL	Not Fixed
			Labor	Equipment	Materials	Subcont	TOTAL	Factor		UNIT $	Total
Dredging Costs											
Mobilization and Site Preparation											
Mobilization	1	LS	384,075	367,073	0	0	751,148	1	751,148	751,148	751,148
Install/ Remove Fence	1,500	LF	0	0	55,545	0	55,545	1	55,545	37	0
Repair Road/ Work Area	10,000	SY	0	0	0	78,689	78,689	1	78,689	8	0
Install Work Lighting	10	EA	0	40,085	0	0	40,085	1	40,085	4,008	0
Unloading Piles and Dolphins	1	EA	0	0	0	325,938	325,938	1	325,938	325,938	0
Building over Stock Piles	30,000	SF	0	0	493,954	0	493,954	1	493,954	16	0
Asphalt Paving	90,000	SF	0	0	97,601	0	97,601	1	97,601	1	0
Demobilization	1	LS	384,075	367,073	0	0	751,148	1	751,148	751,148	751,148
Site Services and Health and Safety											
Electrical Power Hookup	1	LS	0	0	0	33,063	33,063	1	33,063	33,063	0
Water Line Hookup	1	LS	0	0	0	33,063	33,063	1	33,063	33,063	0
Contaminated Water Control System	1	LS	0	0	132,250	0	132,250	1	132,250	132,250	0
Decon Facility	1	LS	2,616	0	661	11,109	14,386	1	14,386	14,386	0
Health and Safety	5	MO	195,539	0	17,259	0	212,798	1	212,798	42,560	212,798
Solids Separation System											
Construct Process Area	1,500	LF	0	0	0	3,968	3,968	1	3,968	3	0
Solidification	16,000	CY	629,645	427,432	239,370	0	1,296,447	1	1,296,447	81	1,296,447
Water Treatment System											
Water Treatment Facility	1	LS	0	0	525,000	0	525,000	1	525,000	525,000	0
Dredging											
Bathymetry Survey - Pre-Dredging	1	LS	0	0	0	26,450	26,450	1	26,450	26,450	0
Debris Removal	16,000	CY	1,623,662	1,123,173	42,320	126,960	2,916,115	1	2,916,115	182	2,916,115
Dredging	16,000	CY	923,193	1,154,913	112,148	0	2,190,253	1	2,190,253	137	2,190,253
Bathymetry Survey - Post Dredging	1	LS	0	0	0	26,450	26,450	1	26,450	26,450	0.0
Total Monitoring Costs											
PCB analysis on dewatered sediment	160.00	EA	47,615	0	0	22,218	69,833	1	69,833	436	69,833
Performance and discharge monitoring	16,000	CY	142,871	200,838	529	24,429	368,667	1	368,667	23	368,667
Environmental monitoring											
Air monitoring	1	LS	141,274	4,232	0	16,928	162,434	1	162,434	162,434	162,434
Water monitoring	3	MO	0	0	0	21,425	21,425	1	21,425	7,935	21,425
Total Dredging Direct Costs									**10,626,707**		**8,740,267**
Submerged Bulkhead											
Submerged Bulkhead	0	LF	0	0	0	0	0	1	0	na	0
Temporary Containment											
Temporary Containment Barrier	0	LF	0	0	0	0	0	1	0	na	0.0
Silt Curtain	2,000	LF	11,773	21,742	349,140	0	382,655	1	382,655	191	382,654.8
Total Temporary Containment									**382,655**		**382,655**
Sealed Bulkhead											
Sealed Shoreline Bulkhead	1,100	LF	0	0	0	8,727,707	8,727,707	1	**8,727,707**	7,934	**8,727,706.5**
Capping Costs											
Cap Construction											
Erosion Protection Layer Gravel	1,597	CY	44,857	46,446	41,190	0	132,493	1	132,493	83	132,493
Erosion Protection Layer Sand	1,597	CY	44,857	46,446	27,460	0	118,763	1	118,763	74	118,763
Chemical Isolation Layer	3,194	CY	89,714	92,892	107,820	0	290,426	1	290,426	91	290,426
Berm	26,192	CY	309,513	320,479	1,576,071	0	2,206,062	1	2,206,062	84	2,206,062
Mixing Layer	1,452	CY	44,857	53,217	24,964	0	123,038	1	123,038	85	123,038
Total Capping Direct Costs									**2,870,782**		**2,870,782**
Markups on Capital Cost Estimate											
Engineering and Admin. Costs (5% of Capital Costs)											
Institutional Controls	1	LS	200,000	0	0	0	200,000	1	200,000	200,000	0
Remedial Design (6%)	1	LS	1,355,138	0	0	0	1,355,138	1	1,355,138	1,355,138	1,355,138
Project Management (5%)	1	LS	1,129,282	0	0	0	1,129,282	1	1,129,282	1,129,282	1,129,282
Construction Related Services (6%)	1	LS	1,355,138	0	0	0	1,355,138	1	1,355,138	1,355,138	1,355,138
Dredging Demonstration Project	1	LS	0	0	0	500,000	500,000	1	500,000	500,000	0
Total Markup Costs									**4,539,557**		**3,839,557**
Disposal Costs											
Off-site transport/disposal at TSCA haz waste	0	TN	0	0	0	0	0	1	0	na	0
Off-site transport/disposal to RCRA Part 360 S	27,600	TN	0	0	0	2,007,555	2,007,555	1	2,007,555	73	2,007,555
Total Disposal Costs									**2,007,555**		**2,007,555**
Monitoring and Maintenance											
Post-Construction Inspection and Maintenance											
Cap Maintenance (every five years)	1	YR	84,014	94,244	55,199	0	233,457	2.16	503,333	503,333	503,333
Total Post-Construction Monitoring (for 30 yea	1	YR	0	0	0	163,350	163,350	12.41	2,027,010	2,027,010	0
Total Monitoring and Maintenance									**2,530,343**		**503,333**
Contingency											
Construction Contingency Costs (25% of Capi	1	LS	7,382,388	0	0	0	7,382,388	1	**7,382,388**	7,382,388	**6,307,496**
Total Cost			16,526,093	4,360,286	3,898,479	12,149,300	36,934,157		39,067,693		33,379,351

TOTAL
NOT FIXED

check: 39,067,693 33,379,351

Task	Qty	Unit	Cost: Labor	Equipment	Materials	Subcont	TOTAL	NPV Factor	NPV	TOTAL UNIT $	Not Fixed Total
Dredging Costs											
Mobilization and Site Preparation											
Mobilization	0	LS	0	0	0	0	0	1	0	na	0
Install/ Remove Fence	1,500	LF	0	0	55,545	0	55,545	1	55,545	37	0
Repair Road/ Work Area	10,000	SY	0	0	0	78,689	78,689	1	78,689	8	0
Install Work Lighting	10	EA	0	40,085	0	0	40,085	1	40,085	4,008	0
Unloading Piles and Dolphins	1	EA	0	0	0	325,938	325,938	1	325,938	325,938	0
Building over Stock Piles	30,000	SF	0	0	493,954	0	493,954	1	493,954	16	0
Asphalt Paving	90,000	SF	0	0	97,601	0	97,601	1	97,601	1	0
Demobilization	0	LS	0	0	0	0	0	1	0	na	0
Site Services and Health and Safety											
Electrical Power Hookup	1	LS	0	0	0	33,063	33,063	1	33,063	33,063	0
Water Line Hookup	1	LS	0	0	0	33,063	33,063	1	33,063	33,063	0
Contaminated Water Control System	1	LS	0	0	132,250	0	132,250	1	132,250	132,250	0
Decon Facility	1	LS	2,616	0	661	11,109	14,386	1	14,386	14,386	0
Health and Safety	1	MO	22,342	0	3,452	0	25,793	1	25,793	25,793	25,793
Solids Separation System											
Construct Process Area	1,500	LF	0	0	0	3,968	3,968	1	3,968	3	0
Solidification	2,100	CY	82,641	56,100	31,417	0	170,159	1	170,159	81	170,159
Water Treatment System											
Water Treatment Facility	1	LS	0	0	525,000	0	525,000	1	525,000	525,000	0
Dredging											
Bathymetry Survey - Pre-Dredging	1	LS	0	0	0	26,450	26,450	1	26,450	26,450	0
Debris Removal	2,100	CY	214,105	147,416	5,555	16,664	383,740	1	383,740	183	383,740
Dredging	2,100	CY	121,969	151,582	60,676	0	334,227	1	334,227	159	334,227
Bathymetry Survey - Post Dredging	1	LS	0	0	0	26,450	26,450	1	26,450	26,450	0.0
Total Monitoring Costs											
PCB analysis on dewatered sediment	21.00	EA	6,213	0	0	2,916	9,130	1	9,130	435	9,130
Performance and discharge monitoring	2,100	CY	23,207	31,512	0	4,876	59,595	1	59,595	28	59,595
Environmental monitoring											
Air monitoring	1	LS	18,542	555	0	2,222	21,319	1	21,319	21,319	21,319
Water monitoring	0	MO	0	0	0	3,174	3,174	1	3,174	7,935	3,174
Total Dredging Direct Costs									**2,893,577**		**1,007,137**
Submerged Bulkhead											
Submerged Bulkhead	0	LF	0	0	0	0	0	1	**0**	na	**0**
Temporary Containment											
Temporary Containment Barrier	0	LF	0	0	0	0	0	1	0	na	0.0
Silt Curtain	330	LF	11,773	21,742	57,608	0	91,123	1	91,123	276	91,122.9
Total Temporary Containment									**91,123**		**91,123**
Sealed Bulkhead											
Sealed Shoreline Bulkhead	470	LF	0	0	0	0	0	1	**0**	0	**0.0**
Capping Costs											
Cap Construction											
Erosion Protection Layer Gravel	621	CY	22,428	23,223	16,018	0	61,670	1	61,670	99	61,670
Erosion Protection Layer Sand	621	CY	22,428	23,223	10,679	0	56,330	1	56,330	91	56,330
Chemical Isolation Layer	1,242	CY	33,643	34,835	74,258	0	142,735	1	142,735	115	142,735
Berm	0	CY	0	0	0	0	0	1	0	na	0
Mixing Layer	565	CY	11,214	13,304	9,708	0	34,227	1	34,227	61	34,227
Total Capping Direct Costs									**294,962**		**294,962**
Markups on Capital Cost Estimate											
Engineering and Admin. Costs (5% of Capital Costs)											
Institutional Controls	1	LS	200,000	0	0	0	200,000	1	200,000	200,000	0
Remedial Design (6%)	1	LS	196,605	0	0	0	196,605	1	196,605	196,605	196,605
Project Management (5%)	1	LS	163,837	0	0	0	163,837	1	163,837	163,837	163,837
Construction Related Services (6%)	1	LS	196,605	0	0	0	196,605	1	196,605	196,605	196,605
Dredging Demonstration Project	1	LS	0	0	0	500,000	500,000	1	500,000	500,000	0
Total Markup Costs									**1,257,047**		**557,047**
Disposal Costs											
Off-site transport/disposal at TSCA haz waste	906	TN	0	0	0	179,653	179,653	1	179,653	198	179,653
Off-site transport/disposal to RCRA Part 360	2,717	TN	0	0	0	197,619	197,619	1	197,619	73	197,619
Total Disposal Costs									**377,272**		**377,272**
Monitoring and Maintenance											
Post-Construction Inspection and Maintenance											
Cap Maintenance (every five years)	1	YR	83,288	93,399	53,795	0	230,482	2.16	496,919	496,919	496,919
Total Post-Construction Monitoring (for 30 ye	1	YR	0	0	0	163,350	163,350	12.41	2,027,010	2,027,010	0
Total Monitoring and Maintenance									**2,523,929**		**496,919**
Contingency											
Construction Contingency Costs (25% of Cap	1	LS	1,326,224	0	0	0	1,326,224	1	**1,326,224**	1,326,224	**503,618**
Total Cost			2,759,682	636,977	1,628,176	1,609,202	6,634,037		8,764,134		3,328,078

TOTAL
NOT FIXED

check: 8,764,134 3,328,078

Hastings-on-Hudson OU-2
Cost Estimate Summary for Alternative NSLIP-2
Table E.22

Task	Qty	Unit	Cost					NPV	NPV	TOTAL	Not Fixed
			Labor	Equipment	Materials	Subcont	TOTAL	Factor		UNIT $	Total
Dredging Costs											
Mobilization and Site Preparation											
Mobilization	0	LS	0	0	0	0	0	1	0	na	0
Install/ Remove Fence	1,500	LF	0	0	55,545	0	55,545	1	55,545	37	0
Repair Road/ Work Area	10,000	SY	0	0	0	78,689	78,689	1	78,689	8	0
Install Work Lighting	10	EA	0	40,085	0	0	40,085	1	40,085	4,008	0
Unloading Piles and Dolphins	1	EA	0	0	0	325,938	325,938	1	325,938	325,938	0
Building over Stock Piles	30,000	SF	0	0	493,954	0	493,954	1	493,954	16	0
Asphalt Paving	90,000	SF	0	0	97,601	0	97,601	1	97,601	1	0
Demobilization	0	LS	0	0	0	0	0	1	0	na	0
Site Services and Health and Safety											
Electrical Power Hookup	1	LS	0	0	0	33,063	33,063	1	33,063	33,063	0
Water Line Hookup	1	LS	0	0	0	33,063	33,063	1	33,063	33,063	0
Contaminated Water Control System	1	LS	0	0	132,250	0	132,250	1	132,250	132,250	0
Decon Facility	1	LS	2,616	0	661	11,109	14,386	1	14,386	14,386	0
Health and Safety	3	MO	96,682	0	10,355	0	107,037	1	107,037	35,679	107,037
Solids Separation System											
Construct Process Area	1,500	LF	0	0	0	3,968	3,968	1	3,968	3	0
Solidification	8,400	CY	330,564	224,402	125,669	0	680,635	1	680,635	81	680,635
Water Treatment System											
Water Treatment Facility	1	LS	0	0	525,000	0	525,000	1	525,000	525,000	0
Dredging											
Bathymetry Survey - Pre-Dredging	1	LS	0	0	0	26,450	26,450	1	26,450	26,450	0
Debris Removal	8,400	CY	853,089	589,666	22,218	66,654	1,531,627	1	1,531,627	182	1,531,627
Dredging	8,400	CY	485,209	606,329	84,005	0	1,175,544	1	1,175,544	140	1,175,544
Bathymetry Survey - Post Dredging	1	LS	0	0	0	26,450	26,450	1	26,450	26,450	0.0
Total Monitoring Costs											
PCB analysis on dewatered sediment	84.00	EA	25,034	0	0	11,664	36,698	1	36,698	437	36,698
Performance and discharge monitoring	8,400	CY	72,653	102,718	0	12,249	187,621	1	187,621	22	187,621
Environmental monitoring											
Air monitoring	1	LS	74,169	2,222	0	8,887	85,278	1	85,278	85,278	85,278
Water monitoring	1	MO	0	0	0	11,109	11,109	1	11,109	7,935	11,109
Total Dredging Direct Costs									**5,701,988**		**3,815,548**
Submerged Bulkhead											
Submerged Bulkhead	0	LF	0	0	0	0	0	1	**0**	na	**0**
Temporary Containment											
Temporary Containment Barrier	0	LF	0	0	0	0	0	1	0	na	0.0
Silt Curtain	330	LF	11,773	21,742	57,608	0	91,123	1	91,123	276	91,122.9
Total Temporary Containment									**91,123**		**91,123**
Sealed Bulkhead											
Sealed Shoreline Bulkhead	470	LF	0	0	0	1,371,644	1,371,644	1	**1,371,644**	2,918	**1,371,644.1**
Capping Costs											
Cap Construction											
Erosion Protection Layer Gravel	621	CY	22,428	23,223	16,018	0	61,670	1	61,670	99	61,670
Erosion Protection Layer Sand	621	CY	22,428	23,223	10,679	0	56,330	1	56,330	91	56,330
Chemical Isolation Layer	1,242	CY	33,643	34,835	74,258	0	142,735	1	142,735	115	142,735
Berm	11,741	CY	139,056	143,983	302,794	0	585,834	1	585,834	50	585,834
Mixing Layer	565	CY	11,214	13,304	9,708	0	34,227	1	34,227	61	34,227
Total Capping Direct Costs									**880,796**		**880,796**
Markups on Capital Cost Estimate											
Engineering and Admin. Costs (5% of Capital Costs)											
Institutional Controls	1	LS	200,000	0	0	0	200,000	1	200,000	200,000	0
Remedial Design (6%)	1	LS	482,033	0	0	0	482,033	1	482,033	482,033	482,033
Project Management (5%)	1	LS	401,694	0	0	0	401,694	1	401,694	401,694	401,694
Construction Related Services (6%)	1	LS	482,033	0	0	0	482,033	1	482,033	482,033	482,033
Dredging Demonstration Project	1	LS	0	0	0	500,000	500,000	1	500,000	500,000	0
Total Markup Costs									**2,065,761**		**1,365,761**
Disposal Costs											
Off-site transport/disposal at TSCA haz waste	3,623	TN	0	0	0	718,613	718,613	1	718,613	198	718,613
Off-site transport/disposal to RCRA Part 360 S	10,868	TN	0	0	0	790,475	790,475	1	790,475	73	790,475
Total Disposal Costs									**1,509,088**		**1,509,088**
Monitoring and Maintenance											
Post-Construction Inspection and Maintenance											
Cap Maintenance (every five years)	1	YR	83,288	93,399	53,795	0	230,482	2.16	496,919	496,919	496,919
Total Post-Construction Monitoring (for thirty y	1	YR	0	0	0	163,350	163,350	12.41	2,027,010	2,027,010	0
Total Monitoring and Maintenance									**2,523,929**		**496,919**
Contingency											
Construction Contingency Costs (25% of Capi	1	LS	3,000,642	0	0	0	3,000,642	1	**3,000,642**	3,000,642	**2,021,924**
Total Cost			6,830,249	1,919,131	2,072,119	4,193,374	15,014,873		17,144,970		11,552,802
											TOTAL NOT FIXED
								check:	17,144,970		11,552,802

Hastings-on-Hudson OU-2
Cost Estimate Summary for Alternative OM-1
Table E.23

Task	Qty	Unit	Cost					NPV	NPV	TOTAL	Not Fixed
			Labor	Equipment	Materials	Subcont	TOTAL	Factor		UNIT $	Total
Dredging Costs											
Mobilization and Site Preparation											
Mobilization	0	LS	0	0	0	0	0	1	0	na	0
Install/ Remove Fence	1,500	LF	0	0	55,545	0	55,545	1	55,545	37	0
Repair Road/ Work Area	10,000	SY	0	0	0	78,689	78,689	1	78,689	8	0
Install Work Lighting	10	EA	0	40,085	0	0	40,085	1	40,085	4,008	0
Unloading Piles and Dolphins	1	EA	0	0	0	325,938	325,938	1	325,938	325,938	0
Building over Stock Piles	30,000	SF	0	0	493,954	0	493,954	1	493,954	16	0
Asphalt Paving	90,000	SF	0	0	97,601	0	97,601	1	97,601	1	0
Demobilization	0	LS	0	0	0	0	0	1	0	na	0
Site Services and Health and Safety											
Electrical Power Hookup	1	LS	0	0	0	33,063	33,063	1	33,063	33,063	0
Water Line Hookup	1	LS	0	0	0	33,063	33,063	1	33,063	33,063	0
Contaminated Water Control System	1	LS	0	0	132,250	0	132,250	1	132,250	132,250	0
Decon Facility	1	LS	2,616	0	661	11,109	14,386	1	14,386	14,386	0
Health and Safety	2	MO	65,048	0	6,903	0	71,951	1	71,951	35,976	71,951
Solids Separation System											
Construct Process Area	1,500	LF	0	0	0	3,968	3,968	1	3,968	3	0
Solidification	6,800	CY	267,599	181,659	101,732	0	550,990	1	550,990	81	550,990
Water Treatment System											
Water Treatment Facility	1	LS	0	0	525,000	0	525,000	1	525,000	525,000	0
Dredging											
Bathymetry Survey - Pre-Dredging	1	LS	0	0	0	26,450	26,450	1	26,450	26,450	0
Debris Removal	6,800	CY	691,389	477,348	17,986	53,958	1,240,682	1	1,240,682	182	1,240,682
Dredging	6,800	CY	393,423	490,838	78,080	0	962,342	1	962,342	142	962,342
Bathymetry Survey - Post Dredging	1	LS	0	0	0	26,450	26,450	1	26,450	26,450	0.0
Total Monitoring Costs											
PCB analysis on dewatered sediment	68.00	EA	20,218	0	0	9,443	29,661	1	29,661	436	29,661
Performance and discharge monitoring	6,800	CY	64,899	90,189	0	12,146	167,234	1	167,234	25	167,234
Environmental monitoring											
Air monitoring	1	LS	60,041	1,799	0	7,194	69,034	1	69,034	69,034	69,034
Water monitoring	1.1	MO	0	0	0	8,729	8,729	1	8,729	7,935	8,729
Total Dredging Direct Costs									**4,987,062**		**3,100,622**
Submerged Bulkhead											
Submerged Bulkhead	0	LF	0	0	0	0	0	1	**0**	na	**0**
Temporary Containment											
Temporary Containment Barrier	0	LF	0	0	0	0	0	1	0	na	0.0
Silt Curtain	620	LF	11,773	21,742	108,233	0	141,748	1	141,748	229	141,748.2
Total Temporary Containment									**141,748**		**141,748**
Sealed Bulkhead											
Sealed Shoreline Bulkhead	200	LF	0	0	0	342,792	342,792	1	**342,792**	1,714	**342,792.0**
Capping Costs											
Cap Construction											
Erosion Protection Layer Gravel	1,065	CY	33,643	34,835	27,460	0	95,937	1	95,937	90	95,937
Erosion Protection Layer Sand	1,065	CY	33,643	34,835	18,307	0	86,784	1	86,784	82	86,784
Chemical Isolation Layer	2,130	CY	67,285	69,669	89,513	0	226,468	1	226,468	106	226,468
Additional Ice Scour Erosion Protection	700	CY	7,850	8,128	18,052	0	34,030	1	34,030	49	34,030
Mixing Layer	968	CY	33,643	39,913	16,642	0	90,198	1	90,198	93	90,198
Total Capping Direct Costs									**533,417**		**533,417**
Markups on Capital Cost Estimate											
Engineering and Admin. Costs (5% of Capital Costs)											
Institutional Controls	1	LS	200,000	0	0	0	200,000	1	200,000	200,000	0
Remedial Design (6%)	1	LS	359,735	0	0	0	359,735	1	359,735	359,735	359,735
Project Management (5%)	1	LS	299,779	0	0	0	299,779	1	299,779	299,779	299,779
Construction Related Services (6%)	1	LS	359,735	0	0	0	359,735	1	359,735	359,735	359,735
Dredging Demonstration Project	1	LS	0	0	0	500,000	500,000	1	500,000	500,000	0
Total Markup Costs									**1,719,248**		**1,019,248**
Disposal Costs											
Off-site transport/disposal at TSCA haz waste	0	TN	0	0	0	0	0	1	0	na	0
Off-site transport/disposal to RCRA Part 360	11,730	TN	0	0	0	853,211	853,211	1	853,211	73	853,211
Total Disposal Costs									**853,211**		**853,211**
Monitoring and Maintenance											
Post-Construction Inspection and Maintenance											
Cap Maintenance (every five years)	1	YR	83,628	93,793	54,426	0	231,848	2.16	499,863	499,863	499,863
Total Post-Construction Monitoring (for 30 ye	1	YR	0	0	0	163,350	163,350	12.41	2,027,010	2,027,010	0
Total Monitoring and Maintenance									**2,526,874**		**499,863**
Contingency											
Construction Contingency Costs (25% of Cap	1	LS	2,240,808	0	0	0	2,240,808	1	**2,240,808**	2,240,808	**1,309,835**
Total Cost			5,296,755	1,584,832	1,842,346	2,489,551	11,213,484		13,345,160		7,800,736

TOTAL
NOT FIXED

check: 13,345,160 7,800,736

Task	Qty	Unit	Cost					NPV	NPV	TOTAL	Not Fixed
			Labor	Equipment	Materials	Subcont	TOTAL	Factor		UNIT $	Total
Dredging Costs											
Mobilization and Site Preparation											
Mobilization	0	LS	0	0	0	0	0	1	0	na	0
Install/ Remove Fence	1,500	LF	0	0	55,545	0	55,545	1	55,545	37	0
Repair Road/ Work Area	10,000	SY	0	0	0	78,689	78,689	1	78,689	8	0
Install Work Lighting	10	EA	0	40,085	0	0	40,085	1	40,085	4,008	0
Unloading Piles and Dolphins	1	EA	0	0	0	325,938	325,938	1	325,938	325,938	0
Building over Stock Piles	30,000	SF	0	0	493,954	0	493,954	1	493,954	16	0
Asphalt Paving	90,000	SF	0	0	97,601	0	97,601	1	97,601	1	0
Demobilization	0	LS	0	0	0	0	0	1	0	na	0
Site Services and Health and Safety											
Electrical Power Hookup	1	LS	0	0	0	33,063	33,063	1	33,063	33,063	0
Water Line Hookup	1	LS	0	0	0	33,063	33,063	1	33,063	33,063	0
Contaminated Water Control System	1	LS	0	0	132,250	0	132,250	1	132,250	132,250	0
Decon Facility	1	LS	2,616	0	661	11,109	14,386	1	14,386	14,386	0
Health and Safety	3	MO	129,898	0	10,355	0	140,253	1	140,253	46,751	140,253
Solids Separation System											
Construct Process Area	1,500	LF	0	0	0	3,968	3,968	1	3,968	3	0
Solidification	15,000	CY	590,292	400,718	224,410	0	1,215,419	1	1,215,419	81	1,215,419
Water Treatment System											
Water Treatment Facility	1	LS	0	0	525,000	0	525,000	1	525,000	525,000	0
Dredging											
Bathymetry Survey - Pre-Dredging	1	LS	0	0	0	26,450	26,450	1	26,450	26,450	0
Debris Removal	15,000	CY	1,522,183	1,052,975	39,675	119,025	2,733,858	1	2,733,858	182	2,733,858
Dredging	15,000	CY	865,493	1,082,731	108,445	0	2,056,669	1	2,056,669	137	2,056,669
Bathymetry Survey - Post Dredging	1	LS	0	0	0	26,450	26,450	1	26,450	26,450	0.0
Total Monitoring Costs											
PCB analysis on dewatered sediment	150.00	EA	44,639	0	0	20,829	65,468	1	65,468	436	65,468
Performance and discharge monitoring	15,000	CY	129,258	182,870	0	21,583	333,711	1	333,711	22	333,711
Environmental monitoring											
Air monitoring	1	LS	132,444	3,968	0	15,870	152,281	1	152,281	152,281	152,281
Water monitoring	3	MO	0	0	0	19,838	19,838	1	19,838	7,935	19,838
Total Dredging Direct Costs									**8,603,937**		**6,717,497**
Submerged Bulkhead											
Submerged Bulkhead	0	LF	0	0	0	0	0	1	**0**	na	**0**
Temporary Containment											
Temporary Containment Barrier	0	LF	0	0	0	0	0	1	0	na	0.0
Silt Curtain	620	LF	11,773	21,742	108,233	0	141,748	1	141,748	229	141,748.2
Total Temporary Containment									**141,748**		**141,748**
Sealed Bulkhead											
Sealed Shoreline Bulkhead	200	LF	0	0	0	683,468	683,468	1	**683,468**	3,417	**683,468.0**
Capping Costs											
Cap Construction											
Erosion Protection Layer Gravel	1,065	CY	33,643	34,835	27,460	0	95,937	1	95,937	90	95,937
Erosion Protection Layer Sand	1,065	CY	33,643	34,835	18,307	0	86,784	1	86,784	82	86,784
Chemical Isolation Layer	2,130	CY	67,285	69,669	89,513	0	226,468	1	226,468	106	226,468
Additional Ice Scour Erosion Protection	700	CY	7,850	8,128	42,122	0	58,100	1	58,100	83	58,100
Mixing Layer	968	CY	33,643	39,913	16,642	0	90,198	1	90,198	93	90,198
Total Capping Direct Costs									**557,487**		**557,487**
Markups on Capital Cost Estimate											
Engineering and Admin. Costs (5% of Capital Costs)											
Institutional Controls	1	LS	200,000	0	0	0	200,000	1	200,000	200,000	0
Remedial Design (6%)	1	LS	597,949	0	0	0	597,949	1	597,949	597,949	597,949
Project Management (5%)	1	LS	498,291	0	0	0	498,291	1	498,291	498,291	498,291
Construction Related Services (6%)	1	LS	597,949	0	0	0	597,949	1	597,949	597,949	597,949
Dredging Demonstration Project	1	LS	0	0	0	500,000	500,000	1	500,000	500,000	0
Total Markup Costs									**2,394,188**		**1,694,188**
Disposal Costs											
Off-site transport/disposal at TSCA haz waste	0	TN	0	0	0	0	0	1	0	na	0
Off-site transport/disposal to RCRA Part 360 S	25,875	TN	0	0	0	1,882,083	1,882,083	1	1,882,083	73	1,882,083
Total Disposal Costs									**1,882,083**		**1,882,083**
Monitoring and Maintenance											
Post-Construction Inspection and Maintenance											
Cap Maintenance (every five years)	1	YR	83,628	93,793	54,426	0	231,848	2.16	499,863	499,863	499,863
Total Post-Construction Monitoring (for 30 year	1	YR	0	0	0	163,350	163,350	12.41	2,027,010	2,027,010	0
Total Monitoring and Maintenance									**2,526,874**		**499,863**
Contingency											
Construction Contingency Costs (25% of Capit	1	LS	3,659,320	0	0	0	3,659,320	1	**3,659,320**	3,659,320	**2,653,822**
Total Cost			9,241,794	3,066,260	2,044,598	3,964,774	18,317,427		20,449,103		14,830,155
											TOTAL NOT FIXED
								check:	20,449,103		14,830,155

Task	Qty	Unit	Cost					NPV	NPV	TOTAL	Not Fixed
			Labor	Equipment	Materials	Subcont	TOTAL	Factor		UNIT $	Total
Dredging or Capping Costs (if no dredging)											
Mobilization and Site Preparation											
Mobilization	1	LS	279,341	222,709	0	0	502,050	1	502,050	502,050	502,050
Install/ Remove Fence	1,500	LF	0	0	55,545	0	55,545	1	55,545	37	0
Repair Road/ Work Area	10,000	SY	0	0	0	78,689	78,689	1	78,689	8	0
Install Work Lighting	10	EA	0	40,085	0	0	40,085	1	40,085	4,008	0
Unloading Piles and Dolphins	1	EA	0	0	0	325,938	325,938	1	325,938	325,938	0
Building over Stock Piles	30,000	SF	0	0	493,954	0	493,954	1	493,954	16	0
Asphalt Paving	90,000	SF	0	0	97,601	0	97,601	1	97,601	1	0
Demobilization	1	LS	279,341	222,709	0	0	502,050	1	502,050	502,050	502,050
Site Services and Health and Safety											
Electrical Power Hookup	1	LS	0	0	0	33,063	33,063	1	33,063	33,063	0
Water Line Hookup	1	LS	0	0	0	33,063	33,063	1	33,063	33,063	0
Contaminated Water Control System	1	LS	0	0	132,250	0	132,250	1	132,250	132,250	0
Decon Facility	1	LS	2,616	0	661	11,109	14,386	1	14,386	14,386	0
Health and Safety	1	MO	18,585	0	3,452	0	22,037	1	22,037	22,037	22,037
Solids Separation System											
Construct Process Area	1,500	LF	0	0	0	3,968	3,968	1	3,968	3	0
Solidification	0	CY	0	0	0	0	0	1	0	na	0
Water Treatment System											
Water Treatment Facility	0	0.00	0	0	0	0	0	1	0	na	0
Dredging											
Bathymetry Survey - Pre-Cap	1	LS	0	0	0	26,450	26,450	1	26,450	26,450	0
Debris Removal	0	CY	0	0	0	0	0	1	0	na	0
Dredging	0	CY	0	0	0	0	0	1	0	na	0
Bathymetry Survey - Post Cap	1	LS	0	0	0	26,450	26,450	1	26,450	26,450	0.0
Total Monitoring Costs											
PCB analysis on dewatered sediment	0.00	EA	0	0	0	0	0	1	0	na	0
Performance and discharge monitoring	0	AC	0	0	0	0	0	1	0	na	0
Environmental monitoring											
Air monitoring	0	LS	0	0	0	0	0	1	0	na	0
Water monitoring	0	MO	0	0	0	0	0	1	0	na	0
Total Dredging or Capping Direct Costs									**2,387,576**		**1,026,136**
Submerged Bulkhead											
Submerged Bulkhead	0	LF	0	0	0	0	0	1	**0**	na	**0**
Temporary Containment											
Temporary Containment Barrier	0	LF	0	0	0	0	0	1	0	na	0.0
Silt Curtain	0	LF	0	0	0	0	0	1	0	na	0.0
Total Temporary Containment									**0**		**0**
Sealed Bulkhead											
Sealed Shoreline Bulkhead	0	LF	0	0	0	0	0	1	**0**	na	**0.0**
Capping Costs											
Cap Construction											
Debris Removal	94	HR	239,475	164,966	6,216	18,647	429,304	1	429,304	4,567	429,304
Sand Cap Layer	10,346	CY	302,784	313,512	230,779	0	847,075	1	847,075	82	847,075
Berm	0	CY	0	0	0	0	0	1	0	na	0
Total Capping Direct Costs									**1,276,379**		**1,276,379**
Markups on Capital Cost Estimate											
Engineering and Admin. Costs (5% of Capital Costs)											
Institutional Controls	1	LS	200,000	0	0	0	200,000	1	200,000	200,000	0
Remedial Design (6%)	1	LS	219,837	0	0	0	219,837	1	219,837	219,837	219,837
Project Management (5%)	1	LS	183,198	0	0	0	183,198	1	183,198	183,198	183,198
Construction Related Services (6%)	1	LS	219,837	0	0	0	219,837	1	219,837	219,837	219,837
Dredging Demonstration Project	1	LS	0	0	0	500,000	500,000	1	500,000	500,000	0
Total Markup Costs									**1,322,872**		**622,872**
Disposal Costs											
Off-site transport/disposal at TSCA haz waste	0	TN	0	0	0	0	0	1	0	na	0
Off-site transport/disposal to RCRA Part 360 S	0	TN	0	0	0	0	0	1	0	na	0
Total Disposal Costs									**0**		**0**
Monitoring and Maintenance											
Post-Construction Inspection and Maintenance											
Cap Maintenance (every five years)	1	YR	86,637	97,303	60,310	0	244,249	2.16	526,602	526,602	526,602
Total Post-Construction Monitoring (for 30 yea	1	YR	0	0	0	163,350	163,350	12.41	2,027,010	2,027,010	0
Total Monitoring and Maintenance									**2,553,612**		**526,602**
Contingency											
Construction Contingency Costs (25% of Capi	1	LS	1,348,607	0	0	0	1,348,607	1	**1,348,607**	1,348,607	**617,388**
Total Cost			3,380,258	1,061,284	1,080,767	1,220,726	6,743,034		8,889,046		**4,069,377**
											TOTAL NOT FIXED
								check:	8,889,046		4,069,377

Task	Qty	Unit	Cost					NPV	NPV	TOTAL	Not Fixed
			Labor	Equipment	Materials	Subcont	TOTAL	Factor		UNIT $	Total
Dredging or Capping Costs (if no dredging)											
Mobilization and Site Preparation											
Mobilization	1	LS	279,341	222,709	0	0	502,050	1	502,050	502,050	502,050
Install/ Remove Fence	1,500	LF	0	0	55,545	0	55,545	1	55,545	37	0
Repair Road/ Work Area	10,000	SY	0	0	0	78,689	78,689	1	78,689	8	0
Install Work Lighting	10	EA	0	40,085	0	0	40,085	1	40,085	4,008	0
Unloading Piles and Dolphins	1	EA	0	0	0	325,938	325,938	1	325,938	325,938	0
Building over Stock Piles	30,000	SF	0	0	493,954	0	493,954	1	493,954	16	0
Asphalt Paving	90,000	SF	0	0	97,601	0	97,601	1	97,601	1	0
Demobilization	1	LS	279,341	222,709	0	0	502,050	1	502,050	502,050	502,050
Site Services and Health and Safety											
Electrical Power Hookup	1	LS	0	0	0	33,063	33,063	1	33,063	33,063	0
Water Line Hookup	1	LS	0	0	0	33,063	33,063	1	33,063	33,063	0
Contaminated Water Control System	1	LS	0	0	132,250	0	132,250	1	132,250	132,250	0
Decon Facility	1	LS	2,616	0	661	11,109	14,386	1	14,386	14,386	0
Health and Safety	1	MO	43,299	0	3,452	0	46,751	1	46,751	46,751	46,751
Solids Separation System											
Construct Process Area	1,500	LF	0	0	0	3,968	3,968	1	3,968	3	0
Solidification	0	CY	0	0	0	0	0	1	0	na	0
Water Treatment System											
Water Treatment Facility	0	0.00	0	0	0	0	0	1	0	na	0
Dredging											
Bathymetry Survey - Pre-Cap	1	LS	0	0	0	26,450	26,450	1	26,450	26,450	0
Debris Removal	0	CY	0	0	0	0	0	1	0	na	0
Dredging	0	CY	0	0	0	0	0	1	0	na	0
Bathymetry Survey - Post Cap	1	LS	0	0	0	26,450	26,450	1	26,450	26,450	0.0
Total Monitoring Costs											
PCB analysis on dewatered sediment	0.00	EA	0	0	0	0	0	1	0	na	0
Performance and discharge monitoring	0	AC	0	0	0	0	0	1	0	na	0
Environmental monitoring											
Air monitoring	0	LS	0	0	0	0	0	1	0	na	0
Water monitoring	0	MO	0	0	0	0	0	1	0	na	0
Total Dredging or Capping Direct Costs									**2,412,291**		**1,050,851**
Submerged Bulkhead											
Submerged Bulkhead	0	LF	0	0	0	0	0	1	**0**	na	**0**
Temporary Containment											
Temporary Containment Barrier	0	LF	0	0	0	0	0	1	0	na	0.0
Silt Curtain	0	LF	0	0	0	0	0	1	0	na	0.0
Total Temporary Containment									**0**		**0**
Sealed Bulkhead											
Sealed Shoreline Bulkhead	0	LF	0	0	0	0	0	1	**0**	na	**0.0**
Capping Costs											
Cap Construction											
Debris Removal	219	HR	555,763	384,336	14,481	43,444	998,025	1	998,025	4,557	998,025
Sand Cap Layer	24,135	CY	706,496	731,528	467,849	0	1,905,873	1	1,905,873	79	1,905,873
Berm	0	CY	0	0	0	0	0	1	0	na	0
Total Capping Direct Costs									**2,903,897**		**2,903,897**
Markups on Capital Cost Estimate											
Engineering and Admin. Costs (5% of Capital Costs)											
Institutional Controls	1	LS	200,000	0	0	0	200,000	1	200,000	200,000	0
Remedial Design (6%)	1	LS	318,971	0	0	0	318,971	1	318,971	318,971	318,971
Project Management (5%)	1	LS	265,809	0	0	0	265,809	1	265,809	265,809	265,809
Construction Related Services (6%)	1	LS	318,971	0	0	0	318,971	1	318,971	318,971	318,971
Dredging Demonstration Project	1	LS	0	0	0	500,000	500,000	1	500,000	500,000	0
Total Markup Costs									**1,603,752**		**903,752**
Disposal Costs											
Off-site transport/disposal at TSCA haz waste	0	TN	0	0	0	0	0	1	0	na	0
Off-site transport/disposal to RCRA Part 360	0	TN	0	0	0	0	0	1	0	na	0
Total Disposal Costs									**0**		**0**
Monitoring and Maintenance											
Post-Construction Inspection and Maintenance											
Cap Maintenance (every five years)	1	YR	91,638	103,143	70,174	0	264,954	2.16	571,242	571,242	571,242
Total Post-Construction Monitoring (for 30 ye	1	YR	0	0	0	163,350	163,350	12.41	2,027,010	2,027,010	0
Total Monitoring and Maintenance									**2,598,252**		**571,242**
Contingency											
Construction Contingency Costs (25% of Cap	1	LS	1,837,061	0	0	0	1,837,061	1	**1,837,061**	1,837,061	**1,047,969**
Total Cost			4,899,307	1,704,509	1,335,966	1,245,522	9,185,305		11,355,253		**6,477,710**

		TOTAL NOT FIXED
check:	11,355,253	6,477,710

Task	Qty	Unit	Cost					NPV	NPV	TOTAL	Not Fixed
			Labor	Equipment	Materials	Subcont	TOTAL	Factor		UNIT $	Total
Dredging or Capping Costs (if no dredging)											
Mobilization and Site Preparation											
Mobilization	1	LS	279,341	222,709	0	0	502,050	1	502,050	502,050	502,050
Install/ Remove Fence	1,500	LF	0	0	55,545	0	55,545	1	55,545	37	0
Repair Road/ Work Area	10,000	SY	0	0	0	78,689	78,689	1	78,689	8	0
Install Work Lighting	10	EA	0	40,085	0	0	40,085	1	40,085	4,008	0
Unloading Piles and Dolphins	1	EA	0	0	0	325,938	325,938	1	325,938	325,938	0
Building over Stock Piles	30,000	SF	0	0	493,954	0	493,954	1	493,954	16	0
Asphalt Paving	90,000	SF	0	0	97,601	0	97,601	1	97,601	1	0
Demobilization	1	LS	279,341	222,709	0	0	502,050	1	502,050	502,050	502,050
Site Services and Health and Safety											
Electrical Power Hookup	1	LS	0	0	0	33,063	33,063	1	33,063	33,063	0
Water Line Hookup	1	LS	0	0	0	33,063	33,063	1	33,063	33,063	0
Contaminated Water Control System	1	LS	0	0	132,250	0	132,250	1	132,250	132,250	0
Decon Facility	1	LS	2,616	0	661	11,109	14,386	1	14,386	14,386	0
Health and Safety	1	MO	35,984	0	3,452	0	39,436	1	39,436	39,436	39,436
Solids Separation System											
Construct Process Area	1,500	LF	0	0	0	3,968	3,968	1	3,968	3	0
Solidification	0	CY	0	0	0	0	0	1	0	na	0
Water Treatment System											
Water Treatment Facility	0	0.00	0	0	0	0	0	1	0	na	0
Dredging											
Bathymetry Survey - Pre-Cap	1	LS	0	0	0	26,450	26,450	1	26,450	26,450	0
Debris Removal	0	CY	0	0	0	0	0	1	0	na	0
Dredging	0	CY	0	0	0	0	0	1	0	na	0
Bathymetry Survey - Post Cap	1	LS	0	0	0	26,450	26,450	1	26,450	26,450	0.0
Total Monitoring Costs											
PCB analysis on dewatered sediment	0.00	EA	0	0	0	0	0	1	0	na	0
Performance and discharge monitoring	0	AC	0	0	0	0	0	1	0	na	0
Environmental monitoring											
Air monitoring	0	LS	0	0	0	0	0	1	0	na	0
Water monitoring	0	MO	0	0	0	0	0	1	0	na	0
Total Dredging or Capping Direct Costs									**2,404,975**		**1,043,535**
Submerged Bulkhead											
Submerged Bulkhead	0	LF	0	0	0	0	0	1	**0**	na	**0**
Temporary Containment											
Temporary Containment Barrier	0	LF	0	0	0	0	0	1	0	na	0.0
Silt Curtain	0	LF	0	0	0	0	0	1	0	na	0.0
Total Temporary Containmen									**0**		**0**
Sealed Bulkhead											
Sealed Shoreline Bulkhead	0	LF	0	0	0	0	0	1	**0**	na	**0.0**
Capping Costs											
Cap Construction											
Debris Removal	182	HR	463,062	319,402	12,035	36,104	830,603	1	830,603	4,564	830,603
Sand Cap Layer	20,054	CY	583,140	603,801	397,674	0	1,584,614	1	1,584,614	79	1,584,614
Berm	0	CY	0	0	0	0	0	1	0	na	0
Total Capping Direct Costs									**2,415,217**		**2,415,217**
Markups on Capital Cost Estimate											
Engineering and Admin. Costs (5% of Capital Costs)											
Institutional Controls	1	LS	200,000	0	0	0	200,000	1	200,000	200,000	0
Remedial Design (6%)	1	LS	289,212	0	0	0	289,212	1	289,212	289,212	289,212
Project Management (5%)	1	LS	241,010	0	0	0	241,010	1	241,010	241,010	241,010
Construction Related Services (6%)	1	LS	289,212	0	0	0	289,212	1	289,212	289,212	289,212
Dredging Demonstration Project	1	LS	0	0	0	500,000	500,000	1	500,000	500,000	0
Total Markup Costs									**1,519,433**		**819,433**
Disposal Costs											
Off-site transport/disposal at TSCA haz waste	0	TN	0	0	0	0	0	1	0	na	0
Off-site transport/disposal to RCRA Part 360	0	TN	0	0	0	0	0	1	0	na	0
Total Disposal Costs									**0**		**0**
Monitoring and Maintenance											
Post-Construction Inspection and Maintenance											
Cap Maintenance (every five years)	1	YR	90,140	101,397	67,264	0	258,801	2.16	557,975	557,975	557,975
Total Post-Construction Monitoring (for 30 ye	1	YR	0	0	0	163,350	163,350	12.41	2,027,010	2,027,010	0
Total Monitoring and Maintenance									**2,584,985**		**557,975**
Contingency											
Construction Contingency Costs (25% of Cap	1	LS	1,690,444	0	0	0	1,690,444	1	**1,690,444**	1,690,444	**916,035**
Total Cost			4,443,500	1,510,103	1,260,435	1,238,183	8,452,220		10,615,054		**5,752,195**
											TOTAL NOT FIXED
								check:	10,615,054		5,752,195

APPENDIX F

OCCUPATIONAL AND TRANSPORTATION RISKS FOR HARBOR AT HASTINGS OPERABLE UNIT 2

PREPARED BY BLASLAND, BOUCK & LEE

APRIL 2006

TABLE OF CONTENTS

Page

ATTACHMENTS

APPENDIX F

OCCUPATIONAL AND TRANSPORTATION RISKS FOR HARBOR AT HASTINGS OPERABLE UNIT 2

F1 INTRODUCTION

This document presents the occupational and transportation risks associated with the proposed remedial alternatives outlined in the Supplemental Feasibility Study (SFS) report for Operable Unit Number Two (OU-2) of the Harbor at Hastings Site (Parsons, 2006). Specifically, this document summarizes risks associated with the following three types of activities:

1. **Onsite Labor –** risks associated with onsite labor involved in dredging operations, including debris removal, and berm and cap placement activities.
2. **Offsite Transportation of Dredged Sediment –** risks associated with offsite transport of dredged river sediments primarily via rail; and
3. **Onsite Transportation of Clean Fill for Placement of Berms and Caps –** risks associated with onsite transport of sand and gravel (i.e., clean fill material) for berm and cap placement in selected areas of OU-2.

The Harbor at Hastings Site is situated on the east shore of the Hudson River in the village of Hastings-on-Hudson, Westchester County, between Yonkers, New York to the south and Tarrytown to the north. As described in Section 1 of this Supplemental Feasibility Study, OU-2 is the portion of the Hudson River adjacent to the Harbor at Hastings Site. The river sediments in OU-2 were divided into the following five areas or management units: 1) Northwest Corner; 2) Southern Area; 3) Slips; 4) Old Marina; and 5) Offshore Area. Table F.1-1 summarizes the dredging and berm/capping quantities (cubic yards) estimated for each remedial action alternative. Table F.1-2 summarizes the same quantities in tons, assuming a volume-to-weight conversion factor of 1.5 tons per cubic yard.

Each remedial alternative poses some potential risk of fatal and non-fatal injury to workers involved in dredging operations and berm/capping operations. Potential onsite worker risks are calculated by multiplying the projected annualized labor estimates (e.g., total hours or full-time employee equivalent person-years) for each of 17 labor categories by the annualized fatality rate (e.g., fatalities per person-years) and injury rate for the corresponding occupations. The employment data and rates of fatal and non-fatal injuries used in this risk assessment are based on national surveys of workers during 1992-2002, with greater emphasis given to the most recent 3 years of data (2000-2002).

Each remedial alternative also poses a risk of fatal and non-fatal injury during the transportation of dredged sediment offsite and clean berm and cap material onsite. The primary mode of transportation is assumed to be by railroad. Risks of fatal and non-fatal injury are based on statewide railroad accident statistics reported in 2000 on the number of injuries per rail mile. Three different scenarios are evaluated: 1) disposal of TSCA classified sediment[1] in Wayne, Michigan (842 miles); 2) disposal of non-TSCA classified sediment in Niagara Falls, New York (447 miles); and 3) onsite transport of clean fill from a quarry near Poughkeepsie, New York (60 miles). For the third scenario, clean fill would also be transported by truck between the quarry and a rail spur, approximately 20 miles round trip. Therefore, transportation risks of fatal and non-fatal injuries include risks of truck accidents and are based on national highway statistics on accident rates (i.e., number of accidents *per vehicle mile traveled*) for heavy trucks in 2003. For comparison, occupational risks of fatality for truck drivers are also calculated from national statistics on total employment and rates of fatal and non-fatal injuries (i.e., number of injuries *per hour of labor*).

The risks of fatalities and non-fatal injuries presented in this document can be used to evaluate and compare the proposed remedial alternatives, including multiple options proposed for some areas of OU-2. To facilitate this comparison, this document includes a discussion of the key sources of uncertainty associated with the assumptions applied to each scenario, the approach used to calculate risk, and the representativeness of the data available from national surveys of injuries and accident rates. Given that certain remedial action alternatives include multiple options, a range of total risks is presented to reflect the combination of lowest possible risks and the combination of highest possible risks. This document does not include a comparison to the theoretical chemical-related human health or ecological risks posed by river sediments that the remediation is intended to mitigate. However, occupational and transportation risks are expressed in units that facilitate such a comparison (i.e., one in *x* chance of fatality, and risk of *at least* one fatality).[2]

F2 OCCUPATIONAL RISKS TO ONSITE WORKERS INVOLVED TO DREDGING AND CAPPING OPERATIONS

F2.1 Description of Population of Concern

Occupational risks represent risks to workers engaged in sediment dredging operations, which includes pre-dredging activities (e.g., debris removal), the placement of berms and caps, and the transportation-related risks to truck drivers and railroad employees (i.e., railroad conductors; railroad break, signal, and switch operators; and mechanics described as rail car repairers). Each remedial action alternative will generally involve some combination of the following types of activities:

- mobilization, site set-up, and demobilization;
- establishing decontamination facility and following health and safety protocols;

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[1] Sediment with PCB concentrations greater than 50 ppm must be transported to a facility that can receive TSCA classified material. Sediment with PCB concentrations less than 50 ppm is classified as non-TSCA material regulated under RCRA Subtitle D.

[2] Risks are rounded to the nearest significant figure (e.g., $1.2x10^{-2}$ is expressed as $1x10^{-2}$) for consistency with common risk assessment practice. Tabular summaries presented in this document give risk estimates rounded to two significant figures (e.g., $1.244x10^{-2}$ is expressed as $1.2x10^{-2}$). The expected total number of fatalities is typically less than 1. Because the meaning of this risk metric may not be intuitive, tabular summaries of risk are presented with two alternative (and equivalent) risk metrics, expressed as a *1 in x chance of fatality* and as *risk of at least one fatality*.

- solidification, debris removal, set pilings, and sediment dredging;
- setting up silt curtains (Southern Area and Old Marina only);
- monitoring and analysis;
- containment system installation and removal;
- berm placement, capping, and debris removal during capping; and
- transportation and disposal.

Descriptions of the specific work effort involved in each activity are presented in main text of this Supplemental Feasibility Study.

Workers associated with each remedial action alternative are represented by one of 17 labor categories shown in Table F.2. While it is assumed that the greatest risks would be for occupations associated with field and construction activities (e.g., Construction Laborer, Deckhands), workers who spend a substantial percentage of time indoors (e.g., Clerks, Engineers) are also included in the population of concern.

Total labor hours for a remedial action alternative are converted to person-year equivalents for each occupation, assuming there are 2,000 working hours per year (40 hours per week, 50 weeks per year). Because labor estimates are expressed in equivalent person-years, the entire population of workers is accounted for – including part-time workers and individuals who may perform tasks associated with multiple occupations. Furthermore, since risk estimates are based on total labor hours, the duration of each remedial action is not a critical factor in this analysis. Statistics on the number of occupational fatalities are reported annually by the U.S. Department of Labor, Bureau of Labor Statistics (BLS) for specific Standard Occupation Codes (SOC). Labor estimates were matched to occupations listed in the 2000 SOC (see Attachment F1).

Risks to non-workers involved in truck or rail accidents (e.g., trespassers on a rail line) are also included as part of the population of concern in this risk assessment. Risks to this subgroup are represented by the transportation risk estimates discussed in Section 3.

In this risk assessment, occupational risk estimates represent risks of worker fatalities rather than non-fatal injuries. While national statistics on non-fatal injuries are available from the Survey of (Non-fatal) Occupational Injuries and Illnesses (Toscano et al., 1996), the classification scheme is based on a standard for classifying industries (Office of Management and Budget's *Standard Industrial Classification* (SIC) *Manual*) rather than occupations. Risk estimates based on these statistics would reflect a combination of industries, none of which can be directly related to workers involved in sediment remediation. Risks of non-fatal injuries associated with transportation of sediment and clean fill are presented as part of the transportation risk estimates discussed in Section 3.

F2.2 Approach and Risk Metrics

Occupational risks to workers involved in dredging and/or berm/cap placement activities for each remedial action alternative are determined from occupation-specific fatality rates, scenario-specific labor rates, and volumes of dredged sediment and/or clean fill material used for berms and caps.

F2.2.1 Fatality Rates

Fatality rates are estimated from national statistics for annual worker fatalities reported for specific occupations combined with estimates of the total labor force employed in each occupation. Using an approach similar to that developed by Hoskin et al. (1994), fatality rates, expressed as the number of fatal occupational injuries per 100,000 workers, are calculated according to Equation 1:

$$injury\ rate = (N / W) \times 100{,}000 \qquad \text{Equation 1}$$

where,

N = number of worker fatalities

W = annual average number of employed workers

100,000 = base for 50 full-time equivalent workers (working 40 hours per week, 50 weeks per year)

The number of worker fatalities is estimated from the annual Census of Fatal Occupational Injuries (CFOI) (BLS, 2006a). Employment data are obtained from the Occupational Employment Statistics (OES) program, which conducts a semi-annual mail survey to produce population estimates of employment among civilian workers aged 16 and older (BLS, 2006b).

Seventeen unique labor categories were used to summarize the labor estimates for this risk assessment (see Table F.2). The first step in the risk assessment is to match the labor categories with the equivalent occupation codes for *N* and *W* in Equation 1. The Standard Occupational Classification (SOC) system, maintained by the BLS, is the federal government's standard for classifying occupation data for statistical purposes (BLS, 2006c). To the extent possible, exact matches were made between each labor category and a 2000 SOC occupation. Attachment A (Table A-1) lists the specific 2000 SOC occupation that was matched with each of the 17 labor categories, the type of match (specific match, group match, assumed match), and the job description according to the U.S. Department of Labor. In most cases (14 of 17), there is a direct match between a labor category and an occupation code. For three labor categories (Industrial Hygiene Technician, Clerk, Mechanic), statistics are based on more than one SOC code. In addition, for Industrial Hygiene Technician, Leverman, statistics are based on SOC occupation(s) that are assumed to be reasonable matches from the perspective of worker safety.

While the CFOI (fatality data) and OES (employment data) programs are both maintained by the BLS, data are categorized according to different versions of the SOC, resulting in slightly different levels of aggregation for certain occupations. For example, the 1980 SOC uses a single code for secretaries, while the 2000 SOC uses four separate codes to distinguish secretaries and administrative assistants as "executive," "legal," "medical," or "other." The CFOI data reported for 1992-2002 can be searched on-line by the occupational classification system developed for the 1990 Census, which is based on the 1980 SOC. Attachment B (Table B-1) gives the number of fatalities reported during 1992-2002 for each occupation considered in this risk assessment.

Prior to 2000, OES coded annual employment data using the 1980 SOC. Beginning in 2000, OES has used the 2000 SOC. Table F.2 shows the 2000 SOC codes and the 1990 Census codes that were applied to each of the 17 labor categories in this risk assessment. The U.S. Census Bureau's 2003 report entitled, *The Relationship between the 1990 Census and Census 2000 Industry and Occupation Classification Systems* (U.S. Department of Commerce, 2003), was referenced to establish the most appropriate groupings of data.

Table F.3 summarizes the employment statistics for 2000, 2001, 2002, and the mean employment for 2000-2002; the CFOI fatality data for 2000, 2001, 2002, and the mean for 1992-1999; and corresponding fatality rates calculated using Equation 1. Because employment statistics presented prior to 2000 are aggregated using a different occupational classification system, they are not directly comparable to statistics presented for 2000-2002. Therefore, the average employment during 1992-1999 is estimated by the average employment during 2000-2002. Uncertainty associated with this extrapolation is considered to be low given that there is no clear trend in employment between 1992 and 2002 for the 17 labor categories evaluated in this risk assessment. The overall average fatality rate for each labor category is based the sum of the rates for 2000, 2001, 2002, and "mean 1992-1999," divided by four. This approach is used to maximize the information available from the two databases, while giving greater weight to the most recent three years of statistics. Including data from the 1990s increases the reliability of the overall average fatality rate for occupations with relatively low employment, and therefore, infrequent incidents of fatality (e.g., Diver, Surveyor).

F2.2.2 Labor Rates

Table F.4-1 summarizes estimated labor rates (hours per 1,000 cy) associated with dredging and berm/cap operations specific to each of the proposed remedial alternatives. Labor rates associated with the use of silt curtains only applies to remedial alternatives for the Southern Area and Old Marina. Therefore, two different labor rates for Laborers are given – one including the labor associated with silt curtains, and one excluding this activity. A breakdown of labor rates associated with specific groups of activities listed in Section 2.1 is given by Table F.4-2. Labor rates are normalized to 1,000 cubic yards of dredged sediment to facilitate scaling risks to each remedial alternative.

Risks of injury to railroad employees can be estimated based on incident rates per train mile (i.e., transportation risk), or by incident rates per labor hour (occupational risk). Both approaches were explored for this risk assessment. Occupational risks include three occupations related to rail transportation: 1) rail railroad conductors; 2) railroad break, signal, and switch operators; and 3) mechanics described as rail car repairers. Estimated labor hours for railroad conductors and switch operators were based on labor hour projections (hours per cubic yard of dredged material) for a similar dredging operation in the Passaic River. Estimated labor hours for mechanics are assumed to be representative of the both mobile heavy equipment mechanics (2000 SOC Code 49-3042) and rail car repairers (2000 SOC Code 49-3043).

Similarly, risks of injury to truck drivers can be estimated based on incident rates per annual vehicle mile traveled (AVMT), which is a transportation risk (see Section 3), or by incident rates per labor hour. Both approaches were explored for this risk assessment. The transportation of clean fill to the Site involves a 20-mile round trip distance. It was assumed that truck drivers would spend one hour per round trip, including loading, driving, and unloading clean fill.

F2.2.3 Risk Metrics

The occupational fatalities associated with each remedial alternative are determined by multiplying the fatality rates (number of fatalities per 100,000 workers) by the total projected labor (number of full time equivalent workers) for each occupation. Total projected labor is determined by multiplying the labor rate (hours per 1,000 cy) by the volume of dredged sediment or clean fill associated with a remedial action alternative. This yields the number of expected fatalities associated with each remedial alternative. Because this value is typically less than 1.0, two alternative risk metrics are used in this risk assessment, both of which are based on the number of expected fatalities or non-fatal injuries.

The first risk metric is simply the inverse of the number of fatalities, expressed as the chance of one fatality per *x* number of events. For example, if the number of expected fatalities associated with a remedial option is 0.25, then there is a 1 in 4 chance (i.e., 1/0.25 = 4) of a fatality.

A second alternative risk metric is given by the risk of *at least* one fatality, which can be computed assuming that the injury-producing process follows a Poisson distribution (Hoskin et al., 1994):

$$f(x) = \frac{(e^{-\mu} \times \mu^{x})}{x!} \qquad \text{Equation 2}$$

where,

f(x) = probability of experiencing exactly *x* fatalities

x = number of fatalities

μ = mean of Poisson distribution equal to the number of success in *n* trials

The probability of experiencing at least one fatality is equal to one minus the probability of experiencing zero fatalities, or 1 – *f*(0). Substituting this expression into Equation 2 yields:

$$1 - f(0) = 1 - \frac{(e^{-\mu} \times \mu^{0})}{0!} = 1 - \frac{e^{-\mu} \times 1}{1} = 1 - e^{-\mu}$$

The value of μ is given by the estimated number of fatalities or non-fatal injuries.

These two risk metrics – the chance of one fatality in *x* events, and the probability of experiencing *at least* one fatality – are presented for each remedial action alternative. In addition, the total risk is estimated by adding the risks associated with remedial action alternatives for each area of OU-2. Because options are proposed for some alternatives, the total risk depends on the options that are selected. A range of total risks can be determined by identifying the set of alternatives that yield the minimum total risk and maximum total risk.

F2.3 Results

Utilizing projected labor rates, occupation-specific fatality rates based on national employment and fatality data, and estimates of dredged sediment volumes, risks of occupational fatalities were determined for each remedial alternative. Occupational risk estimates by labor category for each of the five areas in OU-2 are presented in Tables F.5-1 to F.5-5. Two risk metrics are presented: the chance of a fatality (i.e., 1 in *x*) and the risk of *at least* one fatality. A summary of the overall occupational risk estimates for each area is presented in Tables F.9-1 to F.9-3.

F2.3.1 Total Occupational Risks

The total occupational risk of fatality for all remedial action alternatives can be expressed as a range (Table F.9-1). Different options are presented for specific remedial alternatives in three of the areas. Combining options that yield the *minimum* total dredge volume yields a *minimum* total risk of a fatality of 1 in 4, or a risk of at least one fatality of 2×10^{-1} (rounded from 2.1×10^{-1}). Similarly, combining alternatives that yield a *maximum* total dredge volume yields a *maximum* total risk of 1 in 4 (or 2×10^{-1} rounded from 2.2×10^{-1}). Thus, the uncertainty in the *total* risk associated with the different sets of options appears to be relatively low. A comparison of the specific risk for each option is given below (Section 2.3.3).

F2.3.2 Comparison of All Remedial Action Alternatives

Within each area of OU-2, the following alternatives yield the minimum and maximum occupational risks:

• Northwest Corner	1 in 100	1×10^{-2}	NW-1
	1 in 24	4×10^{-2}	NW-2, Option B
• Southern Area	1 in 624	2×10^{-3}	SA-1
	1 in 53	2×10^{-2}	SA-4
• NSlips	1 in 274	4×10^{-3}	NSlip-1
	1 in 60	2×10^{-2}	NSlip-2
• Old Marina	1 in 88	1×10^{-2}	OM-1
	1 in 44	2×10^{-2}	OM-3
• Offshore Area	1 in 497	2×10^{-3}	OS-2, Option A
	1 in 212	5×10^{-3}	OS-2, Option B

The ratio of maximum to minimum risks within each area provides a measure of variability that can be used to compare areas. Remedial alternatives in the Old Marina area have the most similar occupational risks of fatality, differing only by a factor of two. Remedial alternatives in the Southern Area have the most variable occupational risks, differing by a factor of approximately 19. The highest risk of an occupational fatality is 1 in 24 (4×10^{-2} risk of at least one fatality), associated with Alternative NW-2, Option B, which includes the removal of 27,000 cy of sediment and the placement of 15,300 cy of berm and cap material (Table F.5-1). The lowest risk of a fatality is 1 in 624 (2×10^{-3}), associated with Alternative SA-1, involving no sediment removal and the placement of 7,260 cy of cap material (Table F.5-2). Occupational risks generally increase in proportion to the volume of dredged sediment removed and clean fill material added. The relationships between fatality rates (deaths per 100,000 workers) and labor rates (hours [workers] per 1,000 cy) among the 17 occupations that comprise the overall risks for each remedial alternative are discussed below (Section 2.3.5 below).

F2.3.3 Comparison of Options for Remedial Action Alternatives

A more detailed comparison of risks associated with each remedial action alternative is given by Tables F.9-2 and F.9-3. Three of the five areas of OU-2 evaluated in this risk assessment include a remedial action alternative with more than one option. For Alternative NW-2, risks associated with Options A and B are 1 in 36 and 1 in 25, respectively. Therefore, the relative risk (defined as the ratio of the lower risk divided by the higher risk) is 0.70 or 70 percent. In other words, the occupational risk associated with implementing NW-2 Option A is approximately 70 percent of the risk associated with implementing NW-2 Option B. For Alternative Southern Area-3, risks associated with Options A and B are 1 in 53 and 1 in 50, a difference of about 5 percent. A similar risk for these two options is expected given that the volumes of dredged sediment and berm/cap material are similar for both alternatives. For Alternative Offshore Area-2, risks associated with Options A, B, and C are 1 in 497, 1 in 212, and 1 in 259, respectively. The risk of Options A and C are approximately 43 percent and 82 percent of the risk of Option B, respectively.

F2.3.4 Comparison of OU-2 Areas

The total occupational risks of fatality associated with each area are also summarized in Table F.9-2. Using the option that yields the highest possible risk within each area, the total area-wide risk ranges from 1 in 212 for the Offshore Area alternatives to 1 in 9 for the Northwest Corner alternatives. The overall occupational risk of fatality within OU-2 areas (i.e., sum of total risk from each area) is approximately 1 in 4. Implementation of the alternatives in the Northwest Corner contributes approximately 42 percent to the overall occupational risk, followed by Southern Area alternatives (25 percent), Old Marina (19 percent), NSlips (12 percent), and Offshore Areas (2 percent).

F2.3.5 Occupations with Greatest Risk

Table F.9-3 summarizes the percent contribution of each of the 17 occupations to the risk associated with each remedial action alternative. Risk estimates in each area are generally most sensitive to the labor projections for 5 of the 17 occupations: Deckhand, Laborer, Tug Boat Captain, Leverman/Operator, and Pile Driver. The combined risks of these five occupation categories consistently accounts for 80 percent to 85 percent of the total occupational risk for each remedial alternative. Six of the 17 occupations generally contribute (individually) between 1 percent and 10 percent to the total risk: Truck Driver, Railroad Switch Operator, Railroad Conductor, Superintendent, Diver, and Mechanic. The remaining 6 of the 17 occupations consistently contribute (individually) less than 1 percent to the total risk: Surveyor, Foreman/Project Manager, Industrial Hygiene Technician, Engineer, Industrial Hygienist, and Clerk. Occupational risks associated with the alternatives in the Offshore Area demonstrate a similar pattern; however, because proposed activities are restricted to capping (i.e., there is no sediment removal)., truck drivers contribute a proportionately higher risk (10 percent) than alternatives in other areas.

Occupational risks generally increase in proportion to the volume of dredged sediment removed and clean fill material added. More specifically, occupational risks reflect a combination of fatality rates and labor rates, which are expressed as hours per cubic volume. The different sets of labor projections are summarized in Table F.4.1. For dredging, three different sets of labor projections are given, corresponding to NW-1, NW-4, and all other remedial alternatives. One set of labor projections is assumed for all berm and capping activities. In general, occupations with both high fatality rates and high labor rates have the highest overall risk of fatalities. Conversely, occupations with relative low fatality and/or labor rates have the lowest overall risks. For each remedial alternative, 80 percent to 90 percent of the total occupational risk can typically be attributed to 5 to 7 of the 17 occupations evaluated in this risk assessment.

For dredging operations, the risks generally reflect activities of five occupation groups: Deckhand, Laborer, Tug Boat Captain, Leverman/Operator, and Pile Driver. These five occupation categories account for approximately 85 percent of the total risk for NW-1. While NW-1 has relatively high labor projections for each of these categories, the total dredged sediment volume (5,900 cy) and berm/cap material (11,900 cy) is the lowest among the five alternatives (including two options) in Northwest Corner, resulting in the lowest total risk for NW-1. Alternative NW-4 has the highest volumes of all of the proposed alternatives in OU-2 (51,000 cy of dredged sediment and 36,800 cy of berm/cap material), however, corresponding risks are relatively low because the labor projections for the critical occupations noted above are the lowest for this alternative.

For berm and cap placement activities, approximately 84 percent to 91 percent of the occupational risks are based on 7 of 17 occupations. The critical occupations include four 4 of 5 critical occupations identified for dredging (excluding Pile Driver) - Deckhand, Laborer, Tug Boat Captain, and Leverman/Operator, plus three occupations involved in the transportation of clean material to the Site - Railroad Conductor, Switch Operator, and Truck Driver.

F3 TRANSPORTATION RISKS

F3.1 Description of Population of Concern

There are transportation-related risks associated with moving dredged material to offsite disposal facilities as well as moving clean fill (e.g., sand and gravel) onsite for berm and capping operations. Risks can be estimated for both the occupants of the transportation vehicle (e.g., truck driver, railroad conductor) as well as non-occupants that may be involved in a transportation-related accident. This assessment considers risks to both occupants and non-occupants. Risks to workers involved in the transportation process, but who would not likely be involved in an accident (e.g., rail switch operator) are not considered in the population of concern for offsite transport in this section. Rather, these workers are included as the population of concern for onsite occupational risks (see Section 2).

Transportation risks of fatality and non-fatal injury are both presented in this risk assessment. In order to characterize the population of concern represented by statistics on rates of non-fatal accident-related injuries, it is important to understand how government agencies define a non-fatal injury. Accident data involving transportation by heavy truck used in this risk assessment are summarized by the U.S. Department of Transportation (U.S. DOT) Bureau of Transportation Statistics (U.S. DOT, 2005). Truck accidents include only crashes where a police accident report was completed and the crash resulted in property damage, injury, or death. Since 2002, only injuries requiring immediate medical treatment away from the scene qualify as reportable[3]. (Prior to 2002, any injury was reportable.) Accident data involving transportation by rail used in this risk assessment are summarized by U.S. DOT's Federal Railroad Administration (FRA) Railroad Safety Statistics Annual Report (U.S. DOT, 2001). Rail accidents and incidents include reports of fatalities (defined as death of a person within 365 calendar days of the accident/incident), non-fatal injuries to a person (railroad employee or non-employee) that requires medical treatment, and non-fatal injuries to a railroad employee that results in restriction of work for one or more work days, the loss of one or more work days, termination of employment, transfer to another job, or loss of consciousness (U.S. DOT, 2005). Occupational illnesses of railroad employees are also counted in the total incident rate, but are not included in estimates of non-fatal injury rates for purposes of this risk assessment.

F3.2 Approach

F3.2.1 Rail Transport of Dredged Material

The primary mode of transportation of dredged material offsite would be by rail line. The transportation-related risk is determined by the distance to the disposal facility and the average accident rates along the transportation route. The dredged sediment volumes are the primary factor in determining the total number of train trips required. A volume-to-weight conversion factor of 1.5 tons per cubic yard is used to relate the total volume of dredged sediment (Table F.1-1) to the carrying capacity of transportation vehicles. Table F.1-2 summarizes the mass of material requiring transportation for each proposed remedial alternative. Assuming an average capacity of approximately 100 tons per rail car, and a maximum of 80 rail cars per train, the maximum capacity per trip is 80,000 tons. The maximum capacity of heavy trucks is estimated to be 32 tons.

This risk assessment assumes that dredged sediment will be transported by rail to one of two offsite disposal facilities. A rail line located in Westchester County supports Class 1 carriers (e.g., CSX Transportation), and a rail spur will be installed at the adjacent Operable Unit 1. Tables F.1-1 and F.1-2 summarize estimates of the total volume and weight of dredged sediments to be transported by rail, respectively, and the percentage of material that is likely to be classified as TSCA material and non-TSCA material (i.e., material regulated under RCRA Subtitle D). TSCA-classified dredged material would be transported to an authorized hazardous waste landfill in Wayne, Michigan. Based on the CSX Rail Mileage Calculator (http://shipcsx.com/public/ec.shipcsxpublic/Main), the approximate rail line distance from Hastings-on-Hudson, New York to Wayne, Michigan is 842 miles. Non-TSCA material would

3 Police reports of non-fatal injuries associated with crashes involving heavy trucks may fall into one of three categories: 1) Incapacitating Injury (e.g., severe lacerations, broken or distorted limbs, skull or chest injuries, abdominal injuries, unconsciousness at or when taken from the accident scene, and inability to leave the accident scene without assistance); 2) Nonincapacitating Evident Injury (e.g., lumps on head, abrasions, bruises, minor lacerations, and others evident to observers at the scene); and 3) Possible Injury (e.g., momentary unconsciousness, claim of injuries not obvious, limping, complaint of pain, nausea, hysteria) (U.S. DOT, 2005).

be transported to the hazardous waste landfill located at Pine Avenue in Niagara Falls, New York, located approximately 447 rail miles from the Site. This risk assessment also considers risks associated with transporting clean berm and cap material to the Site from a sand and gravel quarry located approximately 10 miles from the rail junction in Poughkeepsie, New York, which is 60 rail miles north of the Site. Transportation risks for this activity are based on rail transport for 60 rail miles and truck transport for 20 vehicle miles (round trip).

The maximum quantities of dredged sediment (assuming options that yield the highest volume in each area) are approximately 80,600 tons and 196,600 tons for TSCA and non-TSCA material, respectively (see Table F.1-2). Therefore, assuming a maximum carrying capacity of approximately 80,000 tons per train (1,000 tons per rail car x 80 rail cars), the TSCA material can be transported in one trip for a total rail line distance of 842 miles. The non-TSCA material can be transported in three trips, for a total rail line distance of 1,342 miles (447.25 x 3). This risk assessment does not include round-trip distances for trains; it is assumed that the rail carrier will coordinate the availability of rail cars such that rail cars already in New York will be used to load sediment, and rail cars at the disposal facilities will be used in other capacities in close proximity to the disposal facilities. This approach may underestimate the total rail line distance traveled as a result of dredging operations and represents a source of uncertainty in the risk estimates.

The overall transportation-risks are determined by the average accident rates along the proposed routes, which vary by state. The TSCA material would be transported through four states (New York, Pennsylvania, Ohio, and Michigan), whereas the non-TSCA material and clean fill would be transported in one state exclusively (New York). The general formula for estimating the weighted number of accidents associated with transporting materials is given by Equation 3:

$$number\,of\ accidents = \sum_{i=1}^{n} R_i \times D_i \qquad \text{Equation 3}$$

where,

R_i = accident rate per train mile in i^{th} state

D = distance along route between the Site and disposal facility (rail miles) in i^{th} state

National statistics on accident rates and accident-related fatalities and injuries are maintained by the Federal Railroad Administration (FRA). The estimated number of accidents and accident-related fatalities and injuries associated with offsite transport are presented in Tables F.6-1 and F.6-2 for transport of TSCA and non-TSCA classified sediments, respectively. These rates reflect a combination of incidents involving railroad employees and non-railroad employees (e.g., trespassers on a rail line), and highway-rail collisions reported in 2000 (U.S. DOT, 2001). Although the reported number of fatalities and non-fatal injuries is highest for New York, the rate of these incidences is relatively low compared with other states because the total rail miles for Class 1 carriers is highest in New York. As shown in Table F.6-1, the rate of deaths per million rail miles in New York is 1.6, compared with 24.8 for Michigan. Similarly, the rate of non-fatal injuries per million rail miles is 57.9 for New York, compared with 324.0 for

Michigan. The statistics for New York apply to the disposal of non-TSCA material to Niagara Falls, and the transport of clean fill from Poughkeepsie, New York, because both rail routes remains in New York exclusively. For the disposal of TSCA classified sediment, which requires transport to the hazardous waste landfill in Wayne, Michigan, the route crosses through multiple states – New York (59 percent of total trip), Pennsylvania (5 percent), Ohio (26 percent), and Michigan (10 percent). The weighted average rate of fatalities and non-fatal injuries per million rail miles for disposal of TSCA classified sediment is 7.5 and 118.3, respectively.

As described in Section 2.2 above, risks of injury to railroad employees can be estimated based on incident rates per train mile (i.e., transportation risk), or by incident rates per labor hour. For this risk assessment, three occupations related to rail transportation were identified: 1) rail railroad conductors; 2) railroad break, signal, and switch operators; and 3) mechanics described as rail car repairers. A single train trip can transport sediment removed from multiple remedial action alternatives. Similarly, a single train trip can transport clean fill material sufficient to place berms and caps in multiple areas of the Site. Therefore, it is difficult to apportion the transportation risks among each remedial action alternative on the basis of train miles. By contrast, total occupational risks can be apportioned among each alternative based on the relationships between labor hours and quantities of material requiring transportation. To facilitate a comparison of risks associated with each remedial alternative, risks to railroad employees are included in the total occupational risk estimate.

Transportation risks include risks to both employees and non-employees, although the majority of the fatalities are non-employees. According to the FRA, 97 percent (912 of 937) of the fatalities reported in 2000 were identified as non- employees such as trespassers, non-trespassers, and passengers (U.S. DOT, 2001). Therefore, for this risk assessment, transportation risks were added to occupational risks to account for fatalities among both workers and the general public.

F3.2.2 Truck Transport of Material for Berm and Capping Activities

The primary mode of transportation for sand and gravel used in placing berms and protective caps would be by heavy trucks, which are assumed to have a carrying capacity of 32 tons. Clean fill material would be transported from a local sand and gravel quarry located approximately 10 miles from a rail junction at Poughkeepsie, New York; therefore, it is assumed that a 20-mile round-trip distance is traveled by each truck carrying clean fill.

Tables F.7-1 and F.7-2 summarize the total number of truck loads and the corresponding annual vehicle miles (AVMT = number of truck loads x round-trip distance) for each remedial action alternative associated with berm placement and capping activities. Depending on the options selected for each area, the total weight of clean fill that would be transported to the Site ranges from 362,000 tons to 383,000 tons. Dividing these estimates by the 32-ton capacity of heavy trucks, the total number of truck loads to the rail spur would range from 11,300 to 12,000 trips, and the corresponding total round-trip truck mileage (i.e., the AMVT) would range from 226,000 to 239,000 miles.

Tables F.7.-1 and F.7-2 also summarize the projected number of accidents associated with the transport of clean fill to the Site. Given the accident rate for heavy trucks in the U.S. is 2.0 x

10^{-6} accidents per AVMT (or 1 accident per 500,000 miles), and the total AMVT may range from 226,000 to 239,000 (see above), the projected total number of accidents is 0.45 to 0.48, or approximately a 1 in 2 chance of an accident.

National transportation statistics on the number of truck accidents resulting in non-fatal injuries and fatalities are summarized by the Bureau of Transportation Statistics (U.S. DOT, 2005). The number of incidents per AVMT determines the rate of non-fatal injuries and fatalities. For example, there were 723 fatalities related among occupants of large trucks (> 10,000 pounds gross weight) in 2003 and 2.2×10^{11} AVMT by large trucks (U.S. DOT, 2005). Therefore, the rate of fatalities per AVMT is 3.3×10^{-9}. To determine the risk of non-fatal injuries and fatalities associated with each remedial action alternative, the injury rates per AMVT are multiplied by the project-specific AMVT. Tables F.8-1 and F.8-2 summarize the projected number of truck accident related injuries (both fatal and non-fatal) for each remedial action alternative.

Transportation-related risks for truck drivers can be estimated based on incident rates per AMVT (i.e., a transportation risk) as well as by incident rates per labor hour (i.e., an occupational risk). Statistics reported on a per-mile basis may reflect injuries to truck drivers, occupants of other vehicles involved in the crash, and/or pedestrians. By contrast, injuries reported on a per-hour basis will reflect risks to truck drivers exclusively. Both methods are evaluated in this risk assessment for purposes of comparison.

F3.3 Results

A summary of the projected transportation-related fatalities and non-fatal injuries associated with the proposed remedial alternatives for each area in OU-2 is presented in Table F.9.

F3.3.1 Risk of Fatalities

Based on the national accident statistics for railroads in 2000 (U.S. DOT, 2001), the risk of at least one fatality associated with disposal of TSCA and non-TSCA classified sediment is 6×10^{-3} (or 1 in 158) and 2×10^{-3} (1 in 469), respectively. In addition, the risk of at least one fatality associated with transporting sand and gravel to the Site is 4×10^{-4} (1 in 2,625). Altogether, the total risk of risk of at least one fatality associated with transportation by rail is approximately 9×10^{-3} (1 in 113), and approximately 97 percent of the risk is attributable to non-workers involved in rail-related accidents.

Based on the national accident statistics for trucks reported as incidents per vehicle mile (referred to in Table F.9 as the "Mileage Basis"), the risk of at least one fatality associated with the transportation of sand and gravel for berm and capping activities is 8×10^{-4} (approximately 1 in 1,300) for both the minimum and maximum possible weight of material determined by the remedial action alternatives that are selected. An alternative methodology for estimating risks to truck drivers is to estimate the total labor hours and multiply by the rate of fatal accidents per hour – referred to in Table F.9 as the "Labor Basis." Using this approach, risks to truck drivers are greater by approximately one order of magnitude.

F3.3.2 Risk of Non-fatal Injuries

Risks of non-fatal injuries associated with rail-related accidents are summarized Tables F.6-1 and F.6-2. For the disposal of TSCA classified sediment to Wayne, Michigan (Table F.6-1), the risk of at least one train-related non-fatal injury is 1×10^{-1} (1 in 10). For the disposal of non-TSCA classified sediment to Niagara Falls, New York (Table F.6-2), the risk of at least one non-fatal injury is 8×10^{-2} (1 in 13). Finally, for the transport of clean fill to the Site from to Poughkeepsie, New York (Table F.6-2), the risk of at least one non-fatal injury is 1×10^{-2} (1 in 72). Altogether, the total risk of risk of at least one non-fatality injury associated with transportation by rail is approximately 2×10^{-1} (1 in 5).

Based on the national accident statistics for trucks reported as incidents per vehicle mile (see Tables F.8-1 and F.8-2), the risk of at least one non-fatal injury associated with the transportation of sand and gravel for berm and capping activities is 3×10^{-2} (approximately 1 in 33) for both the minimum and maximum possible weight of material determined by the remedial action alternatives that are selected.

F4 SUMMARY OF RISKS

F4.1 Summary of Risks

The total risk associated with all dredging and berm/cap operations was calculated for each remedial alternative by summing the occupational risks and the transportation risks. Occupational risks account for approximately 97 percent of the total risk of fatalities, whereas transportation risks account for approximately 3 percent of total risks. Combining options that yield the *minimum* total dredge volume yields a *minimum* total risk of a fatality of 1 in 4, or a risk of at least one fatality of 2×10^{-1} (rounded from 2.1×10^{-1}). Similarly, combining alternatives that yield a *maximum* total dredge volume yields a *maximum* total risk of 1 in 4 (or 2×10^{-1} rounded from 2.2×10^{-1}). Thus, the uncertainty in the *total* risk associated with the different sets of options appears to be relatively low.

Risks for workers involved in transportation (Truck Driver, Railroad Conductor, and Switch Operator) are estimated on the basis of labor hours rather than vehicle miles. For truck drivers, risks of fatality based on labor projections ranges from 1 in 194 (5×10^{-3}) to 1 in 184 (5×10^{-3}), which is approximately an order of magnitude greater than the risk based on vehicle miles (1 in 1,332 to 1 in 1,259). Risks associated with rail transport of dredged sediment and clean fill were added to occupational risks to determine the total risk. The total risk of at least one fatality associated with transportation by rail is approximately 9×10^{-3} (1 in 113). The total risk of risk of at least one non-fatal injury associated with transportation by rail is approximately 2×10^{-1} (1 in 5). Given that approximately 3 percent of the risks associated with railroad reflect injuries to employees, this approach does not "double count" risks to railroad conductors and switch operators so much as it accounts for non-workers potentially involved in rail-related accidents.

Based on the national accident statistics for trucks reported as incidents per vehicle mile (see Tables F.8-1 and F.8-2), the risk of at least one non-fatal injury associated with the transportation of sand and gravel for berm and capping activities is 3×10^{-2} (approximately 1 in 35) for both the minimum and maximum possible weight of material determined by the remedial action alternatives that are selected.

The remedial action alternative with the highest total occupational risk of 1 in 24 (4×10^{-2}) is the Northwest Corner, NW-2 Option B. The remedial alternative with the lowest total occupational risk of 1 in 624 (2×10^{-3}) is the Southern Area, SA-1. Implementation of the alternatives in the Northwest Corner contributes approximately 47 percent to the overall occupational risk, followed by Southern Area alternatives (29 percent), Old Marina (14 percent), NSlips (9 percent), and Offshore Areas (2 percent).

Three of the five areas of OU-2 evaluated in this risk assessment include a remedial action alternative with more than one option. For Alternative NW-2, risks associated with Options A and B are 1 in 36 and 1 in 25, respectively. Therefore, the occupational risk associated with implementing NW-2 Option A is approximately 70 percent of the risk associated with implementing NW-2 Option B. For Alternative Southern Area-3, risks associated with Options A and B are 1 in 53 and 1 in 50, a difference of about 5 percent. For Alternative Offshore Area-2, risks associated with Options A, B, and C are 1 in 497, 1 in 212, and 1 in 259, respectively. The risk of Options A and C are approximately 43 percent and 82 percent of the risk of Option B, respectively.

Risk estimates in each area are generally most sensitive to the labor projections for 5 of the 17 occupations: Deckhand, Laborer, Tug Boat Captain, Leverman/Operator, and Pile Driver. The combined risks of these five occupation categories consistently accounts for 80 percent to 85 percent of the total occupational risk for each remedial alternative. Remedial options that involve fewer hours of labor for workers in these occupations will have the greatest impact on reducing the overall occupational risks of fatality and non-fatal injury.

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Table F.1-1. Quantities (cubic yards) of Dredged Sediment and Clean Fill for Berm and Cap for All Remedial Action Alternatives.[a]

OU-2 Areas	Remedial Action Alternatives		Sediment Removal (cy) TSCA[b]	Non-TSCA[c]	Total	Berm Volume (cy)	Cap Material (cy)	Berm + Cap (cy)
Northwest Corner	NW-1	Dredge for Cap Stability	5,900	0	5,900	2,600	9,300	11,900
	NW-2, Option A	Dredge to Limit of Bulkhead Stability	9,500	9,500	19,000	5,700	9,100	14,800
	NW-2, Option B	Dredge to Limit of Bulkhead Stability	13,500	13,500	27,000	6,200	9,100	15,300
	NW-3	Redivide OU-1 and OU-2	4,500	13,500	18,000	26,000	5,000	31,000
	NW-4	Penetrate Shoreline Bulkhead into Basal Sands	25,500	25,500	51,000	27,700	9,100	36,800
Southern Area	SA-1	Place a Protective Cap	0	0	0	0	7,260	7,260
	SA-2	Dredge 2 ft and Place a Protective Cap	0	6,900	6,900	23,200	7,300	30,500
	SA-3, Option A	Dredge to Limit of Bulkhead Stability	0	8,300	8,300	24,200	7,300	31,500
	SA-3, Option B	Dredge to Limit of Bulkhead Stability	0	8,800	8,800	25,200	7,300	32,500
	SA-4	Penetrate Shoreline Bulkhead into Basal Sands	0	16,000	16,000	26,200	7,300	33,500
NSlips 1 and 2	NSlip-1	Dredge 2 ft and Place Protective Cap	525	1,575	2,100	0	2,823	2,823
	NSlip-2	Dredge to Limit of Bulkhead Stability	2,100	6,300	8,400	11,700	9,100	20,800
Old Marina	OM-1	Dredge 2 ft and Place Protective Cap	0	7,000	7,000	700	4,800	5,500
	OM-2	Dredge to Limit of Bulkhead Stability	0	15,000	15,000	700	4,800	5,500
Offshore Area	Offshore-2, Option A	OS-2 (PCBs>1ppm and/or Cu982) Place a Protective Cap	0	0	0	0	9,400	9,400
	Offshore-2, Option B	OS-2 (PCBs>1ppm and/or Cu88.7 (PRAP)) Place a Protective Cap	0	0	0	0	22,000	22,000
	Offshore-2, Option C	OS-2 (PCBs>1ppm and/or Cu88.7 (ESI)) Place a Protective Cap	0	0	0	0	18,000	18,000
		Minimum Total[d]	48,025	109,575	157,600	86,700	60,083	146,783
		Maximum Total[e]	52,025	114,075	166,100	87,700	68,683	156,383

[a] See Table F.1-2 for equivalent quantities in tons transported, assuming a volume-to-weight conversion factor of 1.5 tons per cubic yard.

[b] Sediment regulated under TSCA (PCB concentration > 50 ppm) that will be transported to a landfill facility in Wayne, MI (Figure F.1).

[c] Sediment regulated under RCRA Subtitle D that will be transported to a landfill facility in Niagara Falls, NY (Figure F.2).

[d] Sum of all remediation alternative volumes using the minimum options in each area.

[e] Sum of all remediation alternative volumes using the maximum options in each area.

Table F.1-2. Quantities (tons) of Dredged Sediment and Clean Fill for Berm and Cap for All Remedial Action Alternatives.[a]

OU-2 Areas	Remedial Action Alternatives		Sediment Removal (tons)			Clean Fill Material (tons)		
			TSCA[b]	Non-TSCA[c]	Total	Berm	Cap	Berm + Cap
Northwest Corner	NW-1	Dredge for Cap Stability	8,850	0	8,850	3,900	13,950	17,850
	NW-2, Option A	Dredge to Limit of Bulkhead Stability	14,250	14,250	28,500	8,550	13,650	22,200
	NW-2, Option B	Dredge to Limit of Bulkhead Stability	20,250	20,250	40,500	9,300	13,650	22,950
	NW-3	Redivide OU-1 and OU-2	6,750	20,250	27,000	39,000	7,500	46,500
	NW-4	Penetrate Shoreline Bulkhead into Basal Sands	38,250	38,250	76,500	41,550	13,650	55,200
Southern Area	SA-1	Place a Protective Cap	0	0	0	0	10,890	10,890
	SA-2	Dredge 2 ft and Place a Protective Cap	0	10,350	10,350	34,800	10,950	45,750
	SA-3, Option A	Dredge to Limit of Bulkhead Stability	0	12,450	12,450	36,300	10,950	47,250
	SA-3, Option B	Dredge to Limit of Bulkhead Stability	0	13,200	13,200	37,800	10,950	48,750
	SA-4	Penetrate Shoreline Bulkhead into Basal Sands	0	24,000	24,000	39,300	10,950	50,250
NSlips 1 and 2	NSlip-1	Dredge 2 ft and Place Protective Cap	788	2,363	3,150	0	4,235	4,235
	NSlip-2	Dredge to Limit of Bulkhead Stability	3,150	9,450	12,600	17,550	13,650	31,200
Old Marina	OM-1	Dredge 2 ft and Place Protective Cap	0	10,500	10,500	1,050	7,200	8,250
	OM-2	Dredge to Limit of Bulkhead Stability	0	22,500	22,500	1,050	7,200	8,250
Offshore Area	Offshore-2, Option A	OS-2 (PCBs>1ppm and/or Cu982) Place a Protective Cap	0	0	0	0	14,100	14,100
	Offshore-2, Option B	OS-2 (PCBs>1ppm and/or Cu88.7 (PRAP)) Place a Protective Cap	0	0	0	0	33,000	33,000
	Offshore-2, Option C	OS-2 (PCBs>1ppm and/or Cu88.7 (ESI)) Place a Protective Cap	0	0	0	0	27,000	27,000
		Minimum Total[d]	72,038	164,363	236,400	130,050	90,125	220,175
		Maximum Total[e]	78,038	171,113	249,150	131,550	103,025	234,575
		Total Number of Train Trips[f]	1	3				4

[a] See Table F.1-1 for equivalent quantities in cubic yards, assuming a volume-to-weight conversion factor of 1.5 tons per cubic yard.
[b] Sediment regulated under TSCA (PCB concentration > 50 ppm) that will be transported to a landfill facility in Wayne, MI (Figure F.1).
[c] Sediment regulated under RCRA Subtitle D that will be transported to a landfill facility in Niagara Falls, NY (Figure F.2).
[d] Sum of all remediation alternative volumes using the minimum options in each area.
[e] Sum of all remediation alternative volumes using the maximum options in each area.
[f] Assuming maximum capacity of 80,000 tons per train (80 cars x 1,000 tons per car).

Table F.2. Occupation Codes Applied to Labor Categories to Estimate Employment and Occupational Injury Rates.

Remediation Labor Category	Occupational Employement Statistics (OES)[a]		Census of Fatal Occupation Injuries (CFOI)[c]	
	2000 SOC Code[b]	Occupation Title	1990 Census	Occupation Title
Foreman, Project Manager	11-9041	Engineering Manager	021	Managers, service organizations, not elsewhere classified, n.e.c.
Engineer	17-2051	Civil Engineer	053	Civil engineer
Industrial Hygienist	17-2111	Health and Safety Engineers, Except Mining Safety Engineers and Inspectors	56 208	Industrial Engineer Health Technologist and Technician, n.e.c.
Industrial Hygiene Technician	17-3022 to 17-3027 19-4011 to 19-4093	Engineering and Related Technologists and Technicians, Science Technicians[d]	213 - 218	Engineering and Science Technicians
Surveyor	17-1022	Surveyor	063	Surveyor and Mapping Scientist
Clerk	43-6011 to 43-6014	Secretaries and Administrative Assistants[e]	313	Secretary
Mechanic	49-3042	Mobile Heavy Equipment Mechanic, Except Engines[f]	516	Heavy Equipment Mechanic
Superintendent	47-1011	First-Line Supervisor / Manager of Construction Trades and Extraction Workers	558	Supervisor, Construction, n.e.c.
Captain (Tug)	53-5020	Captain, Mate, and Pilot of Water Vessel	828	Ship Captain and Mate, exc. Fishing Boat
Deckhand	53-5011	Sailor and Marine Oiler	829	Sailor and Deckhand
Diver	49-9092	Commercial Diver	833	Marine Engineer
Leverman, Operator	47-2073	Operating Engineer and Other Construction Equipment Operator	844 853	Operating Engineer Excavating and Loading Machine Operator
Pile driver	47-2072	Pile Driver Operator	NA	assume fatality rates equivalent to Operating Eng.
Laborer	47-2061	Construction Laborer	869	Construction Laborer
Truck Driver	53-7051	Industrial Truck and Tractor Operator	804	Truck Driver
Railroad Conductor	53-4031	Railroad Conductor and Yardmaster	823	Railraod Conductor and Yardmaster
Switch Operator	53-4021	Railroad Brake, Signal, and Switch Operator	825	Railroad Brake, Signal, and Switch Operator

[a] OES program adopted the Standard Occupational Classification (SOC) system for coding employment data. OSC is maintained by U.S. Department of Labor, Bureau of Labor Statistics, http://www.bls/gov/soc/soc_a0a0.htm.

[b] Since 2000, OES has used the 2000 SOC, which contains 509 categories arranged into 23 major groups and 821 detailed occupations. Prior to 2000, OES used the 1980 SOC.

[c] CFOI data are coded by 1990 U.S Bureau of Census occupation codes. http://data.bls.gov/PDQ/outside.jsp?survey=cf

[d] Occupation Grouping *Engineering Technicians, Except Drafters* (17-3020) includes civil, electrical/electronic, mechanical, environmental, industrial, and mechanical.

[e] Occupation Grouping *Secretaries and Administrative Assistants* (43-6010) includes executive and admin. assist., legal, medical, and other.

[f] Occupation Grouping Heavy Vehicle and Mobile Equipment Service Technicians and Mechanics (49-3030).

n.e.c. = not elsewhere classified; NA = not available.

Table F.3. Annual Fatality Rates Calculated from Occupational Employment Statistics and CFOI Fatality Data.

Remediation Labor Category	1990 Census Code	2000 SOC Code	Annual Number of Workers Employed[a]				Number of Fatal Injuries[b]				Fatality Rate[c] (deaths per 100,000 / person-yr)				
			2000	2001	2002	Mean (2000 - 2002)	2000	2001	2002	Mean (1992-1999)	2000	2001	2002	Mean (1992-1999)	Grand Mean[d]
Foreman, Project Manager	021	11-9041	242,280	214,760	205,390	220,810	12	7	4	10.5	4.95	3.26	1.95	4.76	**3.73**
Engineer	053	17-2051	207,080	205,370	207,480	206,643	5	8	0	9.7	2.41	3.90	0.00	4.69	**2.75**
Industrial Hygienist	208	17-2111	42,800	36,420	34,160	37,793	4	3	3	4.9	9.35	8.24	8.78	12.85	**9.80**
Industrial Hygiene Technician	213 - 225	17-30XX, 19-40XX	171,810	161,540	151,760	161,703	32	21	24	27.3	18.63	13.00	15.81	16.85	**16.07**
Surveyor	063	17-1022	52,750	54,650	53,340	53,580	0	5	5	4.3	0.00	9.15	9.37	8.09	**6.65**
Clerk	313	43-6011 - 43-6014	3,621,860	3,782,980	3,799,640	3,734,827	12	6	5	12.5	0.33	0.16	0.13	0.33	**0.24**
Mechanic	516	49-3042	118,300	116,260	113,340	115,967	29	34	21	30.3	24.51	29.24	18.53	26.09	**24.59**
Superintendent	558	47-1011	502,010	514,750	508,620	508,460	103	89	101	79.3	20.52	17.29	19.86	15.59	**18.31**
Captain (Tug)	828	53-5020	21,080	22,180	22,530	21,930	7	9	13	10	33.21	40.58	57.70	45.60	**44.27**
Deckhand	829	53-5011	30,090	28,650	25,360	28,033	17	13	14	28.6	56.50	45.38	55.21	102.11	**64.80**
Diver	833	49-9092	2,920	3,050	2,930	2,967	0	0	0	3	0.00	0.00	0.00	101.12	**25.28**
Leverman, Operator	844, 853	47-2073	333,200	353,650	343,710	343,520	80	73	49	64.6	24.01	20.64	14.26	18.81	**19.43**
Pile driver[e]	849	47-2072	4,320	4,950	4,670	4,647	NA	NA	NA	NA	24.01	20.64	14.26	18.81	**19.43**
Laborer	869	47-2061	821,210	825,390	830,860	825,820	289	350	303	290.9	35.19	42.40	36.47	35.22	**37.32**
Truck Driver	804	53-7051	615,390	591,790	586,660	597,947	852	802	808	800.3	138.45	135.52	137.73	133.83	**136.38**
Railroad Conductor	823	53-4031	40,380	40,910	38,070	39,787	6	0	6	9.4	14.86	0.00	15.76	23.56	**13.55**
Switch Operator	825	53-4021	16,830	17,070	15,030	16,310	11	5	0	8.9	65.36	29.29	0.00	54.41	**37.27**

[a]Occupational Employment Statistics (OES), U.S. Department of Labor, Bureau of Labor Statistics, http://stat.bls.gov/oes/home.htm

[b]Census for Fatal Occupational Injuries (CFOI), U.S. Department of Labor, Bureau of Labor Statistics, http://data.bls.gov/PDQ/outside.jsp?survey=cf

[c]Rate = [(number of worker fatalities) / (annual average number of employed workers)] x 100,000

[d]Grand Mean = (Rate_2000 + Rate_2001 + Rate_2002 + Rate_Mean 92-99) / 4

[e]1990 Census does not have pile driver occupation, so fataility data are unavailable; assumed fatatility rates are equivalent to leverman, operator.

Table F.4-1. Labor Rates (Hours per 1,000 CY) for All Activities Related to Dredging and Berm/Cap Placement.

Occupation	Total Labor Rate (Hours per 1,000 cy)				SOC Occupation Title	2000 SOC Code	1990 Census Code
	Dredging			Berm & Cap			
	NW-1	NW-4	All Others[a]	All Alternatives			
Foreman, Project Manager	421.7	74.8	483.8	8.7	Engineering Managers, Survey Chiefs	11-9041	021, 063
Engineer	226.1	124.8	171.9	55.8	Office/Field Engineers/ Inspector (Civil Engineer)	17-2051	053
Industrial Hygienist	10.4	7.0	10.2	0.0	Health and Safety Officer (Health and Safety Engineer)	17-2111	208
Industrial Hygiene Technician	83.5	56.0	81.9	0.0	Engineering Technician[d]	17-3022 to 17-3027	213, 216
Surveyor	271.4	81.8	163.1	69.6	Surveying and Mapping Technician	17-3031	218
Clerk	0.8	0.2	0.8	0.0	Secretary	43-6011 to 43-6014	313
Mechanic	101.5	46.7	101.5	21.0	Mechanic, Heavy Vehicle & Mobile Equipment Mechanic	49-3042, 49-3043	516
Superintendent	349.7	158.9	253.8	97.7	Field Supervisor	47-1011	558
Captain (Tug)	904.3	223.2	744.1	76.7	Tugboat Captain	53-5020	828
Deckhand	1,416.0	372.6	2,049.1	132.5	DeckhandSailors and marine oilers	53-5011	829
Diver	101.5	46.7	101.5	41.9	Diver/ Tender	49-9092	833
Leverman, Operator	1,801.3	510.0	1,654.7	237.3	Operating Engineer, Equipment Operator	47-2073	844, 853
Pile driver	941.5	159.6	1,697.8	0.0	Pile Driver	47-2072	NA
Laborer, S. Area & Marina[b]	0.0	0.0	1,002.3	361.0	Construction Laborer	47-2061	869
Laborer, NW Corner & Offshore[c]	1,238.2	552.4	967.7	326.3	Construction Laborer	47-2061	869
Truck Driver	0.0	0.0	0.0	31.3	Truck DriverIndustrial truck and tractor operators	53-7051	804
Railroad Conductor	197.0	197.0	197.0	197.0	Railraod ConductorRailroad conductor and yard masters	53-4031	823
Switch Operator	84.0	84.0	84.0	84.0	Switch Operator	53-4021	825

[a] Northwest Corner (NW-2, NW-3) excluding truck driver, Southern Area (SA-1, SA-2, SA-3, SA-4), Boat Slips (BS-1, BS-2, BS-3), Old Marina (OM-1, OM-2, OM-3), Offshore Area (OS-1, OS-2, OS-3).

[b] Labor associated with silt curtains (34.62 hours per 1,000 cy) applies to Southern Area and Old Marina only.

[c] Labor excludes silt curtains for Northwest Corner and Offshore Area (36.42 hours per 1,000 cy).

[d] Engineering Technicians include Civil, Electrical/Electronic, Electro-Mechanical, Environmental, Industrial, Mechanical

NA = not available

Table F.4-2. Breakdown of Labor Rates (Hours per 1,000 cy) by Major Activity.

1990 Census Code	2000 SOC Code	Occupation	Major Activity for Sediment Dredging Operations[a]								Total Labor Rate (hrs per 1,000 cy)	
			A	B	C	D	E	F	G	H[b]	Berm & Cap	Dredging[c]
021	11-9041	Foreman, Project Manager	100.0	0.0	20.0	0.0	0.8	362.9	8.7	0.0	8.7	483.8
053	17-2051	Engineer	61.5	0.0	80.0	0.0	30.4	0.0	55.8	0.0	55.8	171.9
208	17-2111	Industrial Hygienist	0.0	10.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.2
213 - 225	17-30XX, 19-40XX	Industrial Hygiene Technician	0.0	81.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	81.9
063	17-1022	Surveyor	123.1	0.0	40.0	0.0	0.0	0.0	69.6	0.0	69.6	163.1
313	43-6011 - 43-6014	Clerk	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.8
516	49-3042	Mechanic	61.5	0.0	40.0	0.0	0.0	0.0	21.0	0.0	21.0	101.5
558	47-1011	Superintendent	153.8	0.0	100.0	0.0	0.0	0.0	97.7	0.0	97.7	253.8
828	53-5020	Captain (Tug)	215.4	0.0	60.0	0.0	0.0	468.7	76.7	0.0	76.7	744.1
829	53-5011	Deckhand	523.1	0.0	120.0	0.0	0.0	1,406.0	132.5	0.0	132.5	2,049.1
833	49-9092	Diver	61.5	0.0	40.0	0.0	0.0	0.0	41.9	0.0	41.9	101.5
844, 853	47-2073	Leverman, Operator	523.1	0.0	300.0	0.0	0.0	831.6	237.3	0.0	237.3	1,654.7
NA	47-2072	Pile driver	246.2	0.0	0.0	0.0	0.0	1,451.6	0.0	0.0	0.0	1,697.8
869	47-2061	Laborer	523.1	7.7	300.0	34.6	136.9	0.0	361.0	0.0	361.0	1,002.3
804	53-7051	Truck Driver[d]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.3	31.3	0.0
823	53-4031	Railroad Conductor[e]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	197.0	197.0	197.0
825	53-4021	Switch Operator[e]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	84.0	84.0	84.0
		Total Hours	2,592.3	99.9	1,100.0	34.6	169.0	4,520.8	1,102.2	312.3	1,414.4	8,797.6

[a] Assumptions include sediment dredging at the rate of 50 cy/hour; 980 ft of submerged bulkhead and containment barrier; and cap installed at rate of 1 acre per 110 hours.

[b] Transportation risks are based on accident rates per mile (train or truck) rather than labor hours.

[c] All areas except NW-1 and NW-4.

[d] Based on estimate of 1-hour of labor per round trip to the local sand and gravel quarry, or 1-hour per 32 tons = 1-hour per 32 cy.

[e] Estimated labor hours based on labor hour estimates projected for similar dredging operations in the Passaic River (BBL, 1997).

Key to Activities:
A. Mobilization/ Site Set-up/ Demobilization
B. Decon Facility / Health and Safety
C. Solidification/ Debris Removal/ Sediment Dredging
D. Silt Curtain (Southern Area & Old Marina Only)
E. Monitoring and Analysis
F. Containment System Installation/ Removal
G. Capping/ Debris Removal During Capping
H. Transportation & Disposal

Table F.5-1. Occupational Risk Estimates Associated with Dredging, Berm, and Capping Operations in Northwest Corner.

Remediation Labor Category	Job Category[a]		Fatality Rate[b] (deaths per 100,000 / person-yr)	Remedial Action Alternative: Sediment Removal (cy) / Berm + Cap Material (cy)																
				NW-1			NW-2 Option A			NW-2 Option B			NW-3			NW-4				
				5,900 / 11,900			19,000 / 14,800			27,000 / 15,300			18,000 / 31,000			51,000 / 36,800				
	SOC Code	SOC Occupation Title		Estimated Hours	% Hours Distribution	Weighted Rate	Estimated Hours	% Hours Distribution	Weighted Rate	Estimated Hours	% Hours Distribution	Weighted Rate	Estimated Hours	% Hours Distribution	Weighted Rate	Estimated Hours	% Hours Distribution	Weighted Rate		
Foreman, Project Manager	11-9041	Engineering Managers, Survey Chiefs	3.73	2,592	4.02	0.15	9,320	4.99	0.19	13,194	5.12	0.19	8,977	4.48	0.17	4,135	2.20	0.08		
Engineer	17-2051	Office/Field Engineers/ Inspector (Civil Engineer)	2.75	1,998	3.10	0.09	4,092	2.19	0.06	5,495	2.13	0.06	4,823	2.41	0.07	8,418	4.47	0.12		
Industrial Hygienist	17-2111	Health and Safety Officer (Health and Safety Engineer)	9.80	62	0.10	0.01	195	0.10	0.01	276	0.11	0.01	184	0.09	0.01	357	0.19	0.02		
Industrial Hygiene Technician	17-3022 to 17-3027	Engineering Techniciand	16.07	492	0.76	0.12	1,557	0.83	0.13	2,212	0.86	0.14	1,475	0.74	0.12	2,856	1.52	0.24		
Surveyor	17-3031	Surveying and Mapping Technician	6.65	2,430	3.77	0.25	4,129	2.21	0.15	5,468	2.12	0.14	5,093	2.54	0.17	6,734	3.58	0.24		
Clerk	43-6011 to 43-6014	Secretary	0.24	5	0.01	0.00	16	0.01	0.00	23	0.01	0.00	15	0.01	0.00	10	0.01	0.00		
Mechanic	49-3042, 49-3043	Mechanic, Heavy Vehicle & Mobile Equipment Mechanic	24.59	849	1.32	0.32	2,239	1.20	0.29	3,062	1.19	0.29	2,478	1.24	0.30	3,151	1.67	0.41		
Superintendent	47-1011	Field Supervisor	18.31	3,226	5.00	0.92	6,269	3.35	0.61	8,349	3.24	0.59	7,598	3.79	0.69	11,699	6.21	1.14		
Captain (Tug)	53-5020	Tugboat Captain	44.27	6,248	9.69	4.29	15,273	8.17	3.62	21,264	8.25	3.65	15,772	7.87	3.48	14,207	7.55	3.34		
Deckhand	53-5011	Deckhand Sailors and marine oilers	64.80	9,931	15.40	9.98	40,894	21.88	14.18	57,353	22.25	14.42	40,991	20.44	13.25	23,881	12.69	8.22		
Diver	49-9092	Diver/ Tender	25.28	1,098	1.70	0.43	2,550	1.36	0.34	3,383	1.31	0.33	3,127	1.56	0.39	3,923	2.08	0.53		
Leverman, Operator	47-2073	Operating Engineer, Equipment Operator	19.43	13,451	20.86	4.05	34,951	18.70	3.63	48,307	18.74	3.64	37,140	18.52	3.60	34,741	18.45	3.59		
Pile driver	47-2072	Pile Driver	19.43	5,555	8.61	1.67	32,258	17.26	3.35	45,840	17.79	3.46	30,560	15.24	2.96	8,139	4.32	0.84		
Laborer, NW Corner & Offshore	47-2061	Construction Laborer	37.32	11,189	17.35	6.47	23,216	12.42	4.64	31,121	12.08	4.51	27,535	13.73	5.13	40,184	21.35	7.97		
Truck Driver	53-7051	Truck Driver Industrial truck and tractor operators	136.38	372	0.58	0.79	463	0.25	0.34	478	0.19	0.25	969	0.48	0.66	1,150	0.61	0.83		
Railroad Conductor	53-4031	Railraod Conductor Railroad conductor and yard masters	13.55	3,507	5.44	0.74	6,659	3.56	0.48	8,333	3.23	0.44	9,653	4.81	0.65	17,297	9.19	1.24		
Switch Operator	53-4021	Switch Operator	37.27	1,495	2.32	0.86	2,839	1.52	0.57	3,553	1.38	0.51	4,116	2.05	0.76	7,375	3.92	1.46		
Total Estimated Hours				64,498	100.00		186,918	100.00		257,711	100.00		200,507	100.00		188,256	100.00			
Weighted Occupational Fatality Rate (deaths per 100,000 / person-yr)						31.14			32.59			32.64			32.41			30.27	**Total Risk**	
Total Projected Person-Years[c]				32.2			93.5			128.9			100.3			94.1			**Min**	**Max**
Expected (Arithmetic Mean) Number of Fatalities[d]						1.00E-02			3.05E-02			4.21E-02			3.25E-02			2.85E-02	**1.0E-01**	**1.1E-01**
Chance of a Fatality[e]						1 in 100			1 in 33			1 in 24			1 in 31			1 in 35	**1 in 10**	**1 in 9**
Risk of at Least One Fatality[f]						9.99E-03			3.00E-02			4.12E-02			3.20E-02			2.81E-02	**9.7E-02**	**1.1E-01**

[a] 2000 Standard Occupational Classification, U.S. Department of Labor, Bureau of Labor Statistics, http://www.bls/gov/soc/soc_a0a0.htm

[b] See Tables 2 and 3. Calculated from Occupational Employment Statistics (OES) and CFOI annual mortality rates for 1992-1999, 2000, 2001, and 2002.

[c] Product of (total estimated hours) x (1/2000 hours per year), based on a 40-hour work week, 50 weeks/yr.

[d] Product of (total project person-years) x (weighted occupational fatality rate) x (1/100,000)

[e] Chance may be expressed as "One in X", where X = (1/N), where N = expected number of fatalities.

[f] Risk of fatality is modeled with a Poisson distribution, $f(x) = (exp[-mu] \times mu^x)/x!$, where mu is the mean number of fatalities. Probability of at least one fatality (x greater than or equal to 1) is equal to one minus the probability of 0 fatalities, or $P = 1 - f(0) = 1 - (exp[-mu] \times 1)/1 = 1 - exp[-mu]$.

Table F.5-2. Occupational Risk Estimates Associated with Dredging, Berm, and Capping Operations in Southern Area.

Remediation Labor Category	Job Category[a]		Fatality Rate[b] (deaths per 100,000 / person-yr)	Remedial Action Alternative: Sediment Removal (cy) / Berm + Cap Material (cy)																
				SA-1			SA-2			SA-3 Option A			SA-3 Option B			SA-4				
				0			6,900			8,300			8,800			16,000				
				7,260			30,500			31,500			32,500			33,500				
	SOC Code	SOC Occupation Title		Estimated Hours	% Hours Distribution	Weighted Rate	Estimated Hours	% Hours Distribution	Weighted Rate	Estimated Hours	% Hours Distribution	Weighted Rate	Estimated Hours	% Hours Distribution	Weighted Rate	Estimated Hours	% Hours Distribution	Weighted Rate		
Foreman, Project Manager	11-9041	Engineering Managers, Survey Chiefs	3.73	63	0.62	0.02	3,603	3.47	0.13	4,289	3.65	0.14	4,540	3.68	0.14	8,032	4.27	0.16		
Engineer	17-2051	Office/Field Engineers/ Inspector (Civil Engineer)	2.75	405	3.94	0.11	2,887	2.78	0.08	3,184	2.71	0.07	3,325	2.70	0.07	4,619	2.46	0.07		
Industrial Hygienist	17-2111	Health and Safety Officer (Health and Safety Engineer)	9.80	-	0.00	0.00	71	0.07	0.01	85	0.07	0.01	90	0.07	0.01	164	0.09	0.01		
Industrial Hygiene Technician	17-3022 to 17-3027	Engineering Techniciand	16.07	-	0.00	0.00	565	0.54	0.09	680	0.58	0.09	721	0.58	0.09	1,311	0.70	0.11		
Surveyor	17-3031	Surveying and Mapping Technician	6.65	505	4.92	0.33	3,249	3.13	0.21	3,546	3.02	0.20	3,698	3.00	0.20	4,941	2.63	0.17		
Clerk	43-6011 to 43-6014	Secretary	0.24	-	0.00	0.00	6	0.01	0.00	7	0.01	0.00	7	0.01	0.00	14	0.01	0.00		
Mechanic	49-3042, 49-3043	Mechanic, Heavy Vehicle & Mobile Equipment Mechanic	24.59	152	1.48	0.36	1,340	1.29	0.32	1,503	1.28	0.31	1,575	1.28	0.31	2,327	1.24	0.30		
Superintendent	47-1011	Field Supervisor	18.31	709	6.91	1.26	4,731	4.56	0.83	5,184	4.41	0.81	5,409	4.38	0.80	7,334	3.90	0.71		
Captain (Tug)	53-5020	Tugboat Captain	44.27	557	5.42	2.40	7,474	7.20	3.19	8,593	7.31	3.24	9,041	7.33	3.24	14,475	7.69	3.41		
Deckhand	53-5011	Deckhand Sailors and marine oilers	64.80	962	9.37	6.07	18,180	17.51	11.34	21,181	18.02	11.67	22,338	18.10	11.73	37,224	19.79	12.82		
Diver	49-9092	Diver/ Tender	25.28	304	2.96	0.75	1,979	1.91	0.48	2,163	1.84	0.47	2,256	1.83	0.46	3,029	1.61	0.41		
Leverman, Operator	47-2073	Operating Engineer, Equipment Operator	19.43	1,723	16.78	3.26	18,655	17.96	3.49	21,209	18.04	3.50	22,274	18.05	3.51	34,424	18.30	3.56		
Pile driver	47-2072	Pile Driver	19.43	-	0.00	0.00	11,715	11.28	2.19	14,092	11.99	2.33	14,940	12.11	2.35	27,164	14.44	2.81		
Laborer, S. Area & Marina	47-2061	Construction Laborer	37.32	2,621	25.52	9.52	17,925	17.26	6.44	19,689	16.75	6.25	20,552	16.66	6.22	28,129	14.95	5.58		
Truck Driver	53-7051	Truck Driver Industrial truck and tractor operators	136.38	227	2.21	3.01	953	0.92	1.25	984	0.84	1.14	1,016	0.82	1.12	1,047	0.56	0.76		
Railroad Conductor	53-4031	Railraod Conductor Railroad conductor and yard masters	13.55	1,430	13.93	1.89	7,368	7.10	0.96	7,841	6.67	0.90	8,136	6.59	0.89	9,752	5.18	0.70		
Switch Operator	53-4021	Switch Operator	37.27	610	5.94	2.21	3,142	3.03	1.13	3,343	2.84	1.06	3,469	2.81	1.05	4,158	2.21	0.82		
Total Estimated Hours				10,269	100.00		103,843	100.00		117,574	100.00		123,387	100.00		188,144	100.00			
Weighted Occupational Fatality Rate (deaths per 100,000 / person-yr)						31.21			32.14			32.20			32.21			32.40	**Total Risk**	
Total Projected Person-Years[c]				5.1			51.9			58.8			61.7			94.1			**Min**	**Max**
Expected (Arithmetic Mean) Number of Fatalities[d]						1.60E-03			1.67E-02			1.89E-02			1.99E-02			3.05E-02	**6.8E-02**	**6.9E-02**
Chance of a Fatality[e]						1 in 624			1 in 60			1 in 53			1 in 50			1 in 33	**1 in 15**	**1 in 15**
Risk of at Least One Fatality[f]						1.60E-03			1.65E-02			1.87E-02			1.97E-02			3.00E-02	**6.5E-02**	**6.6E-02**

[a] 2000 Standard Occupational Classification, U.S. Department of Labor, Bureau of Labor Statistics, http://www.bls/gov/soc/soc_a0a0.htm

[b] See Tables 2 and 3. Calculated from Occupational Employment Statistics (OES) and CFOI annual mortality rates for 1992-1999, 2000, 2001, and 2002.

[c] Product of (total estimated hours) x (1/2000 hours per year), based on a 40-hour work week, 50 weeks/yr.

[d] Product of (total project person-years) x (weighted occupational fatality rate) x (1/100,000)

[e] Chance may be expressed as "One in X", where X = (1/N), where N = expected number of fatalities.

[f] Risk of fatality is modeled with a Poisson distribution, $f(x) = (\exp[-mu] \times mu^x)/x!$, where mu is the mean number of fatalities. Probability of at least one fatality (x greater than or equal to 1) is equal to one minus the probability of 0 fatalities, or P = 1 - f(0) = 1 - (exp[-mu] x 1)/1 = 1 - exp[-mu].

Table F.5-3. Occupational Risk Estimates Associated with Dredging, Berm, and Capping Operations in NSlips 1 and 2.

Remediation Labor Category	Job Category[a]		Fatality Rate[b] (deaths per 100,000 / person-yr)	Remedial Action Alternative: Sediment Removal (cy) / Berm + Cap Material (cy)					
				NSlip -1			NSlip -2		
				2,100			8,400		
				2,823			20,800		
	SOC Code	SOC Occupation Title		Estimated Hours	% Hours Distribution	Weighted Rate	Estimated Hours	% Hours Distribution	Weighted Rate
Foreman, Project Manager	11-9041	Engineering Managers, Survey Chiefs	3.73	1,040	4.63	0.17	4,245	4.11	0.15
Engineer	17-2051	Office/Field Engineers/ Inspector (Civil Engineer)	2.75	518	2.31	0.06	2,604	2.52	0.07
Industrial Hygienist	17-2111	Health and Safety Officer (Health and Safety Engineer)	9.80	22	0.10	0.01	86	0.08	0.01
Industrial Hygiene Technician	17-3022 to 17-3027	Engineering Techniciand	16.07	172	0.77	0.12	688	0.67	0.11
Surveyor	17-3031	Surveying and Mapping Technician	6.65	539	2.40	0.16	2,818	2.73	0.18
Clerk	43-6011 to 43-6014	Secretary	0.24	2	0.01	0.00	7	0.01	0.00
Mechanic	49-3042, 49-3043	Mechanic, Heavy Vehicle & Mobile Equipment Mechanic	24.59	272	1.21	0.30	1,289	1.25	0.31
Superintendent	47-1011	Field Supervisor	18.31	809	3.60	0.66	4,164	4.03	0.74
Captain (Tug)	53-5020	Tugboat Captain	44.27	1,779	7.92	3.51	7,846	7.59	3.36
Deckhand	53-5011	Deckhand Sailors and marine oilers	64.80	4,677	20.82	13.49	19,968	19.33	12.52
Diver	49-9092	Diver/ Tender	25.28	332	1.48	0.37	1,725	1.67	0.42
Leverman, Operator	47-2073	Operating Engineer, Equipment Operator	19.43	4,145	18.45	3.58	18,835	18.23	3.54
Pile driver	47-2072	Pile Driver	19.43	3,565	15.87	3.08	14,261	13.80	2.68
Laborer, S. Area & Marina	47-2061	Construction Laborer	37.32	3,124	13.90	5.19	15,927	15.42	5.75
Truck Driver	53-7051	Truck Driver Industrial truck and tractor operators	136.38	88	0.39	0.54	650	0.63	0.86
Railroad Conductor	53-4031	Railraod Conductor Railroad conductor and yard masters	13.55	970	4.32	0.58	5,752	5.57	0.75
Switch Operator	53-4021	Switch Operator	37.27	414	1.84	0.69	2,453	2.37	0.88

	NSlip -1 Estimated Hours	% Hours	Weighted Rate	NSlip -2 Estimated Hours	% Hours	Weighted Rate	Total Risk Min	Total Risk Max
Total Estimated Hours	22,468	100.00		103,320	100.00			
Weighted Occupational Fatality Rate (deaths per 100,000 / person-yr)			32.52			32.35		
Total Projected Person-Years[c]	11.2			51.7				
Expected (Arithmetic Mean) Number of Fatalities[d]			3.65E-03			1.67E-02	**2.0E-02**	**2.0E-02**
Chance of a Fatality[e]			1 in 274			1 in 60	**1 in 49**	**1 in 49**
Risk of at Least One Fatality[f]			3.65E-03			1.66E-02	**2.0E-02**	**2.0E-02**

[a] 2000 Standard Occupational Classification, U.S. Department of Labor, Bureau of Labor Statistics, http://www.bls/gov/soc/soc_a0a0.htm

[b] See Tables 2 and 3. Calculated from Occupational Employment Statistics (OES) and CFOI annual mortality rates for 1992-1999, 2000, 2001, and 2002.

[c] Product of (total estimated hours) x (1/2000 hours per year), based on a 40-hour work week, 50 weeks/yr.

[d] Product of (total project person-years) x (weighted occupational fatality rate) x (1/100,000)

[e] Chance may be expressed as "One in X", where X = (1/N), where N = expected number of fatalities.

[f] Risk of fatality is modeled with a Poisson distribution, $f(x) = (\exp[-mu] \times mu^x)/x!$, where mu is the mean number of fatalities. Probability of at least one fatality (x greater than or equal to 1) is equal to one minus the probability of 0 fatalities, or P = 1 - f(0) = 1 - (exp[-mu] x 1)/1 = 1 - exp[-mu].

Table F.5-4. Occupational Risk Estimates Associated with Dredging, Berm, and Capping Operations in Old Marina.

Remediation Labor Category	Job Category[a] SOC Code	Job Category[a] SOC Occupation Title	Fatality Rate[b] (deaths per 100,000 / person-yr)	Remedial Action Alternative: Sediment Removal (cy) / Berm + Cap Material (cy)					
				OM-1			OM-2		
				7,000			15,000		
				5,500			5,500		
				Estimated Hours	% Hours Distribution	Weighted Rate	Estimated Hours	% Hours Distribution	Weighted Rate
Foreman, Project Manager	11-9041	Engineering Managers, Survey Chiefs	3.73	3,434	4.95	0.18	7,304	5.23	0.19
Engineer	17-2051	Office/Field Engineers/ Inspector (Civil Engineer)	2.75	1,510	2.18	0.06	2,886	2.06	0.06
Industrial Hygienist	17-2111	Health and Safety Officer (Health and Safety Engineer)	9.80	72	0.10	0.01	154	0.11	0.01
Industrial Hygiene Technician	17-3022 to 17-3027	Engineering Techniciand	16.07	573	0.83	0.13	1,229	0.88	0.14
Surveyor	17-3031	Surveying and Mapping Technician	6.65	1,524	2.20	0.15	2,829	2.02	0.13
Clerk	43-6011 to 43-6014	Secretary	0.24	6	0.01	0.00	13	0.01	0.00
Mechanic	49-3042, 49-3043	Mechanic, Heavy Vehicle & Mobile Equipment Mechanic	24.59	826	1.19	0.29	1,638	1.17	0.29
Superintendent	47-1011	Field Supervisor	18.31	2,314	3.34	0.61	4,345	3.11	0.57
Captain (Tug)	53-5020	Tugboat Captain	44.27	5,630	8.12	3.59	11,583	8.29	3.67
Deckhand	53-5011	Deckhand Sailors and marine oilers	64.80	15,072	21.73	14.08	31,465	22.52	14.59
Diver	49-9092	Diver/ Tender	25.28	941	1.36	0.34	1,754	1.25	0.32
Leverman, Operator	47-2073	Operating Engineer, Equipment Operator	19.43	12,888	18.58	3.61	26,125	18.70	3.63
Pile driver	47-2072	Pile Driver	19.43	11,884	17.13	3.33	25,467	18.22	3.54
Laborer, S. Area & Marina	47-2061	Construction Laborer	37.32	9,001	12.98	4.84	17,020	12.18	4.55
Truck Driver	53-7051	Truck Driver Industrial truck and tractor operators	136.38	172	0.25	0.34	172	0.12	0.17
Railroad Conductor	53-4031	Railraod Conductor Railroad conductor and yard masters	13.55	2,463	3.55	0.48	4,039	2.89	0.39
Switch Operator	53-4021	Switch Operator	37.27	1,050	1.51	0.56	1,722	1.23	0.46

	OM-1 Estimated Hours	OM-1 % Hours Distribution	OM-1 Weighted Rate	OM-2 Estimated Hours	OM-2 % Hours Distribution	OM-2 Weighted Rate	Total Risk Min	Total Risk Max
Total Estimated Hours	69,362	100.00		139,743	100.00			
Weighted Occupational Fatality Rate (deaths per 100,000 / person-yr)			32.62			32.71		
Total Projected Person-Years[c]	34.7			69.9				
Expected (Arithmetic Mean) Number of Fatalities[d]			1.13E-02			2.29E-02	**3.4E-02**	**3.4E-02**
Chance of a Fatality[e]			1 in 88			1 in 44	**1 in 29**	**1 in 29**
Risk of at Least One Fatality[f]			1.12E-02			2.26E-02	**3.4E-02**	**3.4E-02**

[a] 2000 Standard Occupational Classification, U.S. Department of Labor, Bureau of Labor Statistics, http://www.bls/gov/soc/soc_a0a0.htm

[b] See Tables 2 and 3. Calculated from Occupational Employment Statistics (OES) and CFOI annual mortality rates for 1992-1999, 2000, 2001, and 2002.

[c] Product of (total estimated hours) x (1/2000 hours per year), based on a 40-hour work week, 50 weeks/yr.

[d] Product of (total project person-years) x (weighted occupational fatality rate) x (1/100,000)

[e] Chance may be expressed as "One in X", where X = (1/N), where N = expected number of fatalities.

[f] Risk of fatality is modeled with a Poisson distribution, f(x) = (exp[-mu] x mu^x)/x!, where mu is the mean number of fatalities. Probability of at least one fatality (x greater than or equal to 1) is equal to one minus the probability of 0 fatalities, or P = 1 - f(0) = 1 - (exp[-mu] x 1)/1 = 1 - exp[-mu].

Table F.5-5. Occupational Risk Estimates Associated with Capping Operations in Offshore Area.

Remediation Labor Category	Job Category[a]		Fatality Rate[b] (deaths per 100,000 / person-yr)	Remedial Action Alternative: Sediment Removal (cy) / Berm + Cap Material (cy)										
				Offshore -2A			Offshore - 2B			Offshore - 2C				
				0			0			0				
				9,400			22,000			18,000				
	SOC Code	SOC Occupation Title		Estimated Hours	% Hours Distribution	Weighted Rate	Estimated Hours	% Hours Distribution	Weighted Rate	Estimated Hours	% Hours Distribution	Weighted Rate		
Foreman, Project Manager	11-9041	Engineering Managers, Survey Chiefs	3.73	82	0.63	0.02	191	0.63	0.02	157	0.63	0.02		
Engineer	17-2051	Office/Field Engineers/ Inspector (Civil Engineer)	2.75	524	4.04	0.11	1,227	4.04	0.11	1,004	4.04	0.11		
Industrial Hygienist	17-2111	Health and Safety Officer (Health and Safety Engineer)	9.80	-	0.00	0.00	-	0.00	0.00	-	0.00	0.00		
Industrial Hygiene Technician	17-3022 to 17-3027	Engineering Techniciand	16.07	-	0.00	0.00	-	0.00	0.00	-	0.00	0.00		
Surveyor	17-3031	Surveying and Mapping Technician	6.65	654	5.05	0.34	1,532	5.05	0.34	1,253	5.05	0.34		
Clerk	43-6011 to 43-6014	Secretary	0.24	-	0.00	0.00	-	0.00	0.00	-	0.00	0.00		
Mechanic	49-3042, 49-3043	Mechanic, Heavy Vehicle & Mobile Equipment Mechanic	24.59	197	1.52	0.37	461	1.52	0.37	377	1.52	0.37		
Superintendent	47-1011	Field Supervisor	18.31	918	7.08	1.30	2,149	7.08	1.30	1,758	7.08	1.30		
Captain (Tug)	53-5020	Tugboat Captain	44.27	721	5.56	2.46	1,688	5.56	2.46	1,381	5.56	2.46		
Deckhand	53-5011	Deckhand Sailors and marine oilers	64.80	1,246	9.60	6.22	2,915	9.60	6.22	2,385	9.60	6.22		
Diver	49-9092	Diver/ Tender	25.28	394	3.04	0.77	922	3.04	0.77	755	3.04	0.77		
Leverman, Operator	47-2073	Operating Engineer, Equipment Operator	19.43	2,231	17.20	3.34	5,221	17.20	3.34	4,272	17.20	3.34		
Pile driver	47-2072	Pile Driver	19.43	-	0.00	0.00	-	0.00	0.00	-	0.00	0.00		
Laborer, NW Corner & Offshore	47-2061	Construction Laborer	37.32	3,068	23.65	8.83	7,180	23.65	8.83	5,874	23.65	8.83		
Truck Driver	53-7051	Truck Driver Industrial truck and tractor operators	136.38	294	2.26	3.09	688	2.26	3.09	563	2.26	3.09		
Railroad Conductor	53-4031	Railraod Conductor Railroad conductor and yard masters	13.55	1,852	14.28	1.93	4,334	14.28	1.93	3,546	14.28	1.93		
Switch Operator	53-4021	Switch Operator	37.27	790	6.09	2.27	1,848	6.09	2.27	1,512	6.09	2.27		
Total Estimated Hours				12,970	100.00		30,355	100.00		24,836	100.00			
Weighted Occupational Fatality Rate (deaths per 100,000 / person-yr)						31.05			31.05			31.05	Total Risk	
Total Projected Person-Years [c]				6.5			15.2			12.4			Min	Max
Expected (Arithmetic Mean) Number of Fatalities [d]						2.01E-03			4.71E-03			3.86E-03	**2.0E-03**	**4.7E-03**
Chance of a Fatality [e]						1 in 497			1 in 212			1 in 259	**1 in 497**	**1 in 212**
Risk of at Least One Fatality [f]						2.01E-03			4.70E-03			3.85E-03	**2.0E-03**	**4.7E-03**

[a] 2000 Standard Occupational Classification, U.S. Department of Labor, Bureau of Labor Statistics, http://www.bls/gov/soc/soc_a0a0.htm

[b] See Tables 2 and 3. Calculated from Occupational Employment Statistics (OES) and CFOI annual mortality rates for 1992-1999, 2000, 2001, and 2002.

[c] Product of (total estimated hours) x (1/2000 hours per year), based on a 40-hour work week, 50 weeks/yr.

[d] Product of (total project person-years) x (weighted occupational fatality rate) x (1/100,000)

[e] Chance may be expressed as "One in X", where X = (1/N), where N = expected number of fatalities.

[f] Risk of fatality is modeled with a Poisson distribution, f(x) = (exp[-mu] x mu^x)/x!, where mu is the mean number of fatalities. Probability of at least one fatality (x greater than or equal to 1) is equal to one minus the probability of 0 fatalities, or P = 1 - f(0) = 1 - (exp[-mu] x 1)/1 = 1 - exp[-mu].

Table F.6-1. Risks Associated with Transporting TSCA Classified Dredged Sediment via Rail from Harbor on Hastings Site to Wayne, MI.[a]

Location	All States		Michigan		Ohio		Pennsylvania		New York		
Trip mileage in state[b]	842		85		220		44		493		
Year 2000 Total train miles[c]	722,876,632		925,963		1,872,863		6,912,050		20,156,655		**Weighted**
Accident/Incident Data	**Count**	**Rate[d]**	**Count**	**Rate[d]**	**Count**	**Rate[d]**	**Count**	**Rate[d]**	**Count**	**Rate[d]**	**Rate[e]**
Train Accidents											
Accidents	2,983	4.1	47	50.8	120	64.1	127	18.4	139	6.9	26.9
Deaths	10	0.01	-	0.00	-	0.00	1	0.14	1	0.05	0.04
Nonfatal Injuries	275	0.4	4	4.3	5	2.7	17	2.5	18	0.9	1.8
Highway-Rail Accidents											
Incidents	3,502	4.8	134	144.7	148	79.0	69	10.0	41	2.0	37.0
Deaths	425	0.6	13	14.0	15	8.0	8	1.2	5	0.2	3.7
Nonfatal Injuries	1,219	1.7	51	55.1	38	20.3	17	2.5	14	0.7	11.4
Other Incidents											
Incidents	10,433	14.4	253	273.2	307	163.9	556	80.4	1,150	57.1	108.0
Deaths	502	0.7	10	10.8	13	6.9	14	2.0	26	1.3	3.8
Nonfatal Injuries	10,149	14.0	245	264.6	296	158.0	549	79.4	1,136	56.4	105.2
Grand Total											
Accidents/Incidents[f]	16,918	23.4	434	468.7	575	307.0	752	108.8	1,330	66.0	171.9
Deaths	937	1.3	23	24.8	28	15.0	23	3.3	32	1.6	7.5
Nonfatal Injuries	11,643	16.1	300	324.0	339	181.0	583	84.3	1,168	57.9	118.3

	Michigan	Ohio	Pennsylvania	New York	Weighted
Expected Number of Fatalities[f]	2.1×10^{-3}	3.3×10^{-3}	1.5×10^{-4}	7.8×10^{-4}	6.3×10^{-3}
Chance of a Fatality[g]	1 in 474	1 in 304	1 in 6830	1 in 1278	1 in 158
Risk of at Least One Fatality[h]	2.1×10^{-3}	3.3×10^{-3}	1.5×10^{-4}	7.8×10^{-4}	6.3×10^{-3}
Expected Number of Non-fatal Injuries[f]	2.8×10^{-2}	4.0×10^{-2}	3.7×10^{-3}	2.9×10^{-2}	1.1×10^{-1}
Chance of a Non-fatal Injury[g]	1 in 36	1 in 25	1 in 269	1 in 35	1 in 10
Risk of at Least One Non-fatal Injury[h]	2.7×10^{-2}	3.9×10^{-2}	3.7×10^{-3}	2.8×10^{-2}	9.5×10^{-2}

[a] FRA Railroad Safety Statistics Annual Report 2000, Table 1-1 (all states combined, total train mileage) and Table 2-11 (state-specific data).

[b] Rail miles estimated from CSX Rail Mileage Calculator, http://shipcsx.com/public/ec.shipcsxpublic/Main.

[c] Calculated from Federal Railroad Administration operational data summary files, http://safetydata.fra.dot.gov/officeofsafety/Downloads/Default.asp.

[d] Number of occurrences x 1,000,000 / train mile.

[e] Weighted rate = weighting factor x state-specific rate, where weighting factor for each state is equal to the train miles in-state / total trip milage (842).

[f] Incidents reported in the "Other Incidents" category may include any death, injury, or occupational illness of a railroad employee that is not the result of a "train accident" or "highway-rail incident."

[g] Product of (Trip Mileage in State) x (Grand Total Rate) x (1/100,000)

[h] Chance may be expressed as "One in X", where X = (1/N), where N = expected number of fatalities (or non-fatal injuries).

[i] Risk of at least one fatality/non-fatal injury is modeled with a Poisson distribution, $f(x) = (\exp[-mu] \times mu^{x})/x!$, where mu is the mean number of fatalities. Probability of at least one fatality (x greater than or equal to 1) is equal to one minus the probability of 0 fatalities, or P = 1 - f(0) = 1 - (exp[-mu] x 1)/1 = 1 - exp[-mu].

Table F.6-2. Risks Associated with Transporting Dredged Material via Rail from Harbor on Hastings to non-TSCA Landfill in Niagara Falls, NY and Clean Fill from Poughkeepsie, NY to Harbor on Hastings Site.[a]

Location	Niagara Falls, NY		Poughkeepsie, NY	
Trip mileage in state[b]	1,342 [c]		240 [d]	
Year 2000 Total train miles[e]	20,156,655		20,156,655	
Accident/Incident Data	**Count**	**Rate[f]**	**Count**	**Rate[f]**
Train Accidents				
Accidents	139	6.9	139	6.9
Deaths	1	0.05	1	0.05
Nonfatal Injuries	18	0.9	18	0.9
Highway-Rail Accidents				
Incidents	41	2.0	41	2.0
Deaths	5	0.2	5	0.2
Nonfatal Injuries	14	0.7	14	0.7
Other Incidents				
Incidents[g]	1,150	57.1	1,150	57.1
Deaths	26	1.3	26	1.3
Nonfatal Injuries	1,136	56.4	1,136	56.4
Grand Total				
Accidents/Incidents	1,330	66.0	1,330	66.0
Deaths	32	1.6	32	1.6
Nonfatal Injuries	1,168	57.9	1,168	57.9
Expected Number of Fatalities[h]		2.1×10^{-3}		3.8×10^{-4}
Chance of a Fatality[i]		1 in 469		1 in 2625
Risk of at Least One Fatality[j]		2.1×10^{-3}		3.8×10^{-4}
Expected Number of Non-fatal Injuries[h]		7.8×10^{-2}		1.4×10^{-2}
Chance of a Non-fatal Injury[i]		1 in 13		1 in 72
Risk of at Least One Non-fatal Injury[j]		7.5×10^{-2}		1.4×10^{-2}

[a] FRA Railroad Safety Statistics Annual Report 2000, Table 1-1 (all states combined, total train mileage) and Table 2-11 (state-specific data).
[b] Rail miles estimated from CSX Rail Mileage Calculator, http://shipcsx.com/public/ec.shipcsxpublic/Main.
[c] One-way distance of 447.25 miles mulitplied by three to account for three train trips.
[d] One-way distance of 60 miles mulitplied by four to account for four train trips.
[e] Calculated from Federal Railroad Administration operational data summary files, http://safetydata.fra.dot.gov/officeofsafety/Downloads/Default.asp.
[f] Number of occurrences x 1,000,000 / train mile.
[g] Incidents reported in the "Other Incidents" category may include any death, injury, or occupational illness of a railroad employee that is not the result of a “train accident” or “highway-rail incident.”
[h] Product of (Trip Mileage in State) x (Grand Total Rate) x (1/100,000)
[i] Chance may be expressed as "One in X", where X = (1/N), where N = expected number of fatalities (or non-fatal injuries).
[j] Risk of at least one fatality/non-fatal injury is modeled with a Poisson distribution, $f(x) = (\exp[-mu] \times mu^x)/x!$, where mu is the mean number of fatalities. Probability of at least one fatality (x greater than or equal to 1) is equal to one minus the probability of 0 fatalities, or P = 1 - f(0) = 1 - (exp[-mu] x 1)/1 = 1 - exp[-mu].

Table F.7-1. Projected Number of Truck Accidents Based on National Transportation Statistics for 2003 - Northwest Corner and Southern Area.

Transportation Statistics		Northwest Corner					Southern Area					Total (All Areas)	
		NW-1	**NW-2A**	**NW-2B**	**NW-3**	**NW-4**	**SA-1**	**SA-2**	**SA-3A**	**SA-3B**	**SA-4**	**Min**	**Max**
Trucking of Berm and Cap Material on Site	Sand and Gravel (tons)[a]	17,850	22,200	22,950	46,500	55,200	10,890	45,750	47,250	48,750	50,250	361,925	383,075
	Miles Traveled (round trip)	20	20	20	20	20	20	20	20	20	20	20	20
	Number of Trucks[e]	558	694	717	1,453	1,725	340	1,430	1,477	1,523	1,570	11,310	11,971
	AVMT	11,156	13,875	14,344	29,063	34,500	6,806	28,594	29,531	30,469	31,406	226,203	239,422
U.S. Truck AVMT[b]	Truck, single-unit 2-axle 6-tire +	7.78E+10	7.78E+10	7.78E+10	7.78E+10	7.78E+10	7.78E+10	7.78E+10	7.78E+10	7.78E+10	7.78E+10	7.78E+10	7.78E+10
	Truck, combination	1.40E+11	1.40E+11	1.40E+11	1.40E+11	1.40E+11	1.40E+11	1.40E+11	1.40E+11	1.40E+11	1.40E+11	1.40E+11	1.40E+11
	AVMT Total in 2003	2.18E+11	2.18E+11	2.18E+11	2.18E+11	2.18E+11	2.18E+11	2.18E+11	2.18E+11	2.18E+11	2.18E+11	2.18E+11	2.18E+11
U.S. Truck Accident Rate[c, d]	# Accidents in 2003	436,082	436,082	436,082	436,082	436,082	436,082	436,082	436,082	436,082	436,082	436,082	436,082
	Rate (Accidents per AVMT)	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06
Projected Number of Accidents	U.S. Rate x Project-Specific AVMT	0.022	0.028	0.029	0.058	0.069	0.014	0.057	0.059	0.061	0.063	**0.453**	**0.479**
	Chance of Accident[f]	1 in 45	1 in 36	1 in 35	1 in 17	1 in 14	1 in 73	1 in 17	1 in 17	1 in 16	1 in 16	1 in 2	1 in 2

[a] Volume-to-weight conversion factor of 1.5 tons per CY was applied to volumes presented in Table F.1.

[b] U.S. DOT. 2005. Bureau of Transportation Statistics, *National Transportation Statistics 2005.* Table 1-32. U.S. Vehicle-Miles in 2003 (note, 2004 data are available for AVMT, but not # accidents).

[c] U.S. DOT. 2005. Bureau of Transportation Statistics, *National Transportation Statistics 2005.* Table 2-3. Transportation Accidents by Mode in 2003 (data for 2004 are not yet avaialble). U.S. DOT, National Highway Traffic Safety Administration uses the term "crash" instead of accident in its highway safety data. Highway crashes often involve more than one motor vehicle, hence "total highway crashes" is smaller than the sum of the components. Estimates of highway crashes are rounded to the nearest thousand in the source document.

[d] Statistics for large trucks, defined as trucks over 10,000 gross vehicle weight rating, including single-unit trucks and truck tractors.

[e] Assumes truck carrying capacity of 32 tons.

[f] Chance may be expressed as "One in X", where X = (1/N), where N = expected number of truck accidents.

[g] Sum of areas in Table F.7-1 (Northwest Corner and Southern Area) plus areas in Table F.7-2 (Boat Slips, Old Marina, and Offshore Area).

AVMT = Annual Vehicle Miles Traveled = total mileage x number of trucks.

Table F.7-2. Projected Number of Truck Accidents Based on National Transportation Statistics for 2003 - Boat Slips, Old Marina, and Offshore Area.

Transportation Statistics		NSlips		Old Marina		Offshore Area			Total (All Areas)	
		NSlip-1	NSlip-2	OM-1	OM-2	OS-2A	OS-2B	OS-2C	Min	Max
Trucking of Berm and Cap Material on Site	Sand and Gravel (tons)[a]	4,235	31,200	8,250	8,250	14,100	33,000	27,000	361,925	383,075
	Miles Traveled (round trip)	20	20	20	20	20	20	20	20	20
	Number of Trucks[e]	132	975	258	258	441	1,031	844	11,310	11,971
	AVMT	2,647	19,500	5,156	5,156	8,813	20,625	16,875	226,203	239,422
U.S. Truck AVMT[b]	Truck, single-unit 2-axle 6-tire +	7.78E+10	7.78E+10	7.78E+10	7.78E+10	7.78E+10	7.78E+10	7.78E+10	7.78E+10	7.78E+10
	Truck, combination	1.40E+11	1.40E+11	1.40E+11	1.40E+11	1.40E+11	1.40E+11	1.40E+11	1.40E+11	1.40E+11
	AVMT Total in 2003	2.18E+11	2.18E+11	2.18E+11	2.18E+11	2.18E+11	2.18E+11	2.18E+11	2.18E+11	2.18E+11
U.S. Truck Accident Rate[c, d]	# Accidents in 2003	436,082	436,082	436,082	436,082	436,082	436,082	436,082	436,082	436,082
	Rate (Accidents per AVMT)	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06
Projected Number of Accidents	U.S. Rate x Project-Specific AVMT	0.005	0.039	0.010	0.010	0.018	0.041	0.034	**0.453**	**0.479**
	Chance of Accident[f]	1 in 189	1 in 26	1 in 97	1 in 97	1 in 57	1 in 24	1 in 30	1 in 2	1 in 2

[a] Volume-to-weight conversion factor of 1.5 tons per CY was applied to volumes presented in Table F.1.

[b] U.S. DOT. 2005. Bureau of Transportation Statistics, *National Transportation Statistics 2005.* Table 1-32. U.S. Vehicle-Miles in 2003 (note, 2004 data are available for AVMT, but not # accidents).

[c] U.S. DOT. 2005. Bureau of Transportation Statistics, *National Transportation Statistics 2005.* Table 2-3. Transportation Accidents by Mode in 2003 (data for 2004 are not yet avaialble). U.S. DOT, National Highway Traffic Safety Administration uses the term "crash" instead of accident in its highway safety data. Highway crashes often involve more than one motor vehicle, hence "total highway crashes" is smaller than the sum of the components. Estimates of highway crashes are rounded to the nearest thousand in the source document.

[d] Statistics for large trucks, defined as trucks over 10,000 gross vehicle weight rating, including single-unit trucks and truck tractors.

[e] Assumes truck carrying capacity of 32 tons.

[f] Chance may be expressed as "One in X", where X = (1/N), where N = expected number of truck accidents.

[g] Sum of areas in Table F.7-1 (Northwest Corner and Southern Area) plus areas in Table F.7-2 (Boat Slips, Old Marina, and Offshore Area).

AVMT = Annual Vehicle Miles Traveled = total mileage x number of trucks.

Table F.8-1. Projected Number of Truck Accident Related Injuries (Non-fatal and Fatal) - Northwest Corner and Southern Area.

Transportation Statistics		**Northwest Corner**					**Southern Area**					**Total (All Areas)[f]**	
		NW-1	**NW-2A**	**NW-2B**	**NW-3**	**NW-4**	**SA-1**	**SA-2**	**SA-3A**	**SA-3B**	**SA-4**	**Min**	**Max**
see Table F.7	AVMT	11,156	13,875	14,344	29,063	34,500	6,806	28,594	29,531	30,469	31,406	**226,203**	**239,422**
	Number of Accidents	0.022	0.028	0.029	0.058	0.069	0.014	0.057	0.059	0.061	0.063	**0.453**	**0.479**
U.S. Injury Rate[a, b, c]	Total AVMT in 2003	2.18E+11	2.18E+11	2.18E+11	2.18E+11	2.18E+11	2.18E+11	2.18E+11	2.18E+11	2.18E+11	2.18E+11	2.18E+11	2.18E+11
	# Accidents in 2003	4.36E+05	4.36E+05	4.36E+05	4.36E+05	4.36E+05	4.36E+05	4.36E+05	4.36E+05	4.36E+05	4.36E+05	4.36E+05	4.36E+05
	# Non-fatal Injuries in 2003	26,893	26,893	26,893	26,893	26,893	26,893	26,893	26,893	26,893	26,893	26,893	26,893
	# Fatalities in 2003	723	723	723	723	723	723	723	723	723	723	723	723
	Non-fatal Injuries per AVMT	1.23E-07	1.23E-07	1.23E-07	1.23E-07	1.23E-07	1.23E-07	1.23E-07	1.23E-07	1.23E-07	1.23E-07	1.2E-07	1.2E-07
	Non-fatal Injuries per Accident	6.17E-02	6.17E-02	6.17E-02	6.17E-02	6.17E-02	6.17E-02	6.17E-02	6.17E-02	6.17E-02	6.17E-02	6.2E-02	6.2E-02
	Fatalities per AVMT	3.32E-09	3.32E-09	3.32E-09	3.32E-09	3.32E-09	3.32E-09	3.32E-09	3.32E-09	3.32E-09	3.32E-09	3.3E-09	3.3E-09
	Fatalities per Accident	1.66E-03	1.66E-03	1.66E-03	1.66E-03	1.66E-03	1.66E-03	1.66E-03	1.66E-03	1.66E-03	1.66E-03	1.7E-03	1.7E-03
Projected Number of Non-Fatal Injuries	U.S. Rate of Injuries per AVMT x AVMT	1.38E-03	1.71E-03	1.77E-03	3.59E-03	4.26E-03	8.40E-04	3.53E-03	3.64E-03	3.76E-03	3.88E-03	**2.8E-02**	**3.0E-02**
	U.S. Rate of Injuries per Accident x # Accidents	1.38E-03	1.71E-03	1.77E-03	3.59E-03	4.26E-03	8.40E-04	3.53E-03	3.64E-03	3.76E-03	3.88E-03	**2.8E-02**	**3.0E-02**
	Chance of a Non-fatal Injury[d]	1 in 726	1 in 584	1 in 565	1 in 279	1 in 235	1 in 1191	1 in 283	1 in 274	1 in 266	1 in 258	1 in 36	1 in 34
	Risk of at Least One Non-fatal Injury[e]	1.38E-03	1.71E-03	1.77E-03	3.58E-03	4.25E-03	8.40E-04	3.52E-03	3.64E-03	3.75E-03	3.87E-03	**2.8E-02**	**2.9E-02**
Projected Number of Fatalities	U.S. Rate of Fatalities per AVMT x AVMT	3.70E-05	4.60E-05	4.76E-05	9.64E-05	1.14E-04	2.26E-05	9.49E-05	9.80E-05	1.01E-04	1.04E-04	**7.5E-04**	**7.9E-04**
	U.S. Rate of Fatalities per Accident x # Accidents	3.70E-05	4.60E-05	4.76E-05	9.64E-05	1.14E-04	2.26E-05	9.49E-05	9.80E-05	1.01E-04	1.04E-04	**7.5E-04**	**7.9E-04**
	Chance of a Fatality[d]	1 in 27,017	1 in 21,723	1 in 21,013	1 in 10,371	1 in 8,736	1 in 44,284	1 in 10,541	1 in 10,206	1 in 9,892	1 in 9,597	1 in 1,332	1 in 1,259
	Risk of at Least One Fatality[e]	3.70E-05	4.60E-05	4.76E-05	9.64E-05	1.14E-04	2.26E-05	9.49E-05	9.80E-05	1.01E-04	1.04E-04	**7.5E-04**	**7.9E-04**

[a] U.S. DOT. 2005. Bureau of Transportation Statistics, *National Transportation Statistics 2005.* Table 1-32. U.S. Vehicle-Miles in 2003 (note, 2004 data are available for AVMT, but not # accidents).

[b] U.S. DOT. 2005. Bureau of Transportation Statistics, *National Transportation Statistics 2005.* Table 2-1. Fatalities by Mode in 2003 (data for 2004 are not yet available).

[c] U.S. DOT. 2005. Bureau of Transportation Statistics, *National Transportation Statistics 2005.* Table 2-2. Injured Persons by Mode in 2003 (data for 2004 are not yet available).

[d] Chance may be expressed as "One in X", where X = (1/N), where N = expected number of fatalities or non-fatal injuries.

[e] Risk of fatality (or non-fatal injury) is modeled with a Poisson distribution, $f(x) = (\exp[-mu] \times mu^x)/x!$, where mu is the mean number of fatalities. Probability of at least one fatality (x greater than or equal to 1) is equal to one minus the probability of 0 fatalities, or $P = 1 - f(0) = 1 - (\exp[-mu] \times 1)/1 = 1 - \exp[-mu]$.

[f] Sum of areas in Table F.8-1 (Northwest Corner and Southern Area) plus areas in Table F.8-2 (NSlips, Old Marina, and Offshore Area).

Table F.8-2. Projected Number of Truck Accident Related Injuries and Fatalities - Boat Slips, Old Marina, and Offshore Area.

Transportation Statistics		NSlips		Old Marina		Offshore Area			Total (All Areas)[f]	
		NSlip-1	Nslip-2	OM-1	OM-2	OS-2A	OS-2B	OS-2C	Min	Max
see Table F.7	AVMT	2,647	19,500	5,156	5,156	8,813	20,625	16,875	**226,203**	**239,422**
	Number of Accidents	0.005	0.039	0.010	0.010	0.018	0.041	0.034	**0.453**	**0.479**
U.S. Injury Rate[a, b, c]	Total AVMT in 2003	2.18E+11	2.18E+11	2.18E+11	2.18E+11	2.18E+11	2.18E+11	2.18E+11	2.18E+11	2.18E+11
	# Accidents in 2003	4.36E+05	4.36E+05	4.36E+05	4.36E+05	4.36E+05	4.36E+05	4.36E+05	4.36E+05	4.36E+05
	# Non-fatal Injuries in 2003	26,893	26,893	26,893	26,893	26,893	26,893	26,893	26,893	26,893
	# Fatalities in 2003	723	723	723	723	723	723	723	723	723
	Non-fatal Injuries per AVMT	1.23E-07	1.23E-07	1.23E-07	1.23E-07	1.23E-07	1.23E-07	1.23E-07	1.2E-07	1.2E-07
	Non-fatal Injuries per Accident	6.17E-02	6.17E-02	6.17E-02	6.17E-02	6.17E-02	6.17E-02	6.17E-02	6.2E-02	6.2E-02
	Fatalities per AVMT	3.32E-09	3.32E-09	3.32E-09	3.32E-09	3.32E-09	3.32E-09	3.32E-09	3.3E-09	3.3E-09
	Fatalities per Accident	1.66E-03	1.66E-03	1.66E-03	1.66E-03	1.66E-03	1.66E-03	1.66E-03	1.7E-03	1.7E-03
Projected Number of Non-fatal Injuries	U.S. Rate of Injuries per AVMT x AVMT	3.27E-04	2.41E-03	6.36E-04	6.36E-04	1.09E-03	2.55E-03	2.08E-03	**2.8E-02**	**3.0E-02**
	U.S. Rate of Injuries per Accident x # Accidents	3.27E-04	2.41E-03	6.36E-04	6.36E-04	1.09E-03	2.55E-03	2.08E-03	**2.8E-02**	**3.0E-02**
	Chance of a Non-fatal Injury[d]	1 in 3062	1 in 416	1 in 1572	1 in 1572	1 in 920	1 in 393	1 in 480	1 in 36	1 in 34
	Risk of at Least One Non-fatal Injury[e]	3.27E-04	2.40E-03	6.36E-04	6.36E-04	1.09E-03	2.54E-03	2.08E-03	**2.8E-02**	**2.9E-02**
Projected Number of Fatalities	U.S. Rate of Fatalities per AVMT x AVMT	8.78E-06	6.47E-05	1.71E-05	1.71E-05	2.92E-05	6.84E-05	5.60E-05	**7.5E-04**	**7.9E-04**
	U.S. Rate of Fatalities per Accident x # Accidents	8.78E-06	6.47E-05	1.71E-05	1.71E-05	2.92E-05	6.84E-05	5.60E-05	**7.5E-04**	**7.9E-04**
	Chance of a Fatality[d]	1 in 113,886	1 in 15,457	1 in 58,455	1 in 58,455	1 in 34,202	1 in 14,614	1 in 17,861	1 in 1,332	1 in 1,259
	Risk of at Least One Fatality[e]	8.78E-06	6.47E-05	1.71E-05	1.71E-05	2.92E-05	6.84E-05	5.60E-05	**7.5E-04**	**7.9E-04**

[a] U.S. DOT. 2005. Bureau of Transportation Statistics, *National Transportation Statistics 2005.* Table 1-32. U.S. Vehicle-Miles in 2003 (note, 2004 data are available for AVMT, but not # accidents).

[b] U.S. DOT. 2005. Bureau of Transportation Statistics, *National Transportation Statistics 2005.* Table 2-1. Fatalities by Mode in 2003 (data for 2004 are not yet available).

[c] U.S. DOT. 2005. Bureau of Transportation Statistics, *National Transportation Statistics 2005.* Table 2-2. Injured Persons by Mode in 2003 (data for 2004 are not yet available).

[d] Chance may be expressed as "One in X", where X = (1/N), where N = expected number of fatalities or non-fatal injuries.

[e] Risk of fatality (or non-fatal injury) is modeled with a Poisson distribution, $f(x) = (\exp[-mu] \times mu^x)/x!$, where mu is the mean number of fatalities. Probability of at least one fatality (x greater than or equal to 1) is equal to one minus the probability of 0 fatalities, or P = 1 - f(0) = 1 - (exp[-mu] x 1)/1 = 1 - exp[-mu].

[f] Sum of areas in Table F.8-1 (Northwest Corner and Southern Area) plus areas in Table F.8-2 (NSlips, Old Marina, and Offshore Area).

Table F.9-1. Summary of Occupational and Transportation Risks of Fatality for All Remedial Action Alternatives.

OU-2 Areas	Remedial Action Alternatives		All Occupations: Chance of Fatality	All Occupations: Risk of at Least One Fatality	Truck Driver, Labor Basis: Chance of Fatality	Truck Driver, Labor Basis: Risk of at Least One Fatality	Truck Driver, Mileage Basis: Chance of Fatality	Truck Driver, Mileage Basis: Risk of at Least One Fatality
Northwest Corner	NW-1	Dredge for Cap Stability	1 in 100	1.0×10^{-2}	1 in 3,943	2.5×10^{-4}	1 in 27,017	3.7×10^{-5}
	NW-2, Option A	Dredge to Limit of Bulkhead Stability	1 in 33	3.0×10^{-2}	1 in 3,171	3.2×10^{-4}	1 in 21,723	4.6×10^{-5}
	NW-2, Option B	Dredge to Limit of Bulkhead Stability	1 in 24	4.1×10^{-2}	1 in 3,067	3.3×10^{-4}	1 in 21,013	4.8×10^{-5}
	NW-3	Redivide OU-1 and OU-2	1 in 31	3.2×10^{-2}	1 in 1,514	6.6×10^{-4}	1 in 10,371	9.6×10^{-5}
	NW-4	Penetrate Shoreline Bulkhead into Basal Sands	1 in 35	2.8×10^{-2}	1 in 1,275	7.8×10^{-4}	1 in 8,736	1.1×10^{-4}
Southern Area	SA-1	Place a Protective Cap	1 in 624	1.6×10^{-3}	1 in 6,464	1.5×10^{-4}	1 in 44,284	2.3×10^{-5}
	SA-2	Dredge 2 ft and Place a Protective Cap	1 in 60	1.7×10^{-2}	1 in 1,539	6.5×10^{-4}	1 in 10,541	9.5×10^{-5}
	SA-3, Option A	Dredge to Limit of Bulkhead Stability	1 in 53	1.9×10^{-2}	1 in 1,490	6.7×10^{-4}	1 in 10,206	9.8×10^{-5}
	SA-3, Option B	Dredge to Limit of Bulkhead Stability	1 in 50	2.0×10^{-2}	1 in 1,444	6.9×10^{-4}	1 in 9,892	1.0×10^{-4}
	SA-4	Penetrate Shoreline Bulkhead into Basal Sands	1 in 33	3.0×10^{-2}	1 in 1,401	7.1×10^{-4}	1 in 9,597	1.0×10^{-4}
Nslips	Nslip-1	Dredge 2 ft and Place Protective Cap	1 in 274	3.6×10^{-3}	1 in 16,623	6.0×10^{-5}	1 in 113,886	8.8×10^{-6}
	Nslip-2	Dredge to Limit of Bulkhead Stability	1 in 60	1.7×10^{-2}	1 in 2,256	4.4×10^{-4}	1 in 15,457	6.5×10^{-5}
Old Marina	OM-1	Dredge 2 ft and Place Protective Cap	1 in 88	1.1×10^{-2}	1 in 8,532	1.2×10^{-4}	1 in 58,455	1.7×10^{-5}
	OM-2	Dredge to Limit of Bulkhead Stability	1 in 44	2.3×10^{-2}	1 in 8,532	1.2×10^{-4}	1 in 58,455	1.7×10^{-5}
Offshore Area	Offshore-2, Option A	OS-2 (PCBs>1ppm and/or Cu982) Place a Protective Cap	1 in 497	2.0×10^{-3}	1 in 4,992	2.0×10^{-4}	1 in 34,202	2.9×10^{-5}
	Offshore-2, Option B	OS-2 (PCBs>1ppm and/or Cu88.7 (PRAP)) Place a Protective Cap	1 in 212	4.7×10^{-3}	1 in 2,133	4.7×10^{-4}	1 in 14,614	6.8×10^{-5}
	Offshore-2, Option C	OS-2 (PCBs>1ppm and/or Cu88.7 (ESI)) Place a Protective Cap	1 in 259	3.8×10^{-3}	1 in 2,607	3.8×10^{-4}	1 in 17,861	5.6×10^{-5}
Occupational Risks		**Minimum Total[a]**	1 in 4	2.1×10^{-1}	1 in 194	5.1×10^{-3}	1 in 1,332	7.5×10^{-4}
		Maximum Total[b]	1 in 4	2.2×10^{-1}	1 in 184	5.4×10^{-3}	1 in 1,259	7.9×10^{-4}
Transportation Risks (Rail)		**TSCA Total[c]**	1 in 158	6.3×10^{-3}	NA	NA	NA	NA
		Non-TSCA Total[d]	1 in 469	2.1×10^{-3}	NA	NA	NA	NA
		Cleanfill Total[e]	1 in 2,625	3.8×10^{-4}	NA	NA	NA	NA
		Total Transportation Risk	1 in 113	8.8×10^{-3}	NA	NA	NA	NA
Total Risk		**Minimum Total[a]**	1 in 4	2.1×10^{-1}	NA	NA	NA	NA
(Occupational + Transportation)		**Maximum Total[b]**	1 in 4	2.2×10^{-1}	NA	NA	NA	NA

[a] Sum of risks for remedial action alternatives using the options that yield the minimum risk in each area.

[b] Sum of risks for remedial action alternatives using the options that yield the maximum risk in each area.

[c] Sediment regulated under TSCA (PCB concentration > 50 ppm) that will be transported by rail to a landfill facility in Wayne, MI (Figure F.1).

[d] Sediment regulated under RCRA Subtitle D that will be transported by rail to a landfill facility in Niagara Falls, NY (Figure F.2).

[e] Sand and gravel transported by rail and truck from a rock quarry near Poughkeepsie, NY (Figure F.2).

NA = not applicable for the remedial alternative. Note that results are reported to two significant digits to facilitate comparisons, rather than to imply precision.

Table F.9-2. Comparison of Total Occupational Risks of Fatality by Remedial Action Alternative.

OU-2 Areas	Remedial Action Alternatives		All Occupations		Relative Risk in Area[c]		% of Minimum Risk		% of Maximum Risk	
			Chance of Fatality	Risk of at Least One Fatality	All Alternatives	Options	Area[d]	OU-2 Total[e]	Area[d]	OU-2 Total[e]
Northwest Corner	NW-1	Dredge for Cap Stability	1 in 100	1.0×10^{-2}	0.24	--	9.9%	4.4%	8.9%	4.2%
	NW-2, Option A	Dredge to Limit of Bulkhead Stability	1 in 33	3.0×10^{-2}	0.72	0.72	30.0%	13.5%	--	--
	NW-2, Option B	Dredge to Limit of Bulkhead Stability	1 in 24	4.1×10^{-2}	1.00	1.00	--	--	37.2%	17.5%
	NW-3	Redivide OU-1 and OU-2	1 in 31	3.2×10^{-2}	0.77	--	32.0%	14.4%	28.7%	13.5%
	NW-4	Penetrate Shoreline Bulkhead into Basal Sands	1 in 35	2.8×10^{-2}	0.68	--	28.1%	12.6%	25.2%	11.8%
	Minimum Total	NW-1 , NW-2 Option A, NW-3, NW-4	1 in 10	9.7×10^{-2}	--	--	--	45.0%	--	
	Maximum Total	NW-1 , NW-2 Option B, NW-3, NW-4	1 in 9	1.1×10^{-1}	--	--	--	--	--	46.9%
Southern Area	SA-1	Place a Protective Cap	1 in 624	1.6×10^{-3}	0.05	--	2.4%	0.7%	2.3%	0.7%
	SA-2	Dredge 2 ft and Place a Protective Cap	1 in 60	1.7×10^{-2}	0.55	--	24.6%	7.4%	24.3%	6.9%
	SA-3, Option A	Dredge to Limit of Bulkhead Stability	1 in 53	1.9×10^{-2}	0.62	0.95	28.0%	8.4%	--	--
	SA-3, Option B	Dredge to Limit of Bulkhead Stability	1 in 50	2.0×10^{-2}	0.65	1.00	--	--	28.9%	8.2%
	SA-4	Penetrate Shoreline Bulkhead into Basal Sands	1 in 33	3.0×10^{-2}	1.00	--	45.0%	13.5%	44.4%	12.6%
	Minimum Total	SA-1, SA-2, SA-3 Option A, SA-4	1 in 15	6.5×10^{-2}	--	--	--	30.0%	--	
	Maximum Total	SA-1, SA-2, SA-3 Option B, SA-4	1 in 15	6.6×10^{-2}	--	--	--	--	--	28.5%
Nslips	NSlip-1	Dredge 2 ft and Place Protective Cap	1 in 274	3.6×10^{-3}	0.22	--	17.9%	1.6%	17.9%	1.5%
	NSlip-2	Dredge to Limit of Bulkhead Stability	1 in 60	1.7×10^{-2}	1.00	--	82.1%	7.4%	82.1%	6.9%
	Minimum Total	NSlip-1, NSlip-2	1 in 49	3.2×10^{-2}	--	--	--	9.0%	--	
	Maximum Total	NSlip-1, NSlip-2	1 in 49	3.2×10^{-2}	--	--	--	--	--	8.5%
Old Marina	OM-1	Dredge 2 ft and Place Protective Cap	1 in 88	1.1×10^{-2}	0.49	--	33.1%	5.0%	33.1%	4.7%
	OM-2	Dredge to Limit of Bulkhead Stability	1 in 44	2.3×10^{-2}	1.00	--	66.9%	10.1%	66.9%	9.5%
	Minimum Total	OM-1, OM-2, OM-3	1 in 29	5.1×10^{-2}	--	--	--	15.1%	--	
	Maximum Total	OM-1, OM-2, OM-3	1 in 29	5.1×10^{-2}	--	--	--	--	--	14.2%
Offshore Area	Offshore-2, Option A	OS-2 (PCBs>1ppm and/or Cu982) Place a Protective Cap	1 in 497	2.0×10^{-3}	0.43	0.43	100%	0.9%	--	--
	Offshore-2, Option B	OS-2 (PCBs>1ppm and/or Cu88.7 (PRAP)) Place a Protective Cap	1 in 212	4.7×10^{-3}	1.00	1.00	--	--	100%	2.0%
	Offshore-2, Option C	OS-2 (PCBs>1ppm and/or Cu88.7 (ESI)) Place a Protective Cap	1 in 259	3.8×10^{-3}	0.82	0.82	--	--	--	--
	Minimum Total	Offshore-2, Option A	1 in 497	2.0 x 10-3	--	--	--	0.9%	--	
	Maximum Total	Offshore-2, Option B	1 in 212	4.7 x 10-3	--	--	--	--	--	2.0%
Occupational Risks		**Minimum Total[a]**	1 in 4	2.0×10^{-1}						
		Maximum Total[b]	1 in 4	2.1×10^{-1}						

[a] Sum of risks for remedial action alternatives using the options that yield the minimum risk in each area.

[b] Sum of risks for remedial action alternatives using the options that yield the maximum risk in each area.

[c] Risk of fatality for alternative divided by maximum risk of fatality within area.

[d] Risk of fatality for alternative divided by sum of risks of fatality within area. Percentages within area sum to 100%.

[e] Risk of fatality for alternative divided by sum of risks of fatality across all areas (total occupational risk). Percentages across areas sum to 100%.

-- = not applicable for the remedial alternative. Note that results are reported to two significant digits to facilitate comparisons, rather than to imply precision.

Table F.9-3. Percent of Total Risk of Fatality by Remedial Action Alternative and Occupation.

			Occupational Risk		Percent of Total Risk for Remedial Action Alternative by Occupation																
OU-2 Areas	Remedial Action Alternatives		Chance of Fatality	Risk of at Least One Fatality	Deckhand	Laborer	Leverman, Operator	Captain (Tug)	Pile driver	Truck Driver	Switch Operator	Railroad Conductor	Superintendent	Diver	Mechanic	Surveyor	Foreman, Project Manager	Industrial Hygiene Technician	Engineer	Industrial Hygienist	Clerk
Northwest Corner	NW-1	Dredge for Cap Stability	1 in 100	1.0×10^{-2}	32%	21%	13%	14%	5%	3%	3%	2%	3%	1%	1%	1%	< 1%	< 1%	< 1%	< 1%	< 1%
	NW-2, Option A	Dredge to Limit of Bulkhead Stability	1 in 33	3.0×10^{-2}	43%	14%	11%	11%	10%	1%	2%	1%	2%	1%	1%	< 1%	1%	< 1%	< 1%	< 1%	< 1%
	NW-2, Option B	Dredge to Limit of Bulkhead Stability	1 in 24	4.1×10^{-2}	44%	14%	11%	11%	11%	1%	2%	1%	2%	1%	1%	< 1%	1%	< 1%	< 1%	< 1%	< 1%
	NW-3	Redivide OU-1 and OU-2	1 in 31	3.2×10^{-2}	41%	16%	11%	11%	9%	2%	2%	2%	2%	1%	1%	1%	1%	< 1%	< 1%	< 1%	< 1%
	NW-4	Penetrate Shoreline Bulkhead into Basal Sands	1 in 35	2.8×10^{-2}	27%	26%	12%	11%	3%	3%	5%	4%	4%	2%	1%	1%	< 1%	1%	< 1%	< 1%	< 1%
Southern Area	SA-1	Place a Protective Cap	1 in 624	1.6×10^{-3}	19%	31%	10%	8%	0%	10%	7%	6%	4%	2%	1%	1%	< 1%	0%	< 1%	0%	0%
	SA-2	Dredge 2 ft and Place a Protective Cap	1 in 60	1.7×10^{-2}	35%	20%	11%	10%	7%	4%	4%	3%	3%	1%	1%	1%	< 1%	< 1%	< 1%	< 1%	< 1%
	SA-3, Option A	Dredge to Limit of Bulkhead Stability	1 in 53	1.9×10^{-2}	36%	19%	11%	10%	7%	4%	3%	3%	3%	1%	1%	1%	< 1%	< 1%	< 1%	< 1%	< 1%
	SA-3, Option B	Dredge to Limit of Bulkhead Stability	1 in 50	2.0×10^{-2}	36%	19%	11%	10%	7%	3%	3%	3%	2%	1%	1%	1%	< 1%	< 1%	< 1%	< 1%	< 1%
	SA-4	Penetrate Shoreline Bulkhead into Basal Sands	1 in 33	3.0×10^{-2}	40%	17%	11%	11%	9%	2%	3%	2%	2%	1%	1%	1%	< 1%	< 1%	< 1%	< 1%	< 1%
Nslips	NSlip-1	Dredge 2 ft and Place Protective Cap	1 in 274	3.6×10^{-3}	41%	16%	11%	11%	9%	2%	2%	2%	2%	1%	1%	< 1%	1%	< 1%	< 1%	< 1%	< 1%
	NSlip-2	Dredge to Limit of Bulkhead Stability	1 in 60	1.7×10^{-2}	39%	18%	11%	10%	8%	3%	3%	2%	2%	1%	1%	1%	< 1%	< 1%	< 1%	< 1%	< 1%
Old Marina	OM-1	Dredge 2 ft and Place Protective Cap	1 in 88	1.1×10^{-2}	43%	15%	11%	11%	10%	1%	2%	1%	2%	1%	1%	< 1%	1%	< 1%	< 1%	< 1%	< 1%
	OM-2	Dredge to Limit of Bulkhead Stability	1 in 44	2.3×10^{-2}	45%	14%	11%	11%	11%	1%	1%	1%	2%	1%	1%	< 1%	1%	< 1%	< 1%	< 1%	< 1%
Offshore Area	Offshore-2, Option A	OS-2 (PCBs>1ppm and/or Cu982) Place a Protective Cap	1 in 497	2.0×10^{-3}	20%	28%	11%	8%	0%	10%	7%	6%	4%	2%	1%	1%	< 1%	0%	< 1%	0%	0%
	Offshore-2, Option B	OS-2 (PCBs>1ppm and/or Cu88.7 (PRAP)) Place a Protective Cap	1 in 212	4.7×10^{-3}	20%	28%	11%	8%	0%	10%	7%	6%	4%	2%	1%	1%	< 1%	0%	< 1%	0%	0%
	Offshore-2, Option C	OS-2 (PCBs>1ppm and/or Cu88.7 (ESI)) Place a Protective Cap	1 in 259	3.8×10^{-3}	20%	28%	11%	8%	0%	10%	7%	6%	4%	2%	1%	1%	< 1%	0%	< 1%	0%	0%
Occupational Risks		**Minimum Total[a]**	1 in 4	2.0×10^{-1}	19%	14%	10%	8%	0%	1%	1%	1%	2%	1%	1%	< 1%	< 1%	0%	< 1%	0%	0%
		Maximum Total[b]	1 in 4	2.1×10^{-1}	45%	31%	13%	14%	11%	10%	7%	6%	4%	2%	1%	1%	1%	1%	0%	0%	0%

[a] Sum of risks for remedial action alternatives using the options that yield the minimum risk in each area.

[b] Sum of risks for remedial action alternatives using the options that yield the maximum risk in each area.

ATTACHMENT F1

DESCRIPTION OF 2000 SOC OCCUPATIONS MATCHED TO LABOR CATEGORIES

Occupational risks to workers involved in the dredging operations for each remedial action alternative are based on national statistics for rates of worker injuries and fatalities reported for specific occupations. The first step in the risk assessment is to match the labor categories used to plan the dredging operations with the equivalent occupation codes established by the U.S. Department of Labor to report occupational employment (i.e, the 2000 Standard Occupational Classification, or 2000 SOC). Seventeen unique labor categories were used to summarize the labor estimates for this risk assessment. To the extent possible, exact matches were made between each labor category and a 2000 SOC occupation. The following three types of matches were identified for each labor category:

1. **Exact match** **–** no uncertainty in corresponding 2000 SOC occupation.

2. **Group match** **–** labor category is too specific to correspond to a 2000 SOC occupation, but can be represented by a major group in the SOC classification system. Statistics are based on more than one SOC code. The assumption is that the rates of fatalities and injury determined for the group are applicable to all occupations in the group.

3. **Assumed match** **–** professional judgment was used to assign an equivalent SOC code based on the job description and an assumption that work-related injuries are likely to be similar.

Table F-1 lists the specific 2000 SOC occupation that was matched with each of the 17 labor categories, the type of match (specific match, group match, assumed match), and the job description according to the U.S. Department of Labor.

In most cases (14 of 17), there is a one-to-one match between a labor category and an occupation code. For three labor categories (Industrial Hygiene Technician, Clerk, Mechanic), statistics are based on more than one SOC code. For two labor categories (Industrial Hygiene Technician, Leverman), statistics are based on SOC occupation(s) that are assumed to be reasonable matches from the perspective of worker safety.

Industrial Hygiene Technicians required multiple assumptions. The 2000 SOC codes in the 17-302X group represent the subcategories of technicians and assistants; however, there is no subcode for Industrial Hygiene Technician. One simplifying approach would have been to assume that the risks to Industrial Hygiene Technicians are the same as that of professional Industrial Hygienists (assigned to SOC code 17-2111 for Health and Safety Engineers, Except Mining Safety Engineers and Inspectors). However, in comparing the statistics for other categories of professionals and technicians (e.g., Civil Engineers and Civil Engineering Technicians), the rates of injury per 100,000 individuals employed did not appear to correspond well. Therefore, it was assumed that risks were better represented by the average risk among engineering and science technicians for this particular labor category. Given that the Industrial Hygiene and Industrial Hygiene Technicians represent a relatively minor percentage of the overall worker risks in this assessment, uncertainty associated with the classification of this category is relatively minor.

Activities and corresponding worker safety for **Clerks** are well represented by the 2000 SOC codes for secretaries and administrative assistants (43-601X). Statistics for **Mechanics** were compiled from codes for both mobile heavy equipment mechanics (49-3042) and rail car repairers (49-3043) since rail is identified as the major mode of transportation for removal of dredged sediment.

Table F1-1. Descriptions of Standard Occupational Classification (SOC) Codes Matched to the Worker Risk Assessment Labor Categories.

Labor Category	Type of Match	2000 SOC Occupation Code and Job Description[a]
Foreman, Project Manager	**Exact**	**11-9041 Engineering Managers**
		Plan, direct, or coordinate activities in such fields as architecture and engineering or research and development in these fields. Exclude "Natural Sciences Managers" (11-9121).
Surveyor	**Exact**	**17-1022 Surveyors**
		Make exact measurements and determine property boundaries. Provide data relevant to the shape, contour, gravitation, location, elevation, or dimension of land or land features on or near the earth's surface for engineering, mapmaking, mining, land evaluation, construction, and other purposes.
Engineer	**Exact**	**17-2051 Civil Engineers**
		Perform engineering duties in planning, designing, and overseeing construction and maintenance of building structures, and facilities, such as roads, railroads, airports, bridges, harbors, channels, dams, irrigation projects, pipelines, power plants, water and sewage systems, and waste disposal units. Include architectural, structural, traffic, ocean, and geo-technical engineers. Exclude "Hydrologists" (19-2043).
Industrial Hygienist	**Exact**	**17-2111 Health and Safety Engineers, Except Mining Safety Engineers and Inspectors**
		Promote worksite or product safety by applying knowledge of industrial processes, mechanics, chemistry, psychology, and industrial health and safety laws. Include industrial product safety engineers.
Industrial Hygiene Technician	**Group, Assumed**	**17-3022 Civil Engineering Technicians**
		Apply theory and principles of civil engineering in planning, designing, and overseeing construction and maintenance of structures and facilities under the direction of engineering staff or physical scientists.

Table F1-1. Descriptions of Standard Occupational Classification (SOC) Codes Matched to the Worker Risk Assessment Labor Categories.

Labor Category	Type of Match	2000 SOC Occupation Code and Job Description[a]
		17-3023 Electrical and Electronic Engineering Technicians
		Apply electrical and electronic theory and related knowledge, usually under the direction of engineering staff, to design, build, repair, calibrate, and modify electrical components, circuitry, controls, and machinery for subsequent evaluation and use by engineering staff in making engineering design decisions. Exclude "Broadcast Technicians" (27-4012).
		17-3024 Electro-Mechanical Technicians
		Operate, test, and maintain unmanned, automated, servo-mechanical, or electromechanical equipment. May operate unmanned submarines, aircraft, or other equipment at worksites, such as oil rigs, deep ocean exploration, or hazardous waste removal. May assist engineers in testing and designing robotics equipment.
		17-3025 Environmental Engineering Technicians
		Apply theory and principles of environmental engineering to modify, test, and operate equipment and devices used in the prevention, control, and remediation of environmental pollution, including waste treatment and site remediation. May assist in the development of environmental pollution remediation devices under direction of engineer.
		17-3026 Industrial Engineering Technicians
		Apply engineering theory and principles to problems of industrial layout or manufacturing production, usually under the direction of engineering staff. May study and record time, motion, method, and speed involved in performance of production, maintenance, clerical, and other worker operations for such purposes as establishing standard production rates or improving efficiency.
		17-3027 Mechanical Engineering Technicians
		Apply theory and principles of mechanical engineering to modify, develop, and test machinery and equipment under direction of engineering staff or physical scientists.
Clerk	**Group**	**43-6011 Executive Secretaries and Administrative Assistants**
		Provide high-level administrative support by conducting research, preparing statistical reports, handling information requests, and performing clerical functions such as preparing correspondence, receiving visitors, arranging conference calls, and scheduling meetings. May also train and supervise lower-level clerical staff. Exclude "Secretaries" (43-6012 through 43-6014).

Table F1-1. Descriptions of Standard Occupational Classification (SOC) Codes Matched to the Worker Risk Assessment Labor Categories.

Labor Category	Type of Match	2000 SOC Occupation Code and Job Description[a]
		43-6012 Legal Secretaries
		Perform secretarial duties utilizing legal terminology, procedures, and documents. Prepare legal papers and correspondence, such as summonses, complaints, motions, and subpoenas. May also assist with legal research.
		43-6013 Medical Secretaries
		Perform secretarial duties utilizing specific knowledge of medical terminology and hospital, clinic, or laboratory procedures. Duties include scheduling appointments, billing patients, and compiling and recording medical charts, reports, and correspondence.
		43-6014 Secretaries, Except Legal, Medical, and Executive
		Perform routine clerical and administrative functions such as drafting correspondence, scheduling appointments, organizing and maintaining paper and electronic files, or providing information to callers. Exclude legal, medical, or executive secretaries and administrative assistants (43-6011 through 43-6013).
Superintendent	**Exact**	**47-1011 First-Line Supervisors/Managers of Construction Trades and Extraction Workers**
		Directly supervise and coordinate activities of construction or extraction workers.
Laborer	**Exact**	**47-2061 Construction Laborers**
		Perform tasks involving physical labor at building, highway, and heavy construction projects, tunnel and shaft excavations, and demolition sites. May operate hand and power tools of all types: air hammers, earth tampers, cement mixers, small mechanical hoists, surveying and measuring equipment, and a variety of other equipment and instruments. May clean and prepare sites, dig trenches, set braces to support the sides of excavations, erect scaffolding, clean up rubble and debris, and remove asbestos, lead, and other hazardous waste materials. May assist other craft workers. Exclude construction laborers who primarily assist a particular craft worker, and classify them under "Helpers, Construction Trades" (47-3011 through 47-3016).
Pile driver	**Exact**	**47-2072 Pile-Driver Operators**
		Operate pile drivers mounted on skids, barges, crawler treads, or locomotive cranes to drive pilings for retaining walls, bulkheads, and foundations of structures, such as buildings, bridges, and piers.
Leverman, Operator	**Assumed**	**47-2073 Operating Engineers and Other Construction Equipment Operators**
		Operate one or several types of power construction

Table F1-1. Descriptions of Standard Occupational Classification (SOC) Codes Matched to the Worker Risk Assessment Labor Categories.

Labor Category	Type of Match	2000 SOC Occupation Code and Job Description[a]
		equipment, such as motor graders, bulldozers, scrapers, compressors, pumps, derricks, shovels, tractors, or front-end loaders to excavate, move, and grade earth, erect structures, or pour concrete or other hard surface pavement. May repair and maintain equipment in addition to other duties. Exclude "Crane and Tower Operators" (53-7021) and equipment operators who work in extraction or other non-construction industries.
Mechanic	**Exact, Group**	**49-3042 Mobile Heavy Equipment Mechanics, Except Engines**
		Diagnose, adjust, repair, or overhaul mobile mechanical, hydraulic, and pneumatic equipment, such as cranes, bulldozers, graders, and conveyors, used in construction, logging, and surface mining. Exclude "Rail Car Repairers" (49-3043) and "Bus and Truck Mechanics and Diesel Engine Specialists" (49-3031).
		49-3043 Rail Car Repairers
		Diagnose, adjust, repair, or overhaul railroad rolling stock, mine cars, or mass transit rail cars. Exclude "Bus and Truck Mechanics and Diesel Engine Specialists" (49-3031).
Diver	**Exact**	**49-9092 Commercial Divers**
		Work below surface of water, using scuba gear to inspect, repair, remove, or install equipment and structures. May use a variety of power and hand tools, such as drills, sledgehammers, torches, and welding equipment. May conduct tests or experiments, rig explosives, or photograph structures or marine life. Exclude "Fishers and Related Fishing Workers" (45-3011), "Athletes and Sports Competitors" (27-2021), and "Police and Sheriff's Patrol Officers" (33-3051).
Switch Operator	**Exact**	**53-4021 Railroad Brake, Signal, and Switch Operators**
		Operate railroad track switches. Couple or uncouple rolling stock to make up or break up trains. Signal engineers by hand or flagging. May inspect couplings, air hoses, journal boxes, and hand brakes.
Railroad Conductor	**Exact**	**53-4031 Railroad Conductors and Yardmasters**
		Conductors coordinate activities of train crew on passenger or freight train. Coordinate activities of switch-engine crew within yard of railroad, industrial plant, or similar location. Yardmasters coordinate activities of workers engaged in railroad traffic operations, such as the makeup or breakup of trains, yard switching, and review train schedules and switching orders.

Table F1-1. Descriptions of Standard Occupational Classification (SOC) Codes Matched to the Worker Risk Assessment Labor Categories.

Labor Category	Type of Match	2000 SOC Occupation Code and Job Description[a]
Deckhand	**Exact**	**53-5011 Sailors and Marine Oilers**
		Stand watch to look for obstructions in path of vessel, measure water depth, turn wheel on bridge, or use emergency equipment as directed by captain, mate, or pilot. Break out, rig, overhaul, and store cargo-handling gear, stationary rigging, and running gear. Perform a variety of maintenance tasks to preserve the painted surface of the ship and to maintain line and ship equipment. Must hold government-issued certification and tankerman certification when working aboard liquid-carrying vessels. Include able seamen and ordinary seamen.
Captain (Tug)	**Exact**	**53-5021 Captains, Mates, and Pilots of Water Vessels**
		Command or supervise operations of ships and water vessels, such as tugboats and ferryboats, that travel into and out of harbors, estuaries, straits, and sounds and on rivers, lakes, bays, and oceans. Required to hold license issued by U.S. Coast Guard. Exclude "Motorboat Operators" (53-5022).
Truck Driver	**Exact**	**53-7051 Industrial Truck and Tractor Operators**
		Operate industrial trucks or tractors equipped to move materials around a warehouse, storage yard, factory, construction site, or similar location. Exclude "Logging Equipment Operators" (45-4022).

[a] U.S. Department of Labor, Bureau of Labor Statistics, Occupational Employment Statistics, available at http://www.bls.gov/oes/2001/oes_stru.htm#00-0000

Table B-1. Census of Fatal Occupation Injuries (1992 - 2002) Statistics by Occupation Codes used in 1990 Census.[a]

Occupation Code and Description			CFOI Survey Year										
CFOI Series ID	1990 Census	Job Title[b]	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001[c]	2002
CFU0000908O	009	Purchasing Manager		3									
CFU0002108O	021	Manager, Service Organization, n.e.c.	11	15	9	11	10	10	10	8	12	7	4
CFU2003508O	035	Construction Inspector				3							
CFU0005308O	053	Civil Engineer	6	6	16	18	15	4	11	8	5	8	
CFU0005608O	056	Industrial engineers	3		10	6	4	3	4	4	4	3	3
CFU0005908O	059	Engineer, n.e.c.	6	14	6	18	3	5	9	11	3	7	4
CFU0006308O	063	Surveyors and mapping scientists		6	4					3		5	5
CFU00213X8O	NA[d]	Engineering and Related Technologist and Technician	35	18	27	31	23	33	29	22	32	21	24
CFU0020808O	208	Health technologists and technicians, n.e.c.	12	8	12	9	11	7	14	12	12	10	16
CFU0021308O	213	Electrical and Electronic Technician	19	8	15	13	11	16	14	11	15	11	16
CFU0021508O	215	Mechanical Engineering Technician				4							
CFU0021608O	216	Engineering Technician, n.e.c.	5	5		5	5	7	7	5	6	4	3
CFU0021708O	217	Drafting Occupation				3							
CFU0021808O	218	Surveying and Mapping Technician	8		10	6	6	7	6	3	10	6	
CFU0031308O	313	Secretary	13	19	12	21	10	7	12	6	12	6	5
CFU0051608O	516	Heavy Equipment Mechanic	20	33	24	24	38	32	28	43	29	34	21
CFU2025XX8O	NA[e]	Supervisors, construction occupations	72	78	100	82	77	65	80	80	103	89	101
CFU0056708O	567	Carpenter	90	89	87	96	89	96	90	102	90	112	106
CFU0057508O	575	Electrician	83	68	93	112	96	89	113	99	84	96	111
CFU0058508O	585	Plumber, Pipefitter, and Steamfitter	30	40	37	32	32	34	29	38	34	43	32
CFU0069408O	694	Water and Sewage Treatment Plant Operator	5	4	4	7	4	13	3	5		10	6
CFU0069508O	695	Power Plant Operator	6		3		4	7	3	4	3		
CFU0078308O	783	Welder and Cutter	65	58	67	72	63	61	65	67	68	69	53
CFU0080408O	804	Truck Driver	699	739	766	758	796	862	882	900	852	802	808
CFU0082308O	823	Railroad Conductor and Yardmaster	6	12	9	16	3	10	4	15	6		6
CFU0082508O	825	Railroad Brake, Signal, and Switch Operator	13	17	11	3	7	9	5	6	11	5	
CFU0082808O	828	Ship Captain and Mate, exc. Fishing Boat	14	11	13	4	9	14	3	12	7	9	13
CFU0082908O	829	Sailor and Deckhand	40	31	25	30	38	32	18	15	17	13	14
CFU0083308O	833	Marine Engineer			3	3		3	3				
CFU0084308O	843	Supervisor, Material Moving Equipment Operator	10	3	4	6			12	7	7		11
CFU0084408O	844	Operating Engineer	37	39	42	44	38	47	46	57	51	51	33
CFU0084908O	849	Crane and Tower Operator	13	13	11	15	14	15	12	14	16	14	13
CFU0085308O	853	Excavating and Loading Machine Operator	13	22	22	16	26	23	24	21	29	22	16
CFU0085508O	855	Grader, Dozer, and Scraper Operator	22	27	23	23	18	15	20	26	20	14	13
CFU0086908O	869	Construction Laborer	228	236	247	311	294	333	335	343	289	350	303

[a] Source for CFOI data (1992 - 2002): http://data.bls.gov/PDQ/outside.jsp?survey=cf

[b] No fatality statistics are available for the following detailed occupation codes in the 1990 Census: Survey Chief (063) and Pile Driver (849).

[c] Excludes September 11, 2001 terrorist attacks

[d] Aggregate (sum) of engineering technologist and technician counts in CFOI database; equivalent code is not available in the 1990 Census database.

[e] Aggregate (sum) of first-line supervisors of construction trade and extraction workers in CFOI database; equivalent code is not available in the 1990 Census database.

n.e.c. = not elsewhere classified; NA = not available in database