APPENDIX A

CONTAMINANT DISTRIBUTION MODELING BY ENVIRONMENTAL STANDARDS, INC. FOR HARBOR AT HASTINGS OPERABLE UNIT 2

APPENDIX A

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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

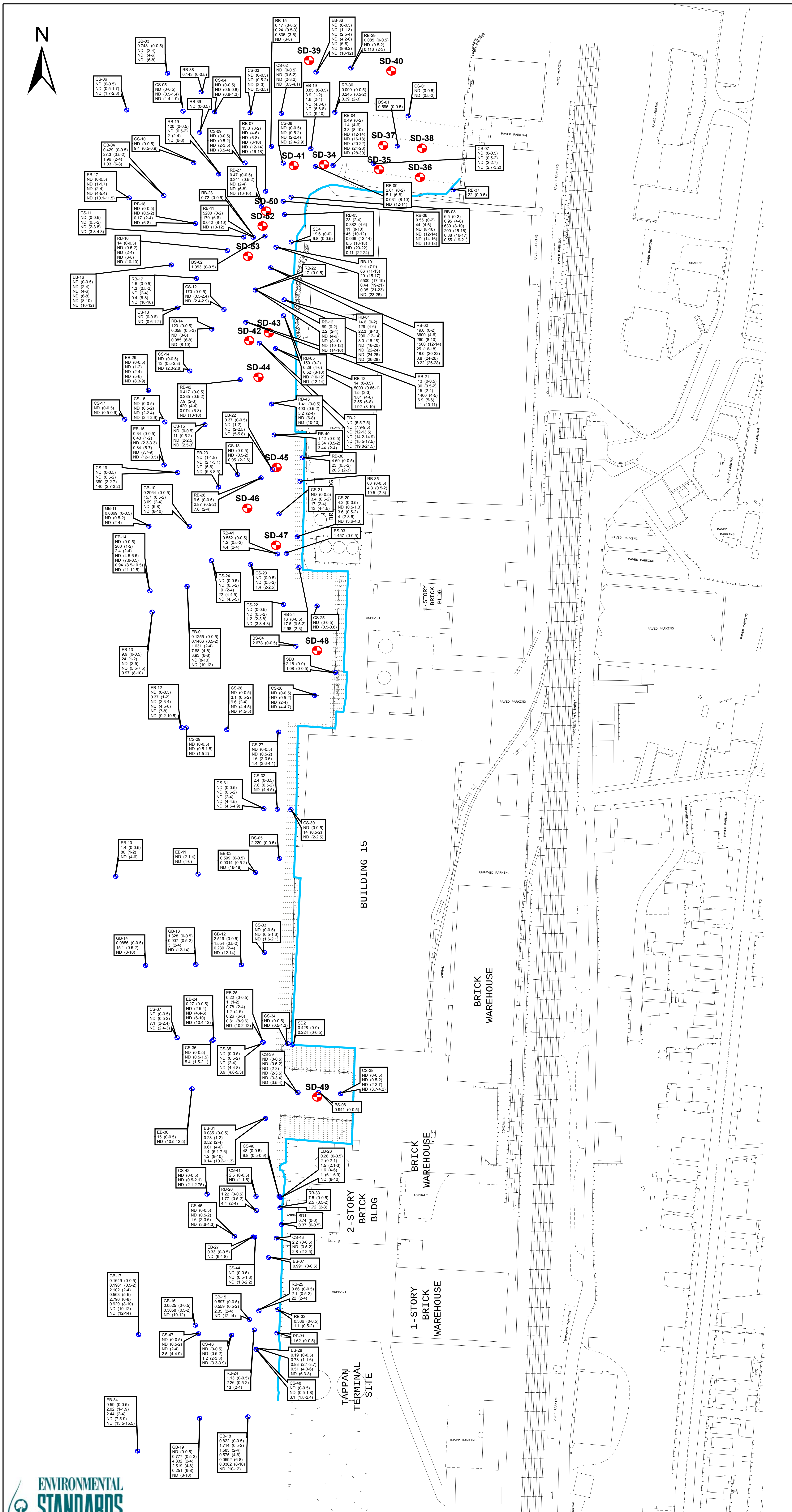
  There is a possibility that clean material may be located within the specified volume and above the top of predicted contamination. This volume is calculated by reviewing each column within the area for which a top of contamination exists and calculating the volume between the top of contamination and 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

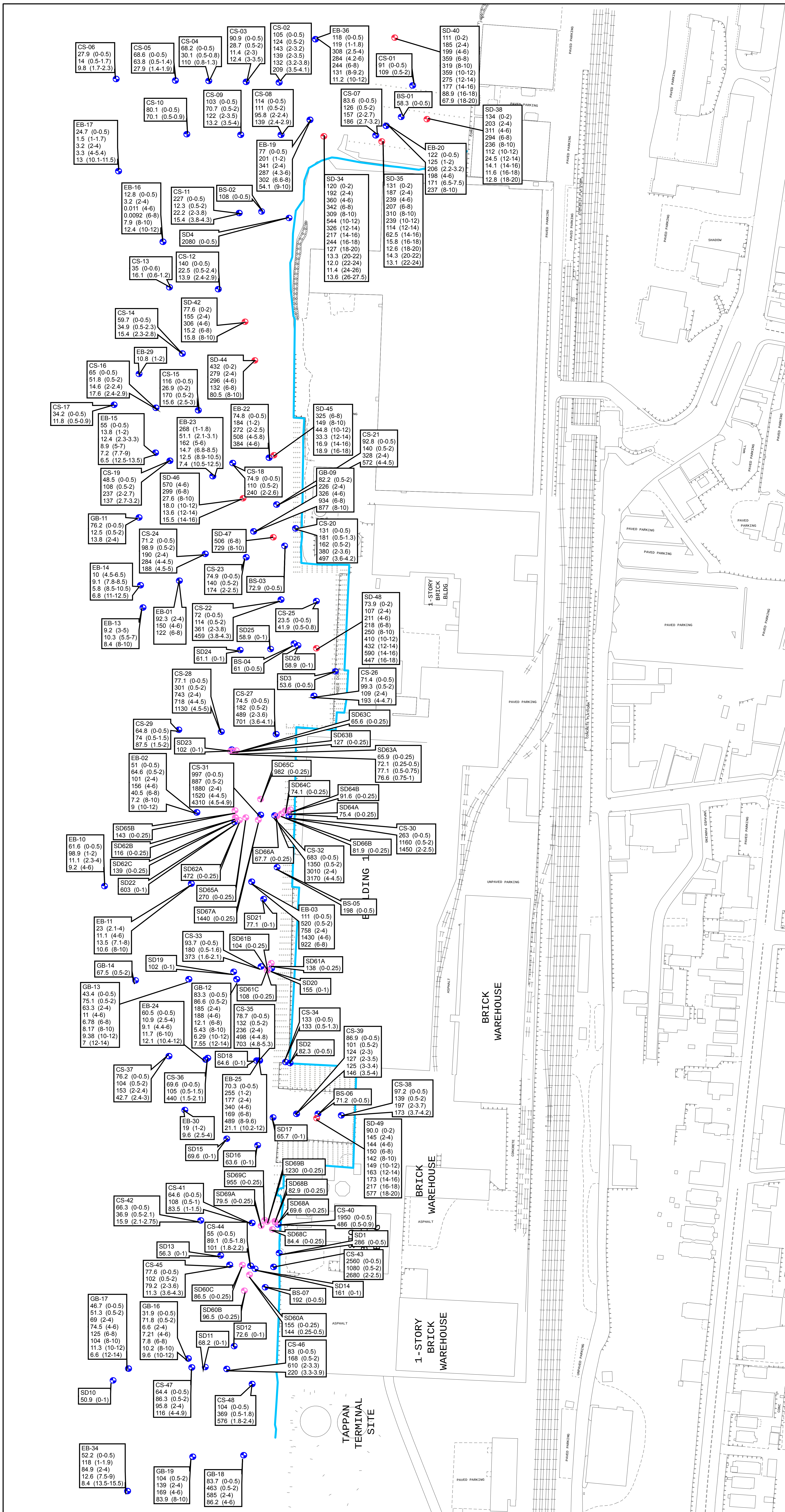
SCALE IN FEET

MARCH 14, 2006

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

- 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)

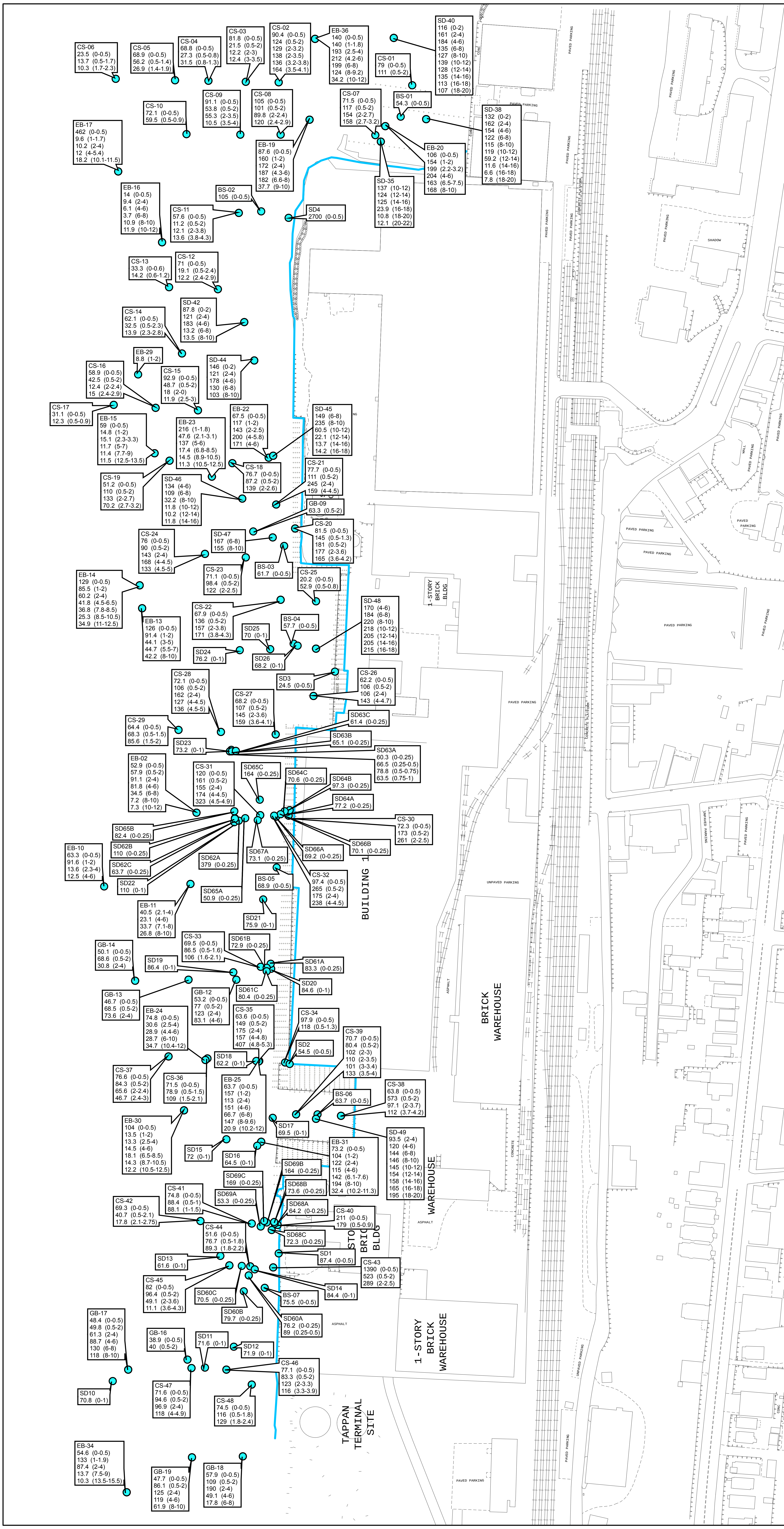
Sample Location ID
First Column:
Copper concentration in mg/Kg. ND is non-detect.
Second Column:
Depth range where Copper sample was collected.
Depth is in feet below mudline.

**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

N

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

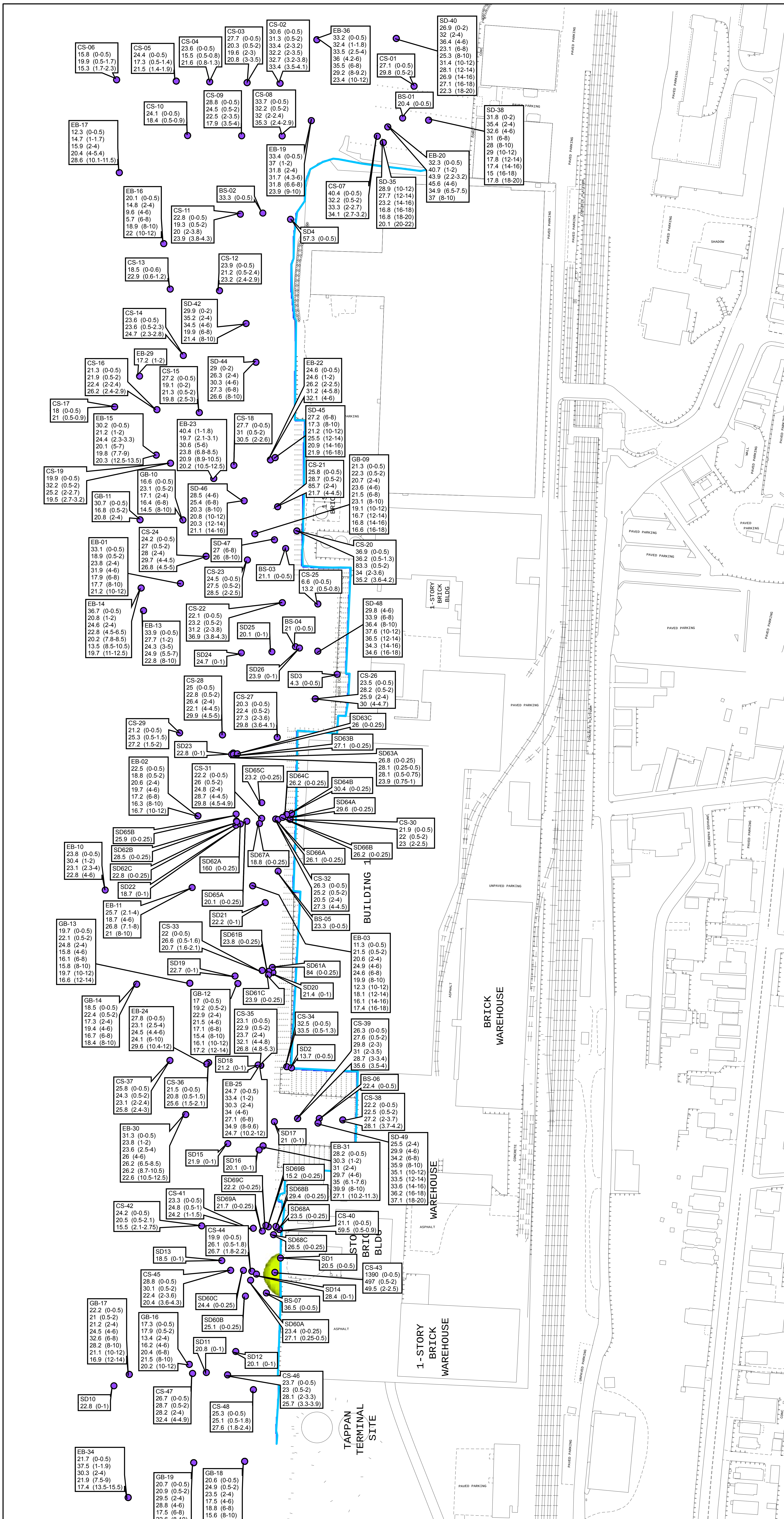
MARCH 14, 2006

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

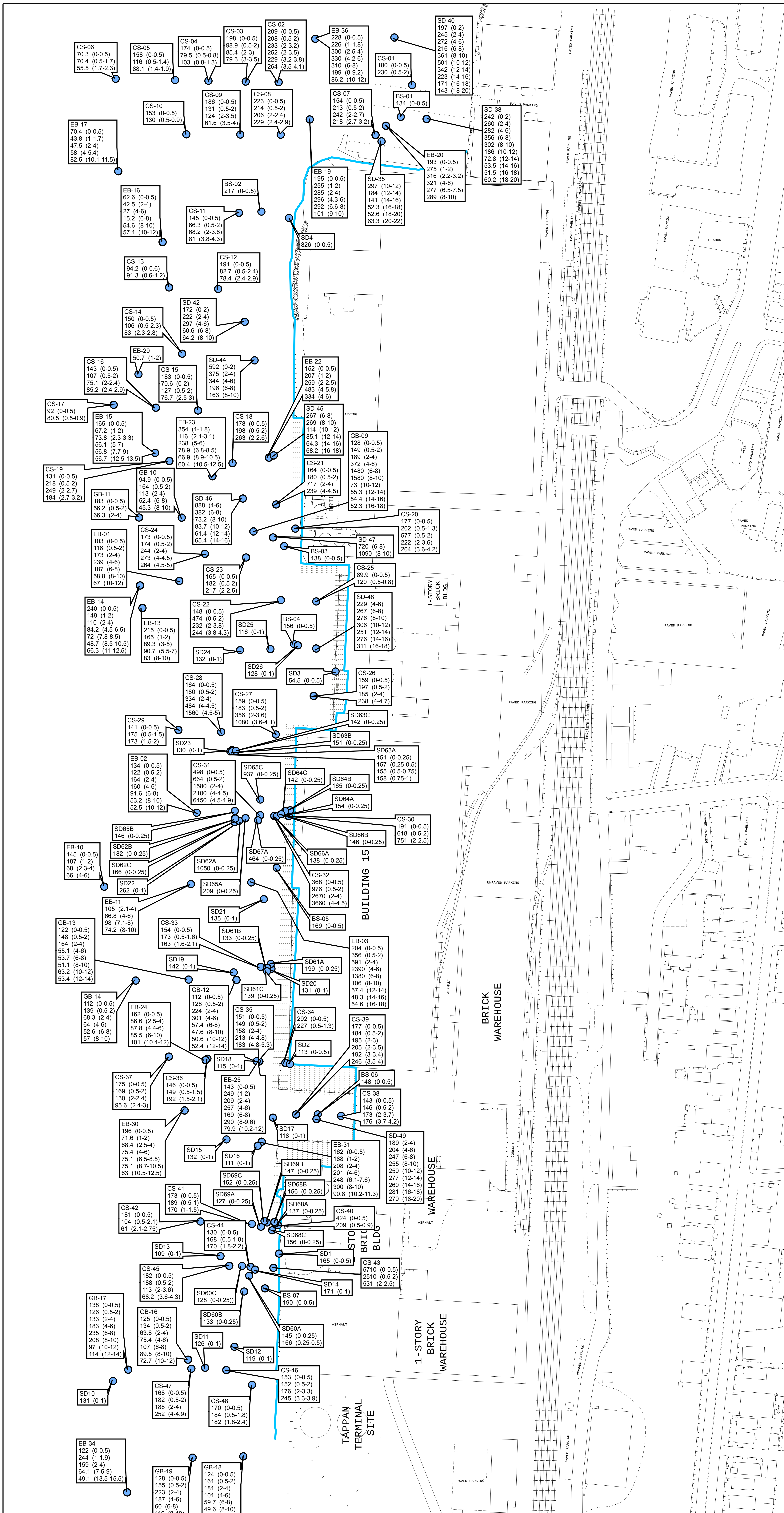
MARCH 14, 2006

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



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

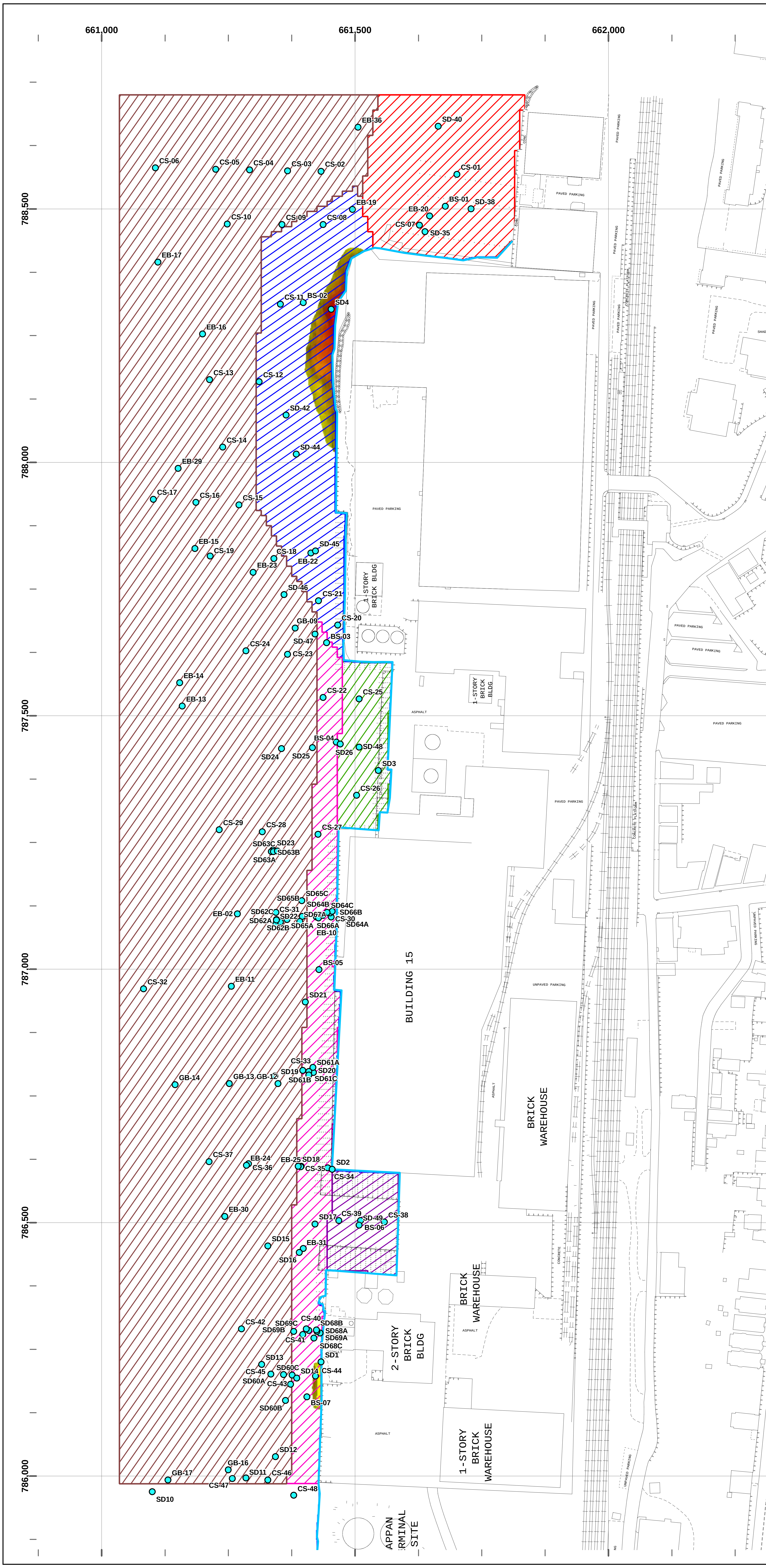
MARCH 14, 2006

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

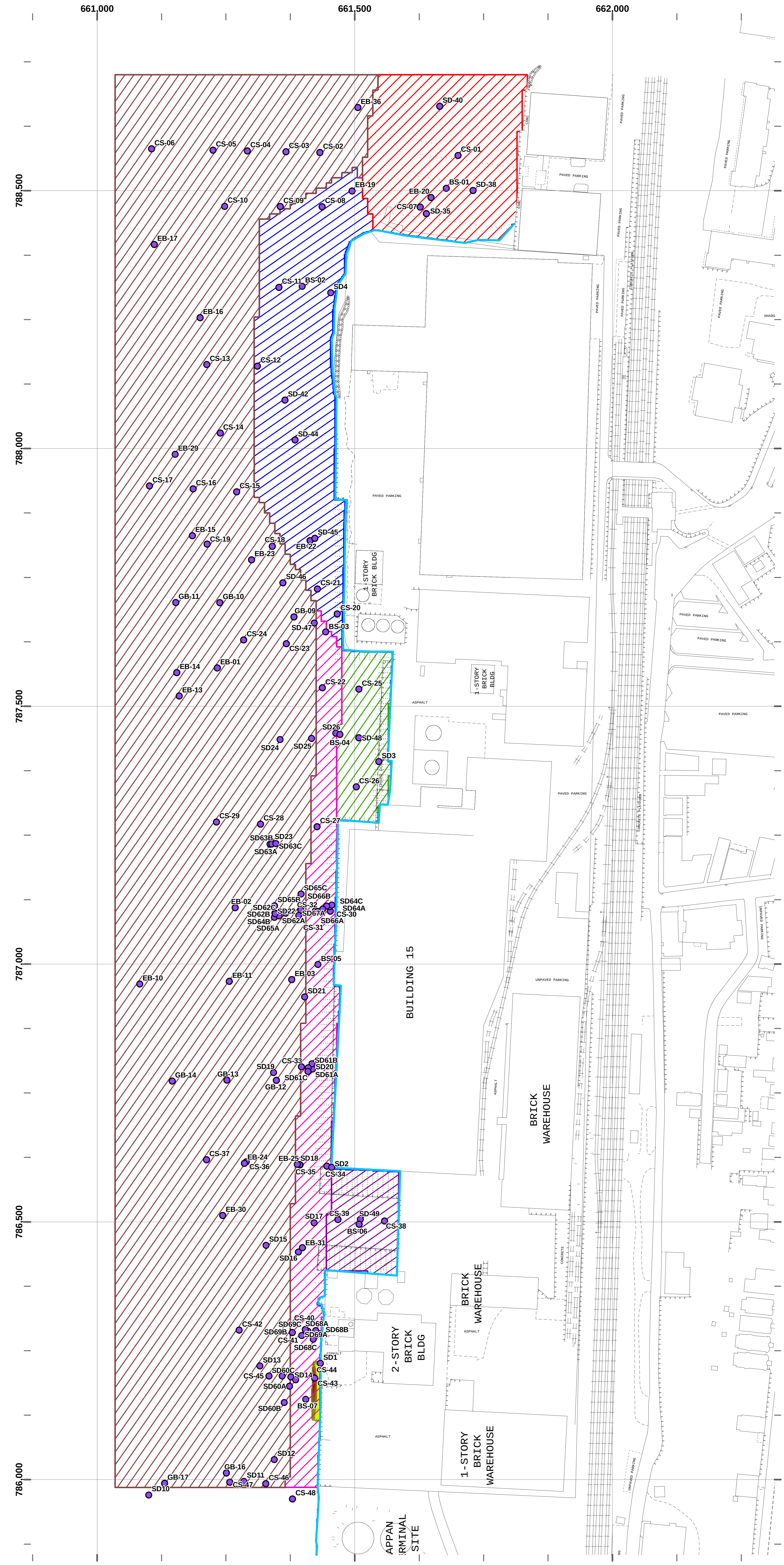
APRIL 7, 2006 rev. 2

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

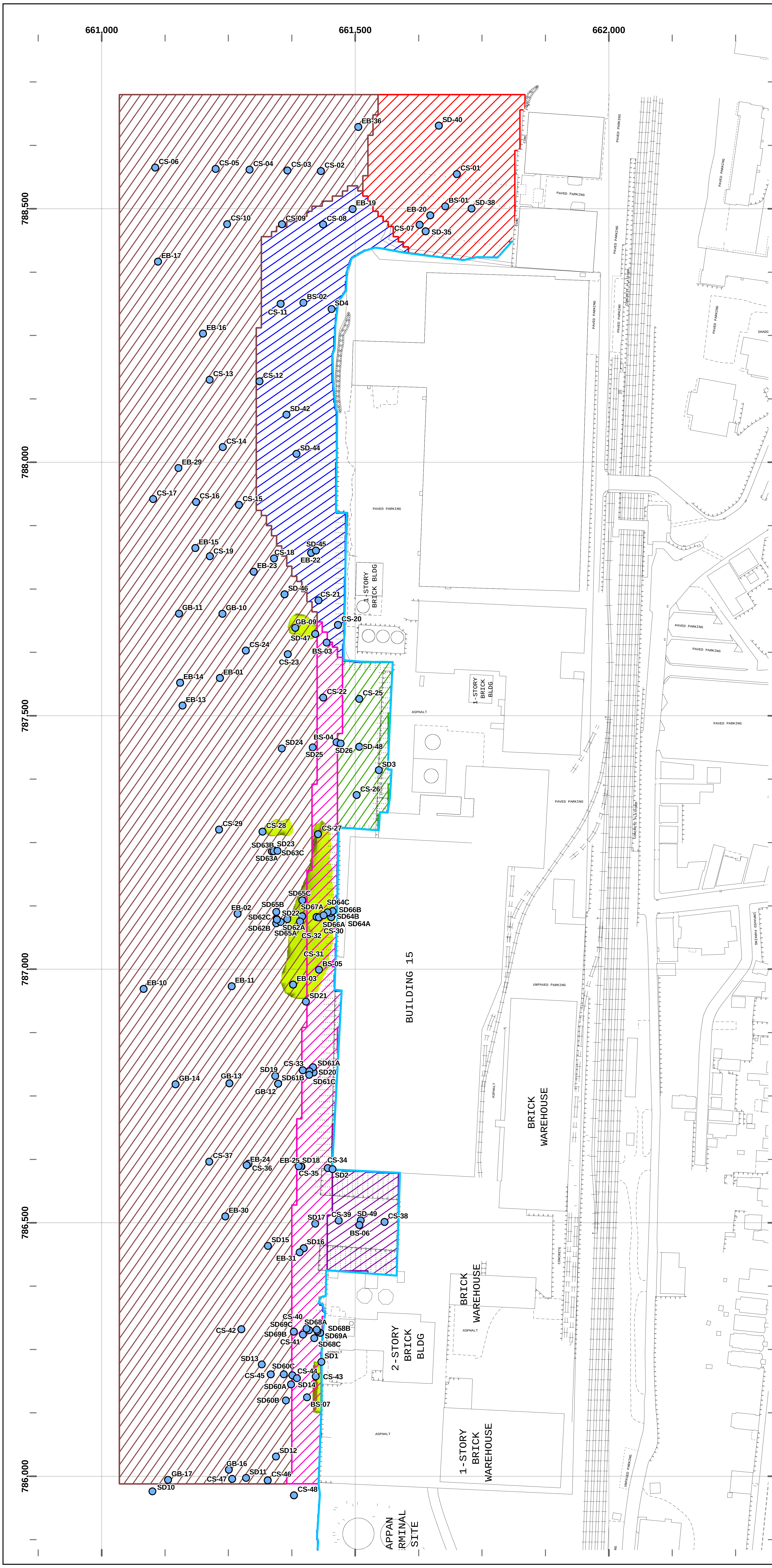
APRIL 7, 2006 rev. 2

ENVIRONMENTAL STANDARDS

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

DEFINED AREAS

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

ZINC CONCENTRATION

3,000 mg/kg
1,050 mg/kg

FIGURE A.8 MAP OF ZINC CONCENTRATIONS IN SEDIMENT ABOVE 1050 MG/KG (PPM)

0 100 200 300 400 500 600

SCALE IN FEET

APRIL 7, 2006 rev. 3

ENVIRONMENTAL STANDARDS

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

Prepared by: Rock J. Vitale, CEAC, CPC
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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.

Northwest Corner Area

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.

Northwest Corner Area Alternative NW-1

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.

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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.

NW-2, Option A

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.

NW-2, Option B

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.

Factor of Safety

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.

<u>Stage 2 - Construct Berm</u>

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.

<u>Stage 3 - Consolidation of Marine Silt under Berm Surcharge Load</u>

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).

<u>Stage 4 - Final Backfill and Application of Surcharge and Differential Water Loading</u>

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.)

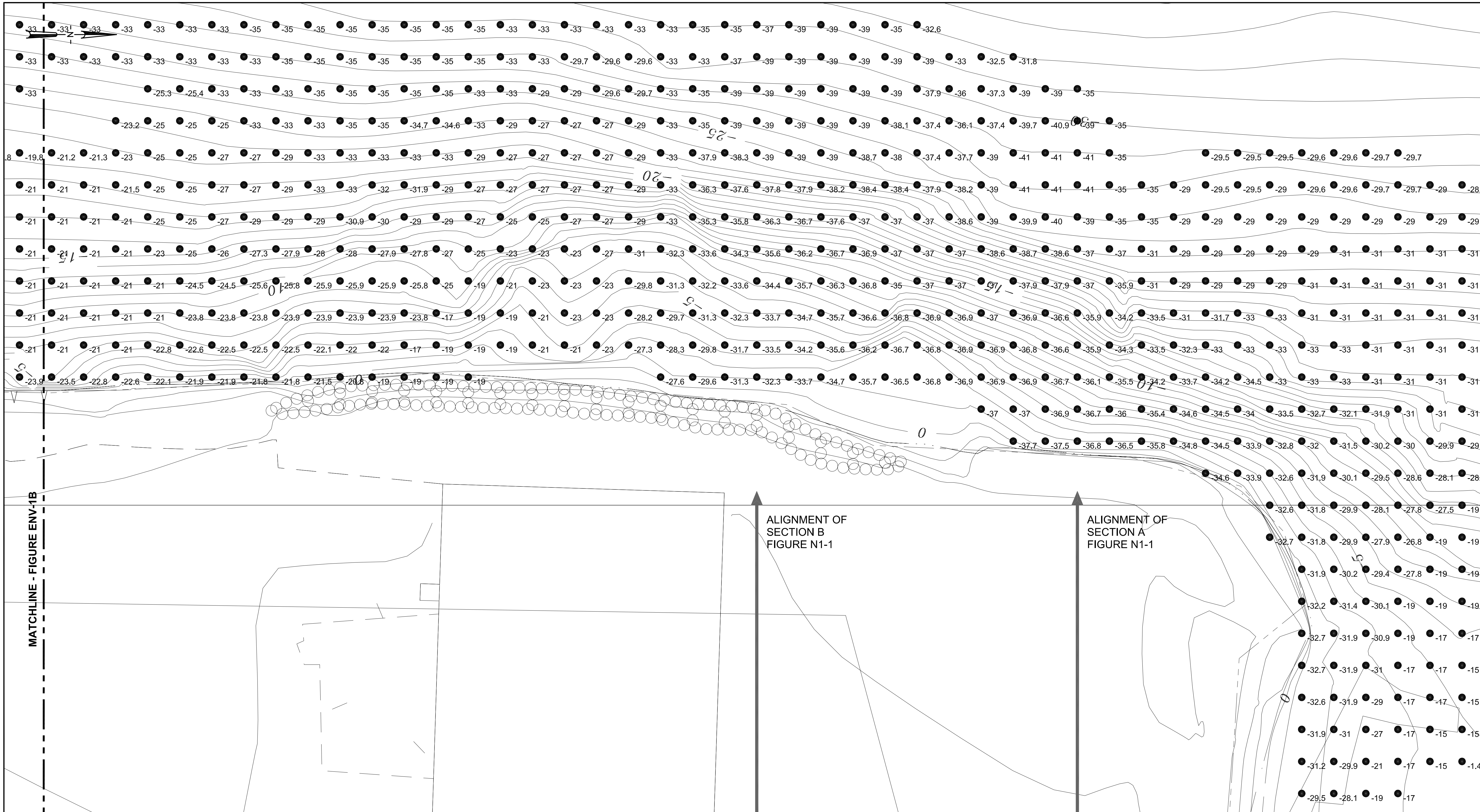
4. “Excavation Evaluation Summary Report – Operable Unit #1” (September 5, 2002), by Shaw Environmental & Infrastructure, Inc. and Haley & Aldrich, Inc. for Atlantic Richfield Company.
5. “Final Feasibility Study Report – Harbor at Hastings Site (OU#2)” (March 7, 2003), by Earth Tech of New York, Inc., 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

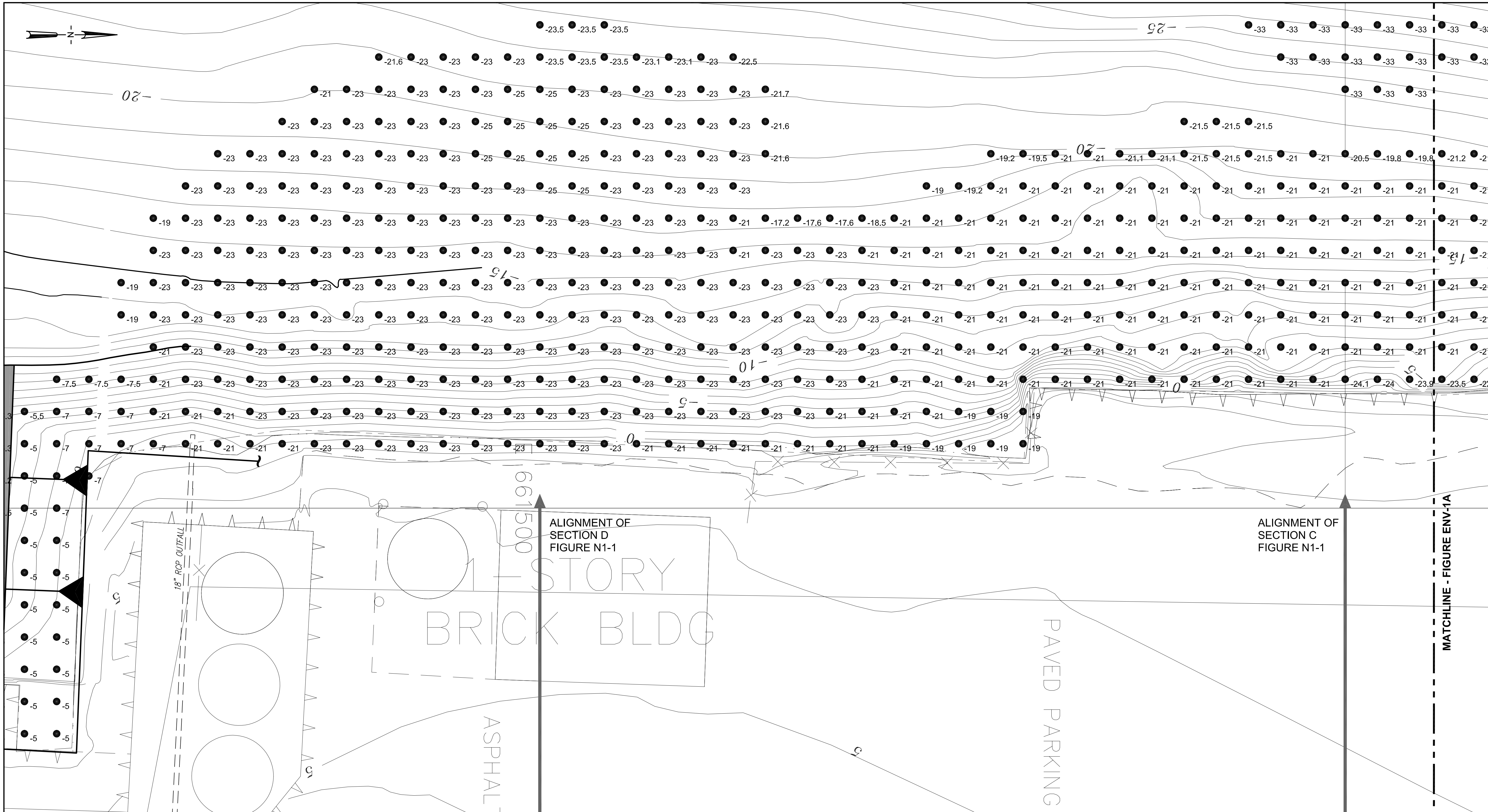
NORTHWEST CORNER AREA PREDICTED MAXIMUM DEPTH OF PCBs IN HASTINGS OU-2 PLAN VIEW

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:

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

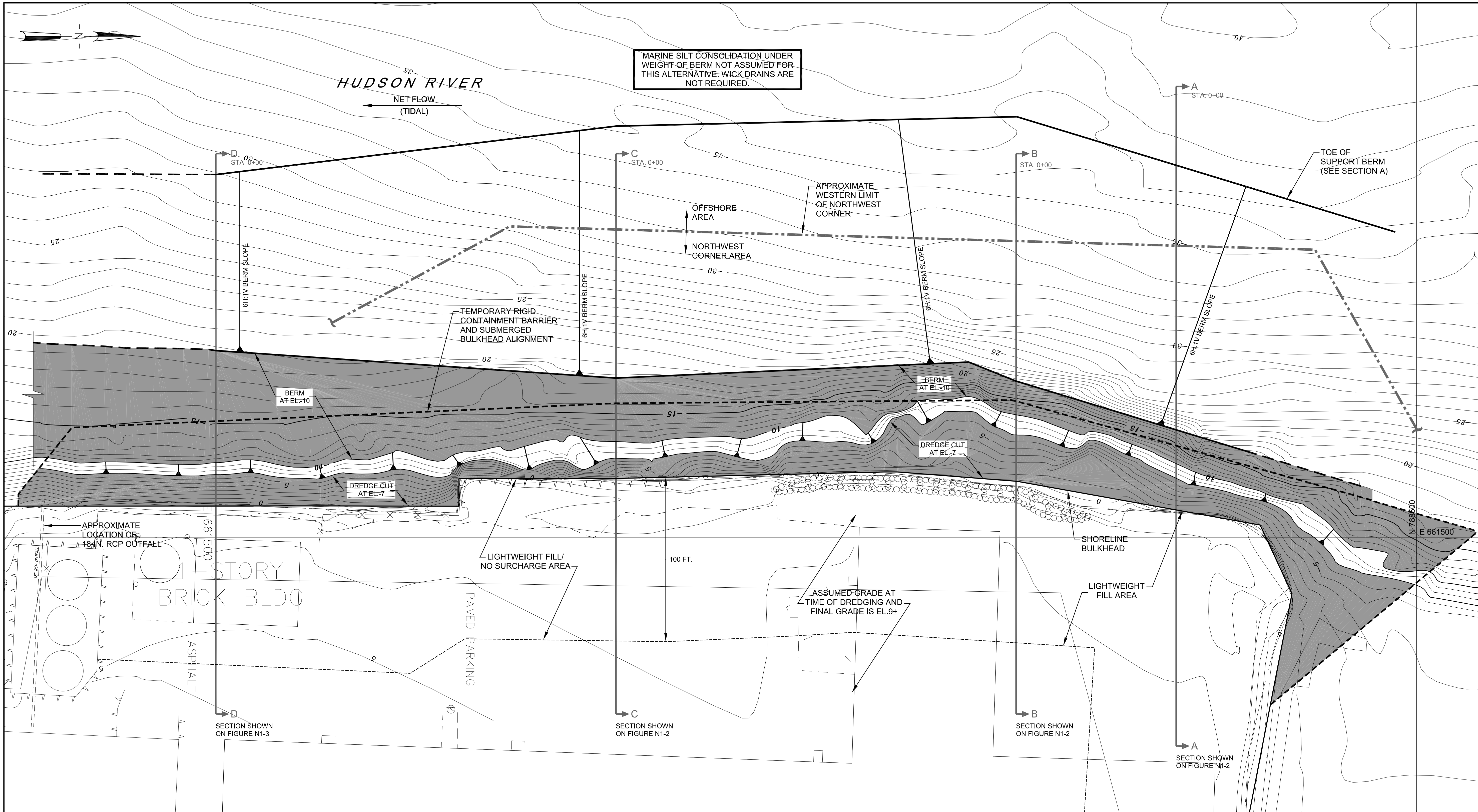
HASTINGS OU-2 ENVIRONMENTAL SITE REMEDIATION
HASTINGS-ON-HUDSON, NEW YORK

NORTHWEST CORNER AREA
PREDICTED MAXIMUM DEPTH OF PCBs
IN HASTINGS OU-2
PLAN VIEW

SCALE: AS SHOWN 24 APRIL 2006

28612-010 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

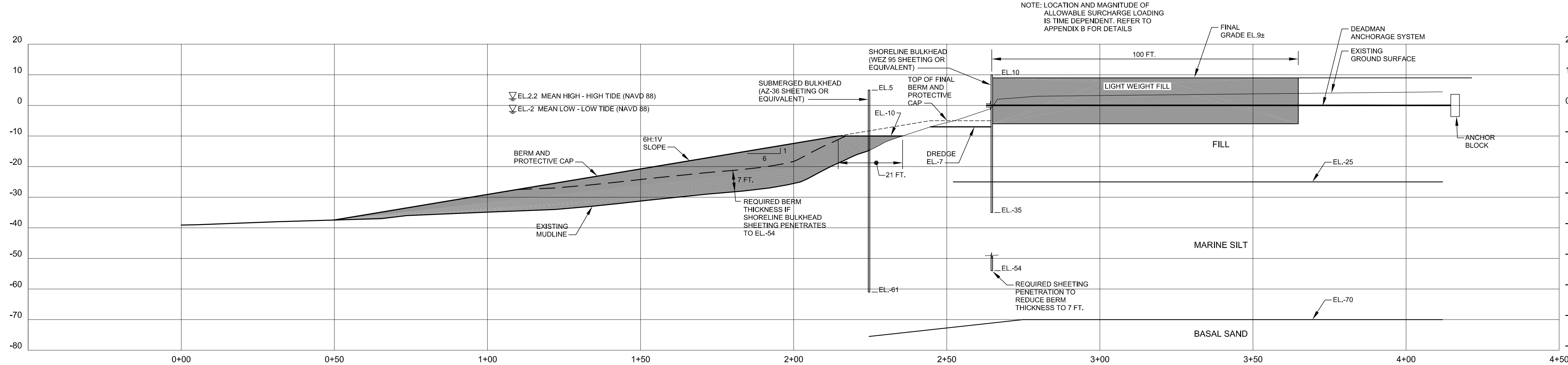
NORTHWEST CORNER AREA
ALTERNATIVE NW-1
FINAL UPLAND GRADE EL.9

SCALE: AS SHOWN

18 APRIL 2006

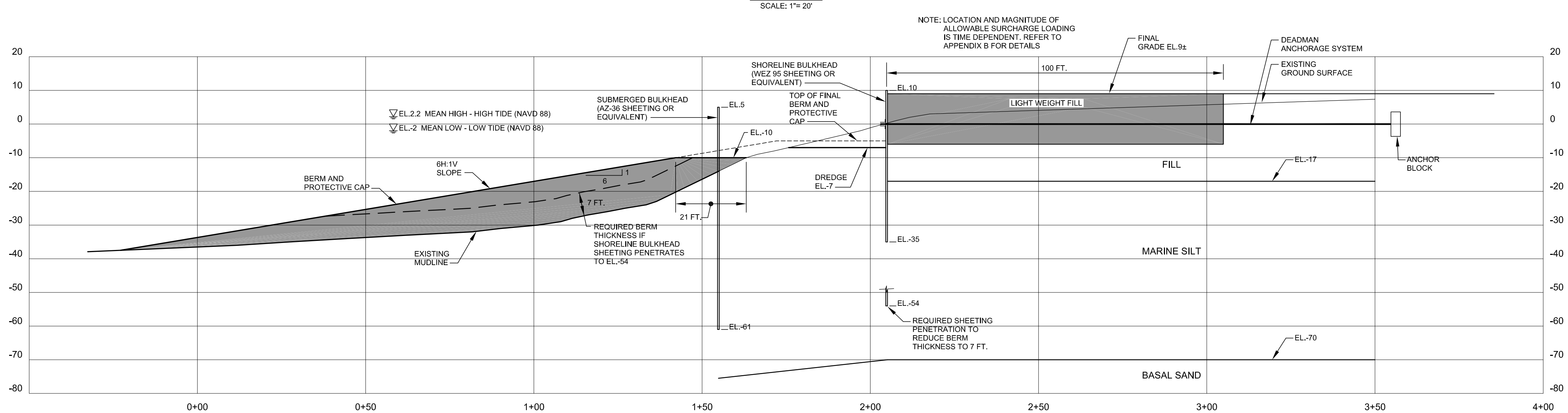
28612-010 D103

FIGURE N1-1



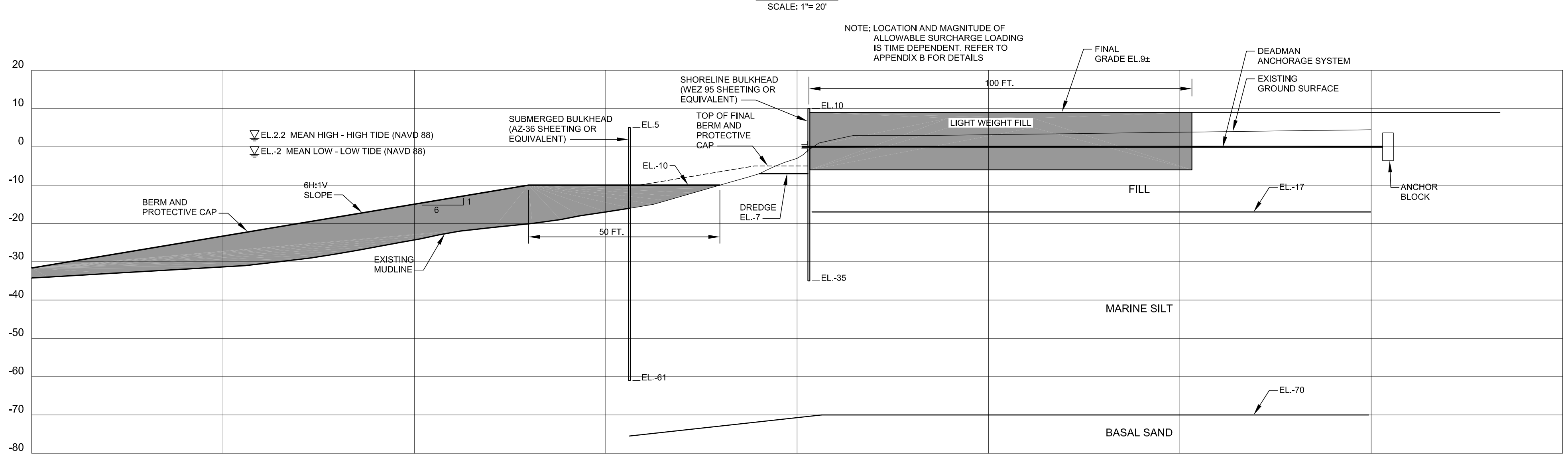
SECTION A-A

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

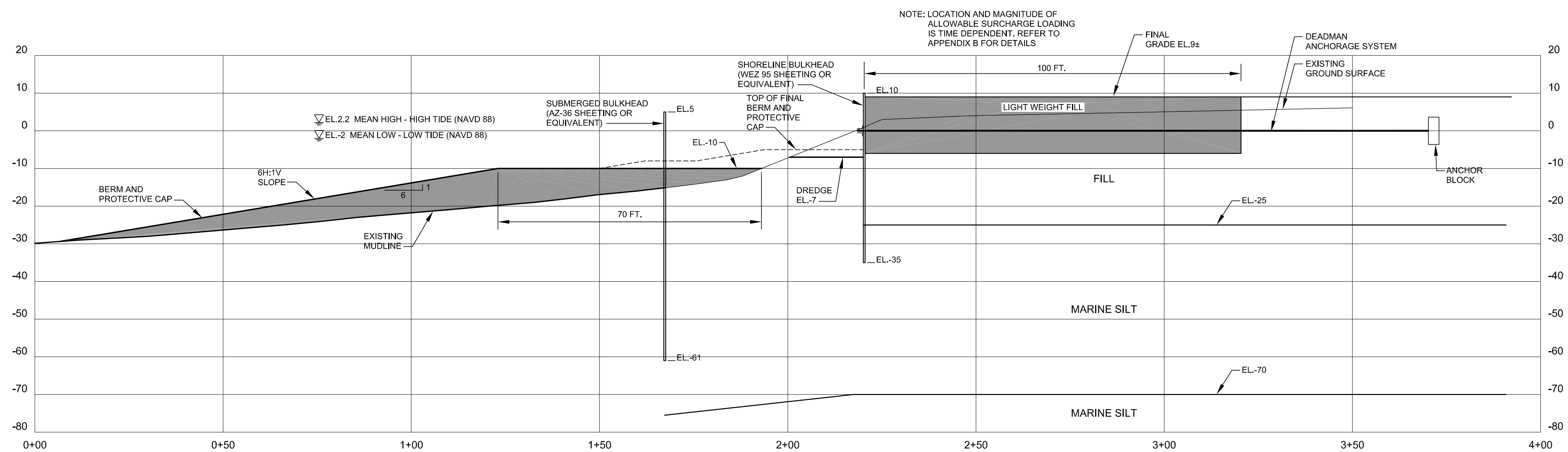
NORTHWEST CORNER AREA ALTERNATIVE NW-1 SECTIONS

SCALE: AS SHOWN

18 APRIL 2006

FIGURE N1-2

28612-010 D104 (D103)



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

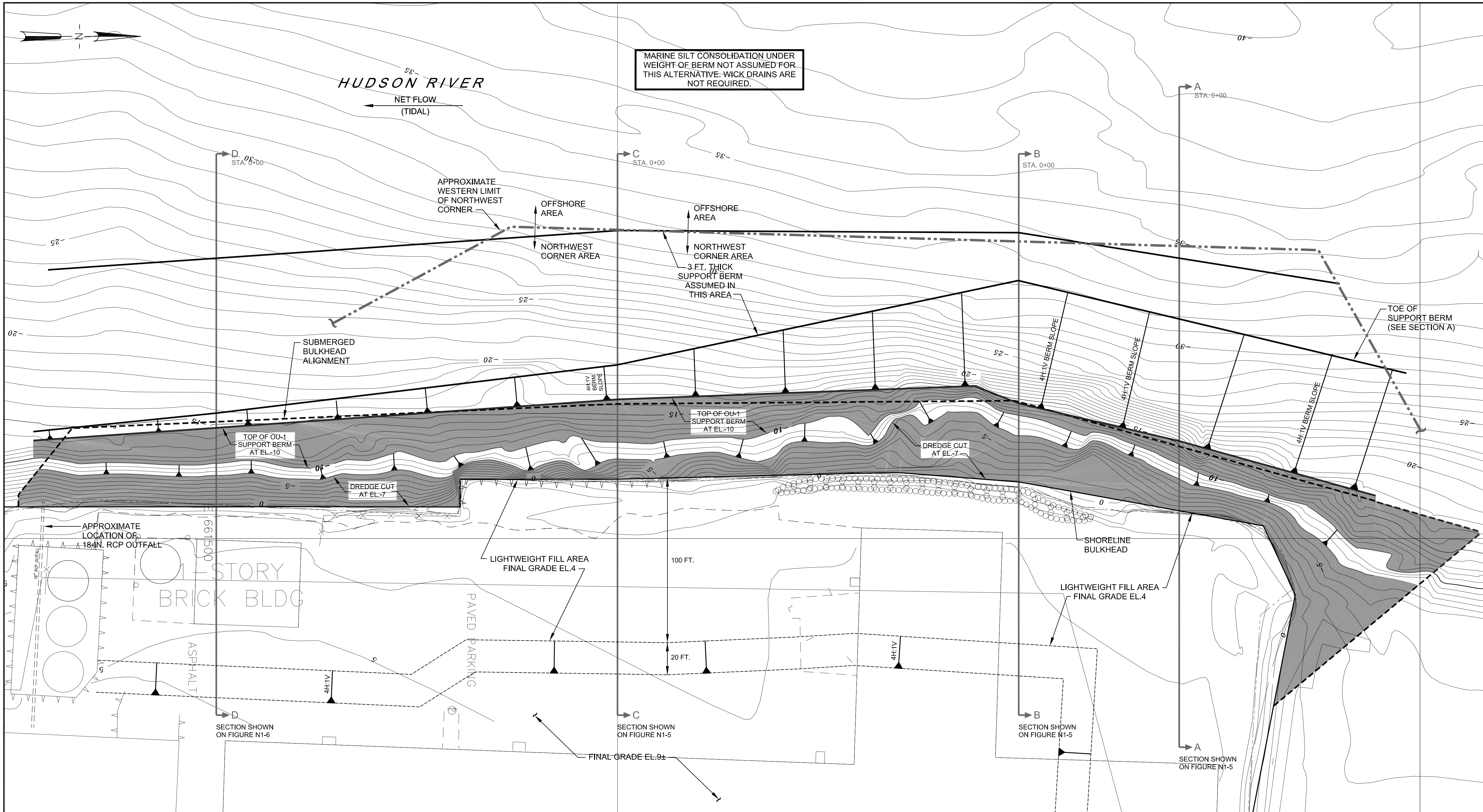
NORTHWEST CORNER AREA
ALTERNATIVE NW-1
SECTIONS

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.

0 30 60 90 120
SCALE IN FEET

HALEY & ALDRICH
UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

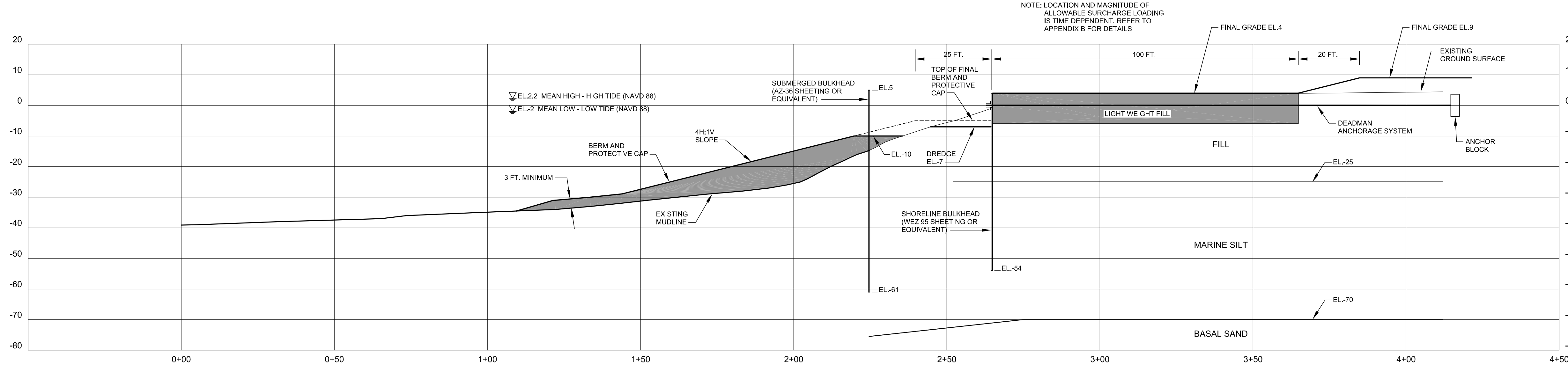
HARBOR AT HASTINGS SITE
SUPPLEMENTAL FEASIBILITY STUDY FOR OU-2
HASTINGS-ON-HUDSON, NEW YORK

NORTHWEST CORNER AREA
ALTERNATIVE NW-1
FINAL UPLAND GRADE EL.4

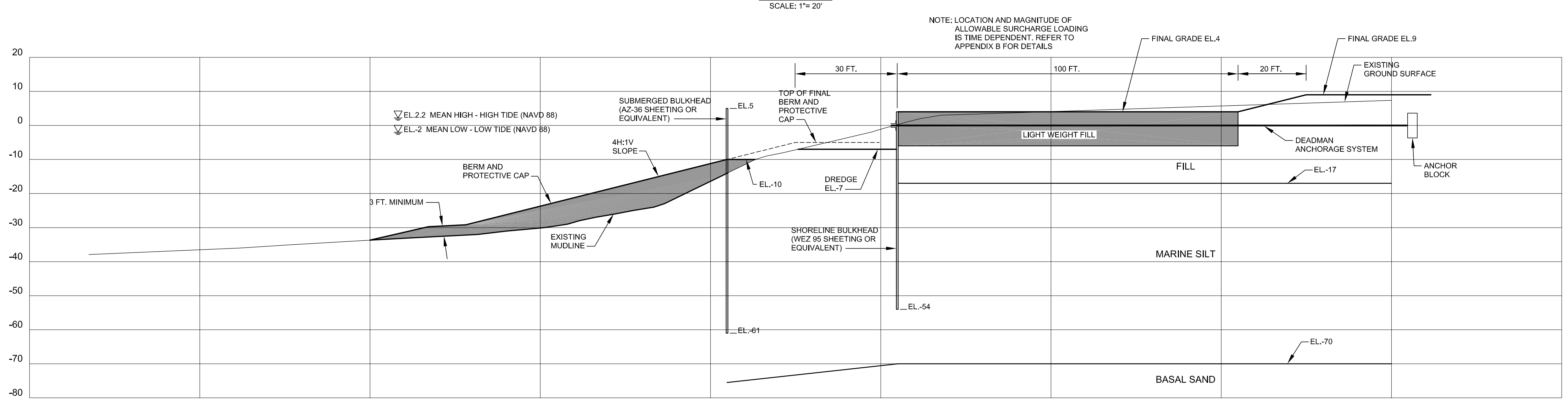
SCALE: AS SHOWN | 18 APRIL 2006

28612-010 D106

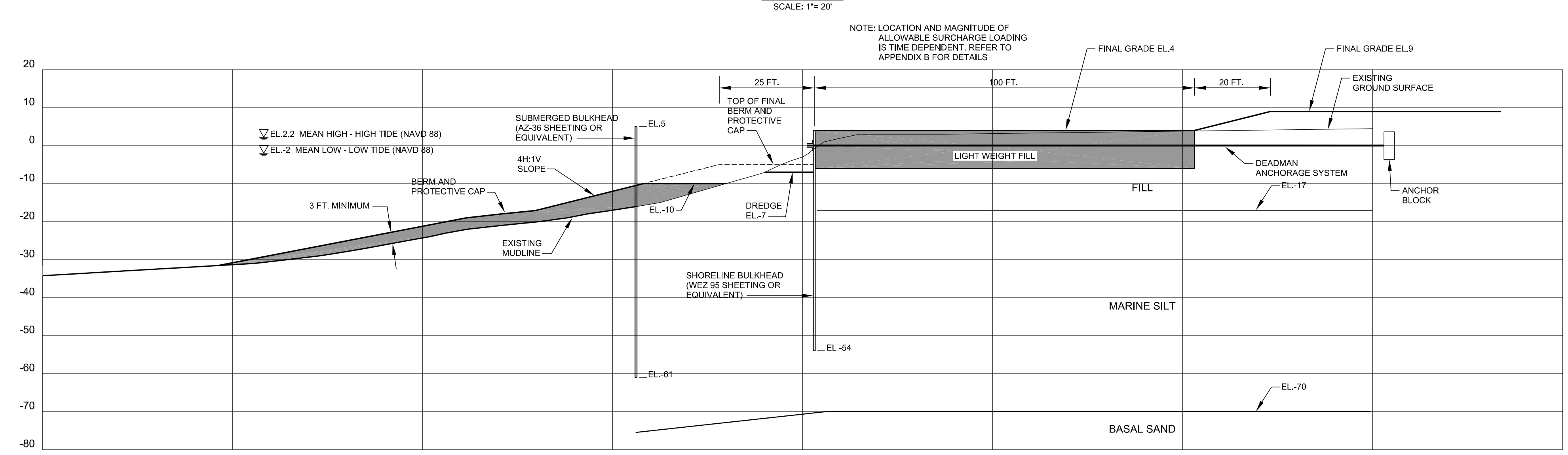
FIGURE N1-4



SECTION A-A
SCALE: 1"= 20'



SECTION B-B
SCALE: 1"= 20'



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

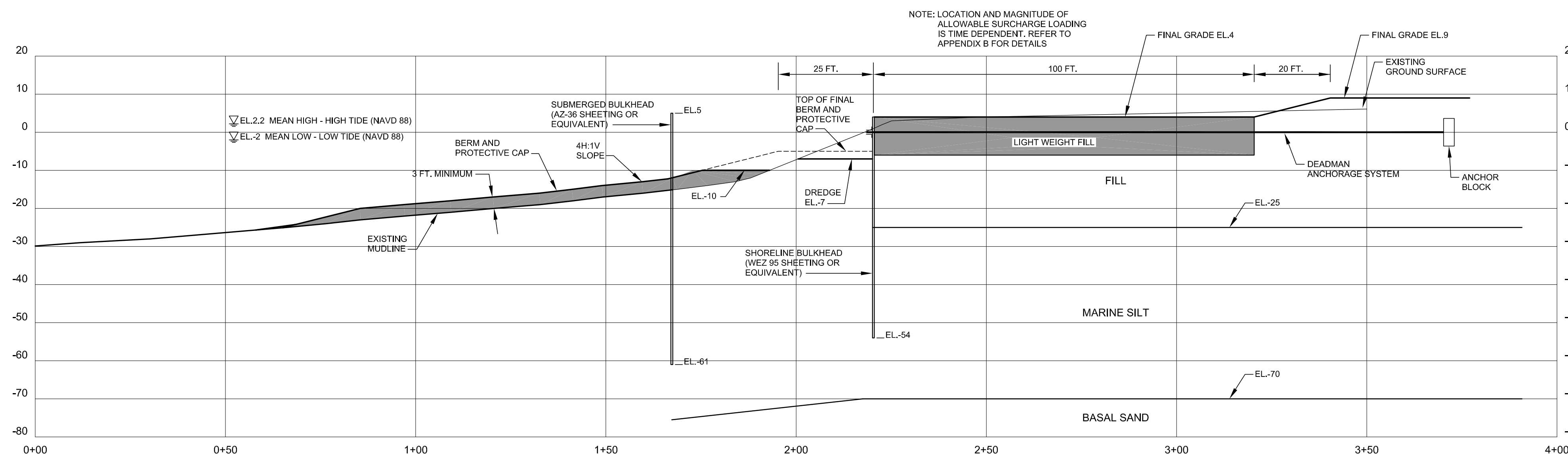
NORTHWEST CORNER AREA
ALTERNATIVE NW-1,
FINAL UPLAND GRADE EL.4
SECTIONS

SCALE: AS SHOWN

18 APRIL 2006

28612-010 D107 (D106)

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

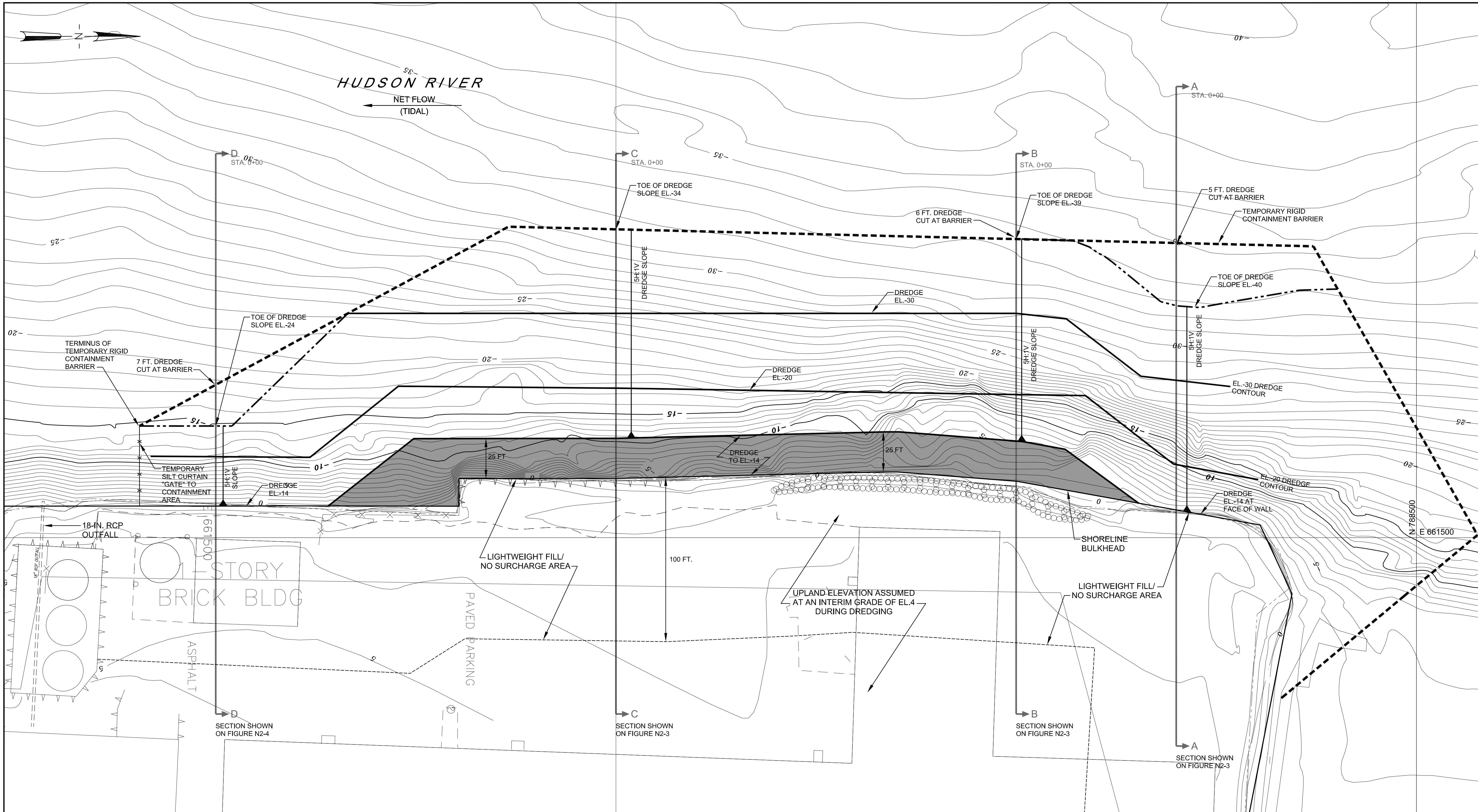
NORTHWEST CORNER AREA
ALTERNATIVE NW-1,
FINAL UPLAND GRADE EL.4
SECTIONS

SCALE: AS SHOWN

18 APRIL 2006

28612-010 D108 (D106)

FIGURE N1-6



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

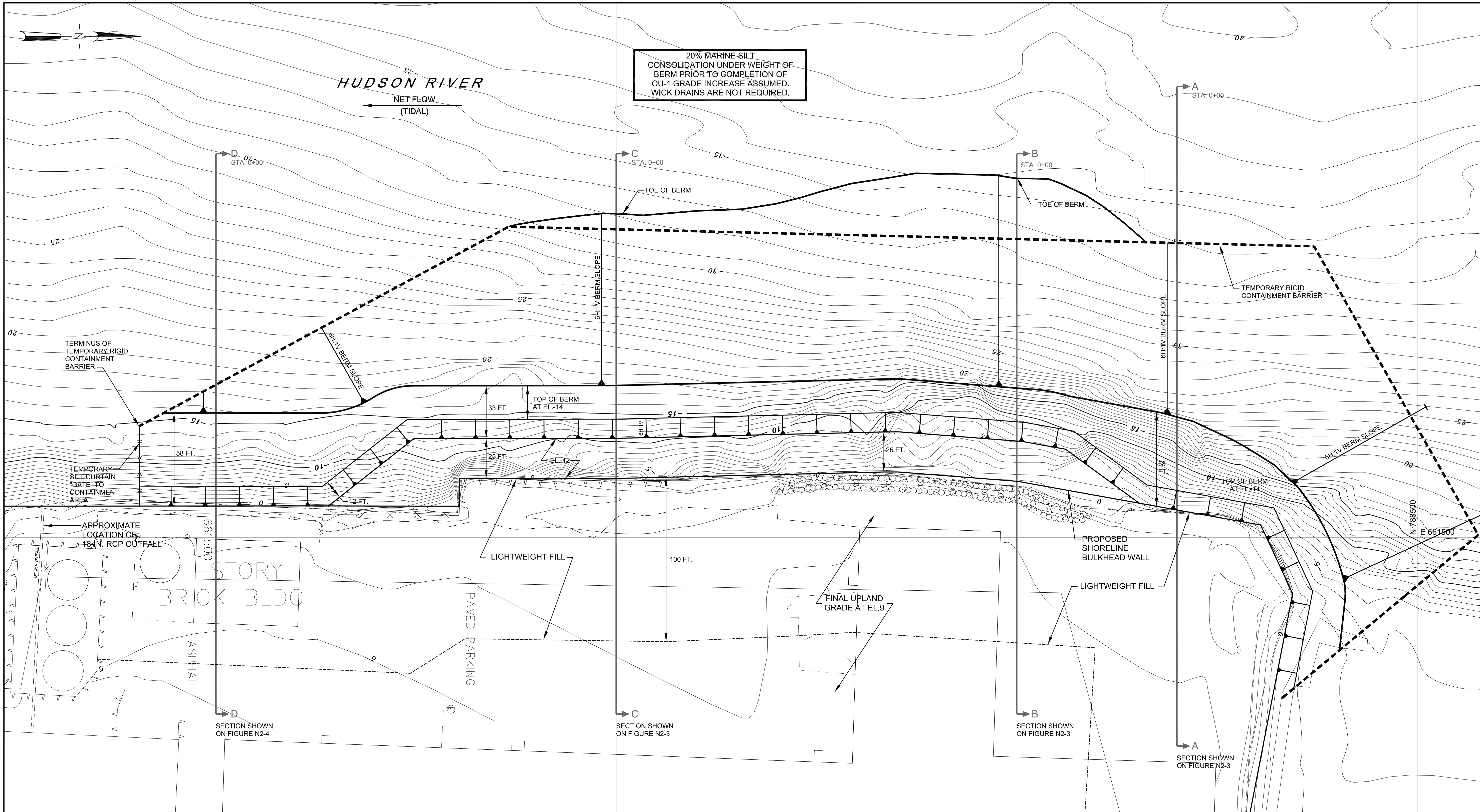
DREDGE CUT
NORTHWEST CORNER AREA
ALTERNATIVE NW-2, OPTION B

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.

HALEY & ALDRICH
UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

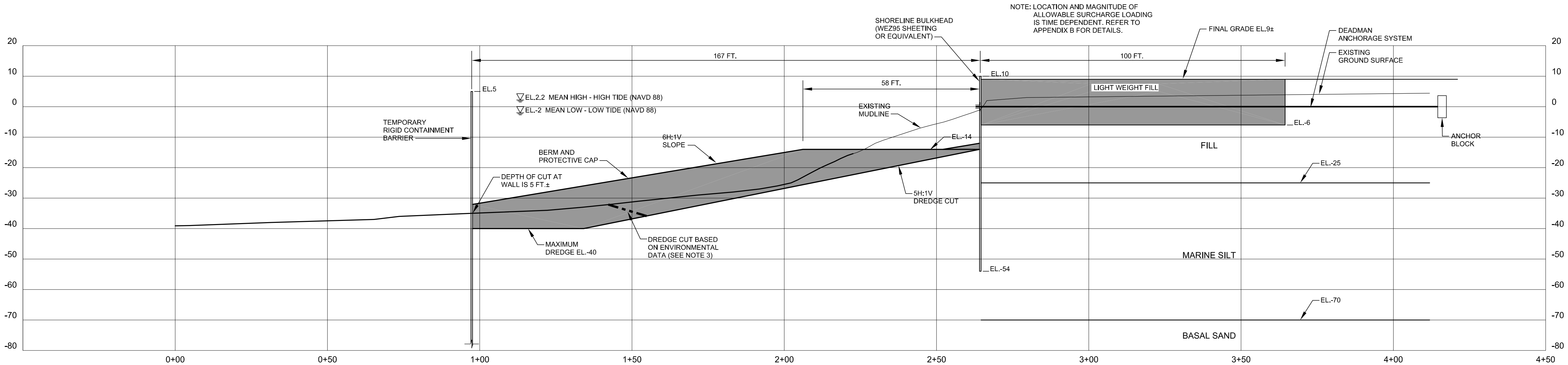
HARBOR AT HASTINGS SITE
SUPPLEMENTAL FEASIBILITY STUDY FOR OU-2
HASTINGS-ON-HUDSON, NEW YORK

NORTHWEST CORNER AREA
ALTERNATIVE NW-2, OPTION B
FINAL UPLAND GRADE EL.9

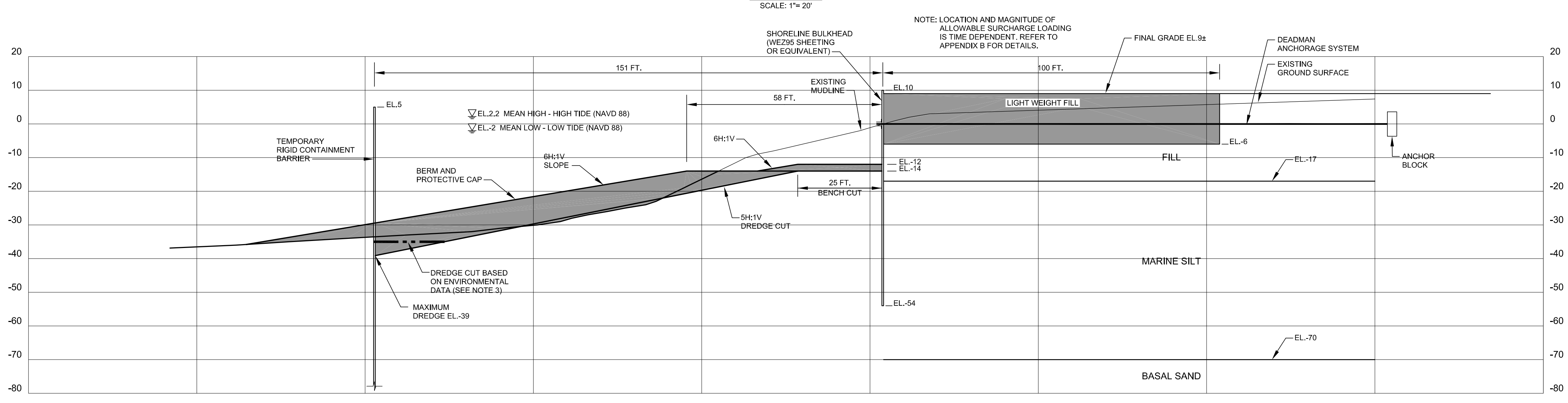
SCALE: AS SHOWN
18 APRIL 2006

28612-010 D110

FIGURE N2-2



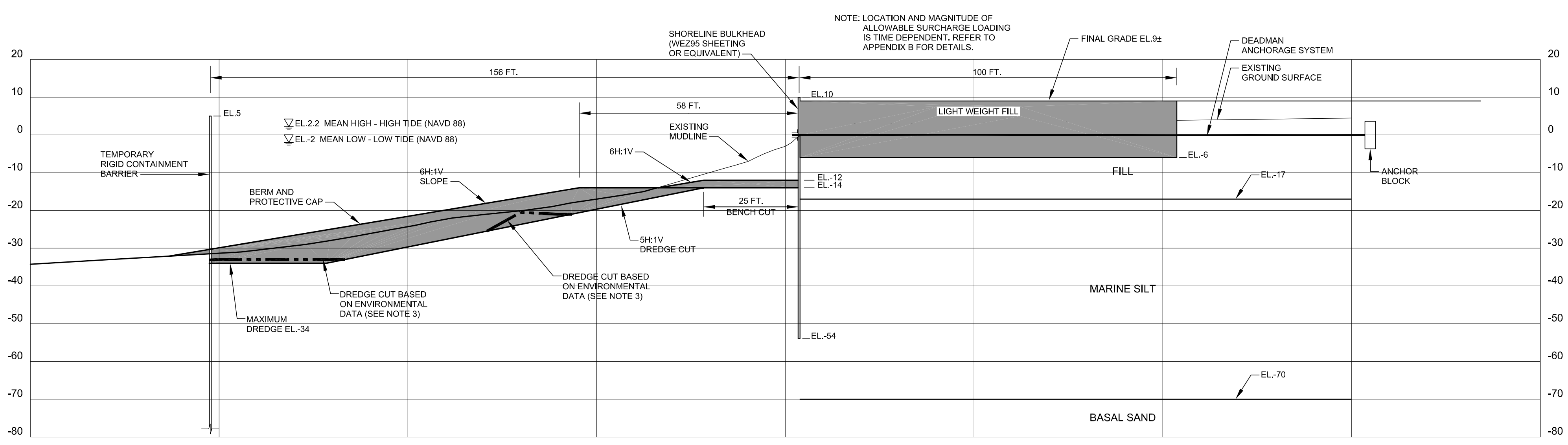
SECTION A-A
SCALE: 1"= 20'



SECTION B-B
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.



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
SECTIONS

SCALE: AS SHOWN

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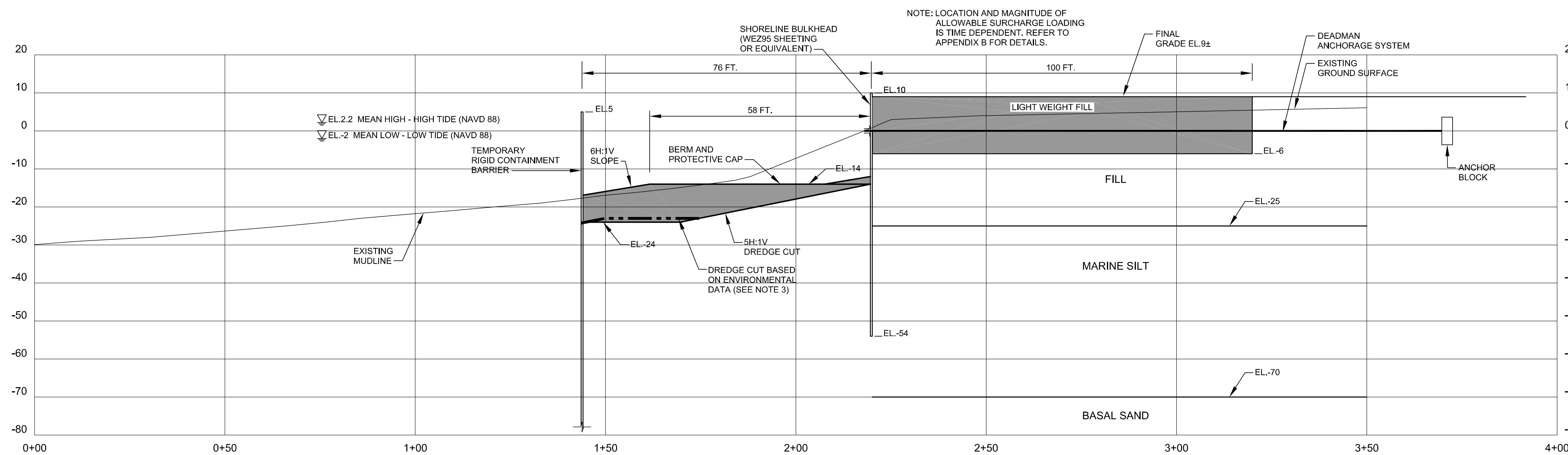
FIGURE N2-3

28612-010 D111



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

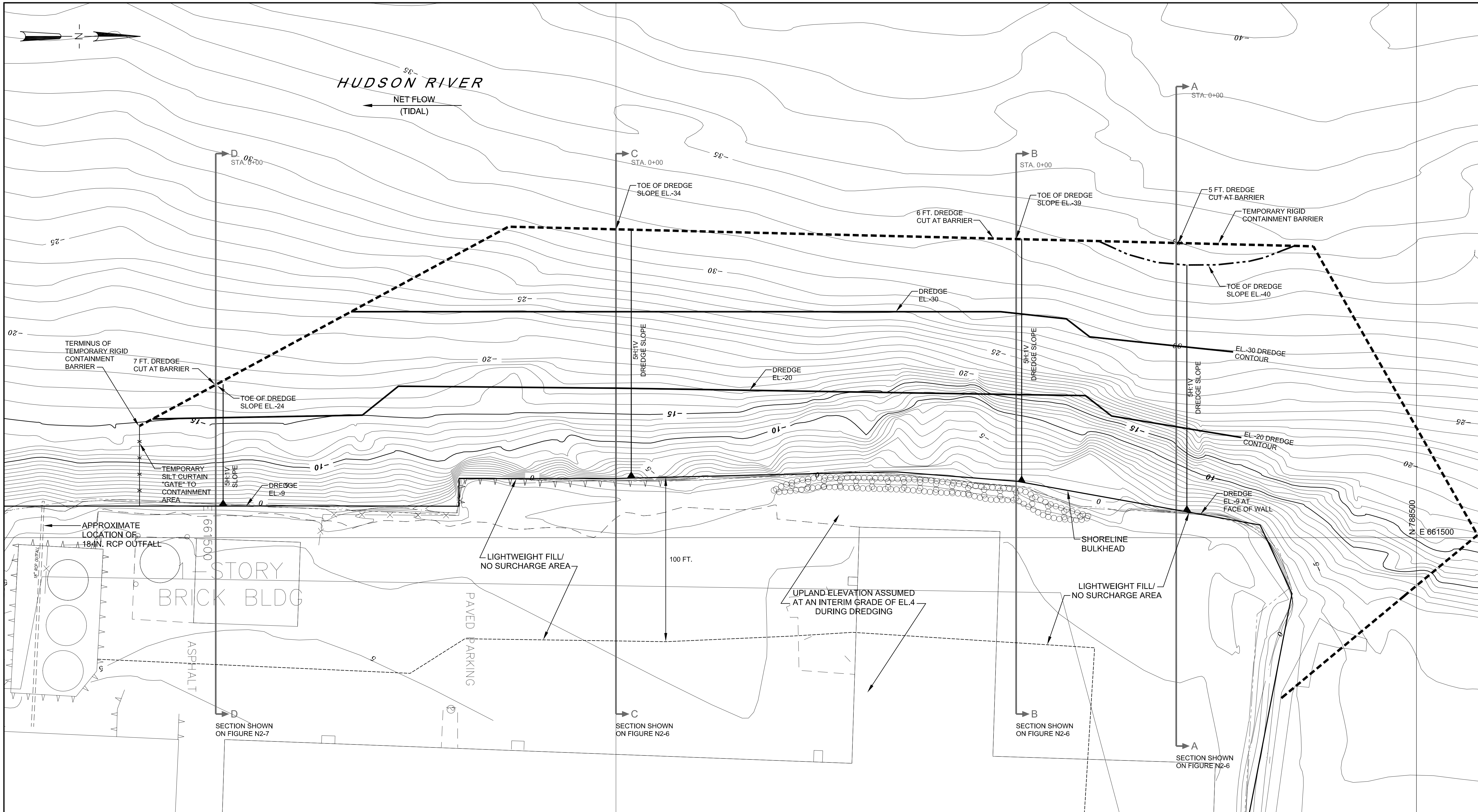
NORTHWEST CORNER AREA
ALTERNATIVE NW-2, OPTION B
SECTIONS

SCALE: AS SHOWN

18 APRIL 2006

FIGURE N2-4

28612-010 D112 (D111)



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

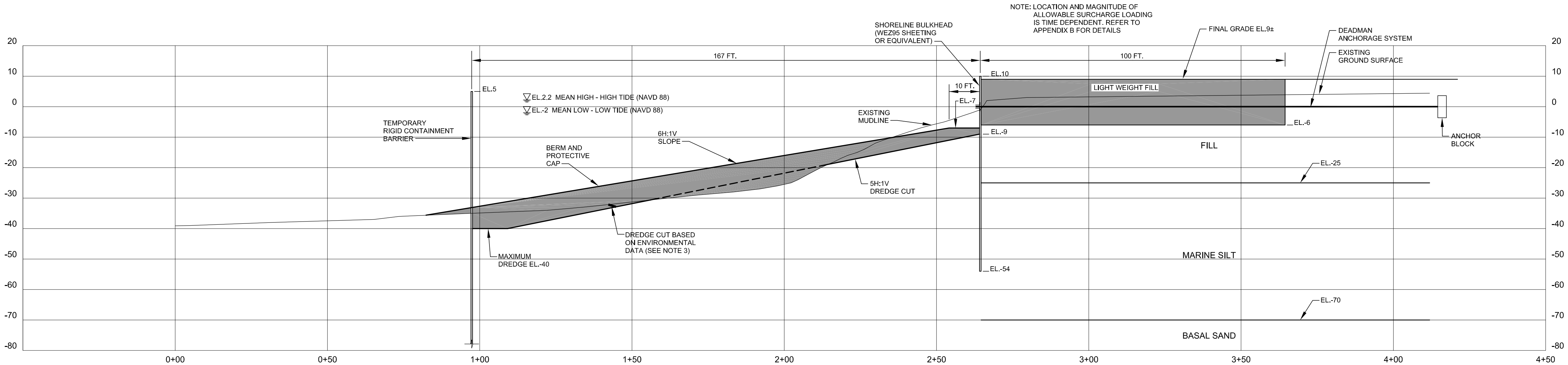
DREDGE CUT
NORTHWEST CORNER AREA
ALTERNATIVE NW-2, OPTION A

SCALE: AS SHOWN

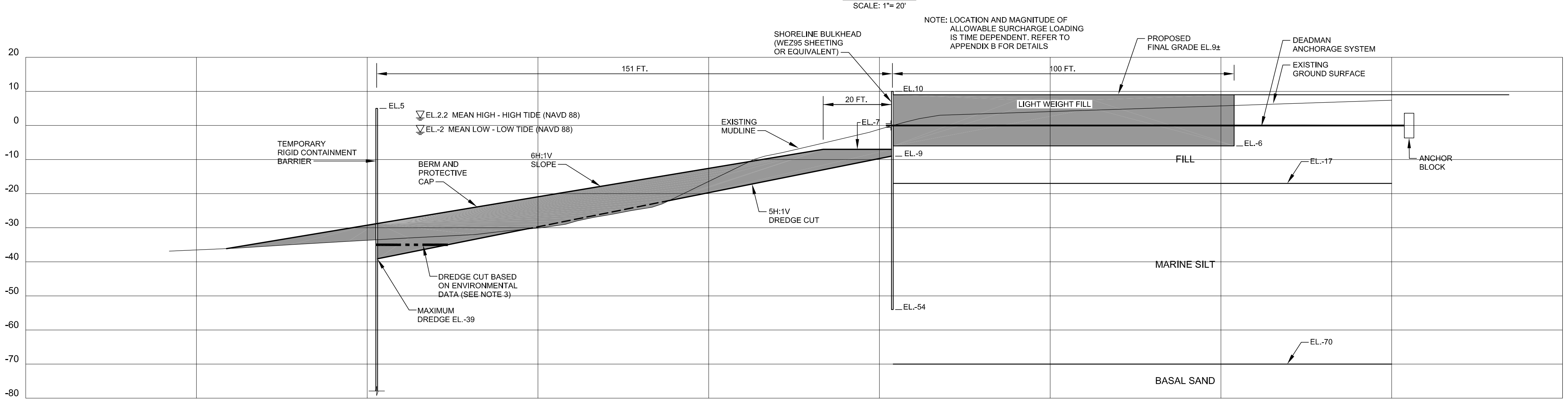
18 APRIL 2006

28612-010 D113

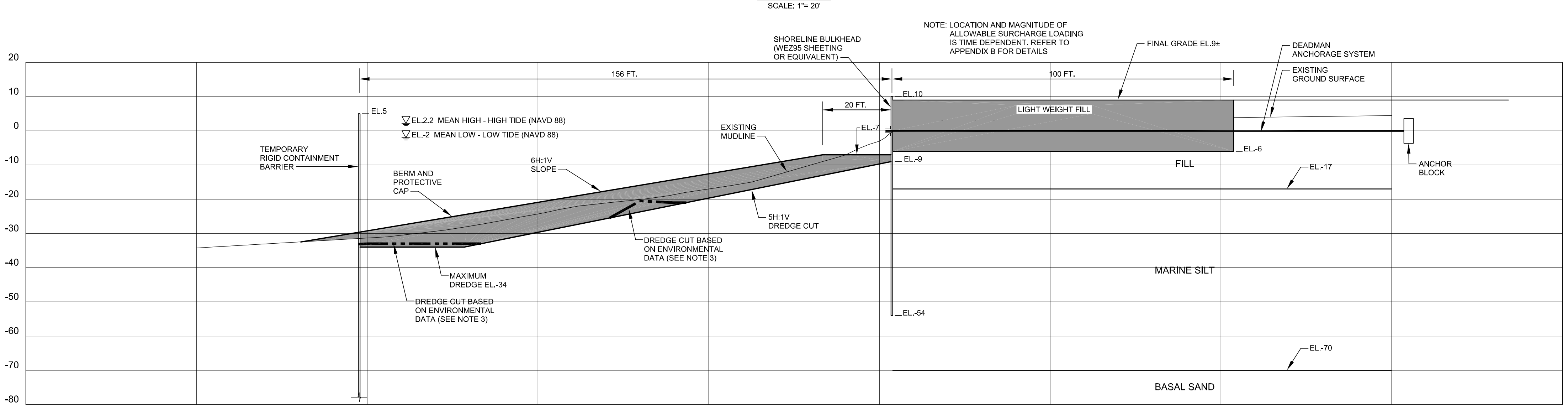
FIGURE N2-5



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.

SCALE IN FEET

HALEY & ALDRICH

UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

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

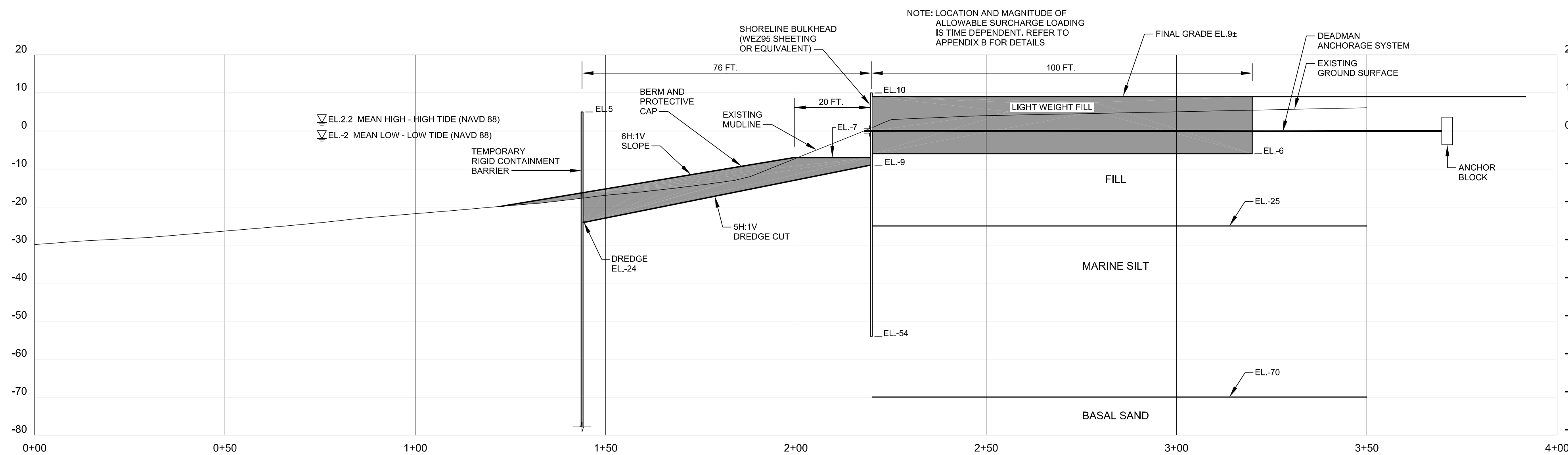
NORTHWEST CORNER AREA
ALTERNATIVE NW-2, OPTION A
SECTIONS

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

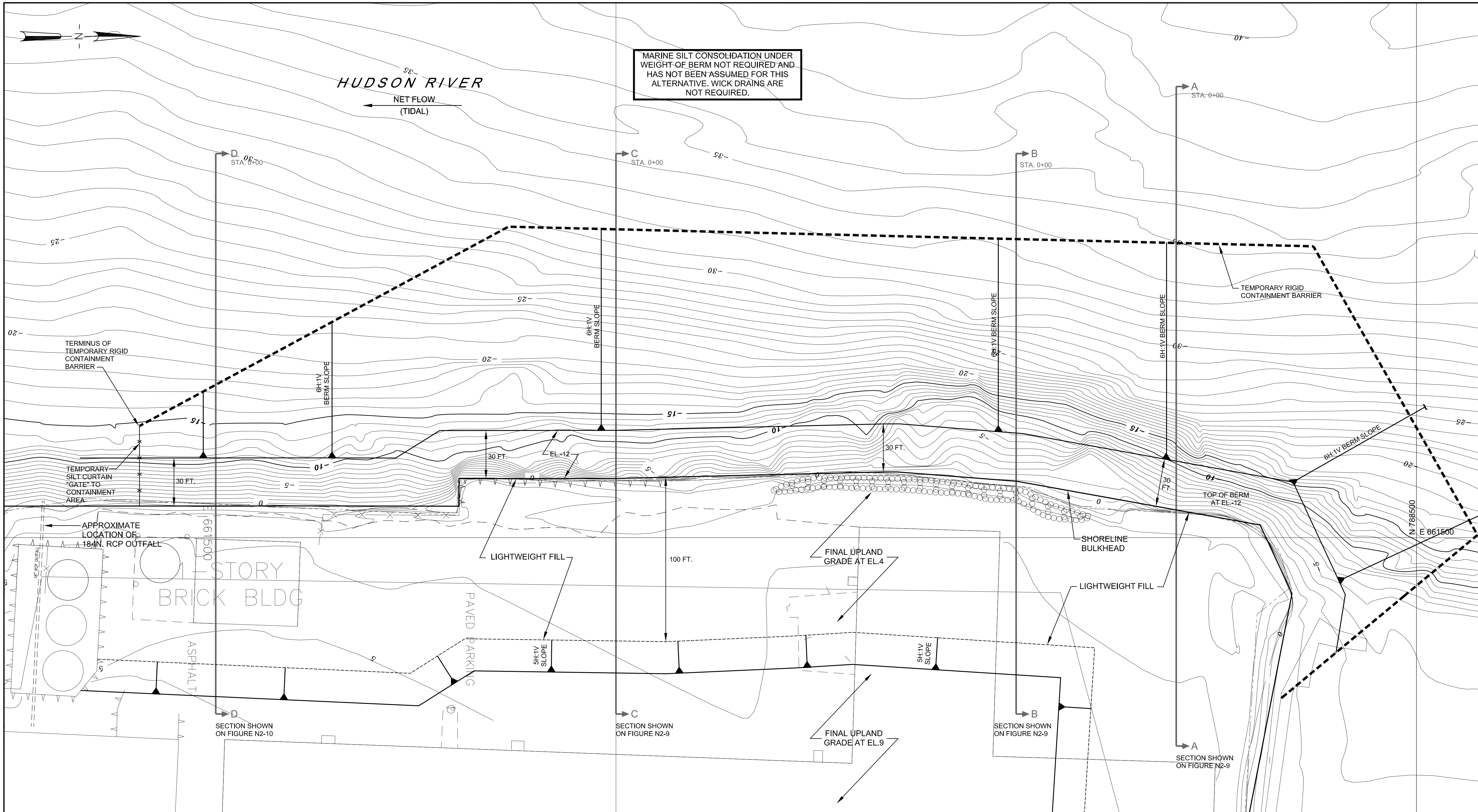
NORTHWEST CORNER AREA
ALTERNATIVE NW-2, OPTION A
SECTIONS

SCALE: AS SHOWN

18 APRIL 2006

FIGURE N2-7

28612-010 D115 (D113)



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

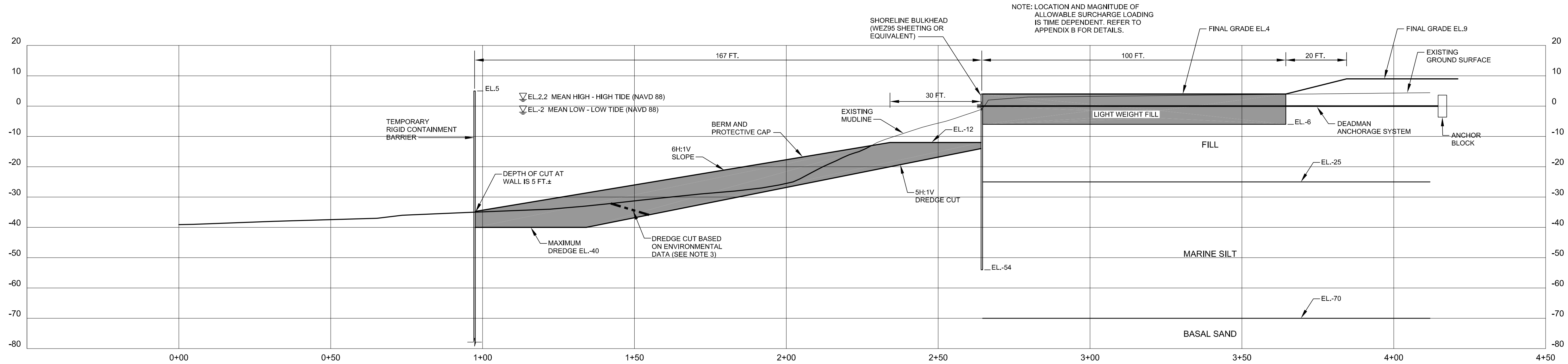
HARBOR AT HASTINGS SITE
SUPPLEMENTAL FEASIBILITY STUDY FOR OU-2
HASTINGS-ON-HUDSON, NEW YORK

NORTHWEST CORNER AREA
ALTERNATIVE NW-2, OPTION B
FINAL UPLAND GRADE EL.4

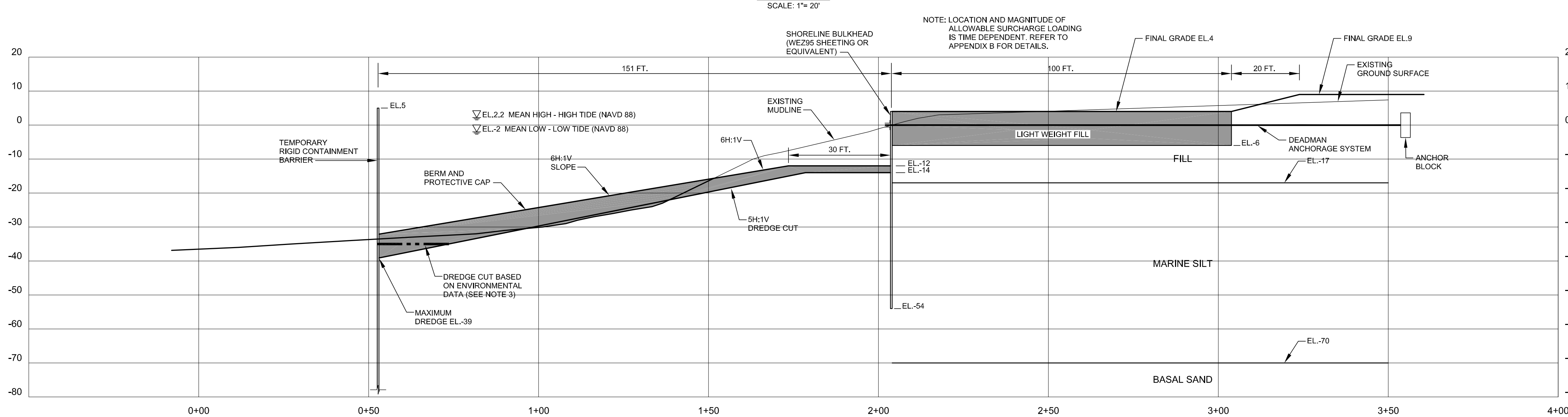
SCALE: AS SHOWN
18 APRIL 2006

28612-010 D116

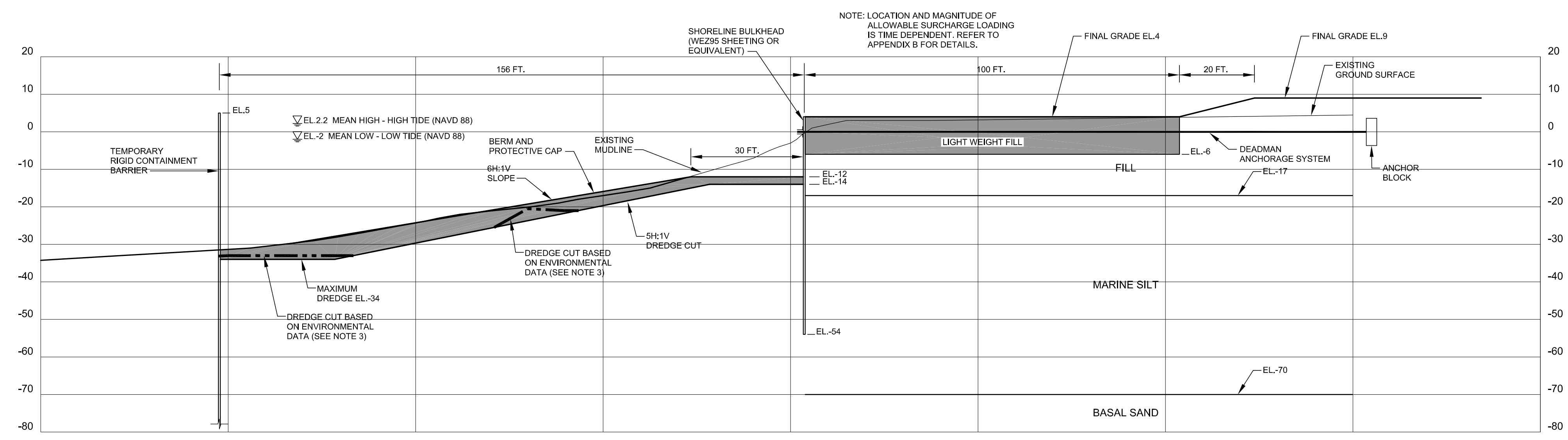
FIGURE N2-8



SECTION A-A
SCALE: 1"= 20'



SECTION B-B
SCALE: 1"= 20'



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

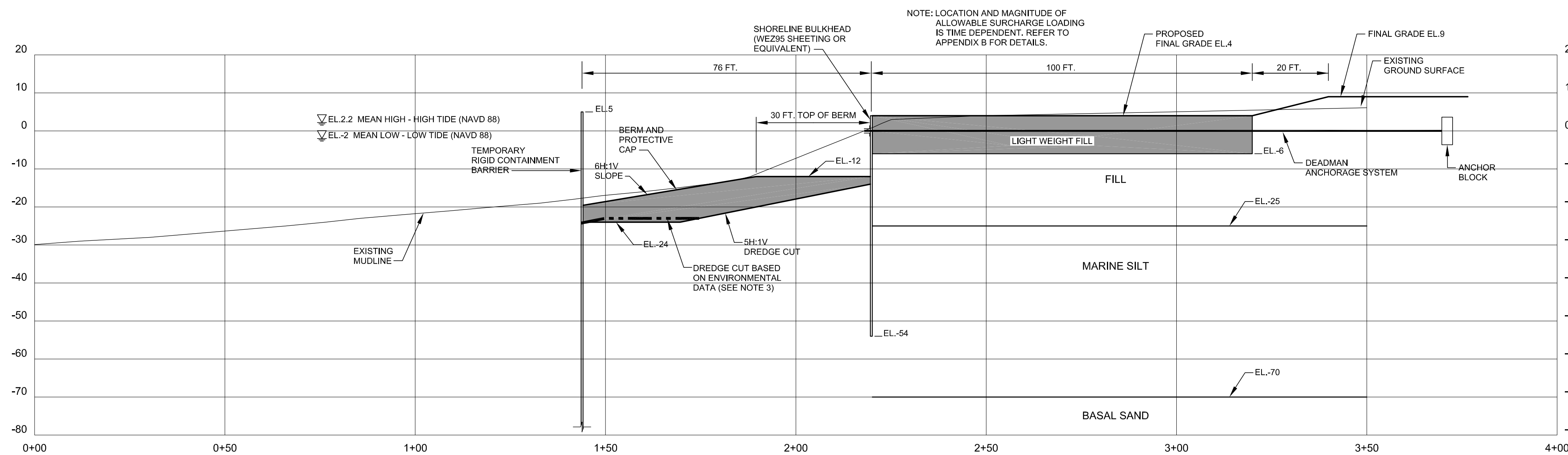
NORTHWEST CORNER AREA
ALTERNATIVE NW-2, OPTION B
FINAL UPLAND GRADE EL.4
SECTIONS

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

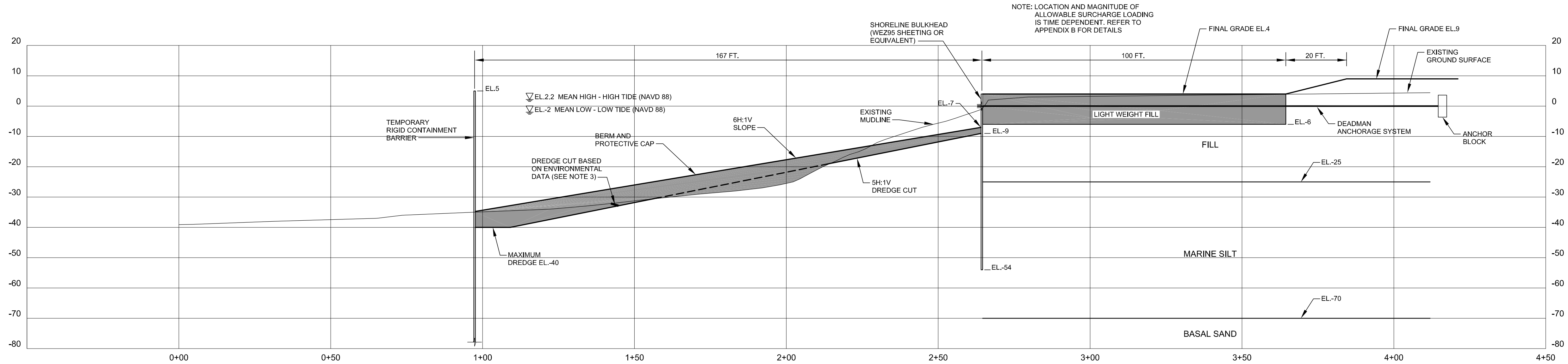
NORTHWEST CORNER AREA
ALTERNATIVE NW-2, OPTION B
FINAL UPLAND GRADE EL.4
SECTIONS

SCALE: AS SHOWN

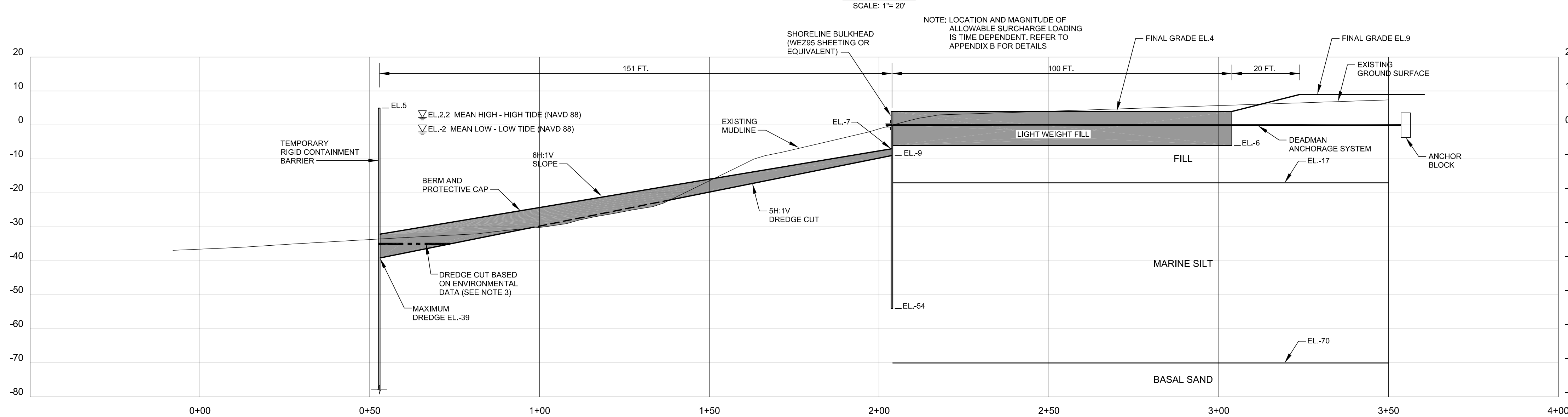
18 APRIL 2006

FIGURE N2-10

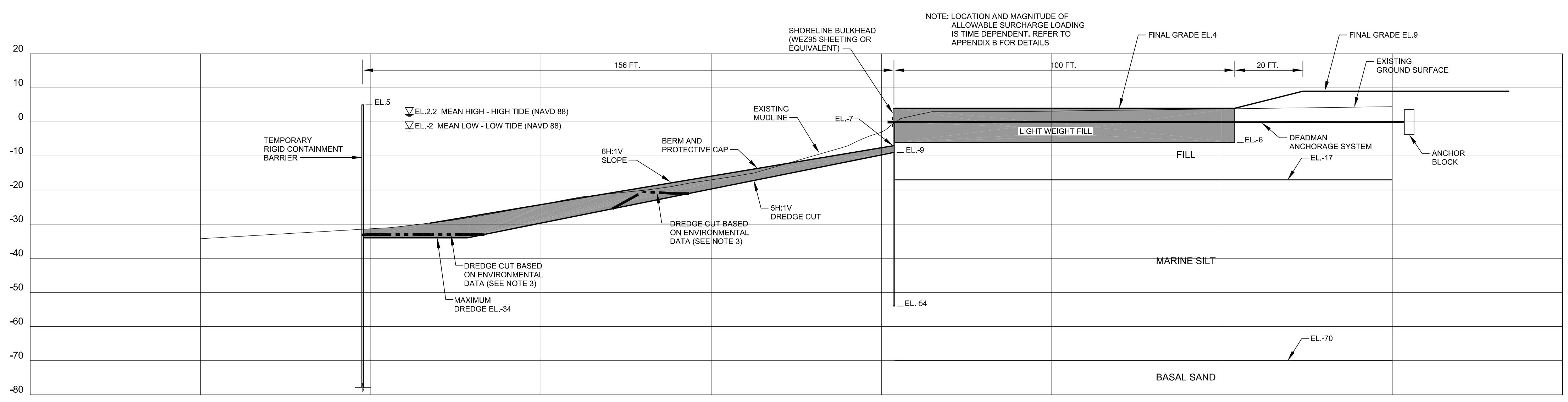
28612-010 D118 (D117)



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

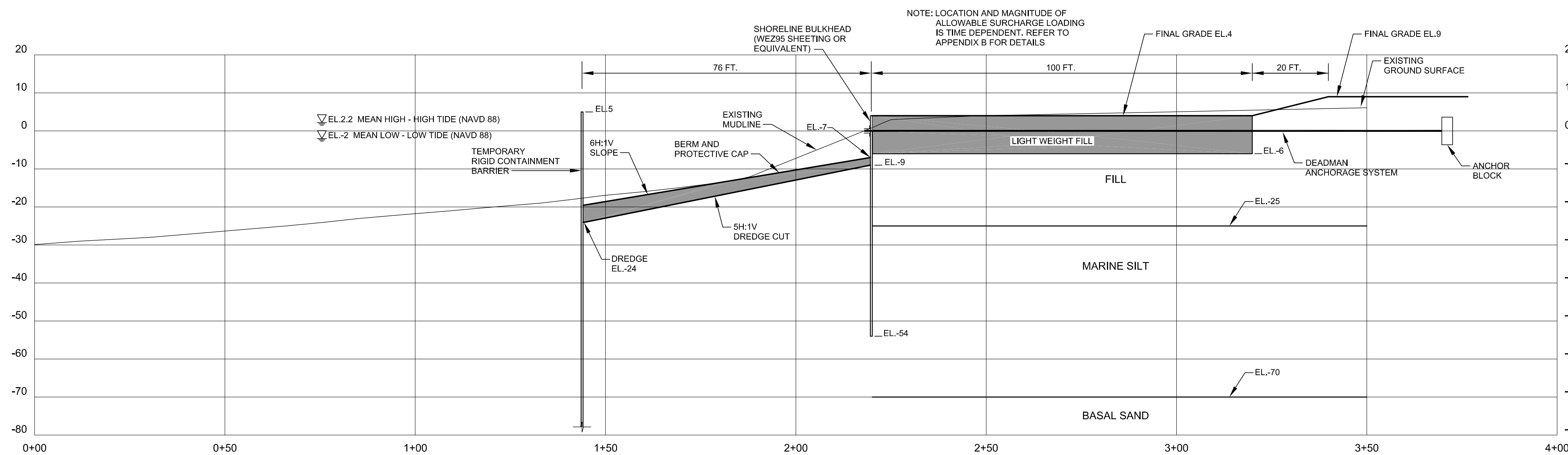
HARBOR AT HASTINGS SITE
SUPPLEMENTAL FEASIBILITY STUDY FOR OU-2
HASTINGS-ON-HUDSON, NEW YORK

NORTHWEST CORNER AREA
ALTERNATIVE NW-2, OPTION A
FINAL UPLAND GRADE EL.4
SECTIONS

SCALE: AS SHOWN
18 APRIL 2006

FIGURE N2-11

28612-010 D119



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

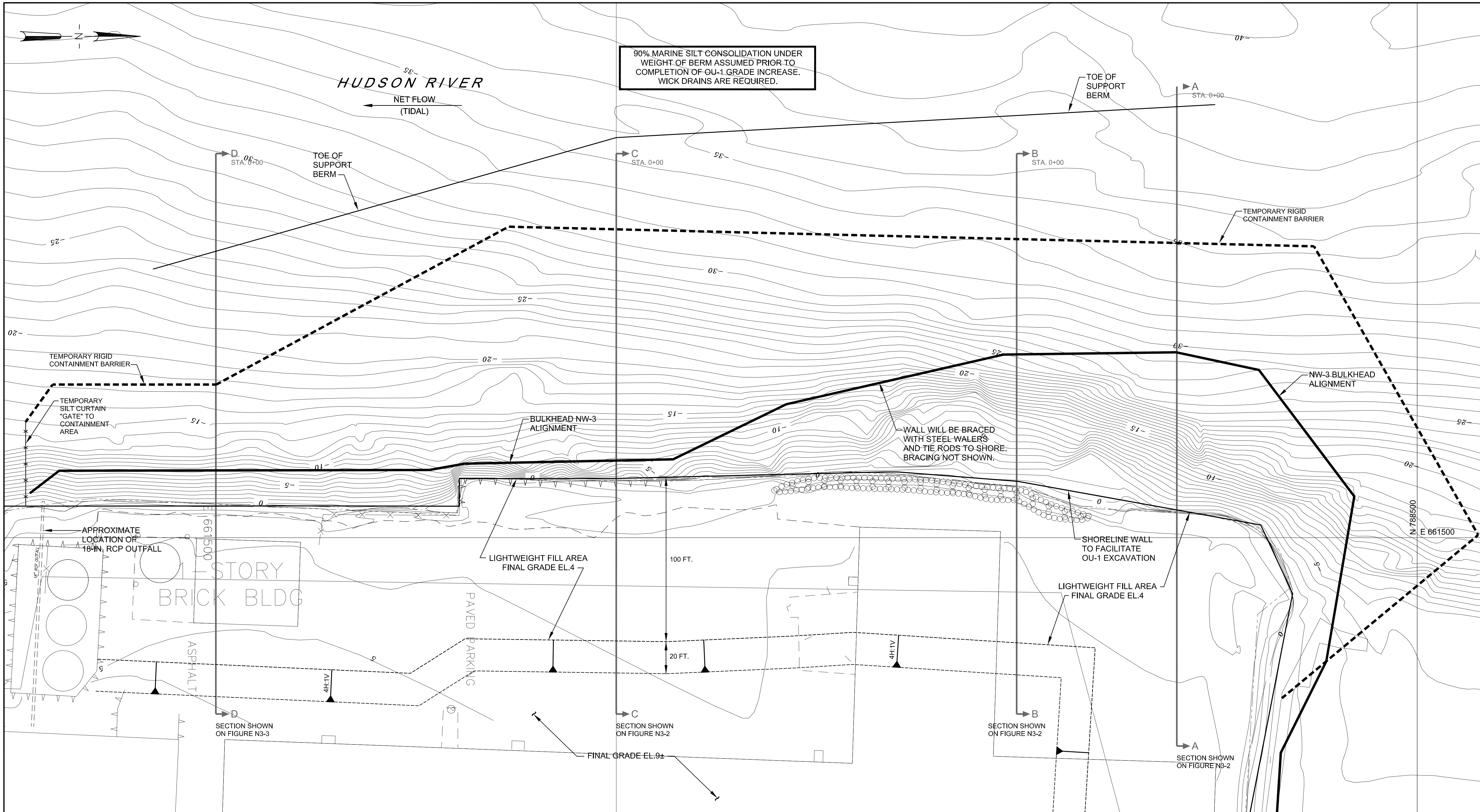
NORTHWEST CORNER AREA
ALTERNATIVE NW-2, OPTION A
FINAL UPLAND GRADE EL.4
SECTIONS

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

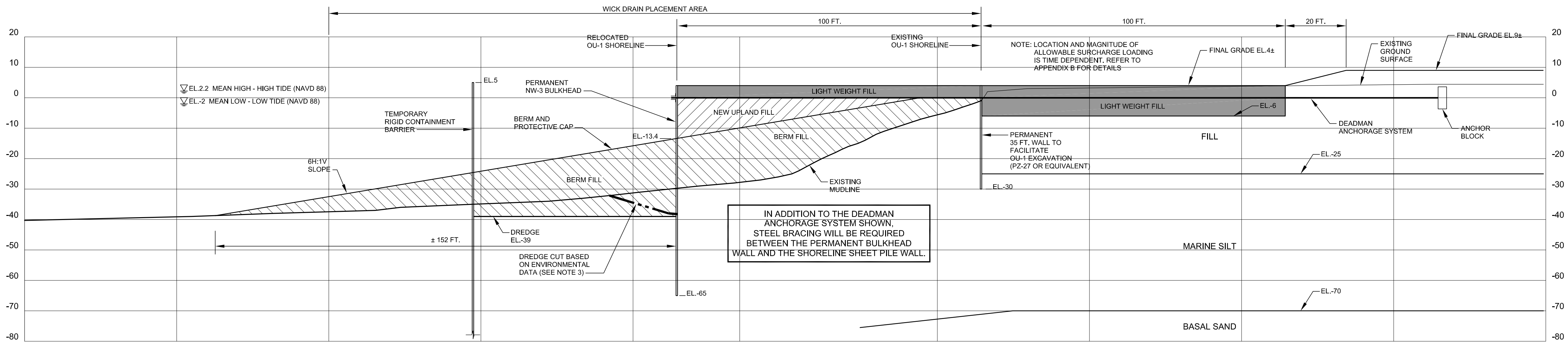
NORTHWEST CORNER AREA ALTERNATIVE NW-3 ALIGNMENT OF STRUCTURAL WALLS

SCALE: AS SHOWN

18 APRIL 2006

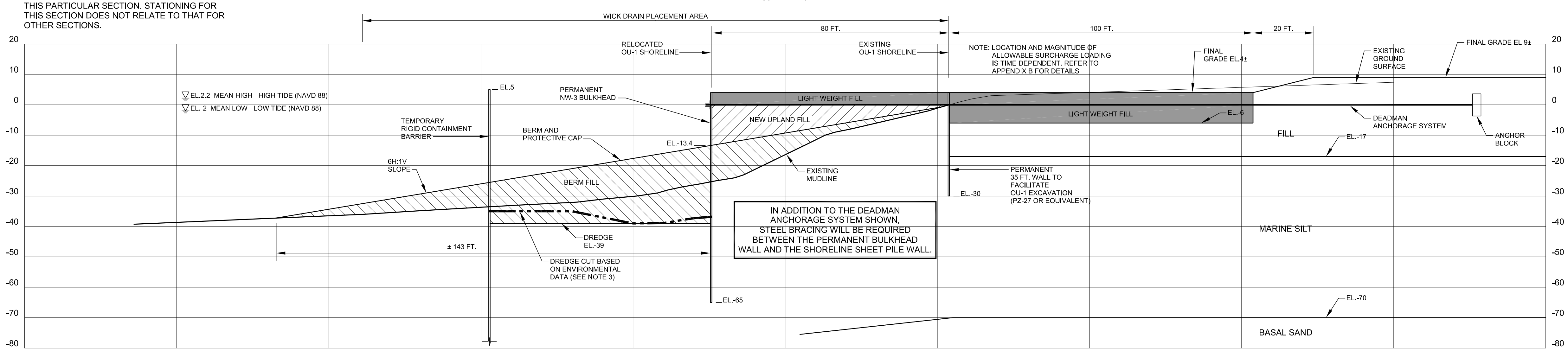
28612-010 D127

FIGURE N3-1



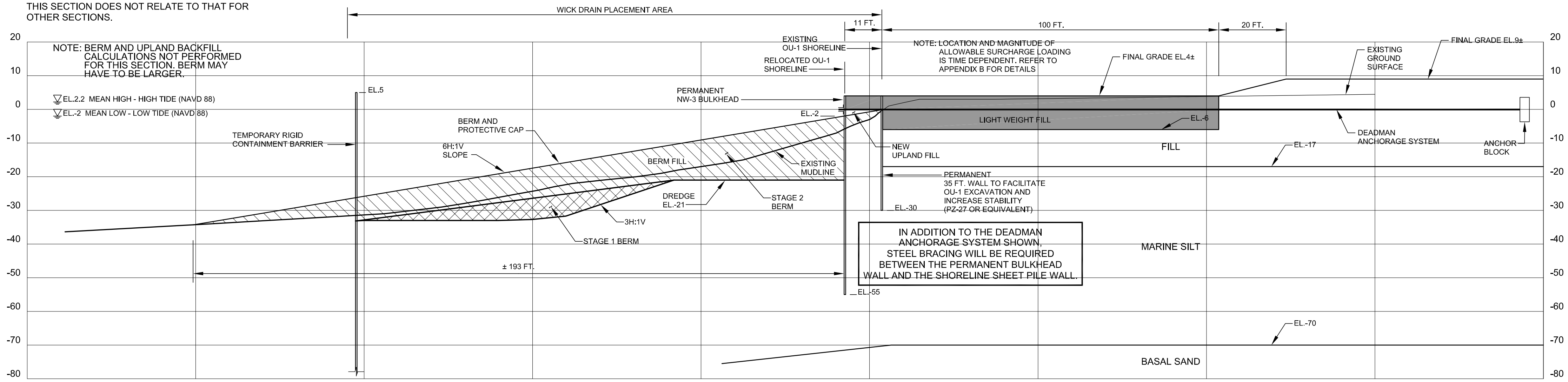
NOTE:
STATIONING IS REFERENCED TO SECTION CUT ON FIGURE N3-1 AND IS UNIQUE TO THIS PARTICULAR SECTION. STATIONING FOR THIS SECTION DOES NOT RELATE TO THAT FOR OTHER SECTIONS.

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'



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'

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

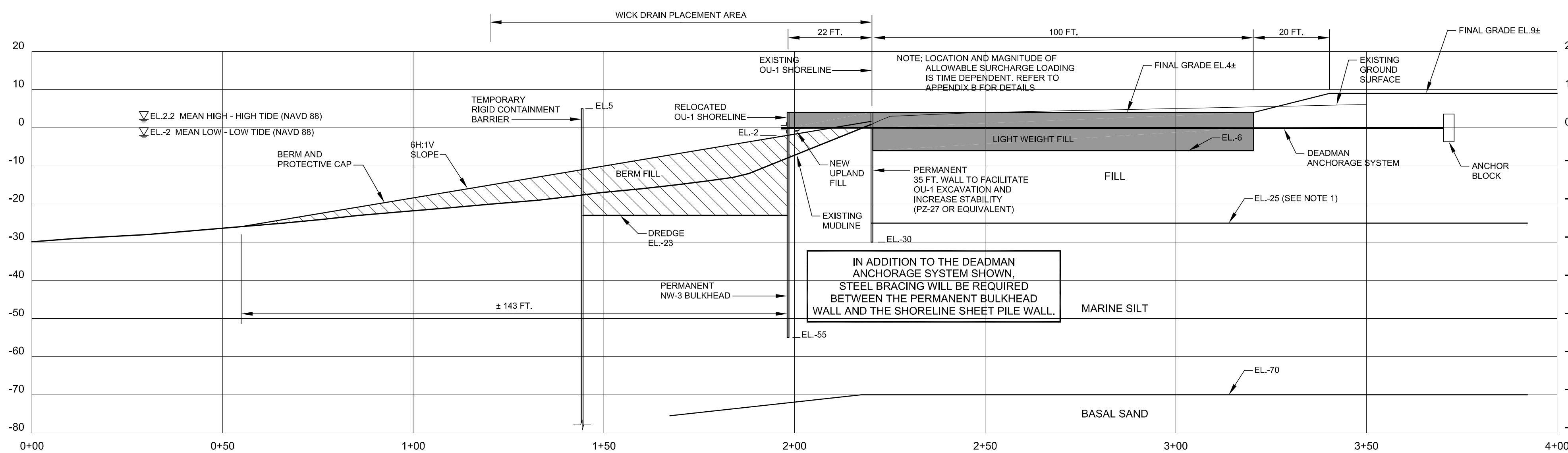
NORTHWEST CORNER AREA
ALTERNATIVE NW-3
SECTIONS

SCALE: AS SHOWN

18 APRIL 2006

28612-010 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

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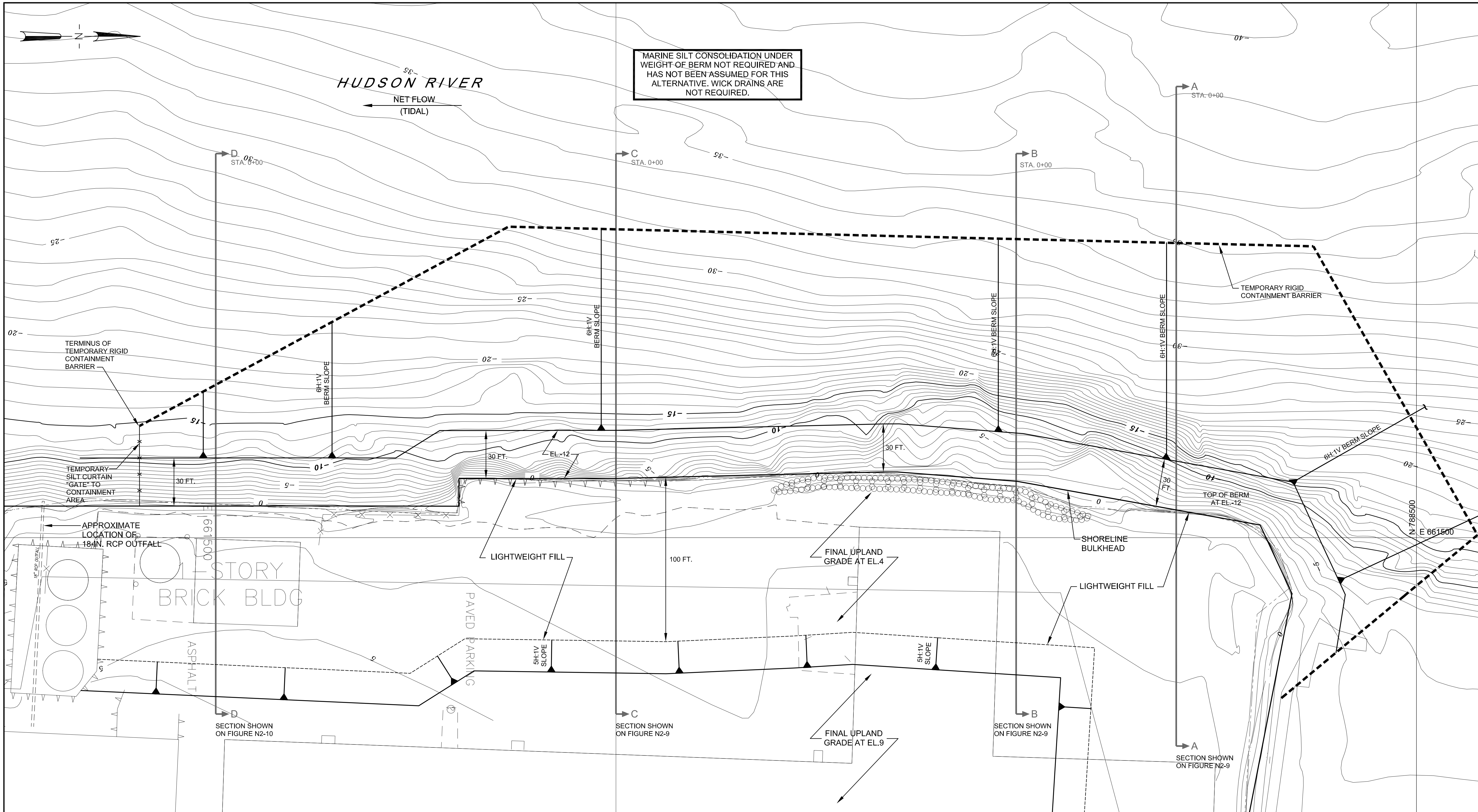
28612-010 D129 (D127)

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.

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

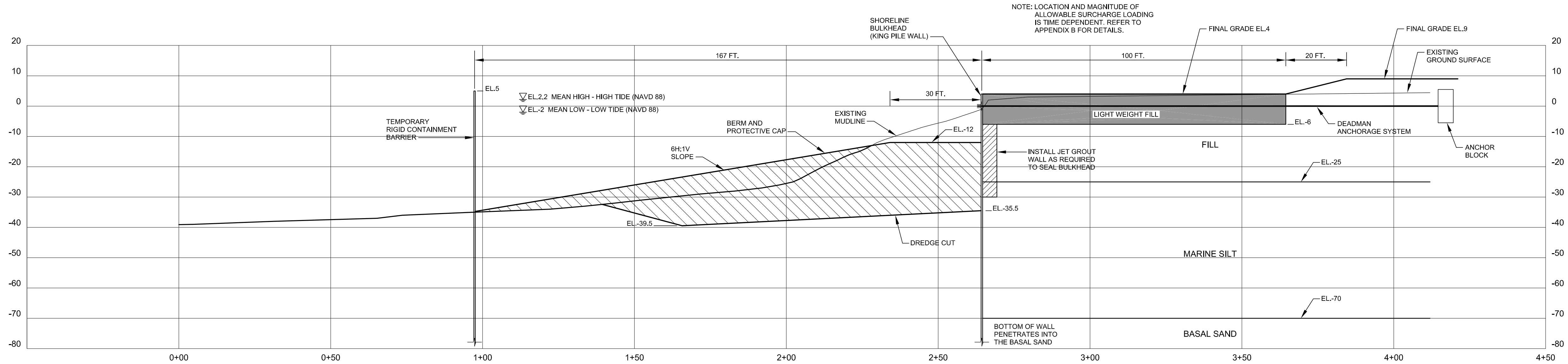
NORTHWEST CORNER AREA
ALTERNATIVE NW-4
PLAN VIEW

SCALE: AS SHOWN

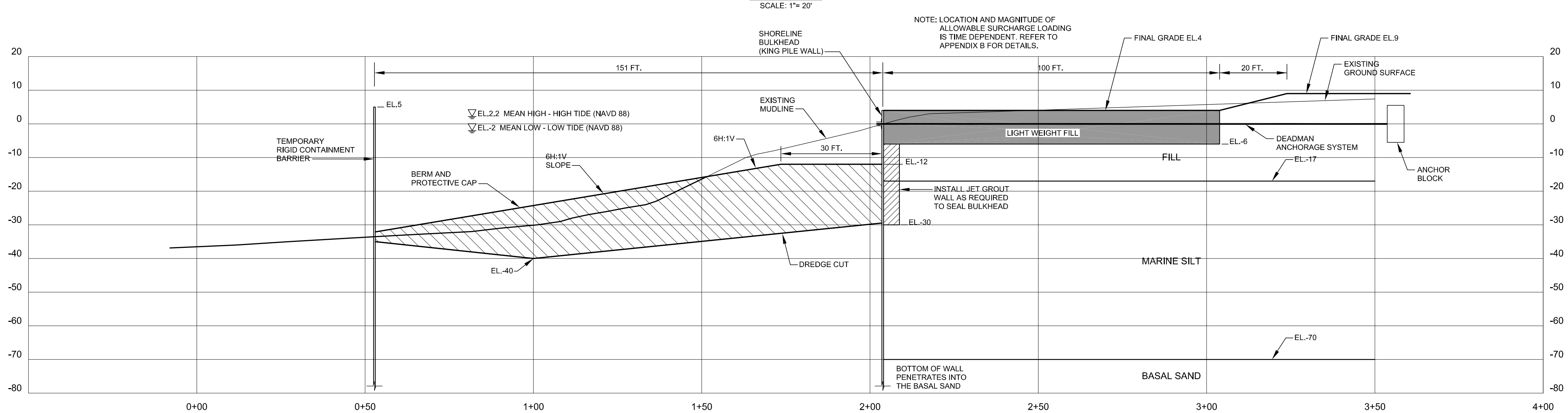
18 APRIL 2006

28612-010 D138

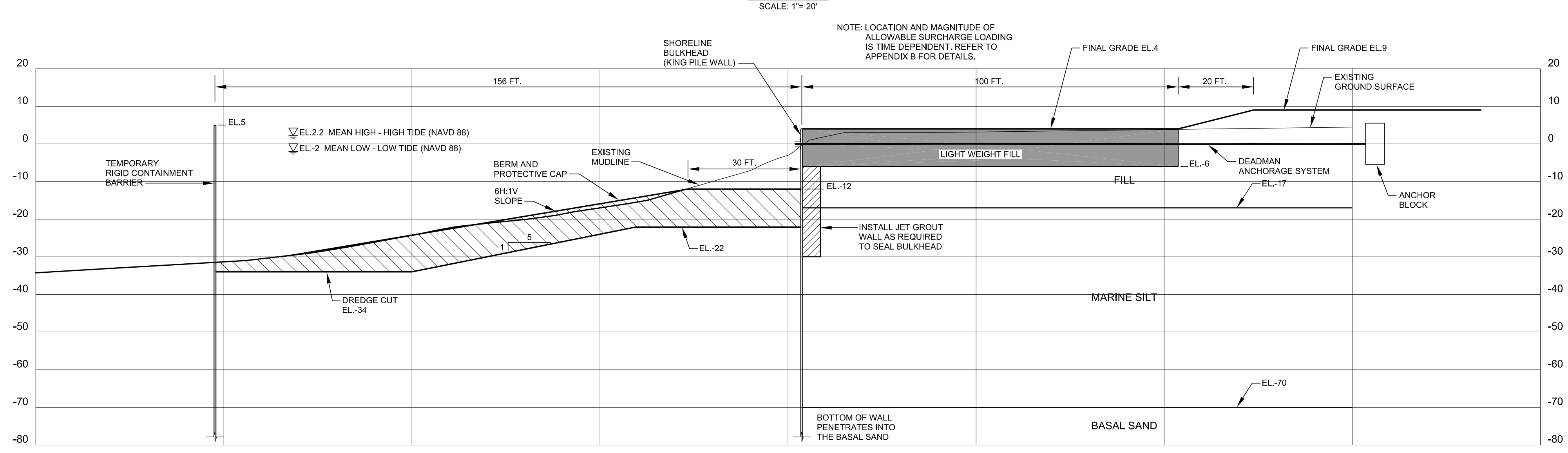
FIGURE N4-1



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

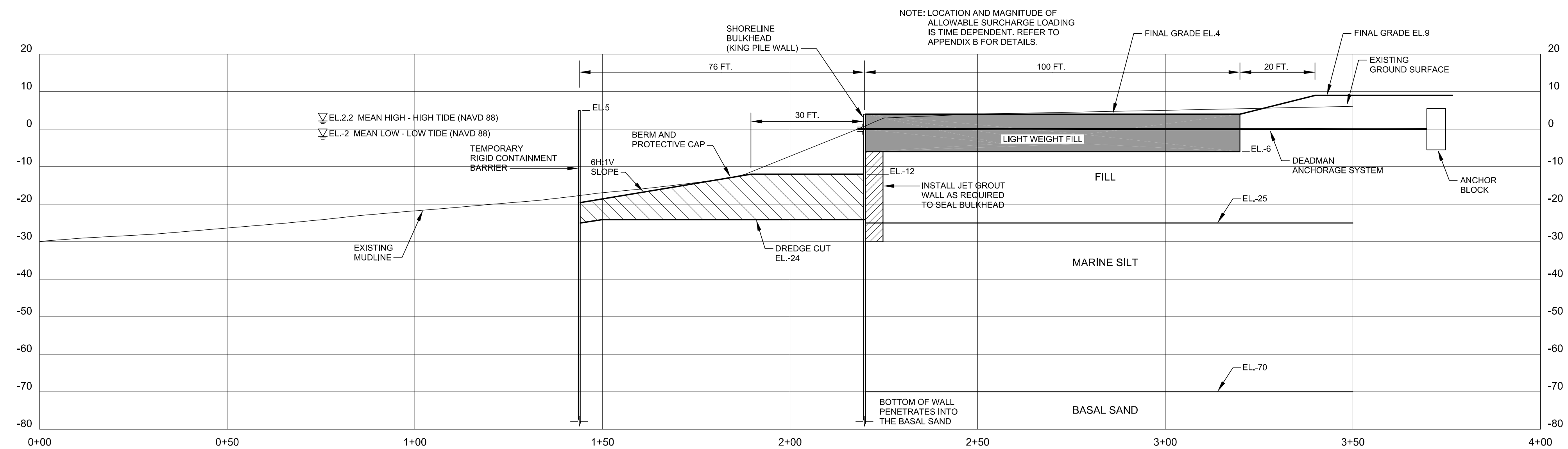
NORTHWEST CORNER AREA ALTERNATIVE NW-4 SECTIONS

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

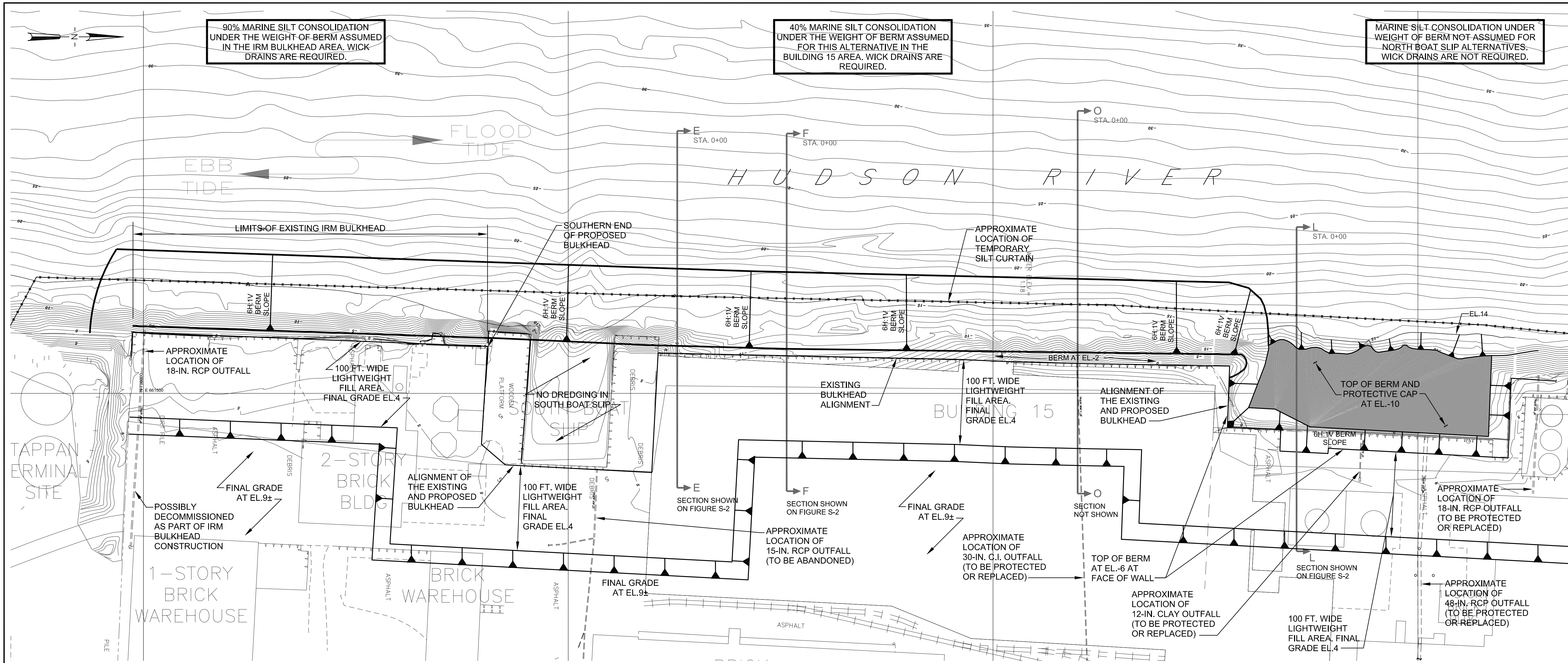
NORTHWEST CORNER AREA
ALTERNATIVE NW-4
SECTIONS

SCALE: AS SHOWN

18 APRIL 2006

28612-010 D131 (D130)

FIGURE N4-3



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

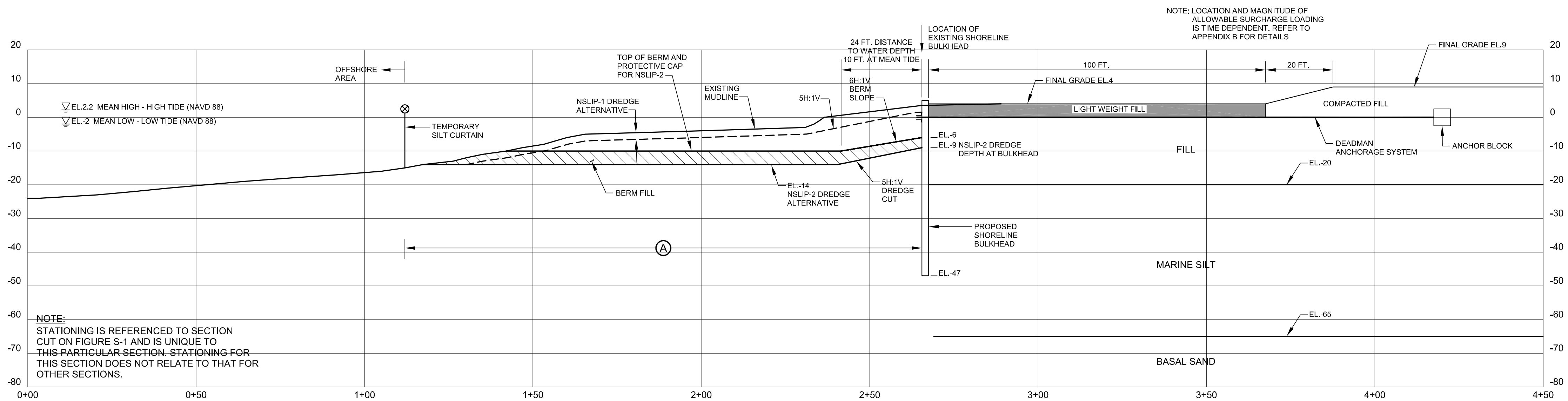
SOUTHERN BULKHEAD AND BOAT SLIP AREAS EXISTING SHORELINE ALIGNMENT PLAN VIEW

SCALE: AS SHOWN

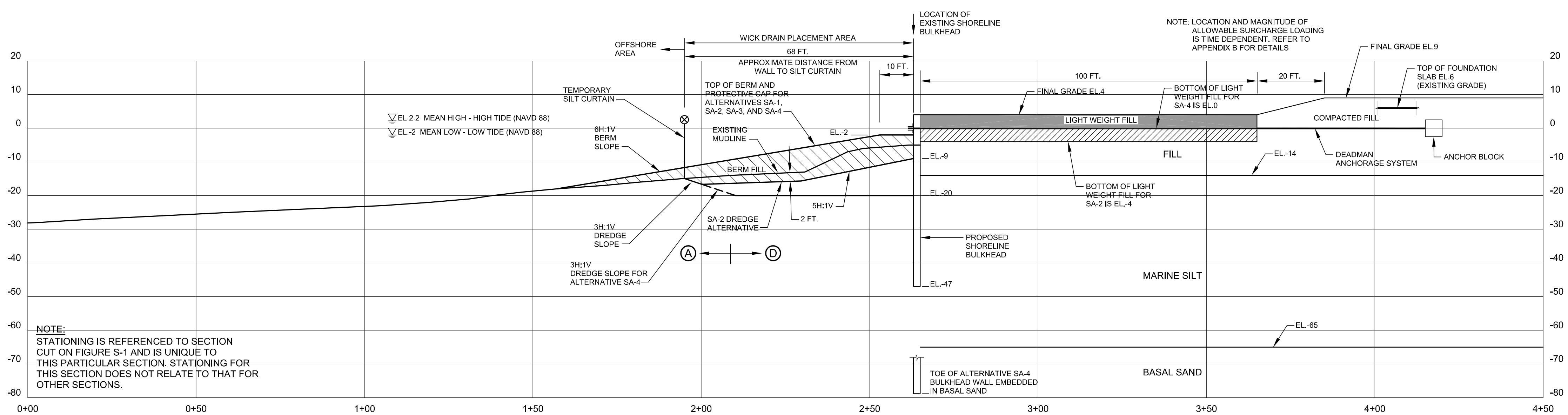
18 APRIL 2006

28612-010 D121

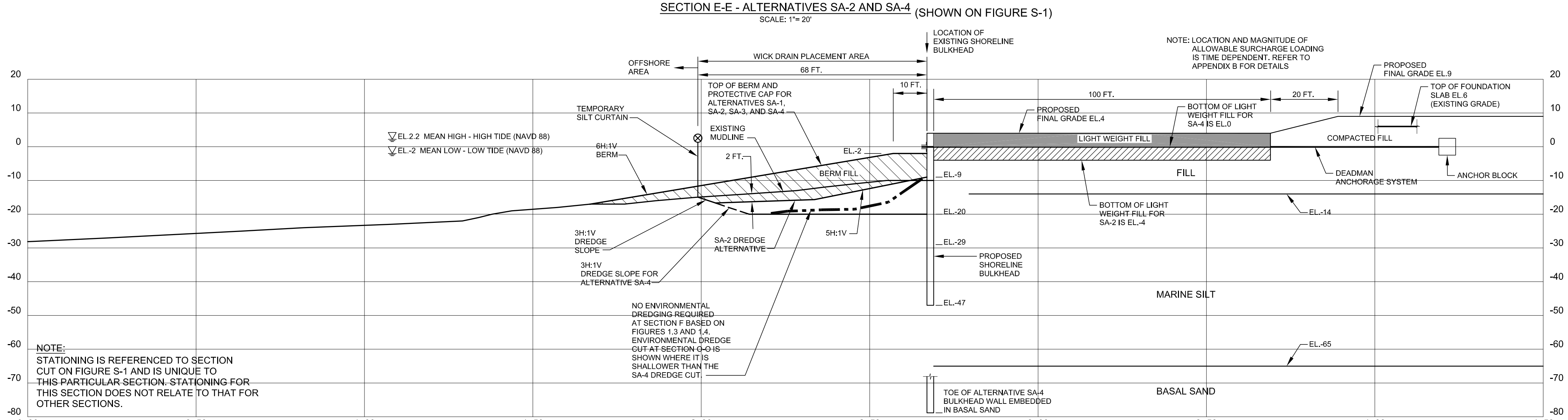
FIGURE S-1



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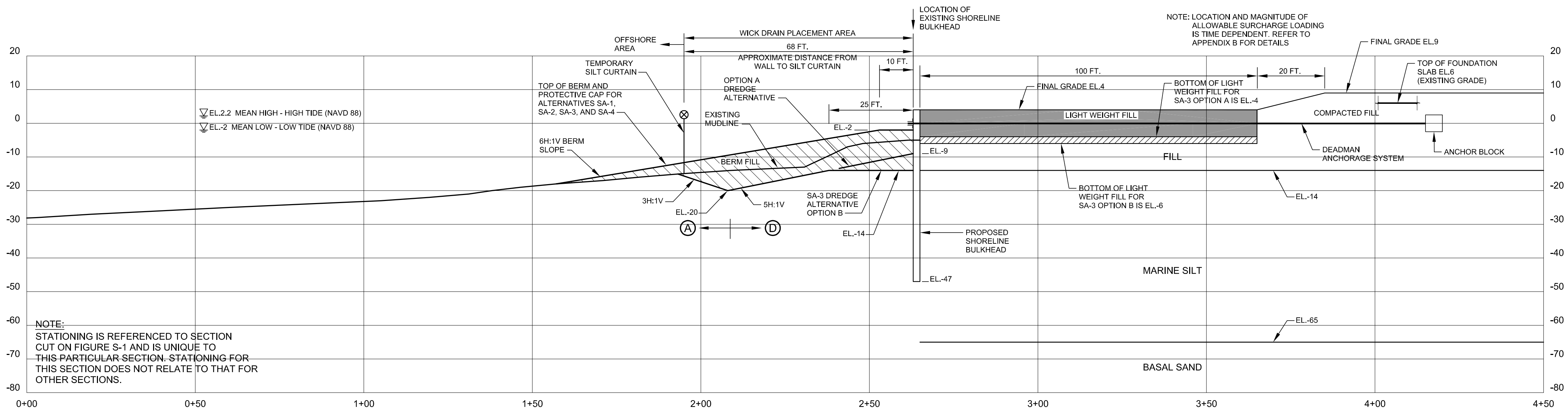
SUPPLEMENTAL FEASIBILITY STUDY FOR OU-2
HASTINGS-ON-HUDSON, NEW YORK

SOUTHERN BULKHEAD AND BOAT SLIP AREAS EXISTING SHORELINE ALIGNMENT ALTERNATIVES SA-2 AND SA-4

SCALE: AS SHOWN
18 APRIL 2006

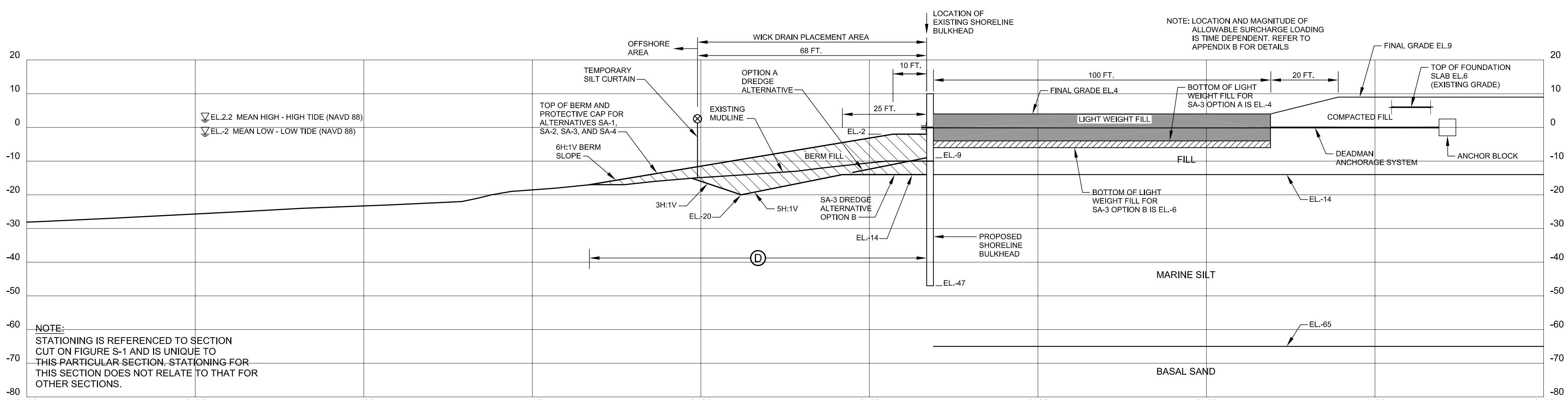
FIGURE S-2

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

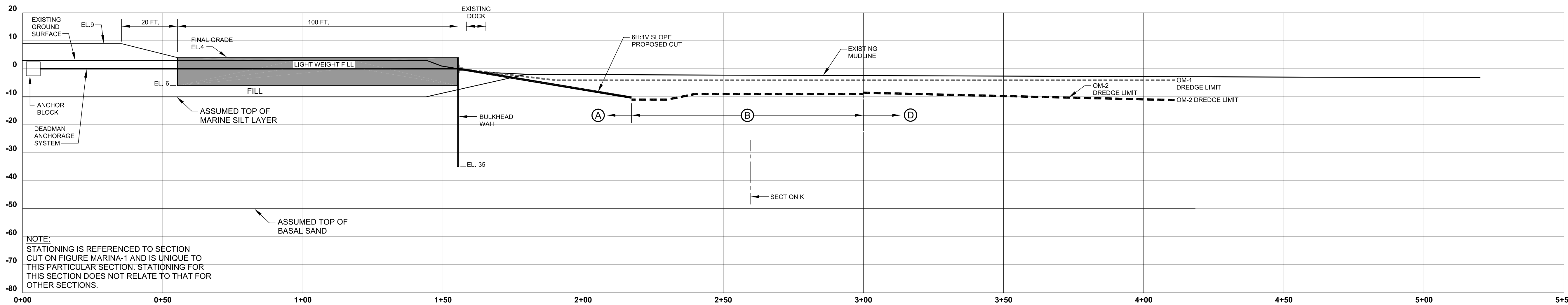
PLAN VIEW OF OLD MARINA AREA ALTERNATIVE OM-2

SCALE: AS SHOWN

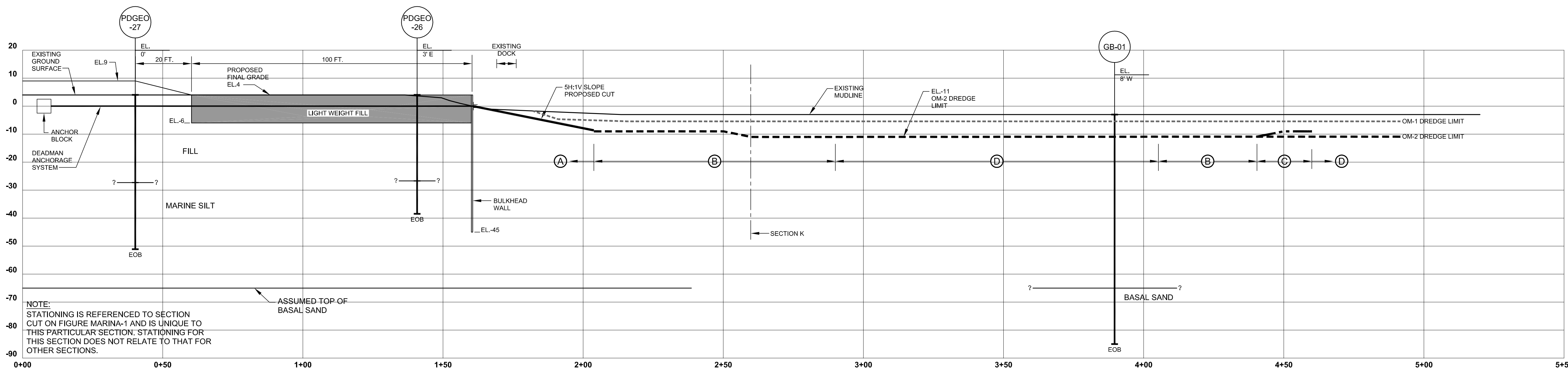
18 APRIL 2006

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:

- (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. 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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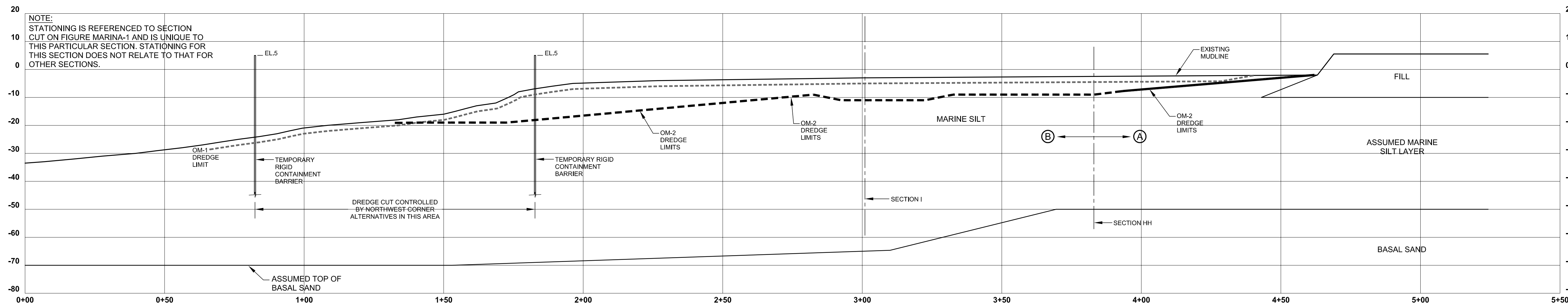
HASTINGS-ON-HUDSON, NEW YORK

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.
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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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

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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 ($\sum$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 $\sum$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 $\sum$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 ($\sum$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 $(\sum SEM\text{-}AVS)/f_{oc}$ 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 (∑SEM-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 (∑SEM-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 (∑SEM-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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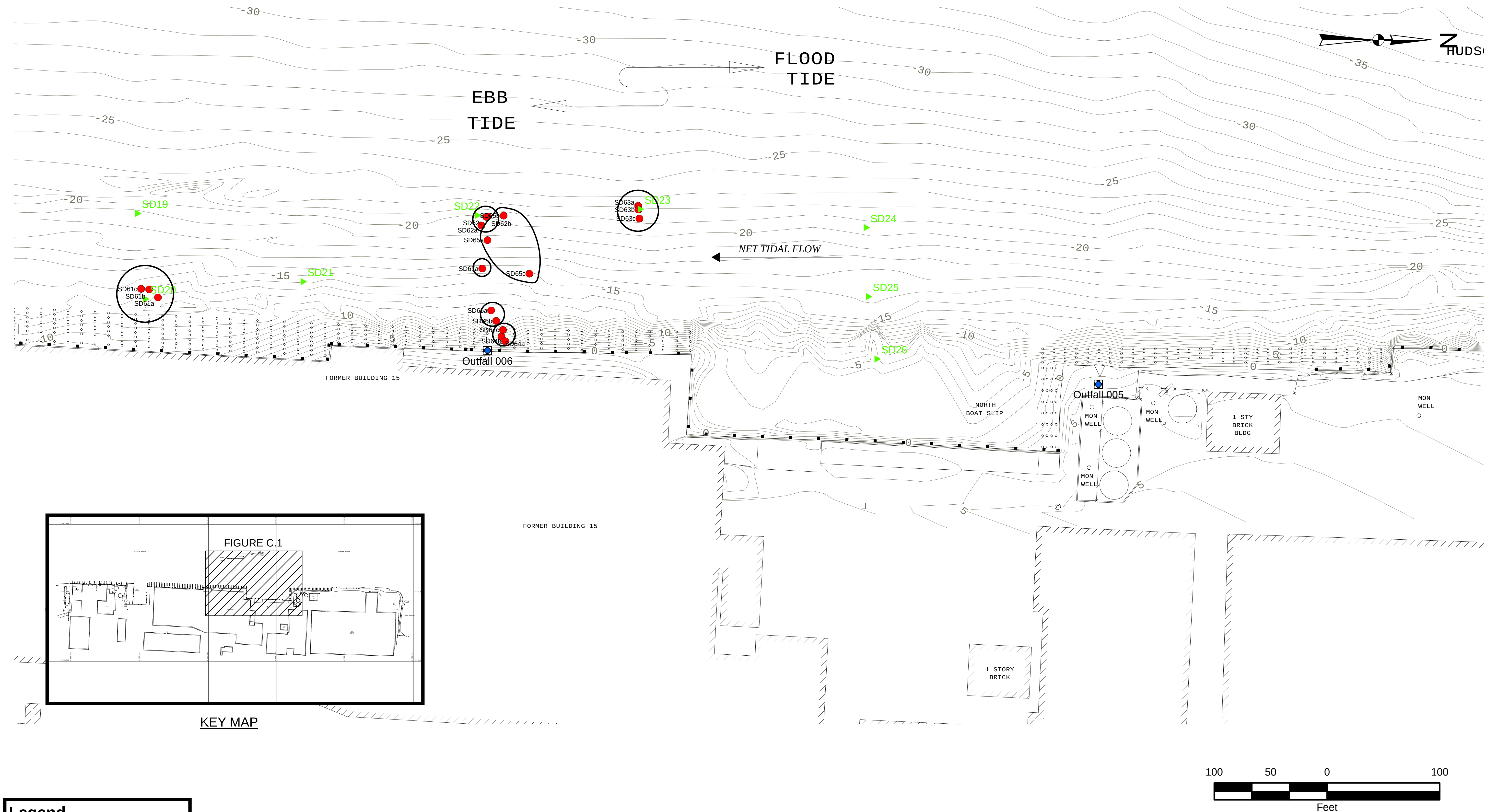


Legend

- 2004 Sample Locations
- 2005 Sample Locations
- SPDES Outfalls

PARSONS
180 LAWRENCE BELL DRIVE, SUITE 104
WILLIAMSVILLE, NEW YORK 14221
716-633-7074

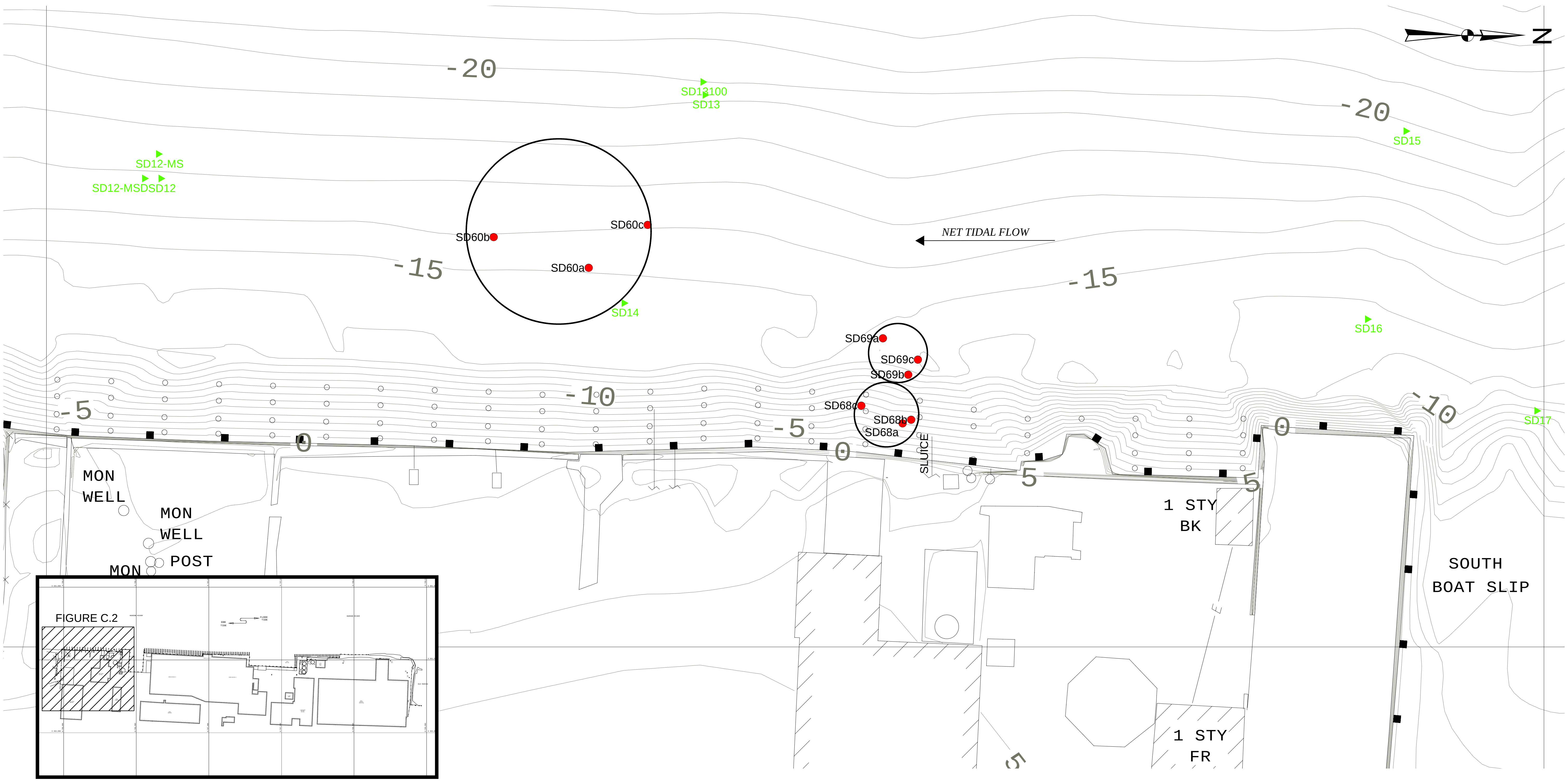
FIGURE C.1

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-C1.MXD 04-24-06



KEY MAP

40 20 0 40
Feet

Legend

- ▲ 2004 Sample Locations
- ● 2005 Sample Locations

FIGURE C.2

AR and AERL

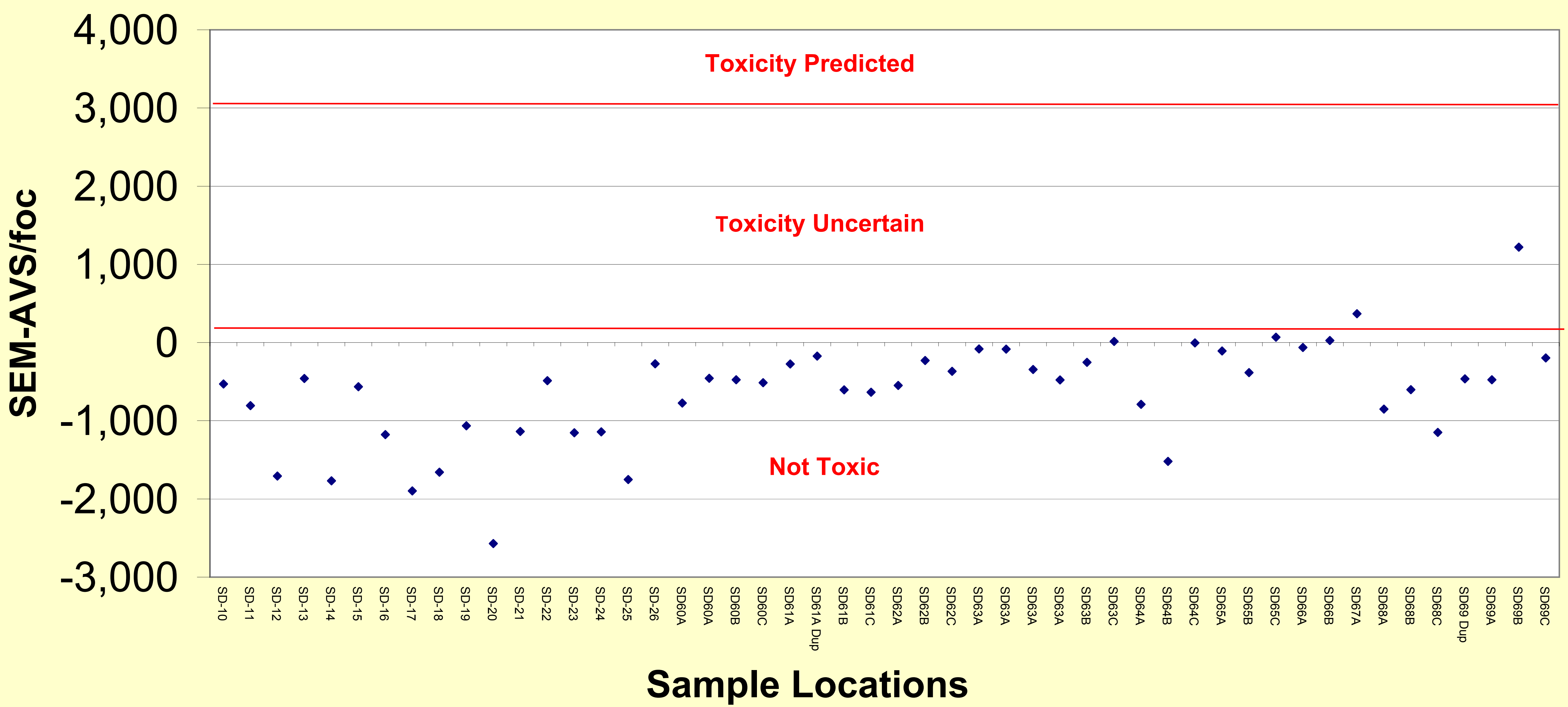
AVS-SEM SAMPLE LOCATIONS

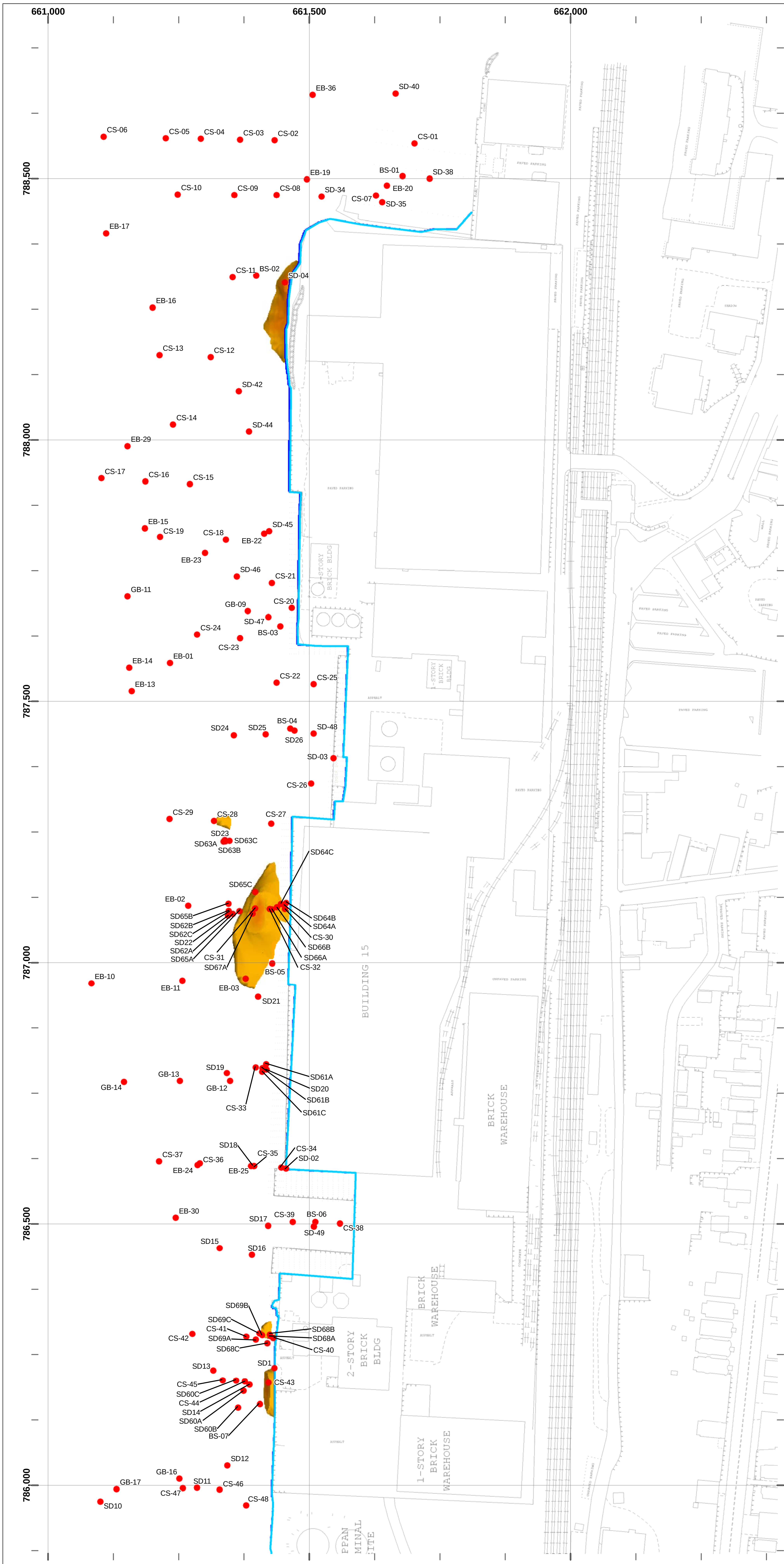
(South of the South Boat Slip)
FORMER AWC PLANT SITE
OU-2
HASTINGS-ON-HUDSON, NEW YORK

PARSONS
180 LAWRENCE BELL DRIVE, SUITE 104
WILLIAMSVILLE, NEW YORK 14221
716-633-7074

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

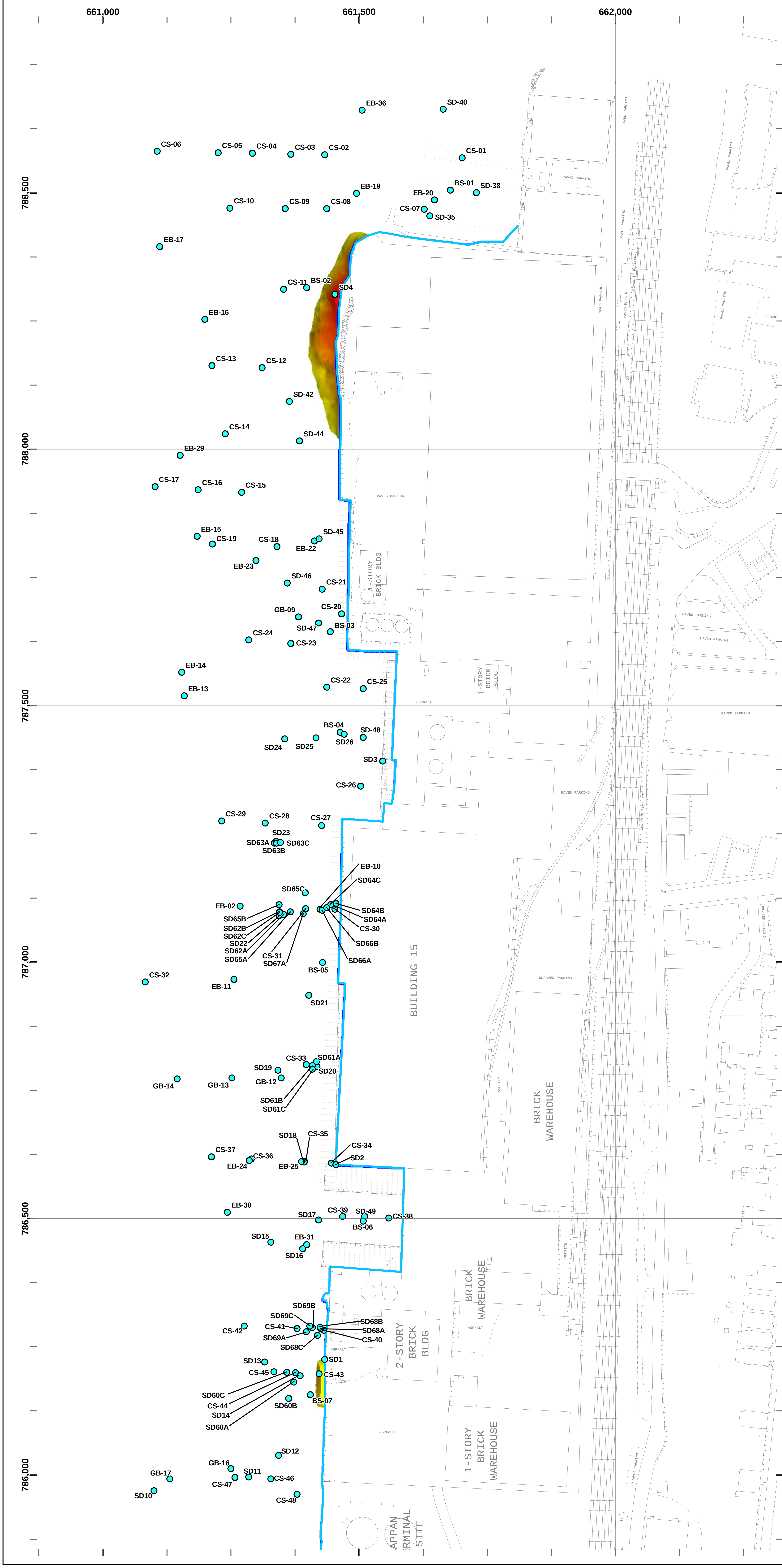
982 mg/kg **1,000 mg/kg**

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

Legend

- Shoreline
- Piling Line
- Piling
- LEAD SAMPLE LOCATIONS

LEAD CONCENTRATION

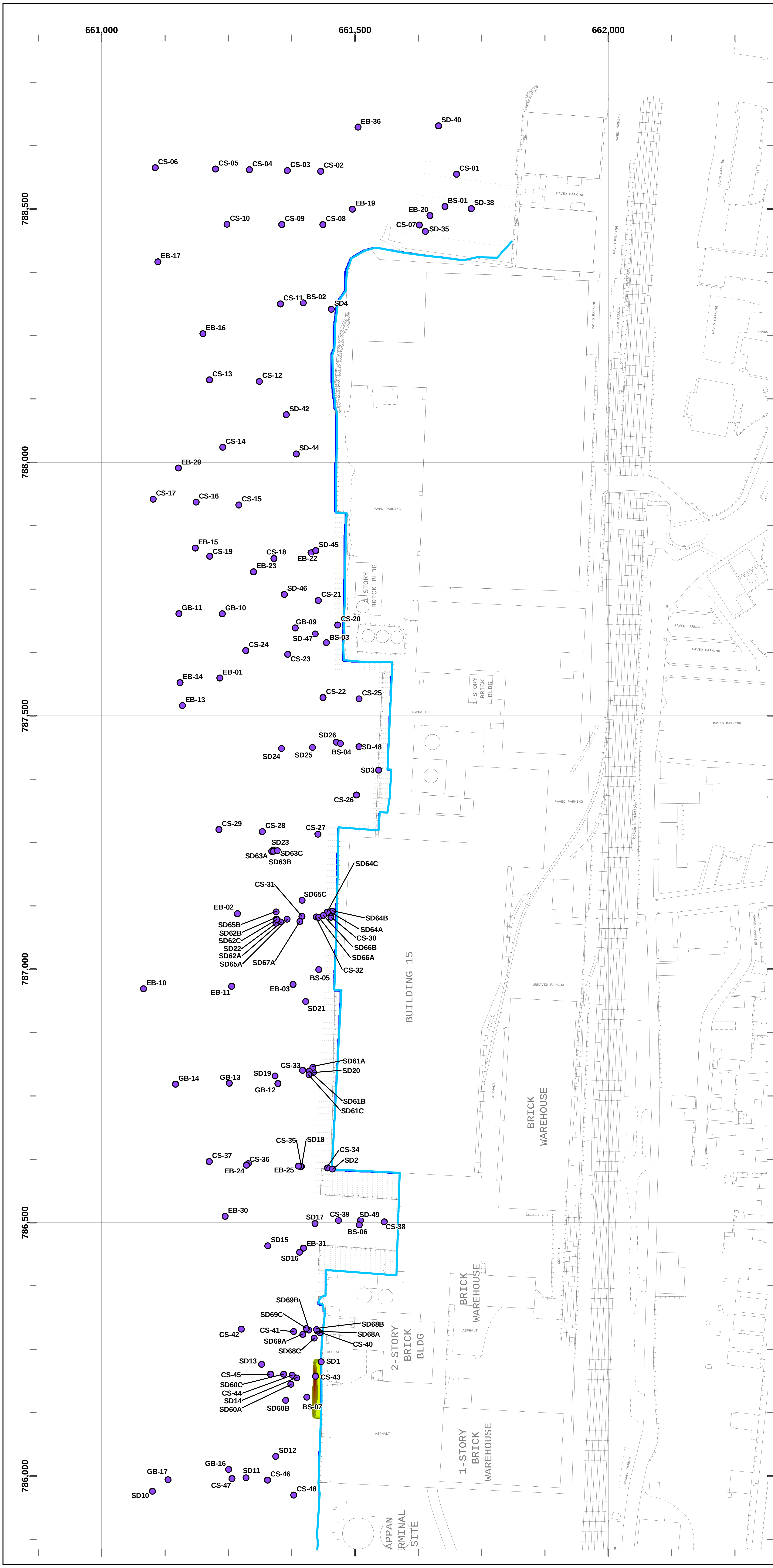
1,000 mg/kg

379 mg/kg

FIGURE C.5 SPATIAL DISTRIBUTION OF LEAD EXCEEDING PROPOSED ESB-BASED LEAD PRG OF 379 MG/KG (PPM)

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
- 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

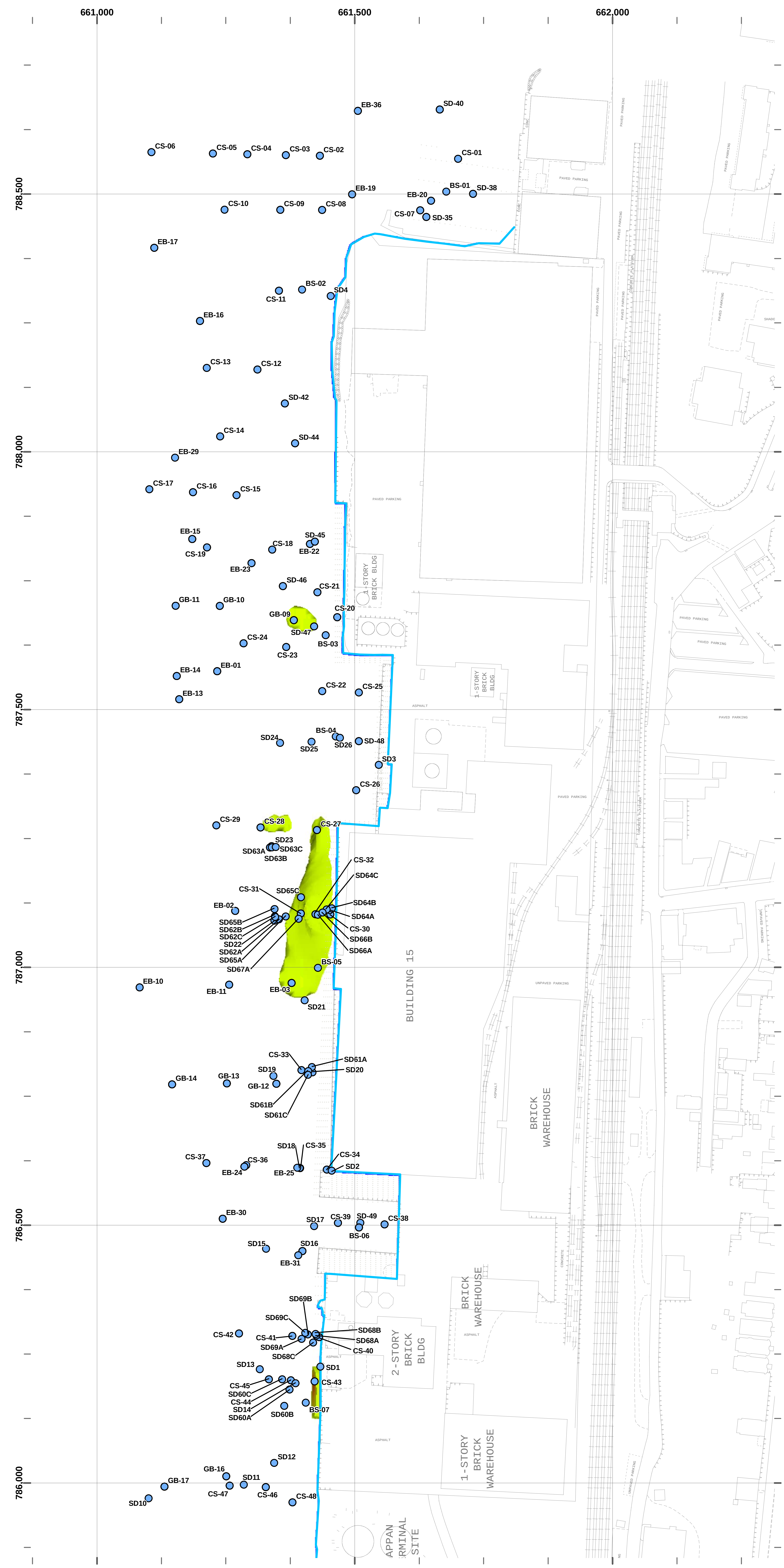
APRIL 7, 2006 rev. 2

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

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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

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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

Hastings-on-Hudson OU-2
Cost Estimate Summary for Alternative NW-1
Table E.11

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	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 Containment									**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: 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	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 Containmen									**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

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
								check:	64,077,414		TOTAL NOT FIXED 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 Containmen									**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

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

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 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 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					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	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
								check:	20,449,103		TOTAL NOT FIXED 14,830,155

Hastings-on-Hudson OU-2
Cost Estimate Summary for Alternative Offshore 2a
Table E.25

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

Hastings-on-Hudson OU-2
Cost Estimate Summary for Alternative Offshore 2b
Table E.26

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

Hastings-on-Hudson OU-2
Cost Estimate Summary for Alternative Offshore-2c
Table E.27

Task	Qty	Unit	Cost					NPV Factor	NPV	TOTAL UNIT $	Not Fixed Total
			Labor	Equipment	Materials	Subcont	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 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	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

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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., $1.2\text{x}10^{-2}$ is expressed as $1\text{x}10^{-2}$) for consistency with common risk assessment practice. Tabular summaries presented in this document give risk estimates rounded to two significant figures (e.g., $1.244\text{x}10^{-2}$ is expressed as $1.2\text{x}10^{-2}$). 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 x 10^{11} AVMT by large trucks (U.S. DOT, 2005). Therefore, the rate of fatalities per AVMT is 3.3 x 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 x 10^{-3} (or 1 in 158) and 2 x 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 x 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 x 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 x 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)			Berm Volume (cy)	Cap Material (cy)	Berm + Cap (cy)
			TSCA[b]	Non-TSCA[c]	Total			
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.

	Total Labor Rate (Hours per 1,000 cy)						
	Dredging			Berm & Cap			
Occupation	**NW-1**	**NW-4**	**All Others[a]**	**All Alternatives**	**SOC Occupation Title**	**2000 SOC Code**	**1990 Census Code**
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			19,000			27,000			18,000			51,000		
				11,900			14,800			15,300			31,000			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] x 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] 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.5-3. 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

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 Risk	
Total Projected Person-Years [c]	11.2			51.7			Min	Max
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] 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.5-4. Occupational Risk Estimates Associated with Dredging, Berm, and Capping Operations in Old Marina.

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)							
				OM-1			OM-2				
				7,000			15,000				
				5,500			5,500				
	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	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		
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 Risk**	
Total Projected Person-Years[c]				34.7			69.9			**Min**	**Max**
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, $f(x) = (exp[-mu] \times mu^x)/x!$, 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.5-5. 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, $f(x) = (\exp[-mu] \times mu^{x})/x!$, 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.6-1. 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] 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.6-2. 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

	Niagara Falls, NY	Poughkeepsie, NY
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] 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].

[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 (Occupational + Transportation)		**Minimum Total[a]**	1 in 4	2.1×10^{-1}	NA	NA	NA	NA
		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.

OU-2 Areas	Remedial Action Alternatives		Occupational Risk: Chance of Fatality	Occupational Risk: 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