FEASIBILITY STUDY REPORT
Harbor-At-Hastings Site
Hastings-On-Hudson, New York

Shaw Environmental and Infrastructure, Inc. Project 806938

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Acronym List

AERL	ARCO Environmental Remediation L.L.C
ALPHA	Alpha Environmental Consultants, Inc.
ARAR	Applicable or Relevant and Appropriate Requirement
ARCO	Atlantic Richfield Company
ASP	Analytical Services Protocol
AST	Above Ground Storage Tank
ASTM	American Society for Testing and Materials
bgs	Below Ground Storage
C&D	Construction and Demolition
CAA	Clean Air Act
CEC	Cation Exchange Capacity
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLP	Contract Laboratory Program
cm/s	Centimeters per Second
COPC	Chemicals of Potential Concern
CWA	Clean Water Act
DNAPL	Dense Non-Aqueous Phase Liquid
DOT	Department of Transportation
DV/DUA	Data Validation / Data Usability Assessment
ECL	Environmental Conservation Law
EEMC	Eldon Environmental Management Corporation
EPT	Exploration Production Technology
FD	Field Duplicate
FDGTI	Fluor Daniel Groundwater Technology Inc.
FS	Feasibility Study
ft/s	Feet per Second
ft^3/s	Cubic Feet per Second
GC/MS	Gas Chromatography / Mass Spectroscopy
gmp	Gallons per Minute
GMS	Groundwater Modeling System
Golder	Golder Associates, Inc.
GRA	General Response Action
GTI	Groundwater Technology Inc.
HASP	Health and Safety Plan
HDPE	High-density Polyethylene
HI	Hazard Index

IRM	Interim Remedial Measure
ITS	Interek Testing Services Environmental Laboratory
LCS	Laboratory Control Sample
LDR	Land Disposal Restriction
LNAPL	Light, Non-Aqueous Phase Liquid
MCL	Maximum Contaminant Level
mg/l	Milligrams per Liter
MS/MSD	Matrix Spike/Matrix Spike Duplicate
MSL	Mean Sea Level
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NIST	National Institute of Standards Technology
NOAA	National Oceanic and Atmospheric Administration
NWC	Northwest Corner
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
NYSDOS	New York State Department of State
O&M	Operation and Maintenance
^{o}F	Degrees Fahrenheit
OSHA	Occupational Safety and Health Administration
OU	Operable Unit
PAH	Polynuclear Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PHC	Petroleum Hydrocarbon Compound
PID	Photo Ionization Detector
ppb	Parts per Billion
ppm	Parts per Million
PRAP	Proposed Remedial Action Plan
PRG	Preliminary Remediation Goal
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RA	Risk Assessment
RAO	Remedial Action Objective
RBC	Risk-Based Concentration
RCRA	Resource Conservation and Recovery Act
RfC	Reference Concentration
RI	Remedial Investigation
ROD	Record of Decision

RPD	Relative Percent Difference
SCG	New York State Standards, Criteria, and Guidelines
SDWA	Safe Water Drinking Act
Shaw E&I	Shaw Environmental & Infrastructure, Inc.
SPL	Separate Phase Liquid
SSL	Soil Screening Levels
SSP	Supplemental Sampling Plan
SSR	Supplemental Sampling Report
STL	Severn Trent Laboratories, Inc.
SVOC	Semi Volatile Organic Compound
TAGM	Technical and Administrative Guidance Memorandum
TAL	Target Analyte List
TCDD	Tetrachlorodibenzodioxin
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
TDS	Total Dissolved Solid
TOC	Total Organic Carbon
TOGS	Technical and Operational Guidance Series
TSCA	Toxic Substances Control Act
USCS	Unified Soil Classification System
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VOC	Volatile Organic Compound
WES	Waterways Experiment Station

1.0 INTRODUCTION

The objective of this report is to identify potential remedial technologies applicable to the Harbor At Hastings Site (Site) and site contaminants, preliminarily evaluate the technologies for their appropriateness and finally to compare the technologies against one another using seven (7) evaluation criteria with the end result of remedial action selection. It is noted that this site presents significant remedial challenges due to difficult site conditions combined with the nature of site contaminants. These factors are discussed below:

- Site Conditions Influencing Selection of Remedial Action Alternatives: The most significant site conditions that influence remedial alternative selection include:

    1. The presence of very soft, weak fill and soil underlying the Site. The presence of the soft, weak fill and soils has a direct implication on the structural support systems necessary for excavation, and;
    2. The presence of a very high hydraulic head in an underlying hydrostratigraphic formation that will likely affect the bottom stability of any structure excavated to depth, and;
    3. The presence of dense contaminants at the Fill Unit and upper portion of the Marine Grey Silt Unit formation. These contaminants are currently located at this depth due to the combination of the relatively small pore size of the Marine Grey Silt and the high hydraulic head within the underlying Basal Sand Unit.

The significance of these site conditions has been the concentration of intensive investigation and evaluation by the Atlantic Richfield Company (Atlantic Richfield, and ARCO Environmental Remediation, L.L.C. (AERL, a company contracted by Atlantic Richfield to perform environmental investigations and remediation). In anticipation of the potential for excavation and removal as a selected remedial alternative for this Site, Atlantic Richfield sought the advice of numerous experts with a background in deep excavations in soft, weak soil with upward hydraulic pressures. As a result of this consultation, additional site evaluation and data analysis was conducted, the results of which are summarized in the *Excavation Evaluation Summary Report, Operable Unit #1, Harbor at the Hastings Site, Hastings on the Hudson, New York September, 2002*. (Excavation Evaluation Summary Report). The conclusions of this report and subsequent evaluation by Atlantic Richfield are as follows:

1. Excavation support structures should not be installed into the Basal Sand Unit. As discussed in the RI report, the Basal Sand Unit aquifer underlying the site is currently not

contaminated. Any penetration of the Basal Sand Unit by an excavation support structure has the potential to contaminate this groundwater resource.

2. Due to the high hydraulic pressure exerted by the Basal Sand Unit aquifer, the primary failure mode of excavation is through bottom heave of the excavation floor. Several engineering measures could be used to overcome this failure mode including the use of de-watering techniques to either lower the head in the Basal Sand Unit or increase the head in the Fill Unit or Marine Grey Silt Unit (i.e., flood the excavation). Each of these techniques has the potential to remobilize contaminants.
3. Excavation should be undertaken in the "dry" because of the difficulties associated with the following:

   - De-watering excavation spoils;
   - identification and removal of subsurface obstructions including the numerous former foundation structures/piles;
   - treatment of excavation water with suspended contaminants;
   - inspection and verification of excavation limits;
   - Increased potential for disturbance of existing structures; and,
   - Increased potential for downward contaminant migration along preferential flowpaths along disturbed structures.

The primary contaminants of concern at the Site are polychlorinated biphenyl compounds (PCBs). Under current site conditions, the PCBs are essentially immobile. During remedial action and in particular during excavation and removal activities, the equilibrium condition that currently maintains the PCBs in their relatively immobile state will be altered. When performing actions to increase the depth of excavation: (i.e. alteration of the hydraulic pressures through de-watering and/or flooding of the excavation; the installation of excavation support structures in areas of high PCB contaminant mass; and, removal of foundation structures/piles), the potential to promote contaminant migration to unaffected natural resources (i.e., Basal Sand Unit aquifer or the Hudson River) will increase.

The above discussion provides the basis for three primary site-wide Basic Principles that have a significant influence on the remedial action selection process. These constraints will ensure that remedial actions at the Site can be conducted in a safe construction environment while reducing the potential for the remedy to cause environmental harm to the underlying non-contaminated Basal Sands Unit aquifer or surface water resources. These site-wide Basic Principles are:

1. Excavation will not include flooding: Flooded excavations will result in difficulty in de-watering excavation spoils, difficulty in treating water with suspended contaminants, and difficulty in inspecting and verifying excavation depths/remedial limits. In addition, depending on the flooding requirements to achieve excavation stability, the resultant head variation may re-mobilize PCBs downward through induced piping of groundwater

and/or through direct transport of contaminants along preferential flowpaths created by existing wood pile structures installed through the Marine Grey Silt.

2. Restriction of the placement of excavation support structures into the upper portion of the Marine Grey Silt: The installation of deep excavation support structures in the Basal Sands Unit in the area with observed high PCB contaminant levels will provide a pathway for downward contaminant migration after (as well as during) excavation support installation. As stated above, the selected remedial alternative must be protective of the environment, reduce/eliminate the risk of contaminant migration and protect the unaffected groundwater resources in the Basal Sand Unit.
3. No hydraulic head modification of the Basal Sand Unit. A common excavation construction technique to reduce the risk of bottom heave is to lower the hydraulic pressures in underlying water bearing units. At this Site, the hydraulic head in the Basal Sand Unit is the primary factor in excavation bottom stability. Under "normal" construction (ie an uncontaminated site), lowering the hydraulic head in the Basal Sand Unit through de-watering would allow for a deeper, "dry" excavation by reducing/alleviating the risk of excavation bottom heave. At this Site, however, lowering the head in the Basal Sand Unit will increase the risk of downward PCB migration. This is particularly true in areas where dense Non-Aqueous Phase Liquids (DNAPL) PCBs have been observed. As stated above, the selected remedial alternative must be protective of the environment, reduce/eliminate the risk of contaminant migration and protect the unaffected groundwater resources in the Basal Sand Unit.

These constraints are unique to the site conditions identified through the extensive remedial investigation activities conducted to date and have been developed from the intensive geotechnical investigation and evaluation activities performed as part of the Excavation Evaluation Summary Report undertaken by the Atlantic Richfield Company and attached hereto as **Appendix B**.

1.1 Purpose and Organization of Report

On November 16, 1995, Atlantic Richfield entered into an Order on Consent (Consent Order, site code #3-60-022) with the New York State Department of Environmental Conservation (NYSDEC) to conduct a remedial investigation/feasibility study (RI/FS) at the Harbor-at-Hastings Site (Site). The Site is located at 1 River Road in the Village of Hastings-on-Hudson, New York. This report was developed to satisfy the requirements of the Consent Order for the development of an FS for the Site. The purpose of the FS is to develop and evaluate potential remedial options that reduce, to the maximum extent practicable, potential risk to human health and the environment associated with potential hazards attributable to the release of hazardous substances at the Site.

Prior to entering into the Consent Order with the NYSDEC, Atlantic Richfield retained Golder Associates, Inc. (Golder) to complete the RI/FS work scope at the Site. In October 1995, Atlantic Richfield submitted an RI/FS Work Plan to the NYSDEC, *Remedial Investigation/Feasibility Study Work Plan, Harbor at Hastings Site, Golder Associates, October 1995.* The initial RI field activities commenced at the Site in December 1995 and were completed on March 22, 1996. In June 1996, Atlantic Richfield submitted a Draft RI Report to the NYSDEC followed by a Final RI Report submitted in December 1996, *Remedial Investigation Report, Harbor at Hastings Site, Golder Associates, Inc., December 1996*. For the purpose of this FS report, the RI Report and the field investigation activities performed by Golder, as well as data collected before December 1995, will be referred to as the 1996 RI.

Atlantic Richfield retained Fluor Daniel GTI, Inc., to complete a Draft FS for the Site. In January 1997, AERL submitted the Draft FS to the NYSDEC, *Draft Feasibility Study, Harbor at Hastings Site, Fluor Daniel, Inc., January 1997*. On March 14, 1997, the NYSDEC provided AERL with comments to the Draft FS. In June 1998, AERL submitted a Draft Final FS to the NYSDEC which addressed NYSDEC comments to the Draft FS, *Draft Final Feasibility Study, Harbor at Hastings Site, Fluor Daniel GTI, Inc., June 1998*.

In response to the NYSDEC comments on the Draft Final FS, a supplemental sampling plan (SSP) was presented as Attachment C of the Response to Comments Document for the Draft FS, *Fluor Daniel GTI, Inc., Correspondence, May 1, 1997*. The SSP was developed to provide additional data to support the remedial alternatives presented in the Draft FS. The SSP was executed under multiple phases of investigation from of September 1997 through May 2000. The SSP investigations were successful in characterizing site conditions and no further sampling is planned for the Site.

Due to the extensive new data developed as part of the SSP, it was necessary to update the 1996 RI Report to develop a comprehensive RI Report. AERL retained IT Corporation, Inc. (IT Corporation) to complete the comprehensive RI Report. IT Corporation is the successor organization to Fluor Daniel Environmental Services and Fluor Daniel GTI, which conducted site investigation activities subsequent to the 1996 RI. The Draft Comprehensive RI Report, *Draft Remedial Investigation Report, Harbor at Hastings Site, IT Corporation, July 7, 2000,* was submitted to the NYSDEC for review. The Draft RI contains the data included within the December 1996 RI Report as well as the data and findings of the various SSP investigation efforts. The NYSDEC and the New York State Department of Health (NYSDOH) provided comments to the Draft RI on September 21, 2000. The final RI Report, *RI Report, Harbor at Hastings Site, IT Corporation, October 27, 2000* was submitted to the NYSDEC; the Final RI Report incorporated revisions to address the NYSDEC and NYSDOH comments to the Draft RI.

The October 27, 2000 RI Report was approved by the NYSDEC in correspondence dated November 3, 2000. For the purpose of this FS report, the comprehensive RI Report supercedes the 1996 RI Report and will be referred to simply as the RI Report.

Subsequent to the completion of Supplemental Sampling efforts, new site data was developed and reported in the RI Report. Due to the extensive amount of new data it was necessary to update the Draft FS. Atlantic Richfield retained Shaw Environmental and Infrastructure Inc. (Shaw E&I) to update and expand the Draft Final FS. Shaw E&I is the successor organization to IT Corporation. This Final FS refines remedial alternatives based on the new site data, addresses NYSDEC comments to the Draft FS (NYSDEC, May 30, 2001 Correspondence) and incorporates new PRGs provided within the *Draft Risk Assessment, Harbor at Hastings Site, Environ Corporation, August 31, 2000* (RA Report). This Final FS Report updates and supercedes previous FS Reports.

This Final FS Report focuses the FS objectives on the land mass within the Site boundaries originally presented in the RI Report. It has been prepared in accordance with United States Environmental Protection Agency (USEPA) and NYSDEC guidance documents, including *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA, 1988) and *Technical and Administrative Guidance Memorandum (TAGM), Guidelines for Remedial Investigations/Feasibility Studies, HWR-89-4025* (NYSDEC, 1989). A variety of information was used to prepare this FS Report, including but not limited to the information contained in the RI Report, and the *Draft Risk Assessment, Harbor at Hastings Site, Environ Corporation, August 31, 2000* (RA Report). These documents provide information relative to the nature and extent of chemical constituents at the Site and the potential risk these impacts may present. Additional information on the approach used for the FS is provided in **Section 2.0**. This FS Report contains the following elements:

- **Section 1.0** describes the FS Report's organization and summarizes the data collected as part of the RI and the RA. **Sections 1.2, 1.3, and 1.4** summarize the RI, including Site background and construction information, relevant geology and hydrogeology, nature and extent of contamination, concentration(s) of contaminants present, areas of contamination, and potential transport routes to the environment. **Section 1.5** summarizes interim remedial measures (IRMs) that have been completed or are underway at the Site. Section **1.6** summarizes the baseline RA.
- **Section 2.0** presents the general approach to the FS, including discussions of the New York State Standards, Criteria and Guidelines (SCGs) for site cleanup, the specific approach for evaluating risk-based preliminary remediation goals at the Site, and the remedial action objectives (RAOs). **Section 2.2** discusses the chemicals of potential concern for which remedial alternatives are developed in this FS. **Section 2.3** discusses

potential exposure pathways that are addressed by the assembled remedial alternatives within this FS to protect public health and the environment. **Section 2.4** presents the qualitative and quantitative RAOs developed for the assembled remedial alternatives.

- **Section 3.0** presents the medium-specific general response actions (GRAs) identified for the Site; provides an estimate of the potentially impacted areas and volumes of the Site; and evaluates representative technologies applicable to the Site based on effectiveness, implementability, and cost. **Section 3.1** presents the GRAs, medium-specific actions satisfying the RAOs, typically used to guide the remedial alternative identification and selection process. Technologies and remedial alternatives are identified and evaluated in a three-tiered selection process in **Section 3.2**. Technologies are evaluated relative to specific criteria specified in guidance (NYSDEC, 1989, USEPA, 1988) in **Section 3.3**. Ultimately, one process option from each class of technology type was selected to represent that technology.
- **Section 4.0** develops site-specific remedial alternatives from representative technology process options, evaluates them according to seven specified criteria, compares these alternatives, and provides recommendations for the implementation of appropriate remedial alternatives. In **Section 4.1**, a summary of the technology evaluation is presented. In **Section 4.2**, a detailed description of each series of alternatives is presented. In **Section 4.3**, the retained alternatives are subjected to a detailed analysis by seven specific criteria: 1) Compliance with SCGs, applicable or relevant and appropriate requirements (ARARs) and Other Regulations; 2) Overall Protection of Human Health and the Environment; 3) Short-Term Effectiveness; 4) Long-Term Effectiveness; 5) Reduction of Toxicity, Mobility, and Volume; 6) Implementability; and 7) Cost. In **Section 4.4**, a comparative analysis of the alternatives is presented.
- **Section 5.0** presents the remedial alternative selected as the most appropriate method for remediating the Site.

1.2 Site Background

1.2.1 Site Description

The Site is approximately 15 miles north of New York City at 1 River Road, Hastings-on-Hudson, Westchester County, New York **Figure 1-1**. The total Site area includes approximately 28 acres and consists of man-made fill material (fill) placed on the east bank of the Hudson River. The Site is bounded by the Hudson Valley Health & Tennis Club (former Tower Ridge Yacht Club) to the north, the Metro-North Commuter Railroad to the east, the Tappan Terminal (Mobil Oil Company and the former Zinsser & Co. Inc.) to the south, and the Hudson River to the west **Figure 1-2**. The Site surface is covered by large buildings and pavement (both asphalt and concrete), with relatively small areas of gravel-covered fill present without paving. Timber pilings, rip-rap bulkheads, dock platforms, and two barge slips comprise the western boundary of the Site along the Hudson River. The Site, and the properties to the north, are accessed by crossing the Metro-North Commuter

Railroad on a double-lane bridge near the Site's northeast corner. The Site's surface elevation ranges from approximately 1 foot above mean sea level (MSL) to approximately 8 feet above MSL with the exception of the access bridge which has an elevation of 29 feet above MSL.

1.2.1.1 Subsurface Structures

Except for a few small discrete areas, over 90% of the Site is covered with buildings, building foundation slabs, and/or asphalt and concrete pavement. Buildings currently cover approximately 41% of the Site. Open areas, paved areas, former building slabs, dock structures, and bulkheads cover the remainder. Many, if not all, of the building foundations consist of a complex network of piles and pile cap foundations. The network of bulkheads and dock structures exists along the Site's shoreline. The bulkheads are believed to have been constructed in intermediate stages (both outward into the river and along the river) using a variety of configurations. Docks supported by piles over open water and/or fill also exist along the river, especially north of Building 15. Hundreds of piles have been driven through the fill material and underlying Marine Grey Silt Unit into the Basal Sands Units to support the buildings, bulkheads, and docks. As a result, the Basal Sands Units have been referred to as "bearing sands" in certain historic reports. Historic maps and aerial photography (1926, 1956, and 1976) showing the location of piles and historical features at the Site (docks, boat slips, etc.) are included as **Figure 1-3**.

The existing surface and subsurface structures at the Site severely limit physical access to the subsurface over the majority of the Site area, especially on the western property boundary, along the Hudson River. This was confirmed by numerous refusals encountered during the installation of many borings during the RI sampling activities and during construction of the bulkhead anchor wall along the southern shoreline of the property.

1.2.1.2 Site Geology

The Site is composed of man-made fill that lies above a Marine Grey Silt Unit. The silt lies above Basal Sands Units, which are underlain by bedrock. A cutaway diagram **Figure 1-4** depicting the geologic formations underlying the Site has been prepared based on the interpretation and compilation of boring information and data collected during the RI. Descriptions of each of the geologic units in order of descending depth are as follows:

Man-Made Fill

The thickness of fill ranges from approximately 10 feet to 20 feet on the Site's eastern boundary to approximately 20 feet to 40 feet along the Site's western boundary. The fill is black to brown in color and varies in composition. The fill material is best characterized as moderately permeable (on the order of $1x10^{-3}$ to $1x10^{-5}$ centimeters per second (cm/s)) silt, sand, and gravel mixed with shell fragments, brick, concrete, stone, timber, ash, cinder, coal, slag, and other debris. The man-made fill appears more consolidated in its upper 10 feet based on lithologic blow count data.

Marine Grey Silt Unit

The Marine Grey Silt Unit comprises the youngest naturally occurring geologic unit at the Site, and underlies the man-made fill. The Marine Grey Silt Unit can be described as soft, plastic, low-permeability (on the order of $1x10^{-5}$ to $1x10^{-7}$ cm/s) silt to clay with shell fragments. The silt is not subject to fracturing and becomes increasingly dense and less moist with depth. The Marine Grey Silt Unit ranges in thickness from approximately 10 feet on the Site's eastern side to approximately 40 feet on the Site's western side and acts as an aquitard to the deeper confined groundwater system within the Basal Sands Units.

Basal Sands Units

The Basal Sands Units are medium to dense, grey and brown coarse sands and coarse gravels, with laterally discontinuous red silts, clay laminations, and trace shell fragments. In some areas, a stiff red clay underlies the sand and is in direct contact with the underlying bedrock. The Basal Sands Units vary in thickness from about 10 feet in the Site's east portion to over 70 feet thick in the Site's west portion and are expected to generally thicken towards the west (towards the axis of the Hudson River valley). The Basal Sands Units unconformably overlie crystalline bedrock at the Site.

Bedrock

Based on previous data, bedrock underlying the Basal Sands Units can be described as a gneiss and schist, and is most likely the Yonkers Gneiss of Proterozoic age (Dolph Rotfeld, 1976). The top of bedrock at the Site occurs at depths ranging from approximately 50 feet below MSL in the Site's east portion to 100 feet below MSL in the Site's west portion, and is generally more shallow in the Site's northern portion than in its southern portion.

1.2.1.3 Surface Water

The Hudson River is approximately 4,700 feet wide at the Site with a maximum depth of about 50 feet at midstream. Throughout the tidal reach, the Hudson River is considered a drowned-river estuary with a mean bed slope of 0.0002 foot/foot and mean tidal range of 5.5 feet. Within the transition zone under normal inflow and tidal conditions, chloride concentrations are typically greater than 3,000 milligrams per liter (mg/l, or parts per million, ppm) at Hastings-on-Hudson. Measured tidal flow is approximately 400,000 cubic feet per second (ft^3/s), equivalent to 179,520,000 gallons per minute (gpm) at Tellers Point Ossining, approximately 15 miles upstream of Hastings-on-Hudson (1996 RI). The river currents vary from about 1.3 knots (equivalent to 2.2 feet per second, ft/s) on the flood tide (flowing upstream) to about 1.7 knots (2.9 ft/s) on the ebb tide (flowing downstream). Depending on wind direction and velocity, up to 5-foot-high waves are generated on the river, with the wakes of passing vessels up to 2.5 feet. During the winter, ice flows can pack up along the river's eastern shore with a strong west wind (1996 RI). The Site is within the floodplain of the Hudson River. Most of the Site falls within the 100-year flood zone, with the remainder within the 500-year flood zone (1996 RI).

1.2.1.4 Site Hydrogeology

The subsurface data collected during the RI and during the historic investigations demonstrate that the Site's hydrogeologic regime consists of a shallow, surficial fill water system, a Marine Grey Silt Unit aquitard; and a deeper, confined groundwater system within the Basal Sands Units and bedrock. It is recognized that from the perspective of NYSDEC all water in subsurface materials is considered groundwater. However, this Feasibility Study Report makes a distinction between the water within the man made fill, and the water within the Basal Sand, to provide the reader with an understanding of the unique characteristics of the Site and water quality within each of these units. Fill water originates from infiltration of precipitation into and through the land surface (surficial soil and fill materials) east of the Site and flows westward through the fill toward and discharging to the Hudson River. Infiltration of precipitation into and through on-site fill is expected to be minimal because over 90% of the land surface is covered by buildings and pavement. The fill water is first encountered at depths ranging from 2 feet to 8 feet below ground surface (bgs) and is influenced by tidal fluctuations of the Hudson River along the Site's western portion. The hydrogeologic testing conducted as part of the RI indicated that tidal fluctuations may cause a reversal of flow such that river water may flow into portions of the Site during high tide. More recent groundwater modeling did not confirm that flow reversal was occurring on-site. Based on the fill composition (brick, slag, wood, and chemical constituents believed to be partially or solely a result of the nature of the fill material itself), the fill water is not currently or likely to ever be a viable potable water source.

The deeper confined hydraulic system within the Basal Sands originates east of the Site along and above the hillside. The Marine Grey Silt Unit causes confined conditions within the deeper hydraulic system that exhibits higher heads than the fill water due to recharge of the groundwater system at higher elevation (on the hillside). The higher heads within the deeper hydraulic system apparently result in a westerly flow within the Basal Sands and an upward vertical gradient. It is noted that in portions of the Site, the hydraulic head in the Basal Sands Unit is above ground surface. It has been confirmed that artesian conditions and groundwater elevations within the Basal Sands Unit are directly influenced by changes in the elevation of the Hudson River. It has also been determined that the artesian conditions vary depending on the area of the Site where monitoring is conducted. This was confirmed by artesian conditions noted in deep monitoring wells that were screened in the Basal Sands. Under natural conditions, the potential downward movement of site-related constituents in fill water is prevented by the presence of the Marine-Grey Silt Unit aquitard and the strong upward (artesian) hydraulic gradients.

1.2.2 Historic and Current Land Use

Prior to 1850, the Site land mass shown on **Figure 1-2** did not exist. From about 1850 through the 1910s, the Site was progressively filled behind a series of bulkheads, in an east to west direction, into the Hudson River. According to records showing the dates of existing foundations (Olko, 1988), the construction of the Site's land mass, as it exists today (with the exception of small areas in the Water Tower area and the Northwest Corner), was completed prior to 1920.

Available documents indicate that the Site has been used as an industrial facility by various owners for more than 120 years. Different site owners constructed a number of buildings at different times during this period. A detailed description of the site history based on a review of available insurance maps and aerial photographs is provided within the RI Report.

On September 23, 1998, AERL purchased the Site from Harbor at Hastings Associates. Currently, the Site's southern portion is an open area covered with pavement and concrete building slabs (Buildings 5A, 5B, 5C, 6, 7, 10, 10A, 13, 14, 78 and three smaller support buildings were demolished during the Fall of 2000 and the Spring of 2002). The Site's central and northern areas house both unoccupied buildings and several industrial and commercial businesses. These businesses include an auto body repair shop, and a trucking business. Subsequent to repurchasing the Site in 1998, AERL has conducted RI activities and completed several IRMs. Additional details of the RI and IRM activities are presented in the RI Report and subsequent sections of this FS Report.

1.3 Nature and Extent of Site-Related Constituents

1.3.1 Site Investigation Summary

To date, eleven (11) Site investigations have been completed, yielding a comprehensive characterization of the Site's physical and chemical conditions. These include eight (8) historic Site investigations, the Site investigation activities conducted by Golder as part of the 1996 RI, the supplemental sampling activities performed from 1997 through 2000, and the Geologic / Hydrogeologic Investigation completed in October 2001, reported in both the *Peer Review Summary Report, IT Corporation, November 30, 2001* (Peer Review Summary Report) and the Excavation Evaluation Summary Report. With the exception of the October 2001 data, all the data collected as part of each of these investigations were compiled and summarized in the RI Report. The chronology and objectives of the various Site investigations are also presented as part of the RI Report. Specific details with respect to each of the Site investigation work scopes are presented in the referenced work plans. The data collected as part of the RI investigation are detailed below, and encompass all of the validated data collected during the Site investigations.

1.3.2 Hudson River Investigation

AERL conducted an investigation in the Hudson River in summer 1998 to further define the vertical and horizontal distribution of Polychlorinated biphenyls (PCBs) in the river sediments, as well as the geology beneath the river. The investigation was conducted in three (3) phases and the sampling results were submitted under a separate cover from the Supplemental Sampling Report (SSR) (*Fluor Daniel GTI, Inc., Correspondence, November 13, 1998*). The three (3) phases of the river investigation reported the presence of PCB impacts to Hudson River sediments. Based on the presence of other contributing upgradient sources of PCBs and to facilitate the completion of RI/FS activities, the NYSDEC separated the Site into two separate operable units (OU). The Site land mass is referred to as OU#1 and the area of the Hudson River near the Site is referred to as OU#2. In 1999, The NYSDEC issued a State Superfund Work Assignment for the completion of an RI/FS for OU#2. The Hudson River Investigation results will be included in a NYSDEC RI/FS Report for OU#2 and will not be discussed within this document.

1.3.3 Remedial Investigation Summary

The RI Report provides a single reference document for Site data collected prior to December 1995 as part of the historical Site Investigations, Site data collected during the 1996 RI, and Site data collected during the more recent SSP Site investigations.

During the RI, fill/silt samples, fill water samples, and groundwater samples were collected and analyzed according to the approved work plans and the associated addenda to evaluate and define Site conditions. Samples were collected across the Site and beneath buildings. A total of 237 soil borings, 17 monitoring wells, 25 temporary piezometers, and 18 recovery wells were used to generate data for the RI Report. A total of 895 fill/silt samples, 44 fill water samples, and 2 groundwater samples were collected and analyzed (for various parameters) from this network of borings/wells. Aquifer testing and geotechnical testing were also performed to further evaluate Site characteristics. A variety of analytical tests were completed on the samples to help define the nature and extent of chemical constituents. Computer modeling was also incorporated into the Site investigation methodology to evaluate the potential for migration of the chemicals and media of potential concern including light, non-aqueous phase liquid (LNAPL) in the vicinity of the Water Tower.

The results of the RI field activities are summarized below. Additional details are available in the RI Report.

1.3.3.1 Fill/Silt Sampling

The chemical and physical attributes of surface and subsurface fill and silt were characterized by the collection of 895 fill/silt samples during the RI. Laboratory analyses were performed on the fill/silt samples as part of the RI. The results of these analyses are as follows:

- PCBs were detected in 619 of the 849 fill/silt samples. Where detected, the total PCB concentrations range from 0.018 ppm (sample SB-118, 6 feet to 10 feet bgs) to 381,000 ppm (sample DB-20, 12 feet to 14 feet bgs). Generally, the most elevated concentrations are associated with a rubbery matrix or a liquid rubbery matrix which likely represents a weathered form of the original PCB product used in the former manufacturing process. 522 of the 849 samples had total PCB concentrations of less than 10 ppm. The primary PCB mixture detected is Aroclor 1260, with several detections of Aroclor 1254 in the Site's southern portion and Northwest Corner. PCB concentrations in fill are depicted in **Figure 1-5**.
- PCB impacts were found primarily in five Site areas: The Northwest Corner, the Water Tower area (including the former north boat slip), the area of Building 72A, the southwest corner, and the southeast corner. With the exception of the Northwest Corner and the area of the former north boat slip, PCBs have been found at generally shallow

depths (<10 feet bgs). The shallow PCB impacts were identified in areas historically used for the storage of various materials.

- The most elevated PCB concentrations are found in a segregated fill sample used to characterize the rubbery matrix in the Northwest Corner (DB-20 at 381,000 ppm total PCBs). High concentrations are generally associated with a rubbery matrix or liquid rubbery matrix (PCBs). The PCB-containing materials are typically found as a DNAPL at the interface of the fill and the Marine Grey Silt Unit (**Figure 1-6)**. The presence of PCB-containing materials in the Northwest Corner is believed to be a result of historic PCB storage and mixing in this area. Based on the physical characteristics and the depth of deposition of the rubbery matrix, as well as current knowledge of historic site operations, it appears that a historic deposit of less-viscous PCB-containing materials moved vertically downward as a PCB/solvent mixture. The further migration of the PCB/solvent mixture appears to have been halted at the fill/Marine Grey Silt interface due to the limiting pore size of the silt unit and the high hydraulic head in the underlying Basal Sands Unit. Varying degrees of degradation of the solvent component of the mixture occurred, forming the rubbery matrix and the liquid rubbery matrix materials. Site observations and testing revealed that the solvent components of the liquid rubbery matrix volatilize rapidly when exposed to air to form the rubbery matrix. The liquid rubbery matrix appears to be a viscous form of PCB/solvent mixture. The rubbery matrix is classified as a solid and will not flow or migrate under current hydraulic conditions and at ambient subsurface temperatures and pressures. Laboratory measured viscosities for the liquid rubbery matrix ranged from 51, 680 cP at 50^{o} F to 395.1 cP at 140^{o} F. These viscosities are many times greater than compounds usually considered mobile in porous media as summarized in the following table:

Viscosity Comparison		
Compound	Viscosity cP	Temperature ^{o}F
Water	1	68
Gasoline	0.45	68
# 2 Fuel Oil	5.92	68
# 6 Fuel Oil	150	100
Liquid Rubbery Matrix	19,590	70

  Since the rubbery matrix is now a solid and the liquid rubbery matrix is highly viscous, future migration of the PCB-containing materials is unlikely under current conditions.

  Refer to **Section 6.4,** (PCB Containing Material Migration Assessment) of the RI Report for additional information and a thorough discussion of PCB containing material migration.

- The presence of rubbery matrix PCB-containing materials in the former north boat slip area is likely the result of the relocation of fill containing the rubbery matrix. The rubbery matrix in this area has the same visual characteristics as the rubbery matrix in the Northwest Corner, and is not subject to migration under current conditions.

- Metals including zinc, copper, lead, arsenic, and beryllium were detected in a majority of the fill samples collected throughout the Site. The Site was constructed of fill containing coal, ash, cinders, brick, stone, cement, timber, slag, and other debris. Concentrations of many of the metals were detected at random depths across the Site, suggesting that their presence is partially a result of Site filling, and that they are inherent in the fill. Reportedly, the historic Site operations included the manufacturing of a variety of metal products that may have contributed to the concentrations of various metals detected in the fill. Zinc and copper were detected most frequently and are widespread both vertically and horizontally in the fill. The most elevated concentrations of lead are found in several shallow fill samples, however, the locations where they were detected are also distributed randomly across the Site. A consistent correlation between the concentrations of the metal analytes (copper, zinc, lead) at specific depths in the fill to potential source areas was not identified. The distribution of lead at the Site is depicted in **Figure 1-7**.

- Semivolatile organic compounds (SVOCs), primarily polynuclear aromatic hydrocarbons (PAHs), were detected in 137 of the 145 fill/silt samples. The PAHs are widespread throughout the Site both vertically and horizontally. SVOCs/PAHs were observed at significant depths below the fill water table in many locations. The inspection of fill samples noted the presence of coal and ash to depths of 34 feet. The source(s) of the SVOCs/PAHs are believed to be from original materials contained within the fill placed at the Site. Two of the PAHs, benzo(a)pyrene and dibenzo(a,h)anthracene, exceeded NYSDEC Technical and Administrative Guidance Document 4046 (TAGM 4046; NYSDEC, 1994) guidance values more frequently than other PAHs. The distribution of these compounds in fill is shown in **Figures 1-8** and **1-9**.
- Relatively low concentrations of VOCs were detected in fill/silt samples at the Site. The source of the low levels of VOCs in the fill/silt samples is likely a result of the fill materials or possibly historic site operations.
- Chlorinated dibenzofurans and dioxins were detected in the seven samples collected on-site and from the two off-site background locations. The on-site locations were deemed potential “worst case” since they were collected in areas of former incinerators. Dioxins were detected in the same locations as elevated PCBs at SB-141, SB-142 and SB-143. NYSDEC TAGM 4046 presents a recommended soil cleanup objective for the protection of groundwater and an allowable soil concentration for the 2,3,7,8 – tetrachlorodibenzo-p-dioxin (2,3,7,8 TCDD) compound. The concentrations of 2,3,7,8 TCDD detected at the Site ranged from 0.000001 ppm in SB-139 to 0.0003 ppm in SB -145. None of the samples collected on-site exceed the TAGM 4046 guidance values.
- Petroleum hydrocarbons (PHC’s) were detected in all 30 fill/silt samples collected during the RI. The most elevated concentrations of total PHCs were found in the Northwest Corner, the Water Tower area, south of Building 15, and west of Building 10C. Because of the widespread distribution of PHCs and detection at depth below the fill water table, the source(s) of PHCs are unclear, and may be from the historical filling, historical site operations, or a combination of the two.

1.3.3.2 Fill Water

The fill water from an array of 14 monitoring wells across the Site was sampled during the RI. Filtered and unfiltered samples were collected from several wells during multiple sampling events. Laboratory analyses were performed on both the filtered and unfiltered samples. Results are summarized below:

- PCBs were only detected in filtered fill water samples from monitoring well MW-12. PCBs are characterized by low solubility, and high organic carbon adsorption. The lower concentrations of PCB concentrations in filtered water samples as compared to unfiltered water samples indicate that the PCBs are attached to particulate in the fill water. It should also be noted that the well location where PCBs were detected in the filtered fill water samples (MW-12) is a well location where the liquid rubbery matrix was identified as a separate phase.
- A total of 44 filtered and unfiltered samples (22 filtered and 22 unfiltered) were collected and analyzed for Target Analyte List (TAL) metals or copper and/or lead. Several metals (calcium, magnesium, manganese, potassium, and sodium) showed little to no change by filtering which is typical for these soluble salts. The concentrations of antimony, arsenic, barium, copper, lead, and zinc revealed significant reductions after filtration. The constituents detected in unfiltered samples are likely to be a function of the presence of suspended particulate matter collected in the unfiltered fill water, since these constituents were generally not detected in the corresponding filtered samples.
- Fill water samples were collected from monitoring wells MW-1A, MW-2A, MW-3A, MW-4 through MW-8, and MW-12 and analyzed for SVOCs. Benzo(a)pyrene was detected in unfiltered samples from monitoring wells MW-1A, MW-5, MW-6, MW-8, and MW-12. Dibenzo(a,h)anthracene was detected in the unfiltered sample from MW-6. Only one filtered sample contained concentrations of benzo(a)pyrene (MW-12). Dibenzo(a,h)anthracene was not detected in filtered samples. SVOCs/PAHs have low aqueous solubilities and exhibit a high tendency for adsorption onto organic matter, such as the high organic carbon content in the fill. Significant reductions in SVOC concentrations occurred after filtration. The majority of the SVOCs detected are not believed to be dissolved in the fill water, but rather are adsorbed onto particulate collected along with the fill water samples.
- Nine (9) unfiltered samples were collected and analyzed for VOCs. VOC compounds were detected in monitoring wells MW-3A and EEW-1. Methylene chloride and chloroform were detected in MW-3A at low estimated concentrations. Both concentrations were below the standards presented for these analytes in the Division of Water Technical and Operational Guidance Series (TOGS 1.1.1) Ambient Water Quality Standards and Guidance Values guidance. Three (3) VOCs (1,1,1-trichloroethane; 1,1-dichloroethane, and 1,1 dichloroethene) were detected in EEW-1 at concentrations of 89 parts per billion (ppb), 12 ppb, and 2 ppb, respectively. The TOGS guidance value for all three analytes is 5 ppb. VOCs were not detected in any other fill water samples.
- PHCs were detected in three (3) fill water samples at concentrations ranging from 1.8 ppb to 7.7 ppb. A guidance value for these compounds was not identified in TOGS guidance.

1.3.3.3 Basal Sands Unit Groundwater

Confined groundwater quality at the Site was studied during the RI via the collection and analysis of two primary samples; one from each of the monitoring wells installed and screened within the Basal Sands Unit. The results of the sample analyses are summarized below:

- VOCs were detected at low levels (7 ppb) in one of the two wells and PHCs were detected at low levels in both wells. These results likely reflect impacts originating within the confined groundwater recharge area east of the Site.
- SVOCs and PCBs were not detected in the confined groundwater.
- Certain inorganic analytes were detected in the confined groundwater samples (iron, manganese, calcium, magnesium, potassium, and sodium). Filtering the groundwater samples significantly reduced concentrations of some of the metals (up to two orders of magnitude). Many of the metals were removed below the method detection limits ("non-detect") by the filtration process. Due to the Marine Grey Silt Unit acting as a confining layer and the artesian conditions observed in the Basal Sands, the analytes detected in these groundwater samples are believed to be naturally occurring and unrelated to the Site.

Based on the above information, it is concluded that the Basal Sands groundwater has not been impacted by former site activities and site compounds of potential concern.

1.3.3.4 Light Non-Aqueous Phase Liquid

LNAPL was observed in two different Site areas during the RI field activities and during unrelated Site maintenance work. The first area where LNAPL was identified is in the Water Tower area, specifically in the vicinity of former 100,000-gallon above-ground storage tanks (ASTs) south of Building 57 and west of Building 51. The second area is near the western side of Building 79A.

Water Tower Area

A measurable thickness of LNAPL was detected in the Water Tower area in a monitoring well south of Building 57, near the former 100,000-gallon ASTs. Golder confirmed the presence of LNAPL in this area during the 1996 RI. An LNAPL sample revealed that it is indicative of a highly degraded fuel oil and contains PCBs. To further delineate and recover the LNAPL identified in the Water Tower area, an IRM work plan was submitted to the NYSDEC in December 1997 (*Interim Remedial Measure Work Plan, Separate Phase Liquid Recovery, ARCO, Harbor at Hastings Site, Fluor Daniel GTI, December 1997)*. Implementation of the work plan has been successful in the recovery of approximately 336 gallons of oil as of August 7, 2002. As of September 2002, recovery operations remain in effect and continue to be successful in LNAPL reduction in the Water Tower area. Additional discussion of LNAPL migration potential is included in **Section 1.4.4**.

Building 79A

The maximum thickness of LNAPL detected in the area of Building 79A was 0.51 feet and was noted in temporary piezometer IT-2. A measurable thickness of LNAPL was not detected in any other piezometer. LNAPL delineation through the use of 11 temporary piezometers limited

LNAPL to the Northwest Corner of Building 79A. The LNAPL does not contain PCBs above the analytical method detection limit of 1 ppm. The temporary piezometers were removed on March 30, 2000. Installation of another temporary piezometer (IT-11) adjacent to IT-2 for LNAPL sample collection did not identify LNAPL in this area. IT-11 was monitored for LNAPL presence throughout 2000 during multiple tide stages. LNAPL was not identified during any of these visits. Monitoring of IT-11 continued through September 2002 to confirm the absence of LNAPL in the area.

1.4 Migration Potential Summary

Review of the site investigation data revealed that there are several chemical constituents of concern within the fill and the fill water at the Site. Generally, the potential for the migration of site related constituents is low under current Site conditions. The migration potential of specific chemicals detected during the RI is discussed below.

1.4.1 PCBs

1.4.1.1 Distribution of PCBs

Northwest Corner

The most elevated concentrations and deepest PCB impacts were detected in the Site's Northwest Corner. The Northwest Corner was an area where PCBs may have been mixed and stored during historic site operations. Based on Site investigation data collected to date, the PCB-containing materials handled in that area as part of the historic manufacturing process apparently originally consisted of a liquid mixture of petroleum-based solvents and PCBs. The PCB/solvent mixture was apparently released at grade and moved downward through the fill as DNAPL, impacting fill materials below the fill water table. When the DNAPL migrated through the fill to the horizon of the less-permeable, fine-textured Marine Grey Silt Unit, it accumulated in depressions at the fill/silt interface. Over time, the solvents in the mixture degraded/weathered, leaving a highly viscous material containing high concentrations of PCBs at the fill/silt interface. The most elevated PCB concentrations in the Northwest Corner are associated with the rubbery matrix and lower concentrations of PCBs are adsorbed to the fill. Impacts in the Northwest Corner extend from the ground surface to the depth of the Marine Grey Silt Unit. One isolated area of less-weathered DNAPL exists in the area of monitoring well MW-12.

There was no observation of PCB DNAPL below the fill/silt interface which indicates that its original migration was likely halted by the reduction in the pore size of the Marine Grey Silt Unit as compared to the fill and the influence of the upward hydraulic head from the underlying Basal Sands unit. Based on significant DNAPL research (Kueper and McWhorter, 1991), and our experience, the original DNAPL downward vertical migration likely occurred relatively rapidly under gravity until the small pore space of the Marine Grey Silt unit was encountered. This, combined with the upward hydraulic head of the underlying Basal Sands unit, halted any further migration of the DNAPL. Again, based on significant published literature (McWhorter, Sale 2001) and our experience, it is expected that the DNAPL that currently exists beneath the site will not migrate downward under current conditions, unless the equilibrium that maintains its current immobility is altered.

The most significant potential for alteration of this equilibrium would be the lowering of the underlying Basal Sands unit hydraulic head or increasing the hydraulic head on the DNAPL through the implementation of a flooded excavation. In addition, any construction activity that includes an increase in the number of penetrations through the confining Marine Grey Silt Unit into the un-impacted Basal Sands groundwater resource and/or increases the “pore space” of the Marine Grey Silt along existing structures that penetrates through the unit has the potential to re-mobilize DNAPL vertically downward.

Water Tower Area

The Water Tower area can be divided into three sub-areas: 1) open areas apparently used for storage, 2) areas that were previously open and may have been used for storage and are now covered with buildings, and 3) the north boat slip fill area.

Buildings 52A and 52B were formerly open areas that appear to have been used for storage. Building 52A was constructed between 1940 and 1954 and Building 52B was constructed in 1956. This former open area and the current open areas appear to have historically been used for material storage. The former storage area is east of the north boat slip area and west of Building 52. Material storage may have resulted in a limited release of PCBs onto the fill surface. The area is characterized by shallow PCB impacts and significantly lower PCB concentrations than those found in the Northwest Corner.

Buildings 51, 52, 53, 54, and 57 covered a significant part of the Water Tower area prior to PCB use. Impacts beneath these buildings are generally shallow and of low PCB concentration. The exception is in the west end of Building 51, where an isolated area of PCBs above 10 ppm extends to a depth of approximately 22 feet.

The Water Tower area includes a former boat slip that existed just south of Building 53. Fill was added to the boat slip itself and along the shoreline on either side of the slip over time. PCB concentrations in this area are more elevated, and extend to greater depths, than in the adjacent area used for storage. The rubbery matrix is found in a few locations adjacent to the former boat slip and may be a result of the use of fill material containing the rubbery matrix.

The Central Area

Only very limited PCB impacts were identified in the Site's central area. The PCB concentrations detected were relatively low and were found at shallow depths. Samples collected beneath buildings and in open areas (covered only with pavement) ranged from non-detect to 20 ppm, with the more elevated concentrations detected in borings and samples collected beneath Building 72A. One boring collected from this building had concentrations exceeding 10 ppm to a depth of 8 feet. Rubbery matrix materials were not found in the central area.

Southern Area

With the exception of three (3) samples collected at boring locations EE-01, EE-03, and HB-06, only low-level PCB concentrations were identified in the southern area. Confirmatory sampling performed immediately adjacent to these historic borings did not confirm elevated PCB concentrations in these Site areas. Material storage may have occurred on the immediate southwest corner (analogous to storage in the Water Tower area), where low concentrations of PCBs were identified to depths of approximately 6 feet bgs.

A second area of PCB contamination was identified during the RI in the Site's southeast corner, behind Building 10A and along an abandoned railway spur. PCB concentrations detected in this area were limited to shallow depths, and some samples from this area contained Aroclor 1254. There is evidence that an electrical transformer may have been in use at or near this location.

1.4.1.2 PCB Mobility

Under current conditions, PCBs at the Site have limited mobility, based on the transport modeling completed during the RI. The high organic carbon content of the fill (which averaged approximately 10%) and the low aqueous solubility of PCBs inhibit PCBs from partitioning into the dissolved phase. Detectable concentrations of PCBs were not found in the filtered fill water samples collected in the Site's Water Tower area, central area, or southern area. Comparison of filtered versus unfiltered fill water samples illustrates that PCBs exist in the fill water as adsorbed particulate matter and are not present in the dissolved phase at appreciable concentrations. PCBs were detected in filtered samples collected from MW-12 in the Northwest

Corner; however this is the area where the liquid rubbery matrix was identified as a DNAPL and it is possible that a portion of the DNAPL was included in the sample.

As discussed above, remaining PCB DNAPL in its highly viscous form is currently immobile. The likelihood of re-mobilization is extremely low unless a change in the current site conditions occurs. Site conditions changes that could re-mobilize PCB DNAPL include the lowering of the hydraulic head in the underlying Basal Sands unit, increasing the head in the fill/silt unit through the implementation of a flooded excavation, and the creation of preferential flow paths within the Marine Grey Silt unit through the installation of excavation support structures or along existing structures that are significantly disturbed during remedial construction.

Considerable evaluation of the potential impacts of excavation on PCB mobility and the resultant deleterious consequences to the environment has been undertaken and is provided in the Excavation Evaluation Summary Report, (**Appendix B**).

1.4.2 Metals

Metals are commonly present in the fill across the entire Site. Most of the metal analytes are distributed randomly both vertically and horizontally in the fill, which suggests that these analytes are related to the original composition of the fill material used to construct the Site. Historic site operations consisting of the manufacturing of a variety of metal products may also have contributed to select metals in the fill. The potential migration of metals in fill water is limited by the low solubility of metals and the adsorption of metals to fill particles. The fill at the Site is alkaline (pH of approximately 8), and the alkalinity of the fill minimizes dissolution of metals contained in the Site fill. Filtered vs. unfiltered fill water data illustrate that metals in fill water are primarily associated with suspended particulate matter in samples rather than being dissolved in the fill water.

1.4.3 SVOCs

SVOCs are also distributed randomly both vertically and horizontally across the Site and are concluded to be inherent in the original fill and possibly a result of historic site operations. SVOC mobility in the subsurface is typically controlled by adsorption to organic matter contained in fill and the low aqueous solubility of PAHs. The organic carbon content of the fill on the Site is very high (approximately 10% average) and limits the amount of SVOCs that can remain in solution. Comparison of filtered and unfiltered fill water chemical data illustrates that SVOCs are adsorbed to fill particles and are not present as dissolved phase constituents.

1.4.4 LNAPL

Two isolated areas of LNAPL exist at the Site. The first is south of Building 57 in an area where ASTs were historically located. LNAPL in this area consists of weathered fuel oil, contains PCBs, and is currently being recovered as part of an LNAPL IRM. The second LNAPL area was identified in an excavation west of Building 79A. Installation of temporary piezometers in the area of the excavation identified one location with 0.51 feet of a brown viscous LNAPL. Analysis of the LNAPL revealed that it did not contain PCBs. In another attempt to delineate the LNAPL extent, installation of a new temporary piezometer in the same location resulted in no measurable LNAPL accumulation. Continued monitoring failed to detect additional LNAPL in that area. No visual evidence of LNAPL impact to the river, as a result of the LNAPL present on the fill water table near the Water Tower (Water Tower IRM), has been detected to date. To assess the potential for LNAPL currently observed near the Water Tower to migrate towards and discharge to the river in the future, a multi-phase transport model was prepared. The results of this model, which simulated 10 years of potential migration, indicates that it is unlikely that measurable or detectable quantities of LNAPL will discharge to the river.

1.5 Interim Remedial Measures

Four IRMs were completed and one is ongoing to minimize potential exposures to impacted media at the Site. The IRMs were implemented according to the provisions of Section IV of the Order on Consent for this site (#3-60-022). The five (5) IRMs were initiated in the following areas to meet the listed objectives:

- In 1997, sediment, water, and a thin layer of oil were noted within three sumps and associated trenches within the floor of Building 14. The oil and water were believed to be a result of historic site operations in Building 14. Analytical results for samples of the oil and sediment revealed the presence of PCBs. On November 18, 1997, IRM activities were implemented within Building 14. The three sumps and associated trenches in Building 14 were cleaned of PCB-contaminated materials, backfilled with clean sand and lined with high-density polyethylene (HDPE) to minimize potential hazardous conditions. The IRM effectively removed the PCBs and the Building 14 IRM activities are therefore complete.
- On December 6, 1996, LNAPL was identified on the fill water table in two temporary piezometers south of Building 57 near the Water Tower area. On March 24, 1998, 18 recovery wells were installed in the Water Tower area to further assess the extent of LNAPL and to provide LNAPL recovery locations. On July 15, 1998, a passive recovery system was installed south of Building 57 to recover the LNAPL and reduce the thickness of LNAPL observed on the fill water table. The LNAPL recovery IRM is

ongoing and will continue until the PCBs are addressed by the selected remedial alternative.

- During the assessment of subsurface conditions on the Site's Northwest Corner, elevated concentrations of PCBs were identified in shallow fill. On July 13, 1998, the Northwest Corner was covered with a 6-inch-thick layer of coarse gravel to minimize exposure to PCBs in the fill. A fence was also installed as part of this IRM to prevent access to this area. The restricted access to the Northwest Corner and maintenance of the surface cover material will be continued until the PCBs within the surface soils in this area are addressed by the selected alternative.
- Historically the shoreline along the Site's southern end between the southern boat slip and the Site's southwest corner was protected with a timber and piling bulkhead. An IRM was developed to prevent failure of the wooden bulkhead. Approximately 330 feet of steel sheet-pile bulkhead was installed during summer and fall 2000. The bulkhead was designed and installed to support and protect the Site's shoreline in this area and the bulkhead IRM is considered complete.
- A resinous material was identified near the shoreline adjacent to the Northwest Corner of Building 57, which contained approximately 168 ppm PCBs. This material was removed, placed in drums, and disposed of off site during November 2000. The activities are summarized in a report transmitted to the NYSDEC on December 7, 2000 and the Building 57 IRM is considered complete.

1.6 Risk Assessment

1.6.1 Chemicals of Potential Concern

During the field activities associated with the 1996 RI and the various phases of the supplemental sampling, extensive chemical and physical data were collected from within the Site fill, fill water, Marine Grey Silt Unit, Basal Sands, and confined groundwater system within the Basal Sands. This data is compiled in the RI Report. The data was collected and summarized to thoroughly characterize the nature and extent of chemical constituents in various media at the Site.

During the development of the *Draft RA*, the data were screened to identify chemicals of potential concern (COPCs) from among the chemical constituents detected in samples collected at the Site. The screening process includes, but is not limited to:

- Evaluation and identification of the true mean concentration of each chemical at the Site to determine the concentration appropriate for exposure evaluation over the long term
- Evaluation of data qualifiers to eliminate rejected data or chemical constituents not positively identified

- Averaging of concentrations in field duplicate samples to obtain a representative concentration for the sample location
- Conversion of individual congeners of polychlorinated dibenzodioxins and polychlorinated dibenzofurans to an equivalent 2,3,7,8 – tetrachlorodibenzodioxin (TCDD) concentration
- Use of the most recent fill water data from each fill water monitoring well and use of unfiltered samples (if available)

The chemicals identified through the screening process were retained for evaluation of potential risks within the RA, and are also addressed in the development of RAOs within the FS. Chemicals identified as COPCs were further evaluated in the RA to determine whether they may pose potentially significant risk. Chemicals not identified as COPCs were not evaluated further within the RA because they were not expected to pose potentially significant risks at the Site. It should be noted that the identification procedures for COPCs were designed to be overly conservative, to ensure that no chemicals that may be of potential concern were eliminated from further evaluation. Because of the conservative numerical screening criteria , some of the chemicals identified as COPCs within the RA do not pose potentially significant health risks at the Site. The following sections describe the identification of COPCs for each medium of concern at the Site.

1.6.1.1 Fill

The fill data were compared to the following highly conservative generic risk-based criteria:

- USEPA generic soil screening levels (SSLs) (USEPA, 1996)
- USEPA Region III risk-based concentrations (RBCs) for residential soil (USEPA, 2000)
- NYSDEC recommended soil cleanup guidelines from TAGM 4046 (NYSDEC, 1994).

Thirteen (13) chemicals were identified as COPCs for fill during the screening evaluation. These chemicals included several PAHs, PCBs (Aroclor-1254 and Aroclor-1260), several metals, and dioxin (2,3,7,8 – TCDD). Although not excluded from further consideration, the levels of two of the metals (arsenic and beryllium) are within the typical background levels of soils within the northeast United States (Dragun and Chiasson, 1991). The COPCs for fill material are listed on
Table 1-1.

1.6.1.2 Fill Water

The fill water data were compared to the following risk-based screening criteria:

- USEPA Region RBCs for tap water (USEPA, 2000)
- NYSDEC groundwater quality criteria from TOGS 1.1.1 (NYSDEC, 1994).

Twenty-four chemicals were identified as COPCs for fill water during the screening evaluation. These chemicals included several VOCs, several PAHs, PCBs (Aroclor-1254 and Aroclor-1260), and several metals. The COPCs for fill water are listed on **Table 1-2**.

1.6.1.3 Confined Groundwater

Confined groundwater in the Basal Sands Units was characterized during the RI and did not contain significant concentrations of site-related chemicals. Also, the hydraulic gradient between the Basal Sands Units and the fill at the Site was found to be upward. Therefore, further consideration of COPCs or remedial alternatives for confined groundwater was not included in this FS.

1.6.1.4 LNAPL

The presence of LNAPL near the Water Tower was detected and investigated during the RI. A sample of the LNAPL was analyzed and determined to contain PCBs. An IRM is being completed to remove recoverable LNAPL from the Site. The COPCs within the fill material that may be related to the presence of this material are discussed in **Section 1.6.1.1**; remedial alternatives were developed and evaluated in this FS relative to their ability to achieve the RAOs for these COPCs.

1.6.1.5 PCB Materials

PCB-containing materials detected at the Site were characterized as a rubbery matrix or as a liquid rubbery matrix. The liquid rubbery matrix was found on the Northwest Corner at significant depths (greater than 30 feet bgs) near the interface of the fill and the Marine Grey Silt Unit. In most cases the rubbery matrix was also found at the interface of the fill and the Marine Grey Silt Unit; however, occasionally it was detected at shallower depths within the fill. Both the liquid rubbery matrix and the rubbery matrix were analyzed and determined to contain elevated concentrations of PCBs. The liquid rubbery matrix material was also determined to contain concentrations of several VOCs. Both matrixes may be considered to exceed screening criteria for COPCs; however, due to their limited occurrence and depth below the ground surface, the potential for exposure to these matrices is unlikely. As stated previously, this material is immobile under current/equilibrium conditions.

1.6.2 Exposure Assessment

Potential exposure pathways and receptors were evaluated during the RA for both current use/current site conditions and hypothetical future uses/future site conditions that might exist if the Site were redeveloped. Although plans for Site redevelopment have not yet been established, redevelopment for use as open space, commercial/industrial or residential use, or a combination of these potential uses is possible.

The exposure point concentrations for COPCs in each media associated with the potential exposure pathways are listed in **Tables 1-1** and **1-2**. These exposure pathways are discussed below and are used during this FS to support the evaluation of the overall protectiveness of human health provided by each alternative. The discussion of current site conditions is presented here as a baseline for comparison risk scenarios associated with hypothetical future uses.

1.6.2.1 Current Site Use

For discussion purposes, the Site has been divided into four areas (the Northwest Corner, the Water Tower area, the central area, and the southern area) as depicted in **Figure 1-2**. The Northwest Corner is unoccupied open space. The Water Tower area and part of the central area house three commercial/industrial businesses and the southern area is unoccupied open space. The majority of the Site is currently unused (either open space or empty buildings) with access restrictions in place. As of the date of this document, the buildings that formerly existed on the Site's southern area have been demolished. Crushed building brick and clean crushed stone have been placed within this area to reduce exposure to Site fill material, while the concrete building floors have been cleaned and left in place. The following exposure pathways and receptors were considered during the RA:

Commercial/Industrial Workers: Workers in commercial businesses in the Site's Water Tower area and central area were considered to have no significant potential for contacting fill or fill water. These media are covered with buildings, pavement, and gravel. An unpaved area in the Northwest Corner and along the shore of the Water Tower area (between Building 57 and Building 53) was covered with crushed stone as part of an IRM. The existing pavement, building foundations, and gravel installed as part of the IRM are regarded as an effective means of preventing exposures to the fill or fill water.

Utilities Maintenance Workers: The workers who maintain structures or utilities on the Site were also considered relative to potential exposures to COPCs. Although the number of active utilities is limited on the Site's Northwest Corner and southern area, some intrusive work could be required to maintain or repair active underground utilities in the Site's Water Tower area and central area. It was determined that workers have no significant potential for exposure to the COPCs in the fill or fill water because it is required that all intrusive work be completed in accordance with the requirements of the existing Site Health and Safety Plan (HASP). The HASP requires proper training, monitoring, supervision, and use of appropriate personal protective equipment by maintenance workers when completing any intrusive work scopes. Because HASP procedures prevent potentially significant exposures of these workers under current site conditions, a quantitative assessment of potential exposures of these workers was considered unnecessary during the RA.

Trespassers: The Site's southern portion is unused. Although restricted by fencing, security patrols, and surface cover, the RA conservatively assumed that trespassers could enter this section of the Site. Exposure routes evaluated under this scenario included ingestion of fill, dermal contact with fill, and inhalation of vapor and particulate from fill.

1.6.2.2 Hypothetical Exposures Under Future Land Uses

Plans for Site redevelopment have not yet been established, so the RA evaluated potential exposures to fill and fill water under a range of alternate land uses that included recreational (park scenario), commercial/industrial, and residential. Site redevelopment may include a combination of these uses. The evaluation of future land-use scenarios assumed that all IRMs, buildings, pavement, health and safety planning, and other exposure controls are removed. Clearly, the exposure scenarios evaluated during the RA are not reflective (i.e., would be far more conservative) of future exposures that would occur if remedial actions are taken before Site redevelopment, or if control measures are in place as part of the future use scenario. The actual potential for exposures to COPCs in fill and fill water under a particular redevelopment scenario would depend on the remediation measures implemented and the details of the redevelopment plan.

The potential exposures to fill and fill water under each of the hypothetical future land-use scenarios considered for the Site are discussed below.

Park Visitors: The RA assumed that to develop a park at the Site all buildings, foundations, and pavement will be removed, and a 1 foot layer of topsoil will be placed on-site to facilitate landscaping. This usage scenario could potentially include exposures of park visitors to surface material including topsoil and the underlying 1 foot of fill. Potential routes of exposure for park visitors could include incidental ingestion of fill, dermal contact with fill, and inhalation of vapor and particulate from fill.

Commercial/Industrial Workers: Because the Site is located in the Hudson River's 100-year flood plain, the RA assumed that the ground surface over much of the Site would have to be raised from 0 to approximately 8 feet to reach the 100-year flood plain for new commercial/ industrial construction. However, the RA evaluated the potential for exposures of commercial/ industrial workers through incidental ingestion, dermal contact, and inhalation of vapor and particulate from the existing fill, assuming that such fill is within the top 2 feet of surface material after Site development, even though this particular scenario is extremely unlikely to occur.
Residents: As with the commercial/industrial scenario described above, redevelopment of the Site for residential use was anticipated to require that the ground surface over much of the Site would have to be raised from 0 to approximately 8 feet. However, the RA evaluated the potential for exposures of residents to existing fill, assuming that such fill is within the top 2 feet of surface material after Site redevelopment even though this scenario is extremely unlikely to occur. It was concluded that under this scenario it is possible for residents to be exposed to existing fill through incidental ingestion, dermal contact, and inhalation of vapor and particulate after Site development, assuming the removal of all existing protective conditions.

Risk assessments at some sites may include potential residential exposure to contaminants in soil via consumption of produce grown on the Site. However, such exposures, if they occur at a particular site, are usually less significant than potential exposure to the contaminants via direct ingestion of contaminated soil. For PCBs, dioxins, and dioxin-like compounds in contaminated soil, USEPA analysis shows that the homegrown produce consumption pathway is less significant than the soil ingestion pathway (USEPA, 1994). Since PCBs are the primary COPCs in fill at the Site, the USEPA analysis suggests that the homegrown consumption pathway should be less significant than the direct consumption pathway; therefore, the quantitative assessment of the homegrown consumption pathway was not considered necessary during the RA.

Utilities Maintenance Workers: The RA included a hypothetical scenario that evaluated potential exposures of workers who encountered fill or fill water during maintenance or repair of underground utilities after Site redevelopment for either recreational, commercial/ industrial, or residential use. This potential exposure scenario did not assume that the current Site HASP would remain in effect after Site redevelopment. For this hypothetical scenario, potential routes of exposure during underground maintenance activities would include incidental ingestion of fill, dermal contact with fill, and inhalation of vapor and particulate from fill. Because fill water is generally encountered within several feet of the ground surface, the RA also evaluated dermal contact with fill water. However, incidental ingestion of fill water is expected to be less significant than potential exposures via dermal contact with fill water and ingestion of fill. Quantitative assessment of fill water exposures was therefore not necessary during the RA.

1.6.3 Toxicity Assessment

The toxicity assessment completed in the RA identified potential adverse health effects associated with exposure to the COPCs in fill and fill water, and the dose-response relationship between exposure and the occurrence of the adverse effects. Toxicological information used in the RA is compiled following the USEPA's hierarchy of sources.

Carcinogens

USEPA considers chemicals belonging to the following USEPA cancer weight-of-evidence groups as human carcinogens:

- Group A: Known human carcinogens sufficient evidence of carcinogenicity in humans
- Group B1: Probable human carcinogens limited evidence of carcinogenicity in humans
- Group B2: Probable human carcinogens sufficient evidence of carcinogenicity in animals with inadequate or lack of evidence in humans
- Group C: Possible human carcinogens limited evidence of carcinogenicity in animals and inadequate or lack of evidence in humans

USEPA has designated several of the COPCs at the Site as belonging to one of these weight-of-evidence groups. However, most of those COPCs are designated as Group B2 or Group C, which means that USEPA acknowledges that there is either inadequate or lack of evidence that these COPCs actually cause cancer in humans. Therefore, evaluating the COPCs as human carcinogens is a highly conservative procedure.

Noncarcinogens

EPA considers COPCs as belonging to the cancer weight-of-evidence Group D (not classifiable as to human carcinogenicity) or not designated as belonging to any cancer group to be noncarcinogens. USEPA has derived chronic reference doses (RfDs) for these COPCs, which were used for the characterization of risk performed in the RA. The inhalation RfDs were converted from USEPA–derived chronic reference concentrations (RfCs). The oral and inhalation RfDs represent conservative estimates of the daily exposure to the human population, including sensitive subpopulations. The RfDs and RfCs were used in the RA as conservative toxicity assessment tools.

Dermal Toxicity Values

The USEPA sources of toxicological information listed above do not provide dermal toxicity values for any of the COPCs except PCBs. Therefore, oral toxicity values (i.e., oral cancer slope factors (SFs) and RfDs) are used as dermal toxicity values in the RA.

1.6.4 Risk Characterization

The human health significance of potential exposures to COPCs under current site conditions and hypothetical future use scenarios was evaluated in the RA relative to NYSDOH – developed qualitative descriptors of cancer risks, as follows:

Less than 10^{-6}	Very Low
Greater than 10^{-6}, less than 10^{-4}	Low
Greater than 10^{-4}, less than 10^{-3}	Moderate
Greater than 10^{-3}, less than 10^{-1}	High
Greater than 10^{-1}	Very High

The estimated cancer risk and Hazard Index (HI) for non-carcinogens were also compared to USEPA established levels for determining whether remedial action is warranted under CERCLA. Potential risks from exposure to lead, which are characterized by blood lead levels rather than cancer risks or non-cancer HI, were evaluated relative to conservative USEPA generic screening levels.

Under the current use, workers for the commercial and industrial businesses in the Site's Water Tower area and central area have no significant potential for contact with fill. This is a result of pavement, buildings, and the Northwest Corner IRM effectively preventing significant contact or exposure to COPCs in the fill. Currently, utilities maintenance workers who occasionally may excavate into the fill and fill water also have no potential for exposure to COPCs because they must follow the requirements set forth in the established HASP to ensure worker protection.

Under the current use, the estimated cumulative cancer risk and Hazard Index for all routes of exposure to potential trespassers are lower than 10^{-4} and 1, respectively. The estimated cancer risks for the trespasser exposure scenario is considered very low to low, according to NYSDOH guidelines.

The conclusion of the RA with respect to the hypothetical future Site use, if current exposure controls are removed and no additional remedial actions are taken before Site redevelopment, are as follows:

- For the Site's Northwest Corner and Water Tower area, the hypothetical cancer risk and HI for exposures under the three land use scenarios evaluated are greater than 10^{-4} and 1, respectively. The estimated cancer risks for all the exposure pathways evaluated ranged from low to high, according to NYSDOH guidelines.
- For the southern portion of the Site, the hypothetical cancer risk and HI for exposures under the future park scenario are less than 10^{-4} and 1, respectively. The estimated cancer risks for the exposure pathways evaluated under the hypothetical park scenario ranged from very low to low, according to NYSDOH guidelines. For the future commercial/industrial scenario, the hypothetical cancer risk for high-end exposures is slightly higher than 10^{-4} and the estimated HI is lower than 1. The estimated cancer risks for the exposure pathways evaluated under the hypothetical commercial/industrial scenario ranged from low to moderate, according to NYSDOH guidelines. For the future residential scenario, the hypothetical cumulative cancer risk and HI exceed 10^{-4} and 1 respectively. The estimated cancer risks for the exposure pathways evaluated under the hypothetical residential scenario ranged from low to moderate, according to NYSDOH guidelines.
- In all cases, the principal COPCs contributing to the hypothetical cumulative cancer risk and HI are PCBs. Carcinogenic PAHs also contribute notably to the hypothetical cancer risk in some scenarios. For all future use scenarios the ingestion pathway contributed significantly to the hypothetical cumulative cancer risk and HI; however, for the commercial/industrial use scenario, dermal contact factored equally into the risk calculations.

2.0 REMEDIAL ACTION OBJECTIVES

2.1 General Process

The purpose of this FS is to develop and evaluate alternatives for remedial response actions that may be applicable for the reduction of potential risks to human health and the environment at the Site. This section of the FS describes the development of Remedial Action Objectives (RAOs) for impacted media detected during the RI, and how the RAOs will be used to evaluate potentially applicable remedial alternatives within this FS. The general requirements for this work are described in the *Order on Consent, Site #3-60-022* (NYSDEC, 1995) and relevant guidance, including the NYSDEC TAGM 4030 (NYSDEC, 1990) and USEPA (USEPA, 1988) guidance for developing remedial actions.

RAOs consist of medium-specific (i.e., fill , fill water, confined groundwater, etc) goals for protecting human health and the environment (USEPA, 1988). The process of developing RAOs includes the identification of:

- COPCs at the Site
- Exposure routes and receptors of potential concern
- Critical natural resources associated with the Site
- Qualitative and quantitative goals for COPC cleanup in each medium that may require treatment.

As described in **Section 1.6** of this FS, the *Draft Human Health Risk Assessment* (Environ, 2000) evaluated human health risks from potential on-site exposures to COPCs under current conditions and hypothetical future land-use scenarios. According to USEPA (1988) guidance, RAOs for protecting human receptors should express a remediation goal for COPCs in association with an exposure route (e.g., fill, fill water, etc.), because protection may be achieved by reducing exposure (such as capping an area, limiting access, or providing an alternate water supply), as well as by reducing COPC levels. In addition, the Excavation Evaluation Summary Report discusses protection of Site-related natural resources particularly during remedial construction. The COPCs identified at the Site during the RI Report and Draft RA Report are discussed in **Section 2.2**. The concentrations and spatial distribution of COPCs across the Site were also evaluated in the context of potentially complete exposure pathways and natural resource protection associated with current and hypothetical future land-use scenarios and remedial construction activities. The potentially complete exposure pathways and potential receptors for these land uses are discussed in **Section 2.3**. Natural resource protection related to remedial construction activities is also discussed in **Section 2.3**. Qualitative and quantitative goals for COPC response actions in each impacted media are discussed in **Section 2.4** and include:

- Published NYSDEC SCGs
- Other state and federal ARARs
- Acceptable contaminant levels (preliminary remediation goals, or PRGs) for the protection of human health for the identified site-specific exposure pathways.

PRGs were calculated in the RA that were within USEPA's and NYSDOH's acceptable risk criteria for each land-use scenario. The PRGs will be used during the evaluation of the protectiveness of human health provided by each alternative developed for this FS. Each alternative will be evaluated relative to its effectiveness in achieving these goals by either limiting exposures to media containing COPCs exceeding these numeric criteria, or by removal of and treatment or off-site disposal of the media.

General Response Action (GRAs) are listed in **Section 3.0** for each medium of concern. Each GRA and relevant technology applications will be screened to select the most applicable technologies to meet the RAO for each medium of concern. In **Section 4.0**, site-specific remedial alternatives are assembled and evaluated relative to their effectiveness in addressing the RAOs and identified areas and/or volumes of impacted media. Areas and/or volumes of media impacted with COPCs at the Site that exceed SCGs, ARARs, and PRGs were developed and are discussed in the evaluation of remedial alternatives. **Section 5.0** compares the selected alternative to RAOs, including an evaluation of the overall protection of health and the environment, implementability, effectiveness, and compliance.

A significant consideration in development of GRAs is protection of valuable natural resources that are not currently impacted by Site COPCs. In the case of the Hastings Site, protection of the Basal Sands Unit groundwater, which has not been impacted by Site COPCs, is a critical factor in the development of Site GRAs.

2.2 Chemicals of Potential Concern

Extensive chemical and physical data collected at the Site were screened during the RA to identify COPCs from among the chemical constituents detected in the various media sampled. The following sections list the COPCs for each medium of concern at the Site for which RAOs were developed.

2.2.1 Fill

During the RA, the fill data were compared to highly conservative generic risk-based criteria. Thirteen chemicals were identified through the screening, including:

- Several PAHs
- PCBs (Aroclor-1254 and Aroclor-1260)
- Several metals
- Dioxin (2,3,7,8 – TCDD).

Although not excluded from further consideration, the levels of two of the metals (arsenic and beryllium) are within the typical background levels of soils within the northeast United States. The COPCs for fill material and their potential exposure point concentrations are listed in **Table 1-1**.

2.2.2 Fill Water

Fill water data were compared with conservative risk-based screening criteria and 24 chemicals were identified as COPCs for fill water during the screening evaluation, including:

- Several VOCs
- Several PAHs
- PCBs (Aroclor-1254 and Aroclor-1260)
- Several metals.

The COPCs for fill water and their potential exposure point concentrations are listed in **Table 1-2**.

2.2.3 Confined Groundwater

Confined groundwater in the Basal Sands Units was characterized during the RI and did not contain significant concentrations of site-related chemicals. Also, the hydraulic gradient between the Basal Sands Units and the fill at the Site was found to be upward. Therefore, further consideration of COPCs or remedial alternatives for confined groundwater was not included in this FS.

2.2.4 LNAPL

The presence of LNAPL near the Water Tower was detected and investigated during the RI. An IRM is being completed to remove recoverable LNAPL from the Site. The COPCs within the fill material that may be related to the presence of this material are discussed in **Section 2.2.1**; remedial alternatives will be developed and evaluated in this FS relative to their ability to achieve the RAOs for these COPCs.

2.2.5 PCB Materials

PCB-containing materials characterized by a rubbery matrix and a liquid rubbery matrix were found at significant depths (30 feet or greater) bgs at the Site's Northwest Corner and former north boat slip fill area. The rubbery matrix material was analyzed and found to contain PCBs, while the liquid rubbery matrix material was found to contain PCBs and several VOCs. These materials may be considered to exceed screening criteria for these COPCs; however, due to their limited occurrence, depth below the ground surface, and immobility under current and future Site conditions, the potential for exposure to these matrices is unlikely. Therefore, PRGs were not developed during the RA for these materials.

2.3 Exposure Assessment

Potential exposure pathways and receptors were evaluated during the RA for both current Site use and hypothetical future Site uses. In subsequent sections of this FS, RAOs are developed for each COPC in terms of each potentially complete exposure pathway. In its current configuration, no significant risks were identified at the Site, due either to:

- No significant exposures exist to commercial/industrial workers at the Site's northern portion (referred to as Area 1 within the RA) because this area is covered by buildings or pavement. Similarly, potential exposures to utilities maintenance workers are currently controlled by the Site HASP, which includes training, monitoring, and PPE appropriate to the tasks.

- For potential trespassers on the Site's southern portion (referred to as Area 2 within the RA), a cumulative cancer risk lower than 10^{-4} and Hazard Index (HI) less than one were estimated for all exposure routes evaluated under this scenario, including ingestion of fill, dermal contact with fill, and inhalation of vapor and particulate from fill. The estimated cancer risks for all the exposure pathways evaluated ranged from very low to low, according to NYSDOH guidelines.

Plans for Site redevelopment have not been finalized, so the RA evaluated potential exposures to fill and fill water under a range of alternate land-uses that included recreational (park), commercial/industrial, and residential scenarios. The potential exposures to fill and fill water under each of the hypothetical future land use scenarios considered in the RA were:

- Park visitors: incidental ingestion of fill, dermal contact with fill, and inhalation of vapor and particulate from fill.
- Commercial/Industrial workers: incidental ingestion of fill, dermal contact with fill, and inhalation of vapor and particulate from fill within the top 2 feet of surface material after Site development.
- Residents: incidental ingestion of fill, dermal contact with fill, and inhalation of vapor and particulate from fill within the top 2 feet of surface material after Site development.
- Utilities maintenance workers: incidental ingestion of fill, dermal contact with fill, inhalation of vapor and particulate from fill; and dermal contact with fill water.

Because the estimated cancer risks associated with the current Site use are considered very low to low, the remedial actions developed under this FS address the potential exposure pathways and risks anticipated by the RA for future land-use scenarios. If current exposure controls are removed and no remedial action is taken before Site redevelopment, the RA characterized potential risk associated with future land use as:

- Northern Site portion (Area 1): The hypothetical cancer risk and HI for exposures to fill under all three (3) hypothetical future use scenarios i.e., (the future park, commercial/industrial, and residential scenarios) could exceed 10^{-4} and 1, respectively.
- Central and southern Site portions (Area 2): The hypothetical cumulative cancer risk and HI for all pathways related to potential fill exposures under the future park scenario are lower than 10^{-4} and 1, respectively. The dermal contact and inhalation pathway hypothetical cancer risks would exceed 10^{-6}. The estimated cancer risks for the park scenario ranged from very low to low, according to the NYSDOH guidelines. For potential exposures to fill under the future commercial/industrial scenario, the

hypothetical cumulative cancer risk is slightly higher than 10^{-4} and the estimated HI is lower than 1. The individual exposure pathway cancer risks for the future commercial/industrial scenario would be considered low, according to NYSDOH guidelines. For potential fill exposures under the future residential scenario, the hypothetical cumulative cancer risk and HI exceed 10^{-4} and 1, respectively.

- For both the Northern and central/southern portions of the Site: The hypothetical cancer risk and HI for potential future utilities maintenance worker exposure to fill water would not exceed 10^{-4} and 1, respectively. The estimated cancer risks are considered low based on NYSDOH guidelines.
- For all scenarios: The principal COPCs contributing to the hypothetical cancer risk and HI are PCBs, although PAHs and lead also contribute to a lesser degree.

The exposure pathways and potential risk characterization identified during the RA are used during this FS to support the evaluation of the overall protection of human health provided by each alternative. The discussion of current site conditions is presented here as a baseline for comparison to the risk scenarios associated with hypothetical future Site uses.

2.4 Natural Resource Protection

Protection of the currently uncontaminated Basal Sands Unit groundwater is a significant Site consideration in addition to the human health exposure pathways described above. The primary COPC associated with Basal Sands Unit groundwater protection is the pure-phase PCBs (DNAPL) located at the Fill Unit – Marine Grey Silt boundary. Soluble phase contaminants are not included as COPCs since the groundwater flow direction is upward from the Basal Sands Unit to the Fill and Marine Grey Silt Units at the Site. However, should PCBs be directly introduced into the Basal Sands Unit during remedial activities, significant lateral and potentially off-site migration of PCBs will occur. This is currently not a problem at the Site, as the PCBs are immobile under their current, equilibrium conditions. The protection of the Basal Sands Unit groundwater, particularly during remedial construction when the risk of PCB remobilization is the highest, is the subject of the significant evaluation provided in the Excavation Evaluation Summary Report provided in **Appendix B**. Since the Basal Sands Unit groundwater is currently uncontaminated and a remedial action goal is to maintain this condition, there is zero tolerance for the potential spread of PCBs to this unit.

2.5 Qualitative/Quantitative Cleanup Goals

2.5.1 Basis for Selection of Cleanup Criteria

This section considers the qualitative and quantitative RAOs for Site cleanup. The development of qualitative and quantitative criteria is specified in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) under the Comprehensive Environmental Response Compensation, and Liability Act (CERCLA), (USEPA, 1988) and the regulations and guidance for New York State's Part 375 program for the cleanup of hazardous waste sites. Qualitative and quantitative criteria based on protection of human health in association with hypothetical exposure scenarios were also developed in accordance with USEPA RA guidance. The criteria considered during this FS included:

- Published NYSDEC SCGs,
- Other applicable federal ARARs,
- Acceptable contaminant levels (PRGs) for the protection of human health for the identified site-specific exposure pathways, and protection of the Basal Sands Unit groundwater.

In accordance with USEPA (1988) guidance, RAOs were developed for each medium and potential exposure route. These RAOs are summarized in **Section 2.4.4**.

2.5.2 NYSDEC SCGs; Federal ARARs

Regulations and guidance for New York State's *Inactive Hazardous Waste Disposal Site Remedial Program*, *6 NYCRR Part 375* (NYSDEC, 1992) were promulgated to promote the orderly and efficient administration of Article 27, Title 13 of the Environmental Conservation Law (ECL). The scope, nature, and content of an inactive hazardous waste site remedial program performed in accordance with this statute are to be determined on a site-specific basis. Specifically, Part 375 pertains to the development and implementation of remedial programs under authority of ECL Article 27. Subpart 375-1.10(c)(1) states that “due consideration” must be given to "standards, criteria and guidelines" (SCGs) when evaluating remedial alternatives for Class 2 inactive hazardous waste disposal sites. The regulation states that such “consideration” should be given to guidance “determined, after the exercise of engineering judgment, to be applicable on a case-specific basis” (6 NYCRR 375.1-10(c)(1)(ii)).

These SCGs include both New York State's criteria applicable to cleanup of contaminated media and federal ARARs that may be more stringent than the State's criteria. As part of this

FS, SCGs were evaluated for Site applicability in order to develop the medium-specific RAOs. SCGs may be chemical-specific, location-specific, or action-specific. Chemical-specific SCGs were evaluated to establish appropriate action levels for impacted site media (e.g., groundwater standards). Action-specific SCGs were evaluated to establish acceptable standards for the management of impacted media (e.g., minimum technology standards for treatment of specific wastes; stormwater and erosion control during construction). Location-specific SCGs were evaluated to establish acceptable actions with respect to location and/or the presence of specific Site conditions (e.g., protection of waters and tidal wetlands). A complete list of SCGs identified for the fill material, fill water, PCB materials, and air is presented in **Table 2-1**. Although location-specific SCGs are potentially relevant with respect to Hudson River sediments, they were not considered within this FS because NYSDEC is completing a parallel investigation of conditions in the river adjacent to the Site.

The New York State SCGs and federal ARARs that were considered during the FS included:

- New York State surface water discharge standards would apply to any discharges to the Hudson River from the Site. These standards provide criteria for the protection of aquatic life in the Hudson River. These standards are applicable to the Site, particularly with regard to discharges that may be required during remedial construction activities. These standards specify the concentration of site-specific COPCS that can be discharged to the Hudson River. Over the duration of the remedial action, these allowable concentrations would determine the corresponding mass of COPCs that would be discharged to the River through construction activities such as dewatering.
- The Technical Guidance for Screening Contaminated Sediments is relevant in establishing a policy for remediating sediments at the Site. These criteria are not considered further in this FS because NYSDEC is conducting a separate investigation of sediment quality in the Hudson River adjacent to the Site. The evaluation of potential remedial actions for the Site in this FS will focus on the elimination of any potential sediment transport from the Site to the Hudson River. During remedial design, all design and construction activities would be specifically planned to prevent sediment transfer from the Site to the river.
- The New York State standards for groundwater quality promulgated under 6NYCRR Part 703 and set forth in Department guidance (e.g., TOGS 1.1.1) were considered and used as screening guidance in the RA. These standards are also listed in the comparison of qualitative cleanup criteria for the Site. However, the fill water beneath the Site is considered a brackish and non-potable water supply; therefore, the numerical criteria contained in these documents are not directly applicable to the evaluation of Site remedies.
- The primary guidance for soil cleanup values under Part 375 remedial actions is derived in the *Technical and Administrative Guidance Memorandum on Determination of Soil Cleanup Objectives and Cleanup Levels HWR-94-4046*, commonly referred to as TAGM 4046 (NYSDEC 1994). This guidance provides a basis for determining generic soil

cleanup values that essentially ensure that all significant threats to human health and/or the environment posed by an inactive hazardous waste site are eliminated. For organic contaminants, the recommendation for an appropriate cleanup objective is based on the following criteria:

- Health-based levels that correspond to excess lifetime cancer risks of 1 in 1 million for Class A and B carcinogens, or 1 in 100,000 for Class C carcinogens.
- Human health-based levels for systemic toxicants, calculated from RfDs.
- Environmental concentrations protective of groundwater/drinking water quality.

The guidelines for the development of TAGM-4046 were used in screening the COPCs for each media and are retained in the development of remedial actions as required by NYSDEC. TAGM 4046 also allows for the development of site-specific guidance values for COPCs using site data. Site-specific TAGM values were developed for use in the evaluation of remedial alternatives during this FS, following the guidance in TAGM 4046, which include the criteria protective of groundwater/drinking water quality listed above. However, these criteria are based on both generic health risk assessments and drinking water protection and are therefore exceedingly conservative in the context of hypothetical future site uses anticipated in the RA, and the ambient quality of the fill water, respectively.

- New York State effluent standards for discharge to groundwater would apply to potential discharges. However, such discharges are not being considered.
- State of New York regulations under 6 NYCRR Part 371 establish that soil, water, and debris with PCB concentrations exceeding 50 ppm are considered hazardous waste. As with the federal requirements pursuant to the Toxic Substance Control Act (TSCA), newly generated PCB waste exceeding 50 ppm must be disposed at a properly permitted facility for PCB-containing materials. Solid wastes subject to TSCA containing PCBs exceeding 50 ppm must be disposed in a TSCA-permitted landfill or incinerator. TSCA is a relevant PCB Spill Cleanup Policy (40 CFR 761.125), but it is not applicable to spills prior to May 1987. Because of the historical nature of PCB soil contamination, the PCB spill cleanup policy does not specifically apply to this Site, but is relevant.
- New York State solid waste regulations guide the disposal of newly generated solid waste (6NYCRR Part 360). The waste categories include material with PCB concentrations less than 50 ppm, TCLP-extracted lead concentrations less than 5.0 ppm, and hydrocarbon-only contamination. Each solid waste landfill will have a specific acceptance criteria for the above-mentioned chemical constituents.
- New York State air emission guidelines would not be applicable unless treatment technologies creating air emissions are used. Applicable guidance for short-term emissions during construction activities is contained in TAGM-4031.
- Federal Resource Conservation and Recovery Act (RCRA) requirements apply to fill, soil, water, or other material removed from the Site and categorized as hazardous. These materials may be subject to all RCRA standards including the 40 CFR 268 land disposal regulations. All RCRA wastes would be disposed at a RCRA-permitted facility where land disposal restrictions would apply. RCRA is not applicable for determining remedial action levels.

- The Clean Air Act (CAA) regulates air emissions of certain hazardous air pollutants. Any future particulate or volatile emissions from the Site would be controlled by risk-based standards, which are more protective than CAA standards. As a result, CAA standards would be fully addressed by the more stringent risk-based standards.
- The Clean Water Act (CWA) provides criteria for the protection of aquatic life in the Hudson River. These standards are applicable to the Site, particularly during remedial construction activities. As mentioned above, the effects of dilution by Hudson River waters are anticipated to be so great that changes in the quality of the Hudson River are not anticipated as a result of potential short-term discharges. CWA standards are also established for the treatment of groundwater, although the saline nature of the fill water eliminates its use from future consideration as drinking water.
- The Safe Drinking Water Act (SDWA) maximum contaminant level (MCL) standards are not applicable to the saline fill water. The SDWA standards would apply to groundwater in the Basal Sands Units; however, the Site does not impact this groundwater. Therefore, further consideration of SDWA standards are not warranted.

The quantitative criteria retained from the review of SCGs for the COPCs identified in each medium at the Site are discussed in **Section 2.4.4**.

2.5.3 Site-Specific Preliminary Remediation Goals

Site-specific risk-based PRGs were developed in the RA for the protection of human health under the exposure pathways associated with each of the hypothetical land-use scenarios evaluated. The exposure scenarios evaluated included hypothetical future adult and child residents, recreational (park) users, commercial/industrial workers, and utilities maintenance workers. The evaluation of future land-use scenarios considered what would happen if no IRMs, buildings, pavement, health and safety planning, or other exposure controls were in place, with the exception of 1 foot of topsoil in place for the park scenario or the placement of additional fill to raise the Site elevation above the 100-year flood plain for the residential and commercial/industrial scenarios. Clearly, the exposure scenarios evaluated during the RA are not reflective of (i.e., would be far more conservative than) future exposures that would occur if remedial action is taken before Site redevelopment, or where control measures are used as part of the future land-use scenario. The actual potential for exposures to COPCs in fill and fill water under a particular redevelopment scenario would depend on the remediation measures implemented and the details of the redevelopment plan.

The value of such an approach is supported by the USEPA as suggested in the following statement taken from the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA, 1988):

"Although the preliminary remediation goals are established on readily available information (e.g., reference doses and risk-specific doses) or frequently used standards (e.g., ARARs), the final acceptable exposure levels should be determined on the basis of the results of the baseline RA and the evaluation of the expected exposures and associated risks for each alternative."

The approach employed during the RA included calculating a PRG for each COPC at a target cancer risk of 10^{-5}. This was done to ensure that remedial actions achieving this target would also achieve cumulative risk levels within USEPA's target risk range (10^{-4} to 10^{-6}), since only a few EPA-designated carcinogenic COPCs contribute to the estimated risks at the Site. In addition, a second set of PRGs was developed at a target cancer risk of 10^{-6}, in response to NYSDEC and NYSDOH comments on the RA. Both sets of PRGs are conservative in that they assume the default USEPA exposure values and toxicity values for each exposure pathway and COPC. The PRGs calculated for each COPC in fill are listed in **Table 2-2**. The PRGs calculated for each COPC in fill water are listed in **Table 2-3.**

Based on the PRGs developed for the hypothetical future Site uses, the RA concluded that prevention of direct contact with surface fill in the northern portion (Area 1) would be an appropriate RAO because the concentrations of PCBs in this area were higher than the PRGs. The RA stated that replacing the top 2 feet of the existing fill or placing a contact barrier over the fill would effectively eliminate the potential for exposure associated with redevelopment of the Site for recreational (park), commercial/industrial, or residential uses. The RA also demonstrated that in the Site's central and southern portions (Area 2), fewer sampling locations contained PCBs exceeding PRGs than in the northern portion of the Site (Area 1). There were also relatively few locations where PAHs and lead exceeded the PRGs; however, these areas did not necessarily coincide with the areas where PCBs exceeded PRGs, as the distribution of PAHs and lead is related to their ubiquitous presence in the fill. Areas exceeding PRGs for these COPCs at target cancer risks of 10^{-5} and 10^{-6} for each future land-use scenario are shown in **Figures 2-1 – 2-6**.

As for the protection of the Basal Sands Unit groundwater, the Excavation Evaluation Summary Report concluded the following:

- Remedial construction that includes excavation must be undertaken in the dry.
- Significant care must be exercised during excavation to minimize disturbance of existing structures that penetrate the Basal Sands Unit.
- Excavation support structures should not be installed into the Basal Sands.
- The current head relationship between the Basal Sands Unit and the overlying groundwater must be maintained during excavation.

2.5.4 *Summary of Qualitative and Quantitative Site Remedial Action Objectives*

This section summarizes the qualitative and quantitative RAOs developed for the Site by medium. The criteria discussed in previous sections of this FS (SCGs, ARARS, and PRGs) are presented in this section relative to each impacted medium and relevant exposure pathway. According to USEPA guidance, RAOs are required to specify:

- The contaminants of concern,
- The media of concern,
- Exposure routes and receptors, and
- The acceptable contaminant levels for each exposure route (i.e., PRGs).

These stipulations have been provided to address protection of human health that may be achieved through exposure reductions. Exposure reduction may be achieved through barriers to contact and/or institutional controls, or by removal actions and/or treatment. NYSDEC's regulations state that the goal of the remedial program for a specific site is "to restore that site to pre-disposal conditions, *to the extent feasible* and authorized by law" (6 NYCRR § 375.1-10(b)). At a minimum, the remedy must "eliminate or mitigate all significant threats" to human health or the environment through the "proper application of scientific and engineering principles." In keeping with this goal, it follows that any remedy selected should minimize the potential spread of contaminants to currently non-impacted media such as the underlying Basal Sands unit groundwater resources.

The media of concern for which RAOs have been developed for the Site include fill material, fill water, surface water (the Hudson River), PCB-containing materials, LNAPL, and air. Although an LNAPL removal is on-going, the removal of this media will be considered as an RAO until it is completed.

2.5.4.1 *Fill Material*

The Site is constructed on a thick layer of man-made fill. The unique physical characteristics of the fill underlying the Site are important to the evaluation of remedial alternatives. These characteristics include:

- The fill is of variable composition, including such materials as coal, ash, and/or cinders that have been identified in numerous borings to depths of over 30 feet. Because of the uncertain origin and unique non-geologic nature of the fill material, traditional standards and guidelines for background concentrations of certain COPCs may not feasibly be achieved. An evaluation of fill samples collected from a range of depths suggests that a large portion of the lead was inherent to the original fill material. Possible sources of lead contamination include historic site operations as well as cinders, boiler slag, ash, and bricks found in the fill. The original fill material is probably also a contributing source of the widespread SVOC (primarily PAHs) contamination found throughout the Site.

- The fill contains a high content of organic materials. Whereas cleanup standards are typically derived assuming a total organic content (TOC) of 1% to 5%, surface fill TOC concentrations at the Site range from 3.9% to 12.6%, with an average of 8.25%. Actual subsurface fill TOC concentrations range from 0.4% to 83.6%, with an average of 10.2%.
- A dense and complex network of subsurface structures (i.e., pilings, foundations, and bulkheads) exists at the Site. Pilings penetrate the Marine Grey Silt Unit and into the Basal Sands Unit, where site contaminants have not migrated.

Review of SCGs and ARARs for Fill Material: The primary guidance for soil cleanup values under Part 375 remedial actions is derived in TAGM 4046 (NYSDEC, 1994). This guidance has been retained during the development of RAOs in accordance with NYSDEC policy, although many of the assumptions used in formulating this guidance are invalidated by the physical and chemical nature of the fill material and fill water underlying the Site. In particular, the fill water is not potable due to the high level of dissolved solids. The distribution of fill exceeding these generic TAGM values (for metals and PAHs) is widespread across the Site as a result of the nature of the non-geologic materials used during the historic infilling of major portions of the Site starting in the mid-1800's. A consolidated summary of RAOs for fill is presented in **Table 2-2**.

The generic TAGM 4046 cleanup objectives include the protection of groundwater/drinking water quality, and are based on a soil organic carbon content of 1% for all constituents with the exception of PCBs. For PCBs, an organic carbon content of 5% is used. Calculation of a Site-specific value was completed as noted in **Table 2-2** and **Table 2-5** as is recommended in TAGM 4046 if the actual soil organic carbon content is known. In addition, the TAGM recommends using more precise organic partitioning coefficients (K_{oc}) for the site-specific COPCs, if known. Because the actual TOC concentrations for surface and subsurface fill vary significantly from these default values and alternative K_{oc} values for the site-specific PCB aroclors were used, site-specific values derived using TAGM 4046 are listed along with the default values shown in TAGM 4046. These values are all based on groundwater/drinking water quality protection, although as explained previously fill water is not currently or likely to ever be a viable potable water source. Site-specific SCGs are shown in **Table 2-2**. The derivation of the site-specific PCB cleanup value using the TAGM 4046 procedure is presented in **Appendix A**. It should be noted that although the derivation of site-specific TAGM PCB cleanup values generated concentrations ranging from 53 to 530 ppm, the more conservative TAGM 4046 generic soil cleanup value of 10 ppm was used for subsurface soils in this FS report. Also relevant

(although not necessarily directly applicable) are standards and guidance for management or treatment of hazardous wastes under 6NYCRR Part 373.
The use of federal guidance values for soil screening purposes was discussed earlier in this FS. These guidance values are generally preempted by the TAGM values described above, except for the soil screening value for lead, which is given a range (rather than a specific value) in the TAGM guidance. Also relevant (although not necessarily directly applicable) are standards and guidance for management or treatment of hazardous wastes under RCRA and TSCA.

Review of PRGs for Fill Material: Based on the conceptual risk framework developed during the RA, PRGs were developed at 10^{-5} and 10^{-6} target cancer risk factors to address potential exposure pathways for hypothetical recreational, residential, or commercial/industrial scenarios, as well as utilities maintenance workers who would access the Site under these scenarios. The PRGs developed for each of these scenarios are compared to SCGs in the summary of RAOs for fill presented in **Table 2-2**. A considerable portion of the Northern portion (Area 1) exceeds the PRGs for PCBs developed during the RA; therefore, prevention of human direct contact with fill materials in this area would be considered a primary RAO (**Figures 2-1 through 2-6**). There are also areas of the central and southern portions (Area 2) where the PRGs for PCBs are exceeded, and prevention of direct human contact to these areas is also considered a primary RAO.

Relatively few locations in both areas exceed the PRGs for PAHs and lead although there are some locations, particularly in Area 2, where PAHs and lead at concentration's exceeding PRGs do not coincide with the locations of PCBs exceeding PRGs. Prevention of potential exposures to these materials would also be considered an RAO.

2.5.4.2 Fill Water

Review of SCGs and ARARs for Fill Water: Water contained in the man-made fill at the Site can not be considered as potable groundwater due to the total dissolved solids (TDS) content of the (brackish) fill water. This characteristic is attributable primarily to the saline nature of the Hudson River and its tidal influence on the Site. Also, due to the presence of chemical substances associated with the fill (metals and PAHs), removal of a majority of the fill would probably be required to achieve the groundwater standards for these substances. However, the New York State groundwater standards are retained as a basis for comparison in the development of fill water RAOs at the request of NYSDEC, although the basis for these standards (protection of groundwater as a drinking water source) is not directly applicable to the Site fill water. A consolidated summary of the RAOs developed for fill water, including a comparison of retained quantitative criteria such as SCGs, are included in **Table 2-3**.

The use of federal risk-based guidance values for groundwater screening purposes was discussed earlier in this FS. These guidance values are generally preempted by the New York State groundwater standards and by site-specific PRGs developed for the protection of future potential receptors under the hypothetical land use scenarios evaluated under the RA.

Review of PRGs for Fill Water: Based on the conceptual risk framework developed during the RA, no current or potential future exposures to fill water were identified that exceeded the RA's target risk criteria.

2.5.4.3 Basal Sands Groundwater

Groundwater in the deeper Basal Sands Units is not included as a media of concern for remedial technology consideration for the following reasons:

- The minimal contamination in the Basal Sands Formation is believed not to be Site related (RI Report)
- The groundwater is separated from the fill and fill water by the Marine Grey Silt Unit
- The groundwater is upgradient of the fill water (i.e., there is an upward vertical gradient).

A relevant and particularly significant RAO for the site, however, is the protection of the non-impacted Basal Sands Unit groundwater resource. As stated previously, remedial construction activities undertaken in the fill and Marine Grey Silt, unless designed and implemented appropriately, include the risk of re-mobilizing site contaminants allowing contaminant migration into the underlying Basal Sands unit groundwater resources.

2.5.4.4 Surface Water

Review of SCGs and ARARs for Surface Water: Water in the Hudson River is included as a media of concern at the NYSDEC's request. During the remedial activity, the substantive requirements of New York's State Pollutant Discharge Elimination System (SPDES; 15 NYCRR Part 750 - 758) would apply to any discharges (such as dewatering) during site construction, although permitting of such discharges would be exempted as the cleanup would be completed under the authorization of 6 NYCRR Part 375. The conditions of New York State's General Permit for Stormwater Discharges Associated With Industrial Activity (Article 17, Titles 7 and 8) would be applicable. Also, the substantive conditions of New York's Use and Protection of Waters (6NYCRR Part 608) and Tidal Wetlands Land Use (6NYCRR Part 661) permit programs (pertaining to work in and around the Hudson River) would apply during the construction phase of the remediation project. The RAOs developed for surface water, including a comparison of retained criteria such as SCGs, are included in **Table 2-4**.

Review of PRGs for Surface Water: A risk-based assessment of PRGs for the Hudson River sediments and surface water was not completed because NYSDEC is completing a separate investigation of the River. In terms of the RAOs for the Site, the primary qualitative goal is to prevent the potential transport of contaminated sediments to the river. From a risk perspective, the effectiveness of potential alternatives must be evaluated relative to their short-term potential impacts to the River during the construction phase of remedial action.

2.5.4.5 PCB-Containing Materials

Review of SCGs and ARARs for PCB Materials: These materials are found at depths of approximately 30 feet bgs or more and are immobile under current equilibrium conditions. The TAGM values for soil cleanup are retained as a basis of comparison, although they are not applicable due to the location of these materials buried within fill at the Site and the negligible possibility of human contact with PCB-containing material. The New York State hazardous waste limit for PCBs and TSCA limit for regulated PCB materials are also relevant but not strictly applicable to this material in its present (in-situ) state. The RAOs developed for PCB-containing materials, including a comparison of retained criteria such as SCGs, are included in **Table 2-5**.

Review of PRGs for PCB Materials: A risk-based assessment of PRGs for PCB material was not completed during the RA because the possibility of human contact with this material was deemed negligible. In terms of the RAOs for the Site, the primary qualitative goal is to prevent the possibility of human contact with these materials in the future and to minimize the potential for remobilization of the materials to prevent the spread of contamination to currently non-impacted media (i.e., the Basal Sand Unit Aquifer).

2.5.4.6 LNAPL

Review of SCGs and ARARs for LNAPL: Groundwater spill cleanup policy guidance issued by NYSDEC (TOGS 2.1.1, 1987) seeks the implementation of source control measures to the extent technically feasible to address leaks or spill of petroleum products. Recovery of LNAPL at the Site has been instituted as an IRM to remove this material to the extent feasible. No other quantitative measure of this RAO will be included in this FS, as the presence of COPCs in fill material that may potentially have originated from the LNAPL is addressed within the RAOs for fill.

Review of PRGs for LNAPL: No characterization of risk associated with the presence of LNAPL was performed during the RA due to its limited areal extent and the on-going removal action under the IRM.

2.5.4.7 Air

Review of SCGs and ARARs for Air: Control and monitoring of fugitive dust emissions during construction activities is specified in NYSDEC guidance (TAGM 4031, NYSDEC, 1989), which will serve as guidance for air monitoring during the construction phase of the remedial action project. The RAOs developed for air, including a comparison of retained criteria such as SCGs, are included in **Table 2-6**.

Review of PRGs for Air: Inhalation exposures were evaluated for hypothetical future residents and utilities maintenance workers at the Site. This exposure pathway was deemed to pose no significant risk; therefore, no PRGs were developed for air pathway exposures.

3.0 TECHNOLOGY EVALUATION

3.1 General Response Actions

3.1.1 Identification of General Response Actions

General Response Actions (GRAs) are media-specific actions that satisfy the RAOs. The process of developing GRAs to address impacted media is consistent with the guidance for implementing the NCP under CERCLA (USEPA, 1988) and NYSDEC (NYSDEC, 1990). The process also ensures that a wide range of potential responses are considered during the development of remedial alternatives for the Site.

GRAs were developed to address the RAOs for fill, fill water, air, PCB-containing material and LNAPL. The following list represents potentially relevant GRAs that could be applied to the impacted media, given the unique Site conditions:

- No further action
- Institutional controls
- Containment
- Source removal
- Ex-situ treatment
- Disposal of fill
- In-situ treatment

Some GRAs are media-specific, or are not applicable to the Site as a whole because of site-specific conditions. The application of specific GRAs is discussed in the following sections.

3.1.1.1 No Further Action

The “No Further Action” category serves as a baseline against which other response actions can be compared. The “No Further Action” category can include activities such as soil sampling, groundwater monitoring, or air quality monitoring to identify changes in site conditions. For this project, the No Further Action alternative also includes the IRM response actions already under taken by Atlantic Richfield.

3.1.1.2 Institutional Controls

Under this response category, measures would be taken to restrict access and/or control specified activities at the Site. Physical and/or legal controls could be used to restrict site access. Physical controls include access restrictions such as fencing, postings, warning signs, or other barriers. Legal controls include zoning or notice of covenant on deed transfers, and the Site's classification within the NYSDEC's Inactive Hazardous Waste Site Registry, in order that future land uses consider the Site limitations specified by those documents.

3.1.1.3 Containment

The containment category refers to the use of natural or engineered barriers on-site to minimize potential direct contact with, or migration of, contaminated media. Technologies within the containment response category include contact barriers, capping, vertical barriers, and surface controls (e.g., drainage/grading).

3.1.1.4 Source Removal

This GRA refers to activities in which impacted media would be removed from the Site. Removal operations at the Site would require the use of both common and highly specialized excavation equipment depending upon the location of the impacted fill with respect to ground surface, fill water, and the Hudson River. Excavated fill material would be conditioned for subsequent transportation to an off-site disposal facility and/or treated to meet land disposal restriction (LDR) treatment standards, if applicable. Extensive dewatering would be required to remove source material below the water table.

As stated in Section 1 of this report, this site presents significant source removal challenges due to difficult site conditions combined with the nature of site contaminants. These factors include:

- Difficult Subsurface Conditions: The two most significant site conditions that influence source removal options include:

  1. The presence of very soft soils underlying site fill. The presence of the soft soils has a direct implication on the structural support systems necessary for excavation, and;
  2. The presence of a very high hydraulic head in an underlying hydrostratigraphic formation that will likely affect the bottom stability of any structure excavated to depth.

  The significance of these site conditions has been studied by Atlantic Richfield. A summary of these studies is presented in the "Excavation Evaluation Summary Report". The conclusions of these studies are as follows:

1. Excavation should be undertaken in the "dry". A flooded excavation should be avoided because of the difficulties associated with the following:
   - dewatering excavated spoils;
   - treating water with suspended contaminants, and;
   - inspecting and verifying excavation depths/remedial limits;
2. Excavation support structures should not be installed into the Basal Sands Unit. As discussed in subsequent sections of this report, the Basal Sands Unit underlying the site is currently not contaminated. Accordingly, any penetration of the Basal Sands Unit by an excavation support structure has the potential to contaminate this groundwater resource.
3. A primary failure mode of excavation is through bottom heave of the excavation floor due to the high hydraulic pressure exerted by the Basal Sands Unit. Several engineering measures could be used to overcome this failure mode including lowering the head in the Basal Sands and/or increasing the head inside the excavation (i.e., flood the excavation), but each of those methods has additional risks associated with it, as discussed below. The calculations determining the maximum safe depth of excavation considering failure by bottom heave is presented in **Appendix B** and is approximately 12 feet below ground surface.

- Nature of Site Contaminants: The primary contaminants of concern at the site are PCBs. As discussed in other sections of this report, the PCBs, under current site conditions are essentially immobile. During remedial action and in particular during excavation and removal activities, the equilibrium condition that currently maintains the PCBs in their relatively immobile state could be altered if care is not taken to maintain this equilibrium. The key elements of equilibrium maintenance include no alteration of the hydraulic head in the Basal Sands Unit and/or flooding the excavation and eliminating the installation of excavation support structures into the Basal Sands.

As stated in **Section 1**, three primary source removal Basic Principles have been developed for the source removal remedy:

1. Excavation will not include flooding. As stated above, flooded excavations will likely result in difficulty in dewatering excavated spoils, difficulty in treating water with suspended contaminants, and difficulty in inspecting and verifying excavation depths/remedial limits. In addition, depending on the flooding requirements to achieve excavation stability, the resultant head variation may cause relatively immobile PCBs to remobilize and move downward to the Basal Sand Unit.
2. No penetration of the Basal Sands Unit by excavation support structures. The installation of excavation support structures would significantly increase the risk of contaminant drag-down and provide a pathway for downward contaminant migration after (as well as during) excavation support installation. As stated above, the selected remedial alternative will be protective of the environment, which includes reduction/elimination of the risk of contaminant migration and protection of unaffected groundwater resources (i.e., the Basal Sand Unit).

3. No hydraulic head modification of the Basal Sands Unit. A common excavation construction technique to reduce the risk of bottom heave is to lower the hydraulic pressures in underlying water bearing units. At this site, the high hydraulic head in the Basal Sands Unit is a significant factor in the likelihood of excavation bottom instability. Under "normal" construction (i.e., an uncontaminated site), lowering the head in the Basal Sands Unit would allow for a deeper, "dry" excavation by reducing/alleviating the risk of bottom heave. At this Site, however, lowering the head in the Basal Sands Unit will increase the risk of downward PCB migration. This is particularly true in areas where PCB product has been observed. As stated above, the selected remedial alternative will be protective of the environment, which includes reduction/elimination of the risk of contaminant migration and protection of unaffected groundwater resources.

3.1.1.5 Ex-situ Treatment

Ex-situ treatment GRAs refer to appropriate technologies used to treat impacted media either on-site or off-site. Technologies within the ex-situ treatment response category include incineration, thermal desorption, dehalogenation, solvent extraction, biodegradation, soil washing, and ex-situ solidification/stabilization.

3.1.1.6 Disposal of Fill

This GRA refers to disposal of impacted media after operation. Both on-site and off-site disposal options will be evaluated as GRAs.

3.1.1.7 In-Situ Treatment

In-situ treatment GRAs refer to appropriate technologies used to treat impacted media in-place on site. Technologies within the in-situ treatment category include ozonation and chemical fixation and solidification/stabilization.

3.1.2 Estimation of Extent and Volume of Contaminated Media

The objective of this section is to determine the extent and volume of fill at the Site to which GRAs might be applied. These areas and volumes were defined by a computer-aided evaluation of the sampling data presented in the RI Report relative to the RAO concentrations for each COPC presented in **Table 2-2**.

Modeling software (Earth Vision) was used to generate the estimated volumes of impacted fill at the Site. The modeling software accessed a database that was constructed using all of the RI Report data and supplemental studies completed. For PCB-impacted fill, the site was divided into 50-foot by 50-foot working areas. Each working area was then subdivided into 5-foot-depth intervals. The data obtained in each depth interval was evaluated to classify the fill. Fill classification was based upon the highest reported concentrations found within the given depth interval. Volumes were then calculated based upon concentration intervals of ≥1 ppm (for surface fill), 10 to 50 ppm, ≥50 ppm, and ≥1000 ppm PCBs. The specific volumes of impacted fill addressed by the remedial alternatives developed in this FS are discussed in **Section 4.1** and **4.2**.

3.2 Identification and Screening of Technologies

This section identifies and describes potentially applicable technology types for each GRA and presents the preliminary screening of each technology. During this preliminary screening, process options and entire technology types may be eliminated from further consideration on the basis of technical implementability. This was evaluated using three factors, which are specified in the USEPA guidance for conducting RI/FS investigations (USEPA, 1988): the nature of contaminants, the specific media of concern at the Site, and the Site physical characteristics, including geology and hydrogeology.

3.2.1 No Further Action

The “No Further Action” response consists of monitoring and documenting the natural attenuation process. The “No Further Action” response is readily implementable. Pursuant to the NCP and USEPA guidance for conducting RI/FS investigations (USEPA, 1988), the “No Further Action” alternative must be developed and examined as a baseline by which other remedial alternatives will be compared. This alternative, therefore, will be retained for further consideration.

3.2.2 Institutional Controls

Institutional controls are physical or legal measures taken to prevent direct exposure to impacted media. Institutional controls are not technologies; however, they can be used to enhance the long-term effectiveness and permanence of a remedial action. Potentially implementable institutional controls include access restrictions, deed restrictions, and zoning restrictions that prevent exposure to contaminated fill, fill water, or phase-separated liquid.

Access restrictions could include fencing, alarm systems, security gates and patrols, and other physical barriers that restrict access to select Site areas. These measures are currently being utilized at the Site to prevent unauthorized Site entry and reduce the potential risk of exposure. Other measures to control specific activities could be employed as dictated by future land use. Workers engaged in activities potentially exposing them to impacted media would require Occupational Safety and Health Administration (OSHA) training and certification (29 CFR 1910.120), medical fitness testing, and other appropriate documentation, including an approved HASP and requirements. These plans would stipulate appropriate protective measures to prevent worker exposures during the completion of work on-site. In addition, a written summary of work performed or completed, documenting compliance with all established administrative controls, would be a customary requirement for work completed in hazardous environments. Future land-use activities may require control measures such as mandatory periodic training or signed compliance agreements prohibiting specified activities for on-site employees.

Notice of covenant on deed transfers may be used to impose specific legal restrictions for future land use or to require training programs or specific actions designed to prevent exposure to impacted media. For example, prohibitions on excavation or construction in capped areas can be stated in the deed, and maintenance of a cap or other remedial control structures can be required. Future Site remedial actions can also be specified in a notice of covenant on deed transfers, such as requiring that fill material exposed by future construction be handled in a specified manner or that a newly exposed area be capped. Access restriction controls can also be included as a notice of covenant on deed transfers.

Zoning restrictions are similar to deed restrictions and could be used for the same purposes described above. Re-zoning would require working closely with the Village of Hastings-on-Hudson to develop a special zoning district with specific building limitations or prohibitions. Approval would require a public hearing and/or a public participation process in addition to the public participation process necessary for FS approval. This option would limit future exposure through property-use restrictions. The “layering” of this form of property use restriction in addition to deed or title covenants would provide a more effective control mechanism than either of these actions completed individually.

Under New York State’s *Inactive Hazardous Waste Disposal Site Remedial Program*, limitations are placed on physical alterations or substantial change in use of sites included in the Registry[1]. These limitations would effectively limit significant changes in the exposure pathways present at portions of the Site included in the Registry, and require notification and NYSDEC approval prior to the implementation of these changes.

Implementation of any institutional controls would require negotiated agreement between the current property owner and local and state government agencies. Institutional controls would enhance the effectiveness of other technologies and will be retained for further consideration.

3.2.3 Containment

Containment of impacted media would prevent potential receptors from directly contacting these media or potential migration of impacted media through the bulkhead into the river. Technology types identified to achieve containment of the various media include surface fill contact barriers (to prevent contact with impacted media), capping (to prevent contact with impacted media and reduce or eliminate infiltration), surface water/sedimentation controls (to control erosion), and vertical barriers (to prevent potential migration of impacted media).

3.2.3.1 Contact Barriers

The primary purpose of a contact barrier is to serve as a physical barrier or obstruction to the accessibility of impacted media, thereby preventing contact with impacted surface fill, subsurface fill, and fill water. The contact barrier would be designed to facilitate surface water drainage, thereby preventing frost damage and ponding in low-lying areas. The barrier would be a substantially strong and durable layer and would take a considerable and intentional effort to breach.

Contact barrier process options include:

- Asphalt or Concrete
- Steel or Synthetic Mat

Asphalt or Concrete Contact Barriers

A contact barrier constructed of a 6-inch layer of asphalt or wire-reinforced concrete would serve as a flexible, yet durable and strong barrier against exposure to impacted media. Prior to installation of the contact barrier, the Site would be graded to promote drainage and would be compacted to provide a firm base for the asphalt or concrete layer. Construction of an asphalt or concrete contact barrier would be readily implementable. This technology will be retained for further consideration.

Steel or Synthetic Mat

Stabilization mats constructed of steel or a synthetic material are commonly used for such applications as slope stabilizers for various earthwork projects. Steel mats are also used for the construction of temporary airplane runways and haulroads for heavy construction equipment. These woven steel or synthetic mats are installed in sections, which are interlocked to create a continuous surface. These mats are designed to allow free drainage and are flexible enough to follow the existing surface contours, requiring little grading or compaction. Both steel and synthetic mats are durable and strong, and are designed for applications in which they are subjected to much higher stresses than would be experienced on this project. Significant effort would be required to breach these mats.

Mat installation can be accomplished with commonly available equipment, materials, and manpower. This technology will be retained for further consideration.

3.2.3.2 Capping

Containment can be accomplished through the use of a capping system that reduces potential exposures by preventing direct contact with impacted media and inhalation of airborne particulates. Also, capping can reduce the amount of precipitation that infiltrates and percolates into and out of impacted soils. Capping process options include:

- Permeable soil caps
- Asphalt/Concrete caps
- Multi-layered Engineered caps

Permeable Soil Caps

Permeable soil caps typically consist of 1 to 2 feet of locally available, inexpensive earthen materials and a 6-inch layer of topsoil for vegetative support. A permeable soil cap would reduce the risk of direct contact with impacted surface fill. In addition, a soil cap would prevent the potential erosion of exposed surface fill. Compaction of a soil cap to a suitable finished grade and surface texture would allow for a variety of future land uses, and would assist with future maintenance. Drainage would be required to prevent ponding and surface erosion. Appropriate vegetation (grasses) would reduce erosion, but deep-rooted plants should be avoided to prevent cap disruption. Deep-rooted plants could be established on-site in aboveground containers.

Appropriate soil for cap construction is readily available. Soil cap construction could be implemented using conventional engineering practices and construction equipment. Minimal long-term maintenance would be required to ensure cap integrity. This technology will be retained for further consideration.

Asphalt/Concrete Caps

Both asphalt and concrete are considered good cap materials, and effectively reduce surface erosion. By altering the asphalt mix (decreasing the aggregate grain size and adding extra asphalt), hydraulic conductivities of typically less than 10^{-7} cm/sec, and sometimes as low as 10^{-11} cm/sec, can be achieved. These mixtures are known as dense-grade or hydraulic-grade asphalts (Asphalt Institute, 1989) and have been approved for use in environmental caps and pond liners (Asphalt Magazine, Winter 1991/1992). They cannot withstand heavy design loads, but they are resistant to erosion and are more durable than highway asphalt. Asphalt/concrete cap systems should be engineered/constructed with suitable surface water drainage controls because internal, downward drainage of precipitation does not occur. The Site areas already covered by asphalt/concrete or building foundations may not require modification in order to implement this process option. The integrity of these Site areas would have to be evaluated prior to designing an asphalt/concrete cap system. This technology will be retained for further consideration.

Multi-Layered Engineered Caps

A multi-layered engineered cap system is a more sophisticated technology than a soil cap and involves layers of compacted soil underlying and overlying a synthetic liner. These caps are most appropriately used in cases where a low-permeability cap must be constructed to prevent infiltrating water from leaching through the waste. A multi-layered engineered cap meeting the performance requirements of 6NYCCR Part 360 would be implementable and is a proven isolation technology. This technology will be retained for further consideration.

3.2.3.3 Surface Water Controls

Surface water controls can be used to divert surface water from impacted areas or to either minimize infiltration or prevent erosion. The control of surface water run-on/run-off can be accomplished by several measures, including:

- Diversion channels
- Grading
- Revegetation
- Collection basins and drains

Currently, surface water run-on at the Site is minimal because the active railroad tracks and the associated ballast adjacent to the Site divert the surface water draining from the bluffs. Surface water flow is limited to precipitation that falls onto the Site surface. The railroad tracks will remain for the duration of the operation and maintenance (O&M) period required for a containment process option. Surface water run-off flows from the Site to the Hudson River. Surface water controls are readily implementable and will be retained for further consideration.

3.2.3.4 Vertical Barriers

Vertical barriers are low-permeability cutoff walls or diversion walls installed below the ground surface to contain, capture, or redirect subsurface water flow in the Site vicinity. They are designed to prevent migration of particulate and dissolved contaminants, and are most commonly installed across the water table. Vertical barriers may be constructed using sheet-piles, slurry walls, and/or grout curtains.

Sheet-Piles

Sheet-piles are large, interlocking steel plates driven into the ground using a pile driver. Sheet-piles would be placed around the impacted fill material. The depth to which the sheet piling is driven would vary, based on the depth of impacted media in the area under consideration. Sheet-piles may be subject to some leakage at connection joints. The installation of sheet piling would use readily available materials and equipment. Sheet-piles will be retained for further evaluation, although subsurface obstructions may cause some difficulties with installing sheet-piles into the fill. These subsurface obstructions are described in detail in **Section 1.2.1.1**.

Slurry Walls

A slurry wall is constructed in a vertical trench that is excavated under a slurry. The slurry, usually a mixture of bentonite, water and soil, hydraulically shores the trench to prevent collapse and forms a filter cake on the trench walls to prevent fluid losses from the surrounding ground. The materials used to backfill the slurry wall include engineered soil-bentonite mixtures and cement-bentonite mixtures. A slurry wall would prevent migration of subsurface contaminants by creating a low-permeability barrier. Slurry wall technology is implementable for subsurface soils and will be retained for further consideration.

Grout Curtains

Grout curtains are subsurface barriers that can be created in permeable fill material by pressure injection of cement grout. The grout fills the subsurface void spaces, reducing the migration of subsurface contaminants and strengthening the soils. Grout curtain technology is implementable and will be considered for further consideration.

3.2.4 Source Removal

Source removal refers to activities in which impacted media would be removed from the site. Removal of source materials from the Site is considered implementable, although it would be technically challenging due to the shallow water table, proximity of the Hudson River and related hydraulic forces, presence of subsurface debris and obstructions, and poorly compacted fill and underlying the Marine Grey Silt Unit. An evaluation of site-specific conditions would be required including the location of source materials in proximity to the fill water to determine if excavation and removal of materials from below the water table is technically feasible (refer to section **3.3.5.3** for additional discussions on deep excavation). During excavation and removal activities, the equilibrium condition that currently maintains the PCBs in their relatively immobile state must be maintained. The key elements of equilibrium maintenance include undertaking the excavation in the dry, no alteration of the hydraulic head in the underlying Basal Sands unit and restricting the installation of excavation support structures to the upper portions of the Marine Grey Silt unit.

In addition, any excavation technologies used would have to minimize or eliminate the potential for spreading existing contamination during Site remediation. In particular, the Basic Principles outlined in **Section 1.0** must be incorporated into the excavation method selected. Excavation from below the water table would require dewatering, bracing, and/or the use of specialized excavation equipment. Deep grouting or other soil stabilizing measures may have to be undertaken to excavate at depth. Although it is recognized that these procedures will be undertaken at considerable technical and human safety risk, source removal will be retained for further consideration.

3.2.5 Ex-situ Treatment

Excavated fill would be treated to meet the numerical cleanup objectives for fill, or to the limit of the technology. Ex-situ treatment technologies reviewed include incineration, thermal desorption, dehalogenation, solvent extraction, biodegradation, soil washing, and ex-situ solidification/stabilization.

3.2.5.1 Thermal Processes

Two thermal treatment technologies are considered in this FS report: incineration and thermal desorption.

Incineration is performed at high temperatures (1,400 to 2,200 degrees Fahrenheit ºF), which decompose organic compounds to simple non-toxic compounds. Incinerator off-gas requires treatment by an air pollution-control system to remove particulates and neutralize acid gases. Extensive dewatering would be required prior to fill material incineration. The RI Report indicates that the fill is composed of silts and fine sands mixed with debris including bricks, concrete, stone, and timber. The nature and extent of debris in the fill material would limit the applicability of this technology because of specific feed size and material handling requirements. Also, heavy metals, including lead, can produce bottom ashes that require stabilization. Additional gas cleaning systems would be required to remove volatile heavy metals that would leave the combustion unit with the flue gases. The RI Report reports that lead is present in 152 of 154 samples analyzed. Due to the limitations associated with Site conditions, incineration will not be retained for further consideration.

Thermal desorption is a physical separation process and is not designed to destroy organic compounds (destruction can be achieved with additional gas treatment systems). Thermal desorption is either conducted at low temperatures (200 to 600 ºF) or high temperatures (800 to 1,000 ºF). In both cases, the organic compounds and water are volatilized in a desorption unit. A carrier gas transports the volatilized organic compounds and water to a gas treatment system where they are either destroyed in an afterburner or concentrated on activated carbon. The same limitations associated with incineration apply to thermal desorption. Due to these limitations, thermal desorption will not be retained for further consideration.

3.2.5.2 Chemical Processes

Two chemical treatment technologies are considered in this FS report: dehalogenation and solvent extraction.

Dehalogenation is a technology in which chlorine atoms (halogens) are removed from organic compounds via chemical reactions. An alkali metal atom (lithium, sodium, or potassium) is substituted for a chlorine atom, significantly reducing the toxicity of the PCB molecule. Dehalogenation would require the fill material to be formed into a slurry. Dehalogenation is limited by the same site characteristics limiting thermal processes and is generally not cost-effective for large waste volumes (*Remediation Technologies Screening Matrix and Reference Guide*, USEPA, 1994); therefore, it will not be retained for further consideration.

Solvent extraction is a process in which organic contaminants are separated from a soil matrix using organic solvents. Solvent extraction is a volume-reduction process generally used in conjunction with other treatment technologies, and is aimed at reducing the overall cost for site clean-up (USEPA, 1994). Extracted organic compounds require off-site treatment and/or disposal. Solvent extraction has the same disadvantages related to heterogeneous fill as thermal treatment. Additionally, large quantities of organic matter (as evidenced by the high TOC levels reported in the RI Report) would make PCB removal difficult, due to the high affinity of PCBs for organic matter. For these reasons, dehalogenation and solvent extraction will not be retained for further consideration.

3.2.5.3 Biological Processes

Biodegradation of PCBs has been studied under aerobic and anaerobic conditions using naturally occurring microbial populations, selected cultures, isolated strains, and white rot fungi. The less chlorinated Aroclors (Aroclor-1016, Aroclor-1221) may be biodegraded under aerobic conditions. The more highly chlorinated PCBs (Aroclor-1254, Aroclor-1260) may be reductively dechlorinated under anaerobic conditions, and subsequently biodegraded aerobically. Isolated strains of bacteria are capable of degrading specific PCB congeners in the laboratory. However, biodegradation of highly chlorinated PCBs has not been tested or successfully implemented outside of the laboratory. Therefore, biological treatment technologies will not be retained for further consideration.

3.2.5.4 Physical Processes

Physical treatment technologies include soil washing and ex-situ solidification/stabilization.

Soil washing is a volume-reduction technology used in conjunction with other technologies. In this process, soil and water (containing surfactants or enzymes) are mixed together to form a slurry, which is subjected to several stages of intensive scrubbing. Soil washing has the same disadvantages related to heterogeneous fill as thermal treatment. In particular, large quantities of debris would make intensive scrubbing difficult. Additionally, large quantities of organic matter would make PCB removal difficult, due to the high affinity of PCBs for organic matter. For these reasons, soil washing will not be retained for further consideration.

Stabilizing waste improves its material handling characteristics and reduces permeability to leaching agents by reducing waste porosity and exposed surface area. Ex-situ waste stabilization involves the addition of a binder such as Portland cement, cement kiln dust, or fly ash to a waste to convert contaminants into a less soluble, mobile, or toxic form and improving its physical characteristics. Ex-situ waste solidification involves the addition of a binding agent, such as Portland cement and others, to the waste encapsulating the contaminants in solid material. Ex-situ solidification/stabilization (S/S) processes use one or both of these techniques and are different from other PCB remedial technologies in that they reduce mobility, but do not concentrate or destroy them. Waste S/S technology is implementable and will be retained for further consideration.

3.2.6 Disposal of Excavated Fill

Disposal options considered include on-site disposal and off-site disposal of excavated fill material as both non-hazardous and hazardous waste. Off-site disposal is now generally less acceptable than in the past, as CERCLA includes a statutory preference for treatment of contaminants (*Remediation Technologies Screening Matrix and Reference Guide*, USEPA, 1994).

3.2.6.1 On-Site Disposal of Excavated Fill

On-site disposal of excavated fill is a viable option. Excavation and reinterment of fill material would have to be conducted in accordance with NYSDEC and RCRA requirements. A containment cell can be designed that makes on-site disposal technically feasible although the regulatory requirements pertaining to the location of a disposal cell in a flood plain may limit the types of waste that may be interred. This technology will be retained for further consideration.

3.2.6.2 Off-Site Disposal of Excavated Fill

This response action includes: 1) the off-site disposal of excavated fill that has been characterized as non-hazardous in a non-hazardous waste landfill; and 2) the off-site disposal of hazardous fill in a hazardous waste landfill. Off-site disposal of hazardous fill may require off-site treatment prior to land disposal to satisfy LDR requirements. Fill material excavated from below the water table would require on-site dewatering or stabilization prior to transportation to an off-site disposal facility. The U.S. Department of Transportation (DOT) regulates the transportation of hazardous materials (49 CFR Parts 172-179, 49 CFR Part 1387, and DOT-E8876).

Off-Site Disposal as Non-Hazardous Waste: Additional testing would be required for fill that may be characterized as non-hazardous to meet the specific regulatory requirements of the receiving landfill. The concentration of PCBs must be less than 50 ppm, and TCLP analyses would be required to demonstrate that the fill meets the characteristics of hazardous waste for toxicity. Off-site disposal as non-hazardous waste is implementable provided the fill material can be classified as non-hazardous waste. This technology will be retained for further consideration.

Off-Site Disposal as Hazardous Waste: The option of off-site disposal of fill as hazardous waste or TSCA waste without treatment would be the least technically complex solution, provided the fill did not require pretreatment to meet LDR requirements. Analysis and waste characterization of excavated fill would be performed at the time of excavation. Dewatering or stabilization of fill excavated below the water table may be required prior to transportation to the off-site disposal facility. Off-site pre-treatment of the fill may also be required to meet LDR standards, and facilities selected for waste pretreatment would require permitting for the specific treatments to be performed. This disposal process is implementable, subject to the challenges associated with characterization and pretreatment of the fill in accordance with RCRA (40 CFR Parts 261-265, and 268) and NYS ECL (6 NYCRR Part 371 and 7 NYCRR Part 360). This technology will be retained for further consideration.

3.2.7 In-situ Treatment

In-situ treatment technologies would be used to treat fill to meet the RAOs, or the limit of the technology. The relative degree of success of these technologies would be determined by the collection of fill and fill water samples. Technologies within the in-situ treatment response category include in-situ oxidation and in-situ solidification/stabilization.

3.2.7.1 In-situ Oxidation

Ozone is a powerful oxidant, second only in oxidation potential to fluorine. Ozone treatment has been successfully applied for many years in the removal of organic pollutants from municipal and industrial wastewaters, and has more recently been implemented as a method for in-situ treatment of soils and groundwater impacted by organic contaminants. Ozone is generated on-site and injected into the subsurface. Once in contact with PCB molecules, it acts upon the carbon-carbon double bond, causing the bond, and subsequently the molecule, to break open or apart. Theoretically, the molecules are oxidized completely (either chemically by additional ozone addition or biologically by aerobic microorganisms). The oxidized by-products are subsequently extracted and treated. Excess ozone must also be captured and degraded to oxygen before being released to the atmosphere.

There are significant uncertainties associated with the implementation of in-situ oxidation technologies at the Site. Bench-scale studies have been conducted with fill from the Site. Very large amounts of ozone were necessary to degrade PCBs in the fill. Specifically, fill heterogeneity and high organic content may make the effective implementation of this technology difficult. Also, the proximity of the highest concentrations of PCB-impacted fill to the underlying Marine Grey Silt Unit would make oxidant delivery to the impacted fill very difficult. Due to these uncertainties, in-situ oxidation will not be retained for further consideration.

3.2.7.2 In-situ Solidification/Stabilization

In-situ waste stabilization involves the addition of a binder such as Portland cement, cement kiln dust, or fly ash to a waste to convert contaminants into a less soluble, mobile, or toxic form. In-situ waste solidification involves the addition of a binding agent, such as Portland cement and others, to the waste to encapsulate the contaminants in solid material. In-situ waste solidification reduces permeability to leaching agents by reducing waste porosity and exposed surface area. S/S processes use one or both of these techniques to reduce the mobility of PCBs, but do not concentrate or destroy them as do other PCB remedial technologies. In-situ S/S technologies have been successfully applied at other PCB-impacted sites (USEPA, 1990); therefore, this technology will be retained for further consideration.

3.3 Evaluation of Technologies

3.3.1 Technology Evaluation Criteria

In **Section 3.2**, technologies were presented and evaluated primarily with respect to technical implementability. In this section, the technology processes considered to be implementable are evaluated in greater detail. The technologies are evaluated in terms of effectiveness, implementability (primarily administrative feasibility), and cost in accordance with USEPA guidance (USEPA, 1988).

3.3.1.1 Effectiveness

The process options retained in this section are evaluated for their relative effectiveness in achieving remedial action objectives, and addressing the COPCs. Also, technology processes are evaluated further based upon their effectiveness relative to other processes within the same technology type. This evaluation focuses on:

- The potential effectiveness of the process option in handling the estimated areas or volumes of media and meeting the remedial action objectives
- The potential to impact human health and the environment during the construction/implementation phase including the potential for adverse environmental effects of the remedy by increasing the contaminant migration to non-impacted media.

- How reliable the process is with respect to Site conditions

3.3.1.2 Implementability

Process options are evaluated for institutional and technical implementability. Institutional implementability includes the ability to obtain permits and approvals for on-site and off-site actions, the availability of disposal facilities (if required), and the availability of necessary equipment and skilled workers. Technical implementability addresses unique site characteristics (i.e., complex nature of the fill, affinity of the COPCs for the fill, shallow depth to fill water) and the limited open space at the Site. The implementability evaluation includes consideration of construction difficulties associated with the retained technologies.

3.3.1.3 Cost

Process options are evaluated for relative cost. Options are eliminated if they are an order of magnitude or greater in cost and do not offer greater effectiveness, reliability, or environmental protection than other options. Costs are discussed only when the screening process is affected.

In accordance with USEPA guidance (USEPA, 1988), at this stage the evaluation focuses on effectiveness factors, with less emphasis on implementability and cost evaluation. Additionally, at this stage a greater emphasis is placed on the institutional aspects of implementability rather than the technical aspects (that was used as an initial screen in **Section 3.2**).

Remedial action technologies deemed implementable and retained for further consideration at the Site are summarized in **Table 3-1**.

3.3.2 No Further Action

The "No Further Action" technology including IRMs completed or underway provides a baseline from which to evaluate the effectiveness of other alternatives in reducing the toxicity, mobility, or volume of COPCs, or potential exposure pathways to COPCs at the Site. The "No Further Action" technology would be readily implementable as previously discussed. Costs associated with the "No Further Action" technology include annual costs for maintenance and repair of paved surfaces, maintenance of fencing, site security operations, and costs associated with sample collection, laboratory analyses, and reporting of results.

Pursuant to the NCP and USEPA guidance for conducting RI/FS investigations, the "No Further Action" alternative must be developed and examined as a baseline of comparison for other remedial alternatives. This technology will be retained for further consideration.

3.3.3 Institutional Controls

Institutional controls are physical or legal measures taken to deter Site access or direct exposure with impacted media. Potentially implementable institutional controls include access restrictions, deed restrictions, zoning restrictions, and site use limitations under New York State Environmental Conservation Law (NYS ECL). Specific control measures are evaluated below.

3.3.3.1 Access Restrictions

Access restrictions effectively minimize the potential for direct contact with fill, fill water, and phase-separated liquid. Access restrictions include fencing and site security operations.
Site access is currently restricted to authorized personnel who must enter the site through a controlled gate. Visitors must sign in at the gate and be accompanied on-site by authorized personnel. The entire site is encompassed by 6-foot-high chain-link fencing with three strands of barbed wire on top. Several areas within the Site are also fenced, including the Northwest Corner, the Water Tower area, and the entire south end. Continued implementation of the current access restrictions would not be difficult.

Postings regarding Site activities or access to the Site would also be feasible and appropriate.

Costs cannot be accurately assessed at this point in this FS report as measures to restrict Site access with respect to specific remedial alternatives are not defined; however, on an order-of-magnitude basis, the anticipated costs for access restrictions would be reasonable. Access restrictions will be retained for further consideration.

3.3.3.2 Notice of Covenant on Deed Transfers

Notice of covenant on deed transfers can be used to effectively convey information regarding the remedial action. Deed restrictions can also be used to regulate future Site activities such as prohibitions on developing on-site water supplies, and thus control potential exposures to impacted media. These notifications could be placed on the title and all subsequent plot plans for the Site. This option could be implemented provided the appropriate legal actions are taken to prepare a negotiated agreement between the current property owner and local and state government agencies. Since Atlantic Richfield is the current property owner, this is a readily achievable action.

Costs cannot be accurately assessed at this time, but on an order-of-magnitude basis, the anticipated costs for a notice of covenant on deed transfers would be reasonable. Notice of covenant on deed transfers is potentially applicable and will be retained for further consideration.

3.3.3.3 Zoning and Land Use Restrictions

Zoning restrictions could be used to regulate future Site activity and thus control potential exposures to impacted media.

This option could be implemented at the local level; appropriate zoning actions would have to be adopted by local government agencies. Zoning restrictions may be more difficult to implement than deed restrictions due to the local government approval process required to create a special zoning district with specific building restrictions or prohibitions. Once created, this zoning district would require plan review and approval prior to any changes in site conditions that may impact potential exposures. This process creates an additional level of inspection and enforcement to maintain the effectiveness of the implemented remedy. Therefore, zoning restrictions will be retained for further consideration.

NYSDEC may be petitioned to reclassify different portions of the Site (for example, the central and southern portions of the Site may be treated differently from the northern portion) in the NYS Inactive Hazardous Sites Registry. The reclassification would indicate the appropriate status for each area after completion of the remedial action. The procedures for reclassification of the Site and prohibitions on physical alterations and change in use of the Site are set forth in 6 NYCRR Part 375-1. Accordingly, persons wishing to undertake any physical alteration affecting the selected remedy, or to make a substantial change in use of any portion of the Site listed in the Registry would need to obtain the approval of NYSDEC. This requirement would limit significant changes in the use of portions of the Site remaining on the Registry, and potential changes in exposure scenarios. As with zoning restrictions, the requirements of the Registry ensure that agency review and approvals precede any significant changes at the Site.

Costs cannot be accurately assessed at this time, but on an order-of-magnitude basis, the anticipated costs for implementing land use restrictions would be considered minimal relative to the overall estimated Site remedial costs.

3.3.4 Containment

As previously discussed, containment technologies determined to be technically implementable at the Site include contact barriers, capping, surface water controls, and vertical barriers.

3.3.4.1 Contact Barriers

A contact barrier system would be highly effective in preventing human contact with impacted media. The contact barrier system would be designed using a combination of new and existing Site materials. Currently, over 90% of the Site is covered with pavement or building structures with concrete slab floors. **Figures 3-1** and **3-2** document the existing surface conditions at the Site. When buildings are demolished, their foundations and slab floors would remain to serve as a portion of the contact barrier system. The existing pavement and building slabs would require minimal rehabilitation in order to be incorporated into a contact barrier system for the Site. The remaining portion of the Site would be covered with a combination of asphalt, concrete, steel mat, or synthetic mat contact barriers. The contact barrier system would be covered with approximately 2 feet of soil (where applicable), which would be capable of sustaining vegetative growth.

Existing structures are constructed on a network of pilings. Any new construction would also require that foundations be placed on piles. These piles could be installed through the contact barrier, posing only minor difficulty to future Site construction or development.

The installation of asphalt and concrete pavement is routinely performed with readily available materials and equipment. Steel or synthetic mat contact barriers can be designed to allow for free drainage of infiltrate precipitation and require less site preparation than asphalt or concrete. By using combinations of these technologies, the design of a contact barrier system can be very flexible in accommodating many possible future land-use scenarios at the Site.

The capital costs for the installation of a contact barrier system would be relatively low in comparison to the benefits it would provide. This technology will be retained for further consideration.

3.3.4.2 Capping

Over 90% of the Site is currently covered by buildings or pavement, which limits potential direct contact with impacted media and infiltration of rainwater into the subsurface. **Figures 3-1** and **3-2** document the existing surface conditions at the Site. During redevelopment, some or all of the structures may be removed and/or replaced. If a soil cap is installed over newly exposed fill, the potential exists for increased infiltration into the subsurface. However, increased infiltration is not expected to increase fill water concentrations of the primary COPCs (PCBs, benzo[a]pyrene, and dibenzo[a,h]anthracene). This conclusion is supported by the fact that the fill material has a very high organic carbon content (10%, on average) and that the COPCs preferentially adsorb to the fill rather than dissolving into the fill water. The high organic content of the fill is due to the degraded coal, ash, wood, and other similar materials that make up a significant percentage of the fill.

Due to the nature of the Site's COPCs, upward transport of COPCs in soil gas is insignificant at the Site; therefore, provisions for gas venting or capture were not considered in any of the capping processes discussed below. Regardless, it is standard construction practice to install a moisture barrier beneath new foundations to prevent the transport of soil moisture into the structure.

Capping process options retained for further consideration based upon their technical implementability include:

- Permeable soil caps
- Asphalt/Concrete caps
- Multi-layered caps

Permeable Soil Caps: A permeable soil cap would be effective in preventing fill erosion and exposure to impacted media. Compacted soil has several advantages over synthetic materials: it is more durable, requires minimal long-term maintenance, and is not impaired by minor settlement or subsidence, although it may be penetrated rather easily and does not on its own offer a high degree of exposure protection. Additionally, a soil cap can be easily repaired.

Soil that is appropriate for constructing a permeable soil cap is readily available. Soil cap construction could be implemented using conventional engineering and construction practices. Minimal long-term maintenance would be required to ensure the soil cap's integrity.

A permeable soil cap would be the least costly of the capping options evaluated in this report. This process option will be retained for further consideration.

Asphalt/Concrete Caps: Asphalt and concrete caps would be effective in preventing fill erosion and exposure to impacted media; however, the fill's differential settlement may make asphalt and concrete caps problematic as an infiltration barrier. The Site's impacted areas could be covered with asphalt or concrete using conventional construction practices, including removal of the inactive portion of the on-site railroad tracks and ballast. Compared to a soil cap, it would be more difficult and costly to construct an asphalt or concrete cap suited for redevelopment aesthetics. However, the effectiveness would be equal to that of a soil cap. The use of an asphalt cap would have to be carefully integrated with long range development plans for the Site. Therefore, asphalt and concrete caps may be more restrictive for some future land uses. The capital cost of an asphalt or concrete cap would be higher than a permeable soil cap.

The cost of an asphalt/concrete cap would be an order of magnitude greater than a soil cap due to the additional tasks identified above. Asphalt/concrete caps will be retained for further consideration.

Multi-Layered Caps: Multi-layered cap systems are effective and are commonly used for capping hazardous waste landfills. The multi-layered system meeting the substantive performance requirements of 6NYCCR Part 360 and TSCA Part 761 would effectively prevent direct contact with impacted fill and the migration of contaminants due to erosion. One of the primary objectives of a multi-layered cap is to prevent infiltration of rainwater through the fill material.

An impermeable multi-layered cap system incorporating a synthetic liner, an overlying compacted soil layer, and an underlying drainage soil layer could be installed at the Site. Substantial design and construction engineering, site preparation, quality control, and long-term maintenance would be inherent to the use of a multi-layered cap.

This solution would be much more complicated to implement than a soil cap, but there are technical benefits of using an impermeable multi-layered cap rather than a soil cap. The primary benefit is the ability of the multi-layered cap to control infiltration. Institutional controls would be required to prevent damage to a multi-layered system. This would restrict the future land use where multi-layered systems are used.

The cost of a multi-layered system would be an order of magnitude greater than a soil or asphalt cap due to the additional tasks identified above. Multi-layered caps will be retained for further consideration.

3.3.4.3 Surface Controls

Surface controls are generally effective in minimizing erosion caused by surface water run-on and run-off. Surface controls would be used in conjunction with other remedial measures, depending on topography and other factors. The use of surface controls (vegetated areas, retention ponds, drainage swales, etc.) must be consistent with Site conditions such as the riverbank, roads, and buildings. These options would employ standard construction practices, would be effective when employed properly, and would be relatively easy to implement.

The costs associated with surface controls vary depending upon the type and application of the controls. Surface controls will be integrated into any remedial alternative that involves regrading Site topography. Specific controls will be identified in the remedial design.

3.3.4.4 Vertical Barriers

Vertical barrier process options evaluated in this FS include:

- Sheet piling
- Slurry walls
- Grout curtains

Sheet Piling: Sheet piling would be effective in preventing COPC migration from impacted media, provided the sheets can be driven to the required remedial design depths without meeting insurmountable resistance from subsurface obstructions.

Sheet piling installation would use readily available materials and equipment. Subsurface obstructions may cause some difficulties with installing sheet piling into the fill material. The cost of sheet piling is of the same order of magnitude as a slurry wall or grout curtain. The technical risks of this technology have been reduced through implementation of the Southwest Corner Bulkhead Interim Remedial Measure. This technology will be retained for further consideration.

Slurry Walls: Slurry walls would be effective in preventing contaminant migration from impacted areas of concern. Subsurface obstructions would be removed during excavation of the vertical trench.

Slurry wall installation would use readily available materials and equipment. The cost of a slurry wall is of the same order of magnitude as a sheet-pile wall or grout curtain. This option may be retained for consideration as an upgradient vertical barrier.

Grout Curtains: The presence of subsurface structures and miscellaneous debris at the Site may inhibit the effectiveness of a grout curtain. It may not be possible to form an effective slurry seal around the variety of buried debris and subsurface structures existing at the Site. This option will not be retained for further consideration.

3.3.5 Source Removal

The effectiveness of source removal would depend upon the location and depth of the impacted media to be removed by excavation. Excavated materials could either be treated on site or transported off-site for subsequent treatment/disposal. Treatment and disposal issues are further evaluated in the ensuing sections of this FS report.

Fill water is first encountered at the Site at depths ranging from 2 to 8 feet bgs. Excavations greater that 4 feet deep would require bracing and/or sloping to stabilize the side walls of the excavation. Depending on the depth to fill water in the vicinity of the excavation, fill water may or may not be encountered.

Three zones were considered when evaluating the possibility of excavating materials at the Site: shallow excavations requiring no bracing, excavations above the water table requiring bracing, and deep excavations below the water table requiring bracing and control of water.

In all shallow and moderate depth excavation cases, the removal remedy included consideration that excavation would be undertaken in the dry, excavation support stuctures would not penetrate through the Marine Grey Silt unit and provide a conduit for contaminant migration to the underlying Basal Sands unit, and the hydraulic head within the underlying Basal Sands Unit and/or the excavation area would not be altered. Deep excavation alternatives required one or more of the above excavation constraints to be utilized. As such, all of the deep excavation alternatives violate the Basic Principles described in **Section 1.0**.

3.3.5.1 Shallow Excavations

Shallow excavations would be conducted in the top 4 feet of fill at the Site. They would require no bracing to complete and would be effective in removing impacted fill from the subsurface. Shallow excavations would not encounter fill water; therefore, no dewatering/water treatment provisions were considered.

Shallow excavations would be performed with standard construction equipment by labor crews trained and certified in accordance with OSHA Standard 1910.120. In accordance with 29 CFR Part 1926 Subpart P, a Competent Person with the authority and knowledge to make decisions regarding health and safety issues must be designated on-site.

Shallow excavation costs would depend upon the volume of material to be excavated from a given area and the presence/absence of underground utilities in the vicinity of the excavation. Shallow excavations would be the least costly of the source removal process options evaluated in this FS. Shallow excavations will be retained for further consideration.

3.3.5.2 Braced Excavations Above the Water Table

Certain shallow excavations may require bracing and/or sloping. Excavation bracing or sloping may be required if the integrity of an adjacent structure, or the excavation operation, depends upon excavation stability. Braced excavations above the water table (depths greater than approximately 3 feet) would be regarded as an effective method for removing impacted fill from the subsurface. Braced excavations above the water table would not encounter fill water; therefore, no dewatering/water treatment provisions were considered.

Braced excavations above the water table can be completed with standard excavation and shoring equipment labor crews trained and certified in accordance with OSHA Standard 1910.120. In accordance with 29 CFR Part 1926 Subpart P of OSHA, a Competent Person with the authority and knowledge to make decisions regarding health and safety issues must be designated on-site. In areas where braced excavations would be required in the vicinity of building foundations or rail lines, a geotechnical analysis would be required to evaluate the excavation's effects on the Buildings and the adjacent rail line.

Excavation costs will be directly related to the depth of the excavation and the presence/absence of underground utilities and obstructions. Braced excavations above the water table will be retained for further consideration.

3.3.5.3 Braced Excavations Below the Water Table

Excavations below the water table would require shoring, bracing and/or sloping to complete. However, there are several substantial problems associated with the procedures required for excavating below the water table at the Site which must be overcome in order to further consider this technology. **Appendix B** contains the Excavation Evaluation Summary Report which describes options and limitations for conducting deep excavations at the Site. This Excavation Evaluation Summary Report was prepared following a technical review meeting of seven outside geotechnical experts designed to evaluate the potential for deep excavations at the Site. As a result of this report, three primary source removal Basic Principles have been developed for the source removal remedy:

1. Excavation will not include flooding As stated above, flooded excavations will likely result in difficulty in dewatering excavated spoils, difficulty in treating water with suspended contaminants, and difficulty in inspecting and verifying excavation depths/remedial limits. In addition, depending on the flooding requirements to achieve excavation stability, the resultant head variation may cause relatively immobile PCBs to remobilize and move downward to the Basal Sands Unit.
2. No penetration of the Basal Sands Unit by excavation support structures. The installation of excavation support structures would significantly increase the risk of contaminant drag-down and provide a pathway for downward contaminant migration after (as well as during) excavation support installation. As stated above, the selected remedial alternative will be protective of the environment, which includes reduction/elimination of the risk of contaminant migration and protection of unaffected groundwater resources (i.e., the Basal Sands Unit).
3. No hydraulic head modification of the Basal Sands Unit. A common excavation construction technique to reduce the risk of bottom heave is to lower the hydraulic pressures in underlying water bearing units. At this site, the high hydraulic head in the Basal Sands Unit is a significant factor in the likelihood of excavation bottom instability. Under "normal" construction (i.e., an uncontaminated site), lowering the head in the Basal Sands Unit would allow for a deeper, "dry" excavation by reducing/alleviating the risk of bottom heave. At this site, however, lowering the head in the Basal Sands Unit may significantly increase the risk of downward PCB migration. This is particularly true in areas where PCB product has been observed. As stated above, the selected remedial alternative will be protective of the environment, which includes reduction/elimination of the risk of contaminant migration and protection of unaffected groundwater resources.

The technical challenges associated with deep excavation at the Site are detailed in **Appendix B** and are enumerated below.

The debris and abandoned waterfront structures in the man-made fill will make installation of excavation shoring very difficult. It may not be possible to drive steel sheet piling without first removing or cutting through obstructions. The obstructions cannot all be located in advance, so many delays should be expected in this portion of the work. If the excavation is accomplished in small cells, e.g., 50 ft or some similar size, it is anticipated that this difficulty and the associated delays would be encountered repeatedly throughout the course of the work. Large open excavations would lessen this impact, but bracing would become much more difficult, as discussed below.

The loose and saturated man-made fill will exert high lateral pressures on the excavation shoring. Bracing consisting of struts, rakers, or tiebacks would be necessary. Tiebacks would be difficult to implement because they would have to be anchored in the fill and because numerous obstructions, such as foundation piling for the existing buildings, would have to be avoided. Rakers are not feasible because of the weak nature of the Marine Grey Silt Unit. If small cells are used, struts are practical, but ongoing difficulties with shoring installation should be anticipated, as described above. If large open excavations are used, struts are much less practical because of the long strut lengths and the congestion that would be created in the excavation area.

Shoring will also be very difficult along the waterfront. This shoring will have to retain the ground beneath the Hudson River and the Hudson River itself. Construction and removal of a cofferdam in this area would disturb PCBs in the river sediments and increase the distribution of contamination within the river. Cofferdam construction would also take a long period of time and could interfere with river traffic.

Based on the information in the remedial investigation report, the Marine Grey Silt that will be exposed at the bottom of the excavations is very weak. If excavations are made after dewatering is completed in areas contained by shoring, the silt would not have sufficient strength to resist what is known as “bottom heave” or “reverse bearing capacity failure.” This failure mechanism occurs when the weight of the material adjacent to an excavation is greater than can be supported by the sheer strength of the soil at the level of the bottom of the excavation. Because of its weight, the fill material adjacent to the excavation at this site is expected to subside, pushing the underlying weak silt down and toward the excavation in a rotational failure so that the silt at the bottom of the excavation heaves upward. This failure mechanism is expected to cause damage to adjacent structures and property. It could also cause collapse of the shoring. Bottom heave and shoring collapse could produce fatal and non-fatal injuries to construction workers and occupants of adjacent buildings. It is very difficult to prevent bottom heave due to reverse bearing capacity failure when the underlying ground is as weak as the Marine Grey Silt Unit is at this site. One possible approach would be to modify the silt using jet grouting; however, this would be difficult to implement and verify at depth due to the plasticity of the Marine Grey Silt Unit and could result in introduction of PCBs into the silt.
In addition, pilings and other obstructions could cause shadowing that would make the confirmation of grouting effectiveness difficult.

If excavations are made after dewatering is completed in areas contained by shoring, uplift of the silt could also occur due to the elevated water pressures in the underlying basal sand. This failure mechanism is distinct from the reverse bearing capacity failure described above. It will be necessary to relieve the uplifting water pressures by pumping ground water from the basal sand. Pumping water from the basal sand would undoubtedly induce consolidation of the Marine Grey Silt Unit. The very low strength of the silt suggests that it is normally consolidated, and the increase in effective vertical stress that would result from reducing water pressures in the basal sand would be expected to cause significant consolidation in the silt and corresponding settlement of the ground surface. Such settlement is expected to damage pavements, utilities, buildings, and other structures. The settlement would extend beyond the

Site because ground water withdrawal would reduce water pressures in the basal sand beneath adjacent properties. Even buildings supported by piles founded in the basal sand may experience distress because downdrag from the settling silt and fill is expected to cause the piling to settle.

If the excavations are flooded, the problems associated with high lateral pressures on the shoring, reverse bearing capacity failure, and uplift may be reduced. However, this method is not recommended because subaqueous excavation would create several other difficulties: the excavation water would require treatment, excavation duration would increase, inspection and testing of the construction quality and excavation completeness would be extremely difficult, and backfilling would be problematic. In addition, the extent of treatment necessary to stabilize the excavation spoils so that liquid would not drain from the spoils would be increased. The batch plant and staging areas necessary for such treatment are discussed below.

Other important difficulties associated with flooded deep excavation include:

- Debris and buried waterfront structures will make excavation in the man-made fill difficult. The excavated debris and structures may require off-site disposal.
- Should the silt, which is very thin in some locations, be breached by the excavation process, elevated water pressures in the basal sand would be released. This would have at least two negative effects: 1) the upward hydraulic gradient through the silt would be reduced or eliminated, which would make downward migration of contaminants at the site more likely, and 2) reduced pore water pressures in the sand would lower pore water pressures in the silt, which would be accompanied by consolidation of the silt and settlement of the ground surface.
- The risk of exposing construction workers to fatal and non-fatal injuries would be much greater for the excavation alternative than for other remedial alternatives.
- The risk of exposing construction workers to contaminants would be much greater for the excavation alternative than for other remedial alternatives.
- The logistics of the excavation and backfilling operation are formidable. A batch plant would be necessary to process the soil before it is transported to the off-site landfill. The batch plant would treat the excavation spoils by drainage and/or stabilization with amendments so that liquid would not drain from the excavation spoils either during transportation or after placement in the off-site landfill. The operation would progress as follows: 1) provide excavation support, 2) dewater the excavation, 3) excavate, 4) move excavation spoils to a stockpile area, 5) run the stockpiled material through the batch plant, 6) place the treated soil in a second stockpile, and 7) load the treated soil into trucks, rail cars, or barges for transportation to the off-site landfill.
- Steady-state production through the batch plant would have to be matched with the rate at which the trucks, rail cars, or barges are loaded. Stockpile areas will be

necessary leading into and coming out of the batch plant to provide buffers should there be temporary interruptions in the excavation process or the batch plant functioning. Temporary interruptions in the excavation process are especially likely if small cells are used because it is anticipated that obstructions would be encountered very frequently during shoring installation. It is estimated that an area of about one acre will be necessary for the stockpiles, the batch plant, and other contractor staging areas. Even with stockpiles of the size envisioned here, there is still a risk that interruptions will produce delays in loading the treated soil into trucks, rail cars, or barges for transportation to an off-site landfill. If trucks are used, such delays would produce a back-up of trucks at the site. A delay of only two days would likely result in all of the trucks in the fleet becoming backed-up at the site. It will also be necessary to provide stormwater control and stormwater treatment for the stockpile areas. Elaborate inspection and testing services will be necessary to verify that releases of contamination are prevented during the entire operation. Another important logistical issue is that backfill delivery and placement will have to be carefully coordinated with the progress of the excavation.

- The act of deep excavation dewatering will result in a large volume of water requiring treatment. Even if treated to the allowable discharge limits, the potential exists that a greater mass of COPCs (including PCBs) may be discharged to the River than would occur under ambient fill water flow conditions. Even though treated water could be discharged containing PCBs below permitted levels, the total mass of PCBs contained in the millions of gallons of water to be removed through dewatering may release more contaminants to the River than ambient fill water flow at current rates. **Appendix C** contains an evaluation of potential discharge to the River resulting from deep excavation dewatering.

Given these substantial technical challenges and process risks, retention of this technology cannot be justified, although at the request of NYSDEC, this technology will be retained for further consideration.

3.3.6 Ex-situ Treatment

The only ex-situ treatment process option retained for further consideration after evaluation of technical implementability was ex-situ S/S. Ex-situ S/S processes involve: (1) fill material excavation, (2) primary separation to remove oversize debris, and (3) mixing of excavated soil with S/S agents. This approach requires that fill material be mixed with the binding reagents and water in a batch or continuous system. The resultant mix can be cured in-place or poured as a slurry into containers or molds for curing and disposal on-site or off-site.

A laboratory treatability study was conducted using fill material obtained at the Site to assess the effectiveness of S/S treatment. Leachability tests conducted with PCB-impacted fill material treated with Portland cement and other reagents showed lower levels of PCBs from treated fill material than from untreated fill material.

As discussed above, ex-situ S/S treatment requires excavation of the impacted fill material. Concerns regarding excavation for S/S treatment are the same as the concerns presented above for source removal. Also, the fill material must be sorted and all oversize debris must be removed from the waste stream. The heterogeneous nature of the fill material would present difficulties when performing an ex-situ S/S treatment process.

The costs associated with ex-situ S/S would have to be weighed against the costs of off-site disposal of the material. Disposal of treated material would cost less, but the costs of performing the treatment may offset the disposal savings. Also, ex-situ S/S increases the volume of the material (due to the addition of the binders). The increase in material volume would increase the costs associated with material transport and disposal.

Assuming that excavation of the fill material to be treated can be conducted, ex-situ S/S is technically feasible. However, it will not be retained for further consideration due to its cost premium relative to off-site disposal.

3.3.7 Disposal of Excavated Fill

Depending upon the nature of the material requiring disposal and the concentration of the COPCs present in the material, both on-site and off-site disposal, as either non-hazardous solid waste or as hazardous waste, were retained for further consideration. All of the disposal options considered below would effectively limit exposure to potential receptors; however, the volume and toxicity of wastes would not be reduced by those processes.

3.3.7.1 On-Site Disposal

On-site disposal of fill in an engineered containment cell would effectively limit exposure to potential receptors. In the *Record of Decision for the Irvington Waterfront Park* (NYSDEC, March 1998), the NYSDEC's preference under the recommended alternative is to relocate excavated material on the Site and cover it with soil. The subject Site of this FS report and the site in Irvington were both created by filling into the Hudson River using similar fill material. Both sites contain inorganic metals and PAHs inherent to the ash and furnace slag that comprises much of the fill material. However, the creation and maintenance of a disposal cell at the Site may not be consistent with current or future use scenarios. As a result, this technology will not be retained for further consideration.

3.3.7.2 Off-Site Disposal as Non-Hazardous Waste

This disposal process would be effective in removing COPCs from the Site and limiting long-term exposure to potential receptors; however, an increased short-term risk of exposure would be posed to workers during excavation and to potential receptors along the transportation route. This process would result in reductions in the waste's volume, toxicity, and mobility at the Site through the transfer of this waste to a secure, approved, off-site solid waste disposal facility; however, it would not result in an ultimate reduction in toxicity or volume. Waste mobility would be reduced by placement of the waste within a secured landfill.

Assuming that the material can be safely and feasibly excavated from the Site, the staging, loading, and transportation processes would be considered implementable. Depending on the quantities of material to be transported, the result of health risks may exceed those posed by leaving the material in place on-site. Difficulties associated with material excavation are discussed in **Section 3.3.5.**

Disposal of waste as non-hazardous solid waste is the least costly disposal option.
This process will be retained for further consideration.

3.3.7.3 Off-Site Disposal as Hazardous Waste

In NYS, materials containing PCB ≥50ppm are considered hazardous waste, as well as wastes that are hazardous by virtue of their toxicity characteristic (as determined by TCLP analysis). This disposal process would be effective in removing COPCs in hazardous waste from the Site and limiting long-term exposure to potential receptors; however, an increased short-term risk of exposure would be posed to workers during excavation and to potential receptors along the transportation route. This process would result in reductions in waste volume, toxicity, and mobility at the Site through the transfer of this waste to a secure, approved, off-site hazardous waste disposal facility, but it would not result in an ultimate reduction in toxicity or volume. Waste mobility would be reduced by placement of the waste within a secured landfill.

Once the material is excavated from the Site, the staging, loading, and transportation processes would be readily implementable. Depending on the quantities of material to be transported, the result of health risks may exceed those posed by leaving the material in place on-site. Difficulties associated with material excavation are discussed in **Section 3.3.5.**

Disposal costs of hazardous wastes will be significantly higher than disposal as non-hazardous. Costs for transportation, treatment to LDR standards (if required), and disposal costs can range by as much as $368 per ton. This process will be retained for further consideration.

3.3.8 In-situ Treatment

The only in-situ treatment process option retained for further consideration after evaluation of technical implementability was in-situ S/S. In-situ S/S involves injecting binding reagents into the subsurface at targeted locations. The binding reagents either react with the targeted COPCs to form insoluble and stable compounds or they simply reduce the porosity and hydraulic conductivity of the targeted location, thus reducing potential mobility of COPCs.

A laboratory treatability study was conducted using fill material obtained at the Site to assess the effectiveness of S/S treatment. Leachability tests conducted with PCB-impacted fill material treated with Portland cement and other reagents showed lower levels of extractable PCBs from treated fill material than from untreated fill material.

As discussed above, in-situ S/S involves injecting reagents into the subsurface. Subsurface debris may hinder the ability to effectively mix reagents with the fill material. A combination of auger and jet grouting techniques could overcome the difficulties associated with the fill at the Site. Jet grouting would be used in areas with high concentrations of subsurface obstructions and auger mixing would be used in the areas that were clear of obstructions.

The cost of in-situ S/S treatment is within an order-of-magnitude of containment or other in-situ containment technologies. This technology would be significantly less expensive than ex-situ treatment or source removal and disposal technologies. In-situ S/S will be retained for further consideration.

3.3.9 Summary

In this section, a wide range of potentially applicable remedial technologies for each GRA were developed, screened, and evaluated for the Site based upon their effectiveness, implementability, and cost. These technologies include an assemblage of the most widely used processes for the COPCs and impacted media identified in the RAOs for the Site. Technologies that were retained from this evaluation for assemblage into site-wide remedial alternatives are listed below and are summarized in **Table 3-2**.

- No action
- Institutional Controls
    - Access restrictions
    - Notice of covenant on deed transfers
    - Zoning restrictions

- Containment
  - Contact barriers (asphalt, concrete, steel, synthetics)
  - Caps (permeable soil, asphalt/concrete, multi-layered)
  - Surface controls
  - Vertical barriers (sheet piling, slurry walls)
- Source removal
  - Shallow fill excavation
  - Deep fill excavation
- Disposal of Excavated Fill
  - Off-Site Disposal
- In-Situ Treatment
  - Stabilization/Solidification

4.0 DEVELOPMENT AND ANALYSIS OF REMEDIAL ALTERNATIVES

4.1 Development of Remedial Alternatives

The technologies retained in **Section 3.3** were assembled into twelve (12) remedial alternatives designed to achieve the RAOs discussed in **Section 2.5**. The RAOs are goals developed to protect human health and the environment. The five (5) IRMs completed at the Site as described in **Section 1.5** are either complete or incorporated into each of the twelve (12) alternatives.

The following sections present a discussion of each assembled remedial action alternative. A summary description of the alternative is provided along with a brief discussion of the alternative's effectiveness in providing protection and the reduction of toxicity, mobility, or volume as well as the implementability, both technical and administrative, compared with other remedial action alternatives. Several of these alternatives were developed in response to the NYSDEC's request in a letter dated December 8, 1999 (NYSDEC, 1999). Others were developed by Atlantic Richfield Company.

4.1.1 Alternative 1: No Action

4.1.1.1 Description

The No Action alternative is the baseline or standard against which other alternatives are measured. No further action would be taken to address the presence of COPCs in the surface fill, subsurface fill, or fill water. However, single- or multiple-media sampling (e.g. fill, water, and/or air sampling) may be included for the purpose of monitoring COPC migration and/or degradation and natural attenuation. Current administrative controls limiting site access would be continued and the bulkhead along the entire waterfront would be repaired to prevent erosion. The Site is fenced and gated, and on-site security personnel control access to the Site. Previously implemented corrective measures would continue to be maintained. The two ongoing IRMs described in **Section 1.5** (LNAPL recovery, Northwest Corner surface cover,) would continue to be implemented and managed external to the FS process. **Figure 4-1** is a site area map that shows the location of the bulkhead, fencing, and the IRMs. This alternative removes 0% of the mass of the existing PCB contamination and restores 0 acres of the Site to productive use.

4.1.1.2 Effectiveness

This alternative would provide protection for trespassers and site workers by continued administrative controls that limit access to the site. The repair of the existing bulkhead along the waterfront is designed to reduce the potential for release of COPCs into the Hudson River. The NYSDEC concluded that bulkhead repair/reconstruction would effectively reduce the potential for off-site migration of similar fill material in their ROD for the Irvington Waterfront Park (NYSDEC, 1998). For cost estimating purposes, a Waterloo Barrier©-type steel sheet-pile bulkhead was evaluated. Final design and future site re-use may dictate an alternative bulkhead design; however, the intent of providing shoreline containment/erosion control would have to be incorporated into any alternative design. Volume and toxicity of impacted fill would not be reduced; however, natural attenuation of COPCs in the fill material would slowly reduce COPC concentrations in the fill.

4.1.1.3 Implementability

The No Action alternative would be readily implementable at the site. This technology would require minimal planned or implemented activities. Suppliers and materials for activities such as fill water monitoring, bulkhead repair, and maintenance of fencing are widely available with no anticipated delays in implementation. This alternative would require the most intensive security measures of all the alternatives assembled.

4.1.1.4 Cost

For the purposes of alternative screening, the net present worth of this alternative was estimated to be approximately $17,000,000. A breakdown of the cost estimate for this alternative is included in **Appendix D**.

4.1.1.5 Summary

Under this alternative, the site would be left in its present condition. Continued implementation of the IRMs and the repair of the bulkhead would provide additional protection to human health and the environment. The major shortcoming of this alternative is that it is not compatible with redevelopment and future uses of the Site. Pursuant to the revised National Contingency Plan (NCP, 1990) and USEPA guidance (USEPA, 1988), the No Action alternative must be developed and assessed as a potential remedial action. The No Action alternative constitutes the baseline by which the other remedial alternatives are compared; therefore, this alternative will be retained, for comparative purposes, throughout the remainder of this FS report.

4.1.2 Alternative 2: Excavation and Off-Site Disposal of All PCB-Impacted Fill and Lead Hot Spots

4.1.2.1 Description

This remedial alternative was originally presented in the Proposed Remedial Action Plan (PRAP) (NYSDEC, September 1988). However, the PRAP underestimated the volume of fill material that exceeded the proposed cleanup levels; therefore, this alternative was reevaluated using a revised estimate of the volume of fill on-site that exceeds the proposed cleanup levels.

This remedial alternative, as defined in the PRAP, would consist of excavation and off-site disposal of all surface fill (i.e., 0 to 1 foot below grade) where PCB concentrations exceed 1 ppm and all subsurface fill where PCB concentrations exceed 10 ppm. These values are NYSDEC's generic soil cleanup objectives from TAGM 4046, unadjusted for site-specific criteria. The estimated total volume of PCB contaminated fill (as measured in place) that would be excavated and disposed off site is 110,000 cubic yards. Depths of excavation would approach 40 feet below grade.

At the request of the NYSDEC, this remedial alternative would also include the excavation and off-site disposal of fill containing elevated lead concentrations. Lead contaminated fill would be excavated in (4), two-foot deep, 50 foot x 50 foot areas surrounding soil borings SB-100, SB-128, SB-131, SB-137 as well as (2), two-foot deep, 25 foot x 50 foot areas surrounding soil borings HB-01 and HB-06. The estimated total volume of lead contaminated fill (as measured in place) that would be excavated and disposed of off-site is 925 cubic yards.

The excavated material will be dewatered on-site to comply with transportation and disposal requirements as solid material. Post excavation analysis of fill material will be used to determine if the material is to be disposed of as non-hazardous solid waste or hazardous waste. The dewatered material will then be transported by rail to a landfill that is permitted to accept the waste in compliance with State and Federal disposal regulations.

The two ongoing IRMs at the Site (Northwest Corner IRM and the LNAPL Recovery IRM) as described in **Section 1.5** would be fully addressed and require no further action subsequent to the implementation of this remedial alternative. This alternative removes approximately 99% by mass of the presently existing PCB contamination and restores 28 acres of the Site to productive use with institutional controls.

Section 3.3.5, Section 4.1.2.3, and **Appendix B** contains a discussion regarding the challenges associated with excavation at the Site. This alternative would require deep excavation below the water table in order to remove the volume of soil described above. The excavated areas will be backfilled with clean soil to existing grades and the bulkhead along the waterfront will be reconstructed to prevent erosion of fill material and particulate transport into the Hudson River. **Figure 4-2** is a site area map that shows a conceptual excavation plan for this alternative and the proposed location of the bulkhead.

4.1.2.2 Effectiveness

This alternative would provide an effective long-term remedy for removing lead and PCB-impacted fill material from the site. However, during the implementation of this remedial alternative, a substantial risk of exposure would be posed to on-site construction workers, the community, the Hudson River environment, and the groundwater located in the Basal Sand Unit underlying the Marine Grey Silt Unit. These increased risks are due to the risks inherent in deep flooded excavations, the potential effect of the excavation on remobilization of contaminants, and the large quantities of material that would have to be excavated and transported off-site.

A remedy implementation risk evaluation conducted for this site (**Appendix E**) concluded that the short-term risks associated with an excavation-based remedy, such as this, are significantly greater than those for containment-based remedies. The remedy implementation risk evaluation also concluded that the short-term risks associated with an excavation-based remedy will more than offset the long-term risk reduction achieved by such a remedy. As a result of those construction activities, even proper engineering controls would increase the short-term mobility of COPCs through vapor and dust inhalation, and dewatering discharge pathways. The volume and toxicity of the impacted fill would not be reduced; however, after placement of the excavated fill material in a secure landfill the long-term potential mobility of the COPCs would be expected to decrease. Re-contamination of backfill materials being placed in the excavation is also possible due to PCBs becoming suspended in the flooded excavation water during deep excavation.

4.1.2.3 Implementability

Although extremely technically challenging, deep excavation of lead and PCB-impacted surface fill can be implemented at this site. However, pilings in the Northwest Corner and the Water Tower extend through the Fill Unit and the Marine Grey Silt Unit to the groundwater aquifer located in the Basal Sands Unit. Removing all PCB-impacted material would require excavation to depths of approximately 40 feet below existing site grade and would likely disrupt the piles which could result in upward and downward movement of groundwater/fill water along the length of the piles. This task would also require the construction of extensive shoring, flooding of the excavation, and the use of specialized excavation equipment. The combination of the flooded excavation and the driving of piles to significant depths within the Basal Sands Unit will drive PCB impacted fill and fill water to contact with the Basal Sands Unit Aquifer, and violate the Basic Principles. As stated in **Section 1**, three primary source removal Basic Principles have been developed for the source removal remedy:

1. Excavation will not include flooding. As stated above, flooded excavations will likely result in difficulty in dewatering excavated spoils, difficulty in treating water with suspended contaminants, and difficulty in inspecting and verifying excavation depths/remedial limits. In addition, depending on the flooding requirements to achieve excavation stability, the resultant head variation may cause relatively immobile PCBs to remobilize and move downward to the Basal Sand.
2. No penetration of the Basal Sands by excavation support structures. The installation of excavation support structures would significantly increase the risk of contaminant drag-down and provide a pathway for downward contaminant migration after (as well as during) excavation support installation. As stated above, the selected remedial alternative will be protective of the environment, which includes reduction/elimination of the risk of exacerbation of contaminant migration and protection of unaffected groundwater resources (i.e., the Basal Sand).
3. No hydraulic head modification of the Basal Sands. A common excavation construction technique to reduce the risk of bottom heave is to lower the hydraulic pressures in underlying water bearing units. At this site, the high hydraulic head in the Basal Sands is a significant factor in the likelihood of excavation bottom instability. Under "normal" construction (i.e., an uncontaminated site), lowering the head in the Basal Sands would allow for a deeper, "dry" excavation by reducing/alleviating the risk of bottom heave. At this site, however, lowering the head in the Basal Sands may significantly increase the risk of downward PCB migration into the Basal Sands. This is particularly true in areas where PCB product has been observed. As stated above, the selected remedial alternative will be protective of the environment, which includes reduction/elimination of the risk of exacerbation of contaminant migration and protection of unaffected groundwater resources (i.e., the Basal Sand).

Debris, buried pilings, and abandoned waterfront structures in the man-made fill will make installation of shoring very difficult. It may not be possible to drive steel sheet piling without first removing or cutting through numerous obstructions which could threaten the stability of the fill. The sheet piling would be required to be driven into the Basal Sands Unit in order to provide the lateral support necessary to achieve the required depths. Flooding of the excavation would also be necessary to overcome hydrostatic uplift forces which would cause bottom heave and failure due to the artesian conditions of the Basal Sands Unit. Some of these issues, specifically the forces of the artesian groundwater, could be alleviated by pumping of the Basal Sands Unit to reduce hydrostatic head, but this would require additional infrastructure to treat the water before it can be discharged, and could potentially reverse the head gradients to the point where cross contamination of the uncontaminated Basal Sands Unit could occur. All of these options also violate the Basic Principles described in **Section 1.0** which were established to prevent the further migration of contaminants during Site remediation.

Similarly, the loose and saturated man-made fill will exert high lateral pressures on the excavation shoring. Bracing consisting of struts, rakers, or tiebacks would be necessary. Tiebacks would be difficult to implement because they would have to be anchored in the fill and because numerous obstructions such as the foundation pilings for existing building or for future redevelopment would have to be avoided. Rakers are not feasible because of the weak nature of the Marine Grey Silt Unit. Struts are not practical in large open excavations. Use of small cells braced by struts would result in significant and repeated delays while fill obstacles are repeatedly removed and cells are installed. Highly specialized sheeting material such as King piling (HZ975A-C1) could be utilized to provide sufficient structural rigidity to support the excavation sidewall, but would have to be driven through the Marine Grey Silt and into the Basal Sands Unit (in excess of 65 feet). A huge amount of steel would have to be utilized to achieve this (in excess of 40,000 tons, assuming simultaneous installation) In addition, flooded excavations and/or pumping of the Basal Sands Unit would be necessary to prevent bottom heave. Lighter grades of sheet piling (AZ-48) could be used successfully in-place of King piling, but would require jet grouting to develop the structural rigidity necessary for support of the pile. This jet grouting would have to be done at multiple depths, would generate significant volumes of waste materials, and may not be implementable in the variable subsurface conditions (see Excavation Evaluation Summary Report, **Appendix B**) In addition, like King piling, flooded excavations and/or pumping of the Basal Sands Unit would be necessary to prevent bottom heave. Thus, both of these deep excavation methods would violate the Basic Principles described in **Section 1.0**.

Of equal concern is the fact that the Marine Grey Silt that will be exposed at the bottom of the excavation is very weak and may not be capable of resisting bottom heave due to a reverse bearing capacity failure, a condition which would likely result in damage to the excavation cell and to any neighboring structures or equipment. This condition would present a significant potential risk of injury to excavation workers. Bottom heave and shoring collapse could produce serious and potentially fatal injuries to construction workers on the site. These injury risks associated with deeper excavation are further discussed in **Appendix B**. It is very difficult to prevent bottom heave due to reverse bearing capacity where the underlying ground is as weak as the Marine Grey Silt Unit is at this Site.

To complete the full excavation of PCB impacted fill, flooded excavations would be necessary to overcome these problems . Although this approach would lessen the risks of bottom heave, reverse capacity bearing failure, and uplift, it would not eliminate them. Moreover, flooded excavations present their own formidable technical challenges. Large volumes of water associated with the excavation would have to be treated before discharge to the River; visually determining whether an excavation was adequately complete would be very difficult, inspections to ensure construction quality would be nearly impossible, installing clean backfill through potentially contaminated excavation water would recontaminate the fill material, and the duration of the project would increase substantially.

In this regard, because deep excavation can only be performed in a flooded condition, the action will require extensive dewatering operations and significant volumes of water to be discharged to the Hudson River. Even if the process water is treated to comply with all applicable discharge limits, a greater mass of residual PCBs (albeit at low concentrations) may be discharged to the River than would occur under ambient fill water flow conditions.

Finally, deep excavation will require a massive planning and coordination effort to treat, transport, and dispose of impacted fill. Extensive dewatering operations would be required on-site to remove contaminated water from the excavated fill materials. Due to poor road access to the site through the Village, extensive rail transport of PCB-materials would be required, requiring coordination with all rail line owners and operators between the site and the disposal facility. Unless disposal facilities with rail terminals can be located, a large trucking operation would need to be undertaken to transport approximately 7,000 truckloads of PCB material from a rail terminal to the disposal facility. Such an operation would have substantial negative impacts on communities along the route from the rail terminal to the disposal facility.

A remedy implementation risk evaluation conducted for this site (**Appendix E**) concluded that the short-term risks associated with an excavation-based remedy, such as this, are significantly greater than those for containment-based remedies. The remedy implementation risk evaluation also concluded that the short-term risks associated with an excavation-based remedy will more than offset the long-term risk reduction achieved by such a remedy.

4.1.2.4 Cost

For the purposes of alternative screening, the net present worth of this alternative was estimated to be approximately $150,000,000. Preliminary alternative screening cost estimates are presented in **Appendix D**.

4.1.2.5 Summary

Deep excavation and off-site disposal of the PCB-impacted fill material in a secured landfill, to the extent excavation is even technically feasible, would encounter extensive technical challenges; would present significant process, health and environmental risks during implementation; and would increase mobility and potential release of COPCs during construction. Any deep excavation technique utilized would violate one or more of the Basic Principles and likely increase the spread of contamination during Site remediation. Ultimately, the removal of PCB-impacted fill material from the site and placement in a secure off-site landfill will not reduce the volume or toxicity of such material. The repair of the shoreline bulkhead would effectively retain fill that contains COPCs (such as PAHs or lead) exceeding TAGM values from eroding into the Hudson River. Although extremely challenging technically and its implementation potentially detrimental to the environment, Remedial Alternative 2 was retained for comparative purposes through the remainder of the FS Report.

4.1.3 Alternative 3: Excavation and Off-Site Disposal of All Fill Located Above the Water Table Exceeding TAGM Values and All PCB- Impacted Fill Located Below the Water Table ≥ 10 PPM, Excavation and Off-Site Disposal of Lead Hot Spots

4.1.3.1 Description

This remedial alternative was developed in response to the NYSDEC's request in a letter dated December 8, 1999 (NYSDEC, 1999). In addition to the material specified in Alternative 2, this alternative would also excavate all subsurface fill located above the water table that contains any COPCs exceeding any TAGM value. Additionally, the NYSDEC requested the removal of fill containing elevated lead "hot spots", as specified in Alternative 2. As in Alternative 2, the soil cleanup objectives are NYSDECs generic TAGM values, unadjusted for site-specific criteria. The IRMs that have been completed or that are ongoing at the Site (LNAPL Recovery,

Northwest Corner) would be fully addressed by this Alternative and would require further action subsequent to Remedial Alternative implementation. The estimated volume of fill (as measured in place) that would be excavated and disposed off site is 287,000 cubic yards. Depth of excavation would approach 40 feet below grade.
The NYSDEC also requested that a variation to this alternative be developed to evaluate its cost effectiveness. The variation is to excavate all subsurface fill located above the water table and all PCB-impacted fill located below the water table ≥10 ppm. Due to the nature of the material used to create the site (demolition debris, ash, and furnace slag), the variation requested by NYSDEC was determined to be identical to Alternative 3 as described above; therefore, the variation was no longer considered for evaluation.

All of the substantial challenges associated with Alternative 2 regarding deep excavation, dewatering, sampling, and transportation to an off-site disposal facility apply to this alternative. The excavations will be backfilled with clean soil to existing grades and the bulkhead along the waterfront will be reconstructed to prevent erosion of fill material and particulate transport into the Hudson River. **Figure 4-3** is a site area map that shows a conceptual excavation plan for this alternative and the proposed location of the bulkhead. The area of deep excavation is the same as for Alternative 2; however, additional soil volume would be generated by shallow excavation over the remainder of the site. This alternative removes approximately 99% by mass of the presently existing PCB contamination and restores 28 acres of the Site to productive, use with institutional controls.

4.1.3.2 Effectiveness

This alternative would provide an effective long-term remedy for removing fill material containing COPCs exceeding TAGM values located above the water table, and PCB-impacted fill material located below the water table ≥ 10 ppm from the site. However, during the implementation of this remedial alternative, an increased risk of exposure would be posed to the on-site construction workers, the community, the Hudson River environment, and the groundwater underlying the Marine Grey Silt Unit. In order to successfully conduct excavations to the depths necessary to implement this alternative, violation of one or more of the Basic Principles (flooded excavations, penetration of the Basal Sands Unit, or pumping of the Basal Sands Unit) will be necessary. These constraints were developed to prevent the spread of contamination into the uncontaminated Basal Sands Unit and as noted in **Section 4.1.2.3**, the implementability and effectiveness of this alternative is questionable. A remedy implementation risk evaluation conducted for this site (**Appendix E**) concluded that the short-term risks associated with an excavation-based remedy, such as this, are significantly greater than those for containment-based remedies. The remedy implementation risk evaluation also concluded that the short-term risks associated with an excavation-based remedy will more than offset the long-term risk reduction achieved by such a remedy. Also, during the implementation of this remedial alternative, the community impacts and risk associated with waste transportation would be even greater than Alternative 2 due to the increased volume of material that would require off-site disposal. The volume and toxicity of the impacted fill would not be reduced; however, placement of the excavated fill material in a secure landfill would reduce the potential mobility of the COPCs.

4.1.3.3 Implementability

Implementation of this remedial alternative would be subject to similar substantial risks and formidable technical obstacles as discussed under Alternative 2. For those reasons, as well as others outlined in **Appendices B and E**, it is concluded that deep excavation is not viable at the Site. The concerns regarding excavation and transportation risks, transportation coordination, and disposal facility capacity are even greater than Alternative 2 due to the greater volume of material associated with this alternative.

4.1.3.4 Cost

For the purposes of alternative screening, the net present worth of this alternative was estimated to be approximately $225,000,000. A breakdown of the cost estimate for this alternative is included in **Appendix D**.

4.1.3.5 Summary

Off-site disposal of the impacted fill material in a secure landfill, to the extent excavation is even technically feasible, would encounter extensive technical challenges; would present significant process, health and environmental risk during implementation; and would increase mobility and potential release of COPCs during construction. As with Alternative 2, the permanence of off-site disposal of fill impacted with PCBs and other COPCs is countered by the potential increased mobility/release of these compounds to the River during construction, and resulting long-term exposure risk. Ultimately, the removal of impacted fill material from the site and placement in a secure landfill will not reduce volume or toxicity. Although extremely challenging technically and its implementation potentially detrimental to the environment, Remedial Alternative 3 was retained for comparative purposes through the remainder of the FS Report.

4.1.4 Alternative 4: Excavation and Off-Site Disposal of All PCB-Impacted Fill, Excavation and Off-Site Disposal of Lead Hot Spots and Construction of a Multi-Layered Cap System Over the Entire Site

4.1.4.1 Description

This alternative was developed in response to the NYSDEC's request in a letter dated December 8, 1999 (NYSDEC, 1999). This alternative would consist of excavation and off-site disposal of all surface fill where PCB concentrations equal or exceed 1 ppm and all subsurface fill where PCB concentrations equal or exceed 10 ppm. This alternative will also include lead "hot spot" removal as described in **Section 4.1.2.1**. Also, the IRMs that have been completed or that are ongoing at the Site (LNAPL Recovery, Northwest Corner) would be fully addressed by this Remedial Alternative and would not require further action subsequent to Remedial Alternative implementation. As in Alternative 2 and 3, the soil cleanup objectives are NYSDEC's generic TAGM values, unadjusted for site-specific criteria. The estimated total volume of fill (as measured in place) that would be excavated and disposed off site is 110,000 cubic yards. Depth of excavation would approach 40 feet below grade. All of the implementability and environmental impact concerns related to Alternative 2 regarding deep excavation, dewatering, sampling, and transportation to an off-site disposal facility also apply to this alternative.

In addition to the excavation and off-site disposal of PCB-impacted fill and lead "hot spots" as specified in Alternative 2, a multi-layered cap system will be installed over the entire site. The multi-layered cap will meet all of the substantive requirements of 6NYCCR Part 360 and TSCA Part 761 regarding impermeability and grading. No provision for gas collection will be included in the design of the cap for reasons discussed in **Section 3.3.4.2**.

In order to ensure that future activity at the site does not compromise the integrity of the multi-layered cap and to allow for maximum flexibility regarding future use of the Site, a notice of covenant will be placed on the deed and zoning restrictions will be enacted. The notice of covenant and zoning restrictions will specify how future intrusive activities at the Site are to be conducted. These specifications would include Health and Safety, NYSDEC notification and review, soil disposal, and multi-layered cap repair procedures that must be followed in the event that intrusive activities extend below the cap or through the vertical barrier.

Finally, the bulkhead along the waterfront will be reconstructed to prevent erosion of fill material and particulate transport into the Hudson River. **Figure 4-4** is a site area map that shows the conceptual excavation plan for this alternative, the extent of the proposed contact barrier/soil cover system, and the proposed location of the bulkhead. This alternative removes approximately 99% by mass of the presently existing PCB contamination and restores 28 acres of the Site to productive use with institutional controls.

4.1.4.2 Effectiveness

This alternative would provide an effective long-term remedy for removing PCB-impacted fill material from the site. However, as with Alternatives 2 and 3, implementation of this remedial alternative would result in a substantial increase in risk of exposure to on-site construction workers, the community, the Hudson River environment and the groundwater underlying the Marine Grey Silt Unit (see **Section 4.1.2.3**). A remedy implementation risk evaluation conducted for this site (**Appendix E**) concluded that the short-term risks associated with an excavation-based remedy, such as this, are significantly greater than those for containment-based remedies. The remedy implementation risk evaluation also concluded that the short-term risks associated with an excavation-based remedy will more than offset the long-term risk reduction achieved by such a remedy. During the implementation of this alternative, the community impacts and risks associated with waste transportation would be equal to the transportation risks associated with Alternative 2. The volume and toxicity of the PCB-impacted fill would not be reduced.

Exposure to any contaminants exceeding TAGM values that would remain on-site would be prevented by the construction of the multi-layered cap system. Deed and zoning restrictions will ensure that future excavation work below the contact barrier is conducted in a manner that minimizes risk of worker exposure to impacted fill material and is consistent with the objectives achieved by implementation of this remedial action. The volume and toxicity of this material would not be changed. The NYSDEC concluded that bulkhead repair/reconstruction would effectively reduce the potential for off-site migration of similar fill material in their ROD for the Irvington Waterfront Park (NYSDEC, 1998). For Cost estimating purposes, a Waterloo Barrier©-type steel sheet-pile bulkhead was evaluated. Final design and future site re-use may dictate an alternative bulkhead design; however, the intent of providing shoreline containment/erosion control would have to be incorporated into any alternative design.

4.1.4.3 Implementability

Implementation of this remedial alternative would be subject to the same risks and logistical issues discussed under Alternative 2 regarding excavation, transportation, and disposal of waste (see **Section 4.1.2.3**). For these reasons, as well as others outlined in **Appendices B and E**, there is a substantial probability that deep excavation is not viable at the Site.

Construction of the multi-layered cap system would be accomplished with readily available equipment and materials. Placing restrictions on the deed is readily implementable.

4.1.4.4 Cost

For the purposes of alternative screening, the net present worth of this alternative was estimated to be approximately $167,000,000. A breakdown of the cost estimate for this alternative is included in **Appendix D**.

4.1.4.5 Summary

Construction of a multi-layered cap system over the entire site, along with a notice of covenant placed on the deed that specifies how future excavation below the multi-layered cap will be conducted, will effectively reduce potential exposure to impacted fill remaining on-site. A steel sheet-pile bulkhead will effectively retain fill from eroding into the Hudson River. However, off-site disposal of the impacted fill material in a secure landfill, to the extent excavation is even technically feasible, would encounter extensive technical challenges; significant process, health and environmental risk during implementation; and would increase mobility and potential release of COPCs during construction. As Alternative 2 and other deep-excavation alternatives, the permanence of off-site disposal of excavated fill material is offset by potential construction-related releases to the Hudson River and the underlying groundwater aquifer, which may result in greater long-term risk than under the “No Action” alternative. Ultimately, the removal of PCB-impacted fill material from the site and placement in a secure landfill will not reduce the volume or toxicity of such material. Deep excavation, and transportation of a significant volume of impacted fill, also poses short-term community and environmental risks. Although extremely challenging technically and its implementation potentially detrimental to the environment, Remedial Alternative 4 was retained for comparative purposes through the remainder of the FS Report.

4.1.5 Alternative 5: Excavation and Off-Site Disposal of Fill Containing the “Rubbery Matrix” and Lead Hot Spots, Complete Containment of the Water Tower and Northwest Corner Areas, Excavation and Off-Site Disposal of Impacted Fill Located Outside the Limits of the Containment

4.1.5.1 Description

This alternative was developed in response to the NYSDEC’s request in a letter dated December 8, 1999 (NYSDEC, 1999). This alternative would consist of excavation and off-site disposal of all fill containing the “rubbery matrix”. For purposes of estimating volumes and costs of this remedial alternative, the extent of fill containing the “rubbery matrix” was defined as all fill containing PCB concentrations greater than or equal to 1,000 ppm. This assumption is based on RI data that shows the presence of the “rubbery matrix” generally corresponds to soil concentrations greater than 1,000 ppm. The estimated total volume of fill containing the “rubbery matrix” (as measured in place) that would be excavated and disposed off site is 28,000 cubic yards. Depth of excavation would approach 40 feet below grade. At the request of the NYSDEC, the removal of fill containing lead “hot spots”, as specified in Alternative 2, was added to this alternative. The LNAPL recovery would continue and the Northwest Corner would be fully addressed after implementation of this alternative. Because the location of fill containing the “rubbery matrix” is immediately adjacent to the Hudson River and extends down to the Marine Grey Silt Unit, all of the substantial problems of Alternative 2 regarding deep excavation and dewatering apply to this alternative (see **Section 4.1.2.3**).

In addition to the excavation and off-site disposal of fill containing the “rubbery matrix”, a complete containment system would be constructed around the Water Tower and Northwest Corner areas, around the 10 ppm PCB contour or at the shoreline. The complete containment system will consist of a vertical barrier system surrounding the areas and a multi-layer cap. The vertical barrier system would be constructed using a combination of Waterloo Barrier® (or equivalent) sheet-pile along the shoreline (which would also double as a bulkhead) and slurry walls keyed into the underlying Marine Grey Silt Unit. The multi-layered cap will meet all of the substantive requirements of 6NYSDEC Part 360 regarding impermeability and grading. No provisions for gas collection will be included in the design of the cap for reasons discussed in **Section 3.3.4.2**. The cap will extend to the alignment of the vertical barrier system.

In order to ensure that future activity at the site does not compromise the integrity of the containment system and to allow for maximum flexibility regarding future use of the Water Tower and Northwest Corner areas, a notice of covenant will be placed on the deed and zoning restrictions will be enacted. The notice of covenant and zoning restrictions will specify how future intrusive activities within the contained area are to be conducted. These specifications would include Health and Safety, NYSDEC notification and review, soil disposal, and containment system repair procedures that must be followed in the event that intrusive activities extend below the cap or through the vertical barrier.

In areas located outside of the limits of the proposed containment system, all subsurface fill located above the water table that contains COPCs exceeding any TAGM value and all fill below the water table with PCBs ≥ 10 ppm will be excavated and disposed off-site. As in Alternative 2, the soil cleanup objectives are NYSDEC’s generic TAGM values, unadjusted for site-specific criteria. The estimated total volume of fill (as measured in place) that would be excavated outside of the limits of the proposed containment system and disposed off site is 208,000 cubic yards. Depth of excavation would approach 40 feet below grade. In addition to the components of Alternative 2 regarding deep excavation and dewatering risks, the issues regarding transportation to an off-site disposal facility also apply to this alternative due to the proposed scope.

Finally, the bulkhead along the waterfront will be reconstructed to prevent erosion of fill material and particulate transport into the Hudson River. **Figure 4-5** is a site area map that shows the conceptual excavation plan for this alternative, the extent of the proposed containment system, and the proposed location of the bulkhead. This alternative removes approximately 98% by mass of the presently existing PCB contamination and restores 28 acres of the Site to productive, use with institutional controls.

4.1.5.2 Effectiveness

This alternative will provide an effective long-term remedy for removing all fill containing the rubbery matrix from the site. Other PCB-impacted fill in the Water Tower and Northwest Corner areas will be effectively contained on-site. Fill containing COPCs exceeding TAGM values and PCB-impacted fill located outside of the limits of the containment system and generally above the water table will be removed from the Site. During the implementation of this remedial alternative, an increased risk of exposure would be posed to the community, the River environment, and the groundwater underlying the Marine Grey Silt Unit. A remedy implementation risk evaluation conducted for this site (**Appendix E**) concluded that the short-term risks associated with an excavation-based remedy, such as this, are significantly greater than those for containment-based remedies. The remedy implementation risk evaluation also concluded that the short-term risks associated with an excavation-based remedy will more than offset the long-term risk reduction achieved by such a remedy. The removal of all fill containing the rubbery matrix would be a redundant measure when combined with containment of the Water Tower and Northwest Corner Areas. During the implementation of this remedial alternative, the community impacts and risks associated with waste transportation would be even greater than Alternative 2 due to the increased volume of material that would require off-site disposal. The volume and toxicity of the impacted fill will not be reduced; however, the mobility of COPCs will be decreased by construction of the containment system and by reconstruction of the shoreline bulkhead. The NYSDEC concluded that bulkhead repair/reconstruction would effectively reduce the potential for off-site migration of similar fill material in their ROD for the Irvington Waterfront Park (NYSDEC, 1998). For Cost estimating purposes, a Waterloo Barrier©-type steel sheet-pile bulkhead was evaluated. Final design and future site re-use may dictate an alternative bulkhead design; however, the intent of providing shoreline containment/erosion control would have to be incorporated into any alternative design.

4.1.5.3 Implementability

Implementation of this remedial alternative would be subject to the same substantial risks and formidable technical obstacles discussed under Alternative 2 regarding excavation, transportation, and disposal of waste (see **Section 4.1.2.3**). For these and other reasons outlined in **Appendices B and E**, there is a substantial probability that deep excavation is not viable at this Site.

Installation of the vertical components of the containment system (i.e., the sheet-pile and slurry walls) may be complicated by the presence of underground obstructions. Construction of the multi-layered cap is readily implementable. Placing restrictions on the deed is also readily implementable.

4.1.5.4 Cost

For the purposes of alternative screening, the net present worth of this alternative was estimated to be approximately $165,000,000. A breakdown of the cost estimate for this alternative is included in **Appendix D**.

4.1.5.5 Summary

The repair of the shoreline bulkhead and installation of the complete containment system would effectively reduce potential contact with and limit mobility of fill that contains COPCs exceeding TAGM values. However, off-site disposal of the impacted fill material in a secured landfill, to the extent excavation is even technically feasible, would encounter extensive technical challenges; would present significant process, health and environmental risk during implementation; and would increase mobility and potential release of COPCs during construction. As with other deep-excavation alternatives, the permanence of off-site disposal of excavated fill material is offset by potential construction-related releases to the River, which may result in greater long-term risk than under the "No Action" alternative. Ultimately, the removal of impacted fill material from the site and placement in a secure landfill will not reduce the volume or toxicity of such materials. As with Alternative 2, 3, and 4, implementation of Remedial Alternative 5 would be extremely challenging and potentially detrimental to the environment. However, for comparative purposes, this Remedial Alternative will be retained through the remainder of the FS Report.

4.1.6 Alternative 6: Excavation and Off-Site Disposal of Fill Containing the "Rubbery Matrix" and Lead Hot Spots, Complete Containment of the Water Tower and Northwest Corner Areas, Construction of a Multi-Layered Cap over the Entire Site

4.1.6.1 Description

This alternative was developed in response to the NYSDEC's request in a letter dated December 8, 1999 (NYSDEC, 1999). This alternative would consist of excavating fill containing lead "hot spots" (as described in Alternative 2), complete containment of the Water Tower and Northwest Corner Areas excavating the material containing the "rubbery matrix" and (as described in Alternative 5), and construction of a multi-layered cap over the entire site. Deed restrictions will be developed and applied to the entire site. For purposes of estimating volumes and costs of this remedial alternative, the extent of fill containing the "rubbery matrix" was defined as all fill containing PCB concentrations greater than or equal to 1,000 ppm. The RI data shows that the presence of the "rubbery matrix" generally corresponds to soil concentrations greater than 1,000 ppm. The estimated volume of fill material that will be excavated and disposed off-site (as measured in-place) is approximately 28,000 cubic yards. Depth of excavation would approach 40 feet below grade. Because fill containing the "rubbery matrix" is located immediately adjacent to the Hudson River, all of the components of Alternative 2 regarding deep excavation and dewatering apply to this alternative.

Finally, the bulkhead along the waterfront will be reconstructed to prevent erosion of fill material and particulate transport into the Hudson River. **Figure 4-6** is a site area map that shows a conceptual excavation plan for this alternative and the proposed location of the bulkhead. This alternative removes approximately 97% by mass of the presently existing PCB contamination and restores 28 acres of the Site to productive use with institutional controls.

4.1.6.2 Effectiveness

This alternative will provide an effective long-term remedy for removing all fill containing the rubbery matrix from the site. Other PCB-impacted fill in the Water Tower and Northwest Corner areas will be effectively contained on-site. A multi-layered cap will be constructed over the entire site to reduce the potential for exposure to COPCs, although infiltration of precipitation at the Site would not be expected to increase the concentrations of COPCs in fill water. The potential exposure to impacted fill material would be eliminated after implementation of this alternative; however, during the implementation of this remedial alternative, an increased risk of exposure would be posed to the community, the Hudson River environment and groundwater located beneath the Marine Grey Silt Unit in the Basal Sands Unit. A remedy implementation risk evaluation conducted for this site (**Appendix E**) concluded that the short-term risks associated with an excavation-based remedy, such as this, are significantly greater than those for containment-based remedies. The remedy implementation risk evaluation also concluded that the short-term risks associated with an excavation-based remedy will more than offset the long-term risk reduction achieved by such a remedy. The removal of all fill containing the rubbery matrix would be a redundant measure when combined with containment of the Water Tower and Northwest corner Areas. The volume and toxicity of the impacted fill will not be reduced; however, the mobility of COPCs will be decreased by construction of the containment system. The NYSDEC concluded that bulkhead repair/reconstruction would effectively reduce the potential for off-site migration of similar fill material in their ROD for the Irvington Waterfront Park (NYSDEC, 1998). For Cost estimating purposes, a Waterloo Barrier©-type steel sheet-pile bulkhead was evaluated. Final design and future site re-use may dictate an alternative bulkhead design; however, the intent of providing shoreline containment/erosion control would have to be incorporated into any alternative design.

4.1.6.3 Implementability

Implementation of this remedial alternative would be subject to the same substantial risks and formidable technical obstacles discussed under Alternative 2 regarding excavation, transportation, and disposal of waste. For these and other reasons outlined in **Appendices B and E**, there is a substantial probability that deep excavation may be not viable at this Site. Moreover, installation of the vertical components of the containment system (i.e., the sheet-pile and slurry walls) will be complicated by the presence of underground obstructions including foundations and pilings. Construction of the multi-layered cap is readily implementable. Placing restrictions on the deed is also readily implementable.

4.1.6.4 Cost

For the purposes of alternative screening, the net present worth of this alternative was estimated to be approximately $132,000,000. A breakdown of the cost estimate for this alternative is included in **Appendix D**.

4.1.6.5 Summary

The repair of the shoreline bulkhead and installation of the complete containment system will effectively reduce potential contact with and limit mobility of fill that contains COPCs exceeding TAGM values. However, off-site disposal of the impacted fill material in a secured landfill would encounter extensive technical challenges; would present significant process, health and environmental risk during implementation; and would increase mobility and potential release of COPCs during construction. As with other deep-excavation alternatives, the permanence of off-site disposal of excavated fill material is offset by potential construction-related releases to the River and the groundwater system in the Basal Sands Unit which would result in greater long-term risk than under the "No Action" alternative. Ultimately, the removal of impacted fill material from the site and placement in a secure landfill will not reduce the volume or toxicity of such materials. As with Alternatives 2, 3, 4, and 5, implementation of Alternative 6 would be extremely challenging and potentially detrimental to the environment. However, for comparative purposes, this Remedial Alternative will be retained through the remainder of the FS Report.

4.1.7 Alternative 7: Excavation and Off-Site Disposal of Shallow PCB-Impacted Fill (≥10 ppm) and Lead Hot Spots, Complete Containment of the Water Tower and Northwest Corner Areas, Construction of a Contact Barrier and Soil Cover System

4.1.7.1 Description

This alternative was developed by Atlantic Richfield Company and consists of on-site containment with shallow excavation and off-site disposal. This alternative is similar to Alternatives 5 and 6; however, excavation and off-site disposal will be limited to impacted fill containing concentrations of PCBs ≥10 ppm generally located within six feet of the ground surface within and outside of the containment area. This alternative would also include the excavation and off-site disposal of fill containing lead "hot spots" (as described in Alternative 2). The proposed containment system would be constructed in the areas of the site containing the "rubbery matrix", and would provide hydraulic control in areas where the "rubbery matrix" is present. The containment system will consist of a Waterloo Barrier©-type steel sheet-pile bulkhead on the downgradient side of the PCB-impacted fill in the Water Tower and Northwest Corner Areas and a slurry wall on the upgradient side; although hydraulic control can be achieved by other means including various configurations of sheet piling. A contact barrier and soil cover system will also be constructed over the entire site. Of the two ongoing IRMs, the Northwest Corner IRM would be addressed by this Alternative, and the LNAPL IRM would be continued until all LNAPL had been recovered.

The estimated volume of fill that will be excavated and disposed off-site (as measured in-place) is approximately 42,000 cubic yards. Shallow excavation of PCB-containing fill will be limited to the depth of the groundwater table. Dewatering is expected to be minimal. Post excavation sampling and analysis will be used to determine the ultimate disposition of the material.

The contact barrier will consist of a 6-inch layer of asphaltic cement placed on top of adequately prepared subgrade, except for where existing foundations or pavement already provide an effective barrier layer. The contact barrier will then be covered with a 12-inch layer of soil and a 6-inch layer of topsoil that will be seeded and fertilized. The design of the contact barrier/soil cover system will include measures to promote stormwater runoff including grading, drainage swales and/or other surface controls.

In order to ensure that future activity at the site does not compromise the integrity of the containment system and contact barrier and to allow for maximum flexibility regarding future use of the Site, a notice of covenant will be placed on the deed and zoning restrictions will be enacted. The notice of covenant and zoning restrictions will specify how future intrusive activities within the contained area are to be conducted. These specifications would include Health and Safety planning, NYSDEC notification and review, soil disposal, and containment system repair procedures that must be followed in the event that intrusive activities extend below the contact barrier or through the vertical barrier.

Finally, the bulkhead along the entire waterfront will be reconstructed to prevent erosion of fill material and particulate transport into the Hudson River. **Figure 4-7** is a site area map that shows a conceptual excavation plan for this alternative and the proposed location of the bulkhead. This alternative removes approximately 29% by mass of the presently existing PCB contamination and restores 28 acres of the Site to productive use with institutional controls.

4.1.7.2 Effectiveness

PCB-impacted fill located above the groundwater table will be effectively removed from the site. All PCB-impacted fill remaining in the Water Tower and Northwest Corner areas will be effectively contained on-site. On-site containment of PCBs in the Northwest Corner complies with regulations promulgated under ECL (6 NYCRR 375.1-10(6) in that, although it is not feasible to restore the Northwest Corner of the Site to pre-disposal conditions, all significant threats to human health and the environment are eliminated or mitigated. The entire site will be covered with a contact barrier and soil cover system that will effectively reduce the potential for exposure to COPCs exceeding TAGM values. These actions do not require deep excavation or dewatering, eliminating the potential releases to the River associated with the deep-excavation alternatives. The potential for human and environmental exposures to impacted fill material would be eliminated after implementation of this alternative. Community and environmental impacts during implementation of this alternative would exist; however, these impacts are considered to be more manageable than those associated with deeper excavations due to the smaller quantity of material that would have to be excavated and transported off-site. The volume and toxicity of the impacted fill will be reduced by the removal of a limited volume of fill containing PCBs ($\geq$10 ppm); however, the mobility of COPCs will be significantly decreased by construction of the containment system and by placement of some of the excavated fill material into a secure landfill. The NYSDEC concluded that bulkhead repair/reconstruction would effectively reduce the potential for off-site migration of similar fill material in their ROD for the Irvington Waterfront Park (NYSDEC, 1988). For cost estimating purposes, a Waterloo Barrier©-type steel sheet-pile bulkhead was evaluated. Final design and future site re-use may dictate an alternative bulkhead design; however, the intent of providing shoreline containment/erosion control would have to be incorporated into any alternative design.

4.1.7.3 Implementability

The excavation of shallow PCB-impacted fill located above the groundwater table would be readily implementable with conventional equipment and labor crews.

Installation of the vertical components of the containment system (i.e., the sheet-pile and slurry walls) may be complicated by the presence of underground obstructions. Placing restrictions on the deed is readily implementable. Construction of a contact barrier and soil cover system over the site is also readily implementable.

The equipment required for transport and disposal of impacted fill material is readily available. The proposed transportation route is via rail. Coordination with all rail line owners and operators, between the site and the disposal facility, will be required. Disposal facilities are available; however, actual acceptance of impacted fill material would be dependent upon facility capacity and acceptance criteria. Also, potential landfills will be limited to those with rail terminals; otherwise, a trucking operation will be required between the rail line and the disposal facility.

A remedy implementation risk evaluation conducted for this site (**Appendix E**) concluded that the short-term risks associated with this excavation intensive remedy are significantly greater than those for the remedies that rely on containment to a greater degree.

4.1.7.4 Cost

For the purposes of alternative screening, the net present worth of this alternative was estimated to be $46,000,000. A breakdown of the cost estimate for this alternative is included in **Appendix D**.

4.1.7.5 Summary

On-site containment of PCB-impacted fill material in the Water Tower and Northwest Corner areas will provide a long-term remedy to eliminate exposures to COPCs and reduce their mobility. Excavation and off-site disposal of shallow PCB-impacted fill material (≥10 ppm) located above the groundwater table will also result in a long-term remedy to eliminate exposure potential, and will increase future land use potential at the Site. These exposure-reduction measures can be achieved while avoiding the risks inherent to deep excavation and dewatering. The repair of the shoreline bulkhead and installation of the contact barrier/soil cover system will reduce potential contact with fill containing COPCs in excess of TAGM values. Because this alternative achieves all of the remedial action objectives and the short-term risks associated with its implementation are manageable, it will be retained for further consideration.

4.1.8 Alternative 8: Containment of the Water Tower and Northwest Corner Areas, Excavation and Off-Site Disposal of PCB-Impacted Fill (≥10 ppm) and Lead Hot Spots Located Above the Water Table and Outside the Limits of the Containment and Construction of a Contact Barrier and Soil Cover System

4.1.8.1 Description

This alternative consists of on-site containment with limited excavation and off-site disposal. This alternative is similar to Alternatives 5 and 6; however, excavation and off-site disposal will be limited to impacted fill containing concentrations of PCBs ≥10 ppm located above the groundwater table in the central and southern portion of the Site, outside the limits of the proposed containment system. At the request of the NYSDEC, fill containing lead "hot spots" would excavated for off-site disposal, as described in Alternative 2. The containment system would eliminate exposures to PCB-containing fill in the Northwestern and Water Tower areas while avoiding the risks inherent with extensive or deep excavation. The proposed containment system would be constructed in the areas of the site containing the "rubbery matrix", and would provide hydraulic control in these areas. The containment system will consist of a Waterloo Barrier©-type steel sheet-pile bulkhead on the downgradient side of the PCB-impacted fill in the Water Tower and Northwest Corner areas and a slurry wall on the upgradient side; although hydraulic control can be achieved by other means including various configurations of sheetpiling. A contact barrier and soil cover system will also be constructed over the entire site. The estimated volume of fill that will be excavated and disposed off-site (as measured in-place) is approximately 10,000 cubic yards. The depth of excavation that is required to remove PCB-containing fill in the central and southern areas of the Site is not expected to proceed below the groundwater table and dewatering will not be required. Post excavation sampling and analysis will be used to determine the ultimate disposition of the material.

The contact barrier will consist of a 6-inch layer of asphaltic cement placed on top of adequately prepared subgrade, except for where existing foundations or pavement already provide an effective barrier layer. The contact barrier will then be covered with a 12-inch layer of soil and a 6-inch layer of topsoil that will be seeded and fertilized. The design of the contact barrier/soil cover system will include measures to promote stormwater runoff including grading, drainage swales and/or other surface controls.

In order to ensure that future activity at the site does not compromise the integrity of the containment system and contact barrier and to allow for maximum flexibility regarding future use of the site, a notice of covenant will be placed on the deed and zoning restrictions will be enacted. The notice of covenant and zoning restrictions will specify how future intrusive activities within the contained area are to be conducted. These specifications would include Health and Safety planning, NYSDEC notification and review, soil disposal, and containment system repair procedures that must be followed in the event that intrusive activities extend below the contact barrier or through the vertical barrier.

Finally, the bulkhead along the entire waterfront will be reconstructed to prevent erosion of fill material and particulate transport into the Hudson River. **Figure 4-8** is a site area map that shows a conceptual excavation plan for this alternative and the proposed location of the bulkhead. This alternative removes approximately less than 1% by mass of the presently existing PCB contamination and restores 28 acres of the Site to productive use with institutional controls.

4.1.8.2 Effectiveness

PCB-impacted fill in the Water Tower and Northwest Corner areas will be effectively contained on-site while PCB-impacted fill (≥10 ppm) located above the groundwater table and outside the limits of the containment system will be removed from the Site. Additionally, fill containing lead “hot spots” will also be removed from the Site. On-site containment of PCBs in the Northwest Corner complies with regulations promulgated under ECL (6 NYCRR 375.1-10(6) in that, although it is not feasible to restore the Northwest Corner of the Site to pre-disposal conditions, all significant threats to human health and the environment are eliminated or mitigated. The entire site will be covered with a contact barrier and soil cover system that will effectively reduce the potential for exposure to COPCs exceeding TAGM values. These actions do not require deep excavation or dewatering, eliminating the potential releases to the River associated with the deep-excavation alternatives. The potential for human and environmental exposures to impacted fill material would be eliminated after implementation of this alternative. Community and environmental impacts during implementation of this alternative would be minimal due to the smaller quantity of material that would have to be excavated and transported off-site. The volume and toxicity of the impacted fill will be reduced by the removal of a limited volume of fill containing PCBs ($\geq$10 ppm) and fill containing lead "hot spots"; however, the mobility of COPCs will be significantly decreased by construction of the containment system and by placement of some of the excavated fill material into a secure landfill. The NYSDEC concluded that bulkhead repair/reconstruction would effectively reduce the potential for off-site migration of similar fill material in their ROD for the Irvington Waterfront Park (NYSDEC, 1988). For cost estimating purposes, a Waterloo Barrier©-type steel sheet-pile bulkhead was evaluated. Final design and future site re-use may dictate an alternative bulkhead design; however, the intent of providing shoreline containment/erosion control would have to be incorporated into any alternative design.

A remedy implementation risk evaluation (**Appendix E**) conducted for this site concluded that the long-term post-remediation risk reduction achieved by a containment-based remedy, such as this, would be virtually equivalent to the risk reduction achieved by an excavation remedy. In addition, the remedy implementation risk evaluation concluded that the short-term risks associated with the excavation–based remedies are significantly greater than those for containment-based remedies.

4.1.8.3 Implementability

The excavation of PCB-impacted fill located outside of the limits of the proposed containment system would be readily implementable with conventional equipment and labor crews because this fill is at shallower depths than the PCB-impacted fill inside the containment system.

Installation of the vertical components of the containment system (i.e., the sheet-pile and slurry walls) may be complicated by the presence of underground obstructions. Placing restrictions on the deed is readily implementable. Construction of a contact barrier and soil cover system over the Site is also readily implementable.

The equipment required for transport and disposal of impacted fill material is readily available. The proposed transportation route is via rail. Coordination with all rail line owners and operators, between the site and the disposal facility, will be required. Disposal facilities are available; however, actual acceptance of impacted fill material would be dependent upon facility capacity and acceptance criteria. Also, potential landfills will be limited to those with rail terminals; otherwise, a trucking operation will be required between the rail line and the disposal facility.

4.1.8.4 Cost

For the purposes of alternative screening, the net present worth of this alternative was estimated to be $33,000,000. A breakdown of the cost estimate for this alternative is included in **Appendix D.**

4.1.8.5 Summary

On-site containment of PCB-impacted fill material in the Water Tower and Northwest Corner areas will provide a long-term remedy to eliminate exposures to COPCs and reduce their mobility. Excavation and off-site disposal of PCB-impacted fill material (≥10 ppm) located above the groundwater table and outside of the limits of the proposed containment system will also result in a long-term remedy to eliminate exposure potential, and will increase future land use potential in the southern and central portions of the Site. These exposure-reduction measures can be achieved while avoiding the risks inherent to deep excavation and dewatering. The repair of the shoreline bulkhead and installation of the contact barrier/soil cover system will reduce potential contact with fill containing COPCs in excess of TAGM values. Because this alternative achieves all of the remedial action objectives and the short-term risks associated with its implementation are minimal, it will be retained for further consideration.

4.1.9 Alternative 9: In-Situ Stabilization/Solidification of the "Liquid Rubbery Matrix", Containment of the Water Tower and Northwest Corner Areas, Excavation and Off-Site Disposal of PCB-Impacted (≥10 PPM) and Lead Hot Spots Located Above the Water Table and Outside the Limits of the Containment and Construction of a Contact Barrier and Soil Cover System

4.1.9.1 Description

This alternative was retained from the June 1998 Draft Feasibility Study Report; however, it now contains several modifications. In addition to the remedial actions proposed in Alternative 8, the area where the liquid rubbery matrix is present will be stabilized/solidified by injecting binding agents in-situ to further reduce the potential for COPC migration. At the request of the NYSDEC, this alternative would include excavation and off-site disposal of fill containing lead "hot spots", as described in Alternative 2. **Figure 4-9** is a site area map that shows a conceptual excavation plan for this alternative and the proposed location of the bulkhead. This alternative removes approximately less than 1% by mass of the presently existing PCB contamination and restores 28 acres of the Site to productive use with institutional controls.

4.1.9.2 Effectiveness

PCB-impacted fill in the Water Tower and Northwest Corner areas will be effectively contained on-site while fill containing lead “hot spots” and PCB-impacted fill (≥10 ppm) located above the water table and outside the limits of the containment system will be removed from the Site. On-site containment of PCBs in the Northwest Corner complies with regulations promulgated under ECL (6 NYCRR 375.1-10(6) in that, although it is not feasible to restore the Northwest Corner of the Site to pre-disposal conditions, all significantly threats to human health and the environment are eliminated or mitigated. The entire Site will be covered with a contact barrier and soil cover system that will effectively reduce the potential for exposure to COPCs exceeding TAGM values. The potential for human and environmental exposures to impacted fill material would be eliminated after implementation of this alternative. These exposure-reduction measures can be achieved without the risks inherent to deep excavation and dewatering. Community and environmental impacts during implementation of this alternative would be minimal due to the smaller quantity of material that would have to be excavated and transported off-site. The volume and toxicity of the impacted fill will be reduced by the removal of a limited volume of fill containing PCBs (≥10 ppm); however, the mobility of COPCs will be significantly decreased by construction of the containment system and by placement of some of the excavated fill material into a secure landfill. In-situ stabilization/solidification would provide a redundant level of control over contaminant mobility when combined with full containment. The NYSDEC concluded that bulkhead repair/reconstruction would effectively reduce the potential for off-site migration of similar fill material in their ROD for the Irvington Waterfront Park (NYSDEC, 1988). For cost estimating purposes, a Waterloo Barrier©-type steel sheet-pile bulkhead was evaluated. Final design and future site re-use may dictate an alternative bulkhead design; however, the intent of providing shoreline containment/erosion control would have to be incorporated into any alternative design.

A remedy implementation risk evaluation (**Appendix E**) conducted for this site concluded that the long-term post-remediation risk reduction achieved by this containment-based remedy would be virtually equivalent to the risk reduction achieved by the excavation-intensive remedies. In addition, the remedy implementation risk evaluation concluded that the short-term risks associated with the excavation–based remedies are significantly greater than those for containment-based remedies.

4.1.9.3 Implementability

Implementability of in-situ stabilization/solidification (S/S) relies on the ability to inject binding agents uniformly in-situ, and may be difficult due to below ground obstructions. Also, it would also be extremely difficult to measure the effectiveness of the in-situ S/S process in this environment.

The excavation of fill containing lead “hot spots” and PCB-impacted fill located outside of the limits of the proposed containment system would be readily implementable with conventional equipment and labor crews. As with Alternative 8, this fill is located at shallower depths than the fill inside the containment system. Installation of the vertical components of the containment system (i.e., the sheet-pile and slurry walls) may be complicated by the presence of underground obstructions. Placing restrictions on the deed is readily implementable. Construction of a contact barrier and soil cover system is also readily implementable.

The equipment required for transport and disposal of impacted fill material is readily available. The proposed transportation route is via rail. Coordination with all rail line owners and operators between the site and the disposal facility will be required. Disposal facilities are available; however, actual acceptance of impacted fill material would be dependent upon facility capacity and acceptance criteria. Also, potential landfills will be limited to those with rail terminals; otherwise, a trucking operation will be required between the rail line and the disposal facility.

4.1.9.4 Cost

For the purposes of alternative screening, the net present worth of this alternative was estimated to be $37,000,000. A breakdown of the cost estimate for this alternative is included in **Appendix D**.

4.1.9.5 Summary

In-situ S/S would be a redundant measure when combined with the containment of the Northwest Corner and Water Tower areas. There are also significant uncertainties associated with the effectiveness and implementability of in-situ S/S at the Site. Due to these factors, this remedial alternative will not be retained for further consideration.

4.1.10 Alternative 10: Construction of a Contact Barrier and Soil Cover System Over the Entire Site, Excavation and Off-Site Disposal of Lead Hot Spots

4.1.10.1 Description

This alternative was retained from the June 1998 Draft Feasibility Study Report. This alternative consists of excavation and off-site disposal of fill containing lead "hot spots" (as described in Alternative 2) and a contact barrier and soil cover system over the entire Site. This measure was found in the RA report to be adequately protective of all future land use scenarios by limiting potential future exposure to fill material.

The contact barrier will consist of a 6-inch layer of asphaltic cement placed on top of adequately prepared subgrade, except for where existing foundations or pavement already provide an effective barrier layer. The contact barrier will then be covered with a 12-inch layer of soil and a 6-inch layer of topsoil that will be seeded and fertilized. The design of the contact barrier/soil cover system will include measures to promote stormwater runoff including grading, drainage swales and/or other surface controls. Of the ongoing IRM activities, the contact barrier effectively addresses the Northwest Corner IRM, however the LNAPL Recovery IRM will need to continue until LNAPL is absent from the fill water table.

In order to ensure that future activity at the site does not compromise the integrity of the contact barrier and to allow for maximum flexibility regarding future use of the site, a notice of covenant will be placed on the deed and zoning restrictions will be enacted. The notice of covenant and zoning restrictions will specify how future intrusive activities at the site are to be conducted. These specifications would include Health and Safety, NYSDEC notification and review, soil disposal, and contact barrier system repair procedures that must be followed in the event that intrusive activities extend below the contact barrier.

Finally, the bulkhead along the waterfront will be reconstructed to prevent erosion of fill material and particulate transport into the Hudson River. **Figure 4-10** is a site area map that shows a conceptual excavation plan for this alternative and the proposed location of the bulkhead. This alternative removes 0% by mass of the presently existing PCB contamination and restores 28 acres of the Site to productive use with institutional controls.

4.1.10.2 Effectiveness

PCB impacted fill will be effectively contained on site by the reconstructed bulkhead along the waterfront. Impacted fill will be covered with a contact barrier and soil cover system that will effectively reduce the potential for exposure to COPCs exceeding TAGM values. The potential for human and environmental exposure to impacted fill material will be eliminated after implementation of this alternative while avoiding the risks inherent to deep excavation and dewatering. The volume and toxicity of impacted fill will not be reduced, however, the mobility of COPCs will be significantly decreased by construction of a new shoreline bulkhead. Since this alternative contains limited excavation and off-site disposal, the risks and short-term impacts to the surrounding community are minimized. The NYSDEC concluded that bulkhead repair/reconstruction would effectively reduce the potential for off-site migration of similar fill material in their ROD for the Irvington Waterfront Park (NYSDEC, 1988). For cost estimating purposes, a Waterloo Barrier©-type steel sheet-pile bulkhead was evaluated. Final design and future site re-use may dictate an alternative bulkhead design; however, the intent of providing shoreline containment/erosion control would have to be incorporated into any alternative design.

A remedy implementation risk evaluation (**Appendix E**) conducted for this site concluded that the long-term post-remediation risk reduction achieved by this containment-based remedy would be virtually equivalent to the risk reduction achieved by the excavation-intensive remedies. In addition, the remedy implementation risk evaluation concluded that the short-term risks associated with the excavation–based remedies are significantly greater than those for containment-based remedies.

4.1.10.3 Implementability

Excavation of fill containing lead “hot spots” is readily implementable with common excavation crews and equipment. Placing restrictions on the deed is readily implementable. Construction of a contact barrier and soil cover system and shoreline bulkhead is readily implementable.

4.1.10.4 Cost

For the purposes of alternative screening, the net present worth of this alternative was estimated to be $17,500,000. A breakdown of the cost estimate for this alternative is included in **Appendix D**.

4.1.10.5 Summary

On-site containment of impacted fill material will result in long-term permanence and reduced mobility, although volume or toxicity will not be reduced. These exposure-reduction measures can be achieved while avoiding the risks inherent to deep excavation and dewatering. The repair of the shoreline bulkhead and installation of the contact barrier/soil cover system will reduce potential contact with fill containing COPCs in excess of TAGM values. Because this alternative achieves all of the remedial action objectives and the short-term risks associated with its implementation are minimal, it will be retained for further consideration.

4.1.11 Alternative 11: Complete Containment of Water Tower and Northwest Corner Areas, Excavation at Multiple Depths (3, 9, and 12 feet bgs (with grout stabilization)) and Off-Site Disposal of PCB-Impacted Fill Located Within the Containment, Excavation and Off-Site Disposal of PCB-Impacted Fill ≥10 ppm and Lead Hot Spots Located Outside the Limits of the Containment, and Construction of a Contact Barrier and Soil Cover System Over the Entire Site

4.1.11.1 Description

This alternative consists of on-site containment, excavation, and off-site disposal. The containment system would be installed around the Water Tower and Northwest Corner areas of the site where deep PCBs would remain after completion of a dry excavation to the maximum achievable depth. The containment system would consist of a Waterloo Barrier©-type steel sheet pile bulkhead along the shoreline and a slurry wall or equivalent on the upgradient side.

Inside the proposed containment system, PCB-impacted fill would be excavated to varying depths and disposed in a permitted off-site facility. Excavation would be performed in the dry condition. All PCBs above a depth of approximately 12 feet (depth of maximum dry excavation) would be removed from within the containment area with the exception of those areas where PCBs extend to significant depths (>12 feet below grade). A maximum excavation depth of 9 feet would be attained without the use of grout for structural support of the sheet pile wall, while a maximum excavation depth of 12 feet would be attained with the use of grout. The estimated total volume of PCB-impacted fill (as measured in place) that would be excavated and disposed of off-site is approximately 48,000 cubic yards.

The 3-foot depth excavation would be performed in the Northwest Corner and along the shoreline in the Water Tower Area, where the depth of contaminated fill exceeds 15 feet. The 9-foot depth excavation would be located in the central and northern portions of the Water Tower Area, where a 9-foot deep excavation would remove all PCB-impacted fill with a concentration greater than or equal to 10 ppm. The 12-foot deep excavation would be located in the western portion of the Water Tower Area, where a 12-foot deep excavation would remove all PCB-impacted fill with a concentration greater than or equal to 10 ppm.

All PCB-impacted fill located outside of the containment area (≥10 ppm) will be excavated for off-site disposal. Fill containing lead hot spots would be excavated in (4), two-foot deep, 50-foot x 50-foot areas surrounding soil borings SB-100, SB-128, SB-131, SB-137, as well as (2), two-foot deep, 25-foot x 50-foot areas surrounding soil borings HB-01 and HB-06. The estimated total volume of lead contaminated fill (as measured in-place) that would be excavated and disposed of off-site is 925 cubic yards.

The excavated material will be dewatered on-site to comply with transportation and disposal requirements as solid material. Post excavation analysis of fill material will be used to determine if the material is to be disposed of as non-hazardous or hazardous waste. The dewatered material will then be transported by rail to a landfill that is permitted to accept the waste in compliance with State and Federal disposal regulations.

A contact barrier and soil cover system, as described in Alternative 7, would be installed over the entire site. Finally, the bulkhead along the entire waterfront will be reconstructed to prevent erosion of fill material and particulate transport into the Hudson River. **Figure 4-11** is a site map that shows a conceptual excavation plan for this alternative. This alternative removes approximately 15% by mass of the presently existing PCB contamination and restores 28 acres of the Site to productive use with institutional controls.

4.1.11.2 Effectiveness

Shallow PCB-impacted fill located within the limits of the containment system, all PCBs located outside the containment system, and fill containing lead hot spots located outside the containment system will be effectively removed from the site. All PCB-impacted fill remaining in the Water Tower and Northwest Corner areas will be effectively contained on-site. On-site containment of PCBs in the Northwest Corner complies with regulations promulgated under ECL (6 NYCRR 375.1-10(6)) in that, although it is not feasible to restore the Northwest Corner of the Site to pre-disposal conditions, all significant threats to human health and the environment are eliminated or mitigated. The entire site will be covered with a contact barrier and soil cover system that will effectively reduce the potential for exposure to COPCs at the site. During the implementation of this alternative, an increased risk of exposure would be posed to on-site construction workers, the community and the River environment. Even with proper engineering controls, short-term mobility of COPCs would be increased through vapor and dust inhalation, and dewatering discharge pathways. The volume and toxicity of impacted fill would not be reduced; however, after placement of the excavated fill in a secure landfill and containment of COPCs remaining on-site, the long term potential mobility of the COPCs would decrease significantly. The NYSDEC concluded that bulkhead repair/reconstruction would effectively reduce the potential for off-site migration of similar fill material in their ROD for the Irvington Waterfront Park (NYSDEC, 1988).

4.1.11.3 Implementability

Implementation of this alternative would be subject to similar risks and technical obstacles as discussed under Alternative 2 regarding excavation. The extent of risks and obstacles encountered would be reduced by excavating to somewhat limited depths inside the area of containment, and excavating to shallow depths outside the area of containment. While specialized excavation equipment and labor would be required, excavation to the depths proposed in this alternative would be implementable and practicable.

Installation of the vertical components of the containment system (sheet-pile and slurry walls) may be complicated by the presence of underground obstructions, but would be implementable. Construction of a contact barrier and soil cover system over the site would be readily implementable.

The equipment required for transport and disposal of impacted fill material is readily available. The proposed transportation route is via rail. Coordination with all rail line owners and operators between the site and facility would be required. Disposal facilities are available, however, actual acceptance of impacted fill material would be dependent upon facility capacity and acceptance criteria. Also, potential landfills will be limited to those with rail terminals; otherwise, a trucking operation would be required between the rail line and the disposal facility.

4.1.11.4 Cost

For the purpose of alternative screening, the net present worth of this alternative was estimated to be approximately $52,500,000. A breakdown of the cost estimate for this alternative is included in **Appendix D**.

4.1.11.5 Summary

On-site containment of remaining PCB-impacted fill material in the Water Tower and Northwest Corner areas will provide a long-term remedy to eliminate exposures to COPCs and reduce their mobility. Excavation and off-site disposal of PCB-impacted material located inside the containment ranging from 3 to 12-foot depths, and PCB and fill material containing lead hot spots located outside the limits of the proposed containment system will also result in a long-term remedy to eliminate exposure potential. These exposure-reduction measures can be achieved while avoiding the risks inherent with deep excavation and dewatering. The repair of the shoreline bulkhead and installation of the contact barrier and soil cover system will reduce potential contact with fill containing COPCs in excess of TAGM values. Because this alternative achieves all of the remedial action objectives and the short-term risks associated with its implementation are minimal, it will be retained for further consideration.

4.1.12 Alternative 12: Complete Containment of the Northwest Corner and Water Tower Areas, Excavation at 9-Foot and 12-Foot Depths (with grout stabilization) and Off-Site Disposal of PCB-Impacted Fill Located within the Containment; Off-Site Disposal of PCB-Impacted Fill (≥10 ppm) and Lead Hot Spots Located Outside the Containment; Construction of a Contact Barrier and Soil Cover System.

4.1.12.1 Description

This alternative was developed by Atlantic Richfield Company and consists of a combination of on-site containment and excavation and off-site disposal of contaminated fill material. The containment system would be located around the Water Tower and Northwest Corner areas of the site where deep PCBs would remain after completion of a dry excavation to the maximum achievable depth and would consist of a Waterloo Barrier©-type steel sheet pile bulkhead along the shoreline and a slurry wall or equivalent on the upgradient side.

Inside the proposed containment system, PCB-impacted fill would be excavated to 9 or 12-foot depths and disposed in a permitted off-site facility. Excavation would be performed in the dry condition. All PCBs above a depth of approximately 12 feet (depth of maximum dry excavation) would be removed from the containment area with the exception of those areas where PCBs extend to significant depth (>12 feet below grade). A maximum excavation depth of 9 feet would be attained without the use of grout for structural support of the sheet pile wall, while a maximum excavation depth of 12 feet would be attained with the use of grout. The estimated total volume of PCB-impacted fill (as measured in place) that would be excavated and disposed of off-site is approximately 67,000 cubic yards.

The 9-foot depth PCB excavation would be located in the central and northern portions of the Water Tower Area, where a 9-foot deep excavation would remove all PCB-impacted fill with a concentration greater than or equal to 10 ppm. The 12-foot deep PCB excavation would be located in the Northwest Corner Area and the western portion of the Water Tower Area, where either of the following conditions apply; a 12-foot excavation would remove all PCB-impacted fill with a concentration greater than or equal to 10 ppm, or the depth of contaminated fill is greater than 12-feet.

Outside the limits of the containment system, fill material containing PCBs $\geq$10ppm and lead hot spots will be excavated for off-site disposal, as described in Alternative 2.

The excavated material will be dewatered on-site to comply with transportation and disposal requirements as solid material. Post excavation analysis of fill material will be used to determine if the material is to be disposed of as non-hazardous or hazardous waste. The dewatered material will then be transported by rail to a landfill that is permitted to accept the waste in compliance with State and Federal disposal regulations.

A contact barrier and soil cover system, as described in Alternative 7, would be installed over the entire site. Finally, the bulkhead along the waterfront will be reconstructed to prevent erosion of fill material and particulate transport into the Hudson River. **Figure 4-12** is a site map that shows a conceptual excavation plan for this alternative. This alternative removes approximately 52% by mass of the presently existing PCB contamination and restores 28 acres of the Site to productive use with institutional controls.

4.1.12.2 Effectiveness

PCB-impacted fill up to a depth of 12-feet below grade located within the limits of the containment system, all PCB impacted fill ($\geq$10 ppm) located outside of the containment system, and fill containing the lead hot spots located outside the containment system will be effectively removed from the site. All PCB-impacted fill remaining in the Water Tower and Northwest Corner areas will be effectively contained on-site. On-site containment of PCBs in the Northwest Corner complies with regulations promulgated under ECL (6 NYCRR 375.1-10(6)) in that, although it is not feasible to restore the Northwest Corner of the Site to pre-disposal conditions, all significant threats to human health and the environment are eliminated or mitigated. The entire site will be covered with a contact barrier and soil cover system that will effectively reduce the potential for exposure to COPCs at the site. During the implementation of this alternative, an increased risk of exposure would be posed to on-site construction workers, the community and the River environment. Even with proper engineering controls, short-term mobility of COPCs would be increased through vapor and dust inhalation, and dewatering discharge pathways. The volume and toxicity of impacted fill would not be reduced; however, after placement of the excavated fill in a secure landfill and containment of COPCs remaining on-site, the long term potential mobility of the COPCs would decrease significantly. The NYSDEC concluded that bulkhead repair/reconstruction would effectively reduce the potential for off-site migration of similar fill material in their ROD for the Irvington Waterfront Park (NYSDEC, 1988).

4.1.12.3 Implementability

Implementation of this alternative would be subject to similar risks and technical obstacles as discussed under Alternative 2 regarding excavation. The extent of risks and obstacles encountered would be reduced by excavating to somewhat limited depths inside the area of containment, and excavating to shallow depths outside the area of containment. While specialized excavation equipment and labor would be required, excavation to the depths proposed in this alternative would be implementable.

Installation of the vertical components of the containment system (sheet-pile and slurry walls) may be complicated by the presence of underground obstructions, but would be implementable. Construction of a contact barrier and soil cover system over the site would be readily implementable.

The equipment required for transport and disposal of impacted fill material is readily available. The proposed transportation route is via rail. Coordination with all rail line owners and operators between the site and facility would be required. Disposal facilities are available, however, actual acceptance of impacted fill material would be dependent upon facility capacity and acceptance criteria. Also, potential landfills will be limited to those with rail terminals; otherwise, a trucking operation would be required between the rail line and the disposal facility.

4.1.12.4 Cost

For the purpose of alternative screening, the net present worth of this alternative was estimated to be approximately $74,500,000. A breakdown of the cost estimate for this alternative is included in **Appendix D**.

4.1.12.5 Summary

On-site containment of remaining PCB-impacted fill material in the Water Tower and Northwest Corner areas will provide a long-term remedy to eliminate exposures to COPCs and reduce their mobility. Excavation and off-site disposal of PCB-impacted material located inside the containment ranging from 9 to 12-foot depths, and PCB –impacted fill material and fill material containing lead hot spots located outside the limits of the proposed containment system will also result in a long-term remedy to eliminate exposure potential. These exposure-reduction measures can be achieved while avoiding the risks inherent with deep excavation and dewatering. The repair of the shoreline bulkhead and installation of the contact barrier and soil cover system will reduce potential contact with fill containing COPCs in excess of TAGM values. Because this alternative achieves all of the remedial action objectives and the short-term risks associated with its implementation are minimal, it will be retained for further consideration.

4.2 Detailed Analysis of Alternatives

In this section, the eleven alternatives introduced and retained for further consideration in **Section 4.1** (Alternative No. 9 was eliminated as redundant in **Section 4.1.9**) are evaluated using the seven criteria recommended by NYSDEC TAGM 4030 and the National Contingency Plan (USEPA, 1988). This evaluation provides information to facilitate the comparison of alternatives and the selection of a final remedy. The following criteria are used in the detailed analysis:

1. Overall Protection of Human Health and the Environment
2. Compliance with SCGs, ARARs and Other Regulations
3. Short-Term Effectiveness
4. Long-Term Effectiveness and Permanence
5. Reduction in Mobility, Toxicity, and Volume
6. Implementability
7. Cost

The analysis is two tiered. The first tier is comprised of threshold factors 1) overall protection of human health and the environment, and 2) compliance with SCGs, ARARs and other regulations. Any selected remedy must result in overall protection of human health and the environment. Similarly, the SCGs, ARARs, and other regulations must be complied with unless there is an overriding reason why compliance is not possible. The second tier is comprised of, the remaining five criteria. The relative merits and problems associated with meeting these factors must be balanced in arriving at a remedy. The issues associated with each of these seven criteria are briefly described below.

Overall Protection of Human Health and the Environment
This criterion is concerned with the overall protection of human health and the environment which would be achieved by eliminating, reducing, or controlling site risks posed through the

exposure pathways. This criterion includes direct contact risks and potential risks to ecosystems. Also included are the Basic Principles detailed in **Section 1.0** which inhibit the potential spread of contamination by limiting any penetration or pumping of the Basal Sands Unit or any excavation methods which would cause cross contamination of the Basal Sands Unit.

Compliance with SCGs, ARARs, and Other Regulations
This criterion evaluates the compliance of each alternative with SCGs, ARARs, and other regulations. The three regulatory categories that will be considered are chemical specific, location-specific, and action-specific SCGs and ARARs. These regulations are discussed in detail in **Section 2.4**.

Short-Term Effectiveness
The effectiveness of an alternative in protecting human health and the environment during construction and implementation of the remedial alternative is assessed under short-term effectiveness. This criterion encompasses concerns about short-term impacts, as well as the length of time required to implement the alternative. Factors such as cross-media impacts, the need to transport impacted material through populated areas, current site operations, and the potential disruption of neighborhoods and ecosystems may be pertinent. Due to the affinity of COPCs to preferentially adsorb to organics in the Fill, excavation remedies that release dust could create potential short-term risks through the inhalation pathway. Also, excavation scenarios which could cause cross contamination of otherwise uncontaminated media are also evaluated here. The health and safety issues associated with the implementation of any remedial action involving excavation and transport of fill are included under this criterion.

Long-Term Effectiveness and Permanence
The long-term effectiveness of a remedial alternative is evaluated under this criterion with particular focus on the residual contamination remaining in a particular medium after completion of the selected alternative, and the degree to which a remedial measure provides a permanent remedy for the Site. The long-term integrity of containment options is also evaluated, including the potential for an alternative to create additional contaminant migration pathways during its implementation.

Reduction in Mobility, Toxicity, and Volume
This criterion evaluates contaminant reductions with respect to concentration and/or mass based on a percentage or generalized estimate, and the mass of contaminants or the volume of impacted media that will be destroyed or contained through treatment. This criterion also addresses potential decreased risks associated with changes in the mobility, toxicity, and

volume. For this Site, the current potential risk levels are low for all impacted media. However, during some of the alternatives, the potential mobilization of contaminants during implementation of the alternative presents a risk factor that must be considered. Of particular risk are the dangers of bottom heave and piping failures during deeper excavations, which could cause cross contamination of the Basal Sands Unit. Other, less invasive alternatives have been designed to further reduce potential risk and to meet remedial objectives.

Implementability

This criterion involves an evaluation of the alternative with respect to performance, reliability, and technical implementability. Performance and reliability focus on the ability of the alternative to meet specific goals or remedial levels. The technical implementability of an alternative addresses construction and operation with regard to site-specific conditions, including the operational impact of the existing on-site activities and the ability to safely implement the alternative. Administrative implementability focuses on the time and effort required to obtain appropriate approvals and addressing other administrative issues. Special concerns are associated with implementing remedial action on a site that has other ongoing activities. Implementability for many of the excavation alternatives is further discussed in the Excavation Evaluation Summary Report (**Appendix B)**.

Cost

Estimated costs are included for each alternative. These costs may include design and construction costs, remedial action O&M costs, other capital and short term costs, and costs of field and project management associated with the implementation of the remedial alternatives. Estimates of permitting costs have also been included where appropriate. Costs are also calculated on a present worth basis, assuming a 30 year period and a 5% inflation factor. Detailed cost estimate for each alternative evaluated are provided in **Appendix D**.

4.2.1 Alternative 1: No Action

Alternative 1 is the No Action alternative. No further action will be taken to address the presence of COPCs at the Site; however, current administrative controls limiting site access will continue to be implemented, along with the five IRMs described in **Section 1.5** which have been implemented, and reconstruction of the bulkhead across the entire waterfront. A more detailed description of this alternative is presented in **Section 4.1.1**.

4.2.1.1 Overall Protection of Human Health and the Environment

Current administrative controls (limited site access, as well as the procedures outlined in the HASP) would remain in place providing protection to potential trespassers and site workers. However, this alternative would not reduce potential risks to human health or the environment for future reuse scenarios.

4.2.1.2 Compliance with SCGs, ARARs and Other Regulations

Under this alternative, current administrative controls would remain in place. However, because fill and fill water with concentrations exceeding PRGs would remain available for direct contact; site cleanup objectives would not be achieved for future use scenarios. Installation of the IRM bulkhead and repair of the existing bulkhead would reduce migration of impacted media from the site by reducing shoreline erosion.

4.2.1.3 Short-Term Effectiveness

Since no action would be taken to disturb the impacted fill or fill water under this alternative, no short-term risks to workers, the community, or the environment would be presented as a result of construction activities.

4.2.1.4 Long-Term Effectiveness and Permanence

The long-term risk of direct contact with the impacted fill or fill water is not reduced under this alternative. However, the volume and toxicity of impacted media would gradually decrease over extended time period through natural degradation and attenuation. Redevelopment of the Site and changes in its usage scenario could present an increased potential for risks to human health and the environment.

4.2.1.5 Reduction in Mobility, Toxicity, and Volume

This alternative removes 0% of the mass of the existing PCB contamination and restores 0 acres of the site to productive use. The volume and toxicity of impacted media would gradually decrease over an extended time period through natural degradation and attenuation. While PCBs have historically been considered resistant to biodegradation, the results of on-going laboratory and field studies indicate that PCBs slowly biodegrade in the environment (*Technology Alternatives for the Remediation of PCB-Contaminated Soil and Sediment*, EPA/540/S-93/506, USEPA, 1993). Although the rate of PCB degradation at the Site has not been modeled, it is reasonable to expect that this process would take longer than 30 years, which is often used as the time frame of comparison for CERCLA remedies.

Potential off-site migration of PCBs in their current state is minimal due to the chemical characteristics of the COPCs, including their low solubilities and strong tendencies to sorb to organic fill. The current rate of PCB migration off-site is characterized in the RI as very low, and is not expected to increase. Currently, there are no known direct or point-source discharges of PCBs to the Hudson River. Future releases of impacted fill material to the River are not likely to occur, because reconstruction of the southern area of the bulkhead has already been completed and complete reconstruction of the remainder of the bulkhead along the River is proposed as a component of all the Alternatives evaluated.

4.2.1.6 Implementability

No construction (other than the bulkhead reconstruction) would be required to implement this alternative. Subsequently, technical feasibility and performance are not an issue.

4.2.1.7 Cost

The estimated present worth, including bulkhead reconstruction, of this remedial alternative is $17,000,000. A breakdown of this estimate is included in **Appendix D**.

4.2.2 Alternative 2: Excavation and Off-Site Disposal of all PCB-Impacted Fill and Lead Hot Spots

This alternative consists of excavation and off-site disposal of all surface fill (i.e., 0 to 1 foot below grade) where PCB concentrations exceed 1 ppm and all subsurface fill where PCB concentrations equal or exceed 10 ppm. A detailed description of the alternative is presented in **Section 4.1.2**.

4.2.2.1 Overall Protection of Human Health and the Environment

This alternative provides overall protection of human health and the environment by:

Eliminating the following: 1) all current exposures to surface and subsurface fill above PRGs; 2) future-use occupant exposures to subsurface fill above PRGs; and 3) short-term future-use construction exposures to air, fill, fill water above PRGs by removal and containment of this material; and

Preventing the transport of PCB impacted fill into the Hudson River (where applicable) by removing it by excavation and by constructing a new shoreline bulkhead.

However, this alternative has substantial risk of increasing the short-term risk of cross contamination to the uncontaminated Basal Sands Unit, due to the necessity of constructing deep excavations which would be conducted in both a flooded excavation and with sheet piling that penetrated the Basal Sands Unit. This penetration and flooded condition would open up additional pathways for contaminant migration during construction. This Alternative could contaminate the Basal Sands Unit which is a violation of all of the Basic Principles outlined in **Section 1.0**, developed from the conclusions of the Excavation Evaluation Summary Report (**Appendix B**). The high risk of spreading contamination during the Site remediation increases the present short-term and long-term risks at the Site.

4.2.2.2 Compliance with SCGs, ARARs and Other Regulations

This alternative would eliminate exposures to fill and fill water exceeding SCGs through the removal and off-site disposal of fill exceeding the TAGM 4046 objectives for PCBs. Surface fill (i.e., 0 to 1 foot below grade) where PCB concentrations exceed 1 ppm and all subsurface fill where PCB concentrations exceed 10 ppm would be excavated. Because fill exceeding the (PCB content) criteria for hazardous waste in New York State would be removed, the site could be removed from the NYSDEC's Inactive Hazardous Sites Registry.

4.2.2.3 Short-Term Effectiveness

Significant short-term risks of exposure to on-site construction workers and the communities surrounding the transportation route exist during the excavation and transportation of waste and clean fill by truck, rail and barge. These risks are inherent in deep excavation and the large quantities of material that would have to be excavated and transported off-site. Short-term mobility of CPOCs would be increased through vapor and dust inhalation, and dewatering discharge pathways. Short-term risks to construction workers including vapor and dust inhalation can be reduced with the use of proper engineering controls such as soil wetting and the use of personal protective equipment. Construction of a shoreline bulkhead poses little to no short-term risk. Short term cross contamination of the Basal Sands Unit during construction is also possible due to the necessity of conducting deep excavations in a flooded state with sheet piling penetrating the Basal Sands Unit.

4.2.2.4 Long-Term Effectiveness and Permanence

Placement of PCB-impacted fill in an off-site landfill is a permanent solution to reduce the mobility of PCBs in the environment. However, the dewatering activities associated with deep excavation have possible long term risks such as potential increase in PCB mobility through excavation dewatering discharge into the Hudson River. The potential for driving the contamination deeper into the soils also exists if penetration of the Basal Sands Unit occurs during deep excavation. Currently, as described in the Excavation Evaluation Summary Report (**Appendix B**), any excavation scenario implemented to this depth would require violation of one or more of the Basic Principles developed to prevent the further spread of contamination from the Site into deeper, presently uncontaminated areas (i.e., the Basal Sands Unit). This in turn would compromise the normal long-term effectiveness and permanence of excavation and potentially spread contamination to depths and areas where excavation becomes impossible. This alternative also has no provisions for reducing potential human contact to PAHs in surface soil. Therefore, some long-term risks to humans will remain upon the completion of this alternative.

4.2.2.5 Reduction in Mobility, Toxicity, and Volume

This remedial alternative removes approximately 99% by mass of the presently existing PCB contamination and relies upon excavation of COPCs at the Site instead of treatment.
A limited volume of PCB-impacted fill (10 ppm or less) will remain on-site in subsurface soils. There is no expected reduction in the volume, toxicity or mobility of the CPOCs excavated and removed from the Site. However, the excavation technologies required to be used to achieve deep excavation could potentially increase the mobility of PCB-impacted sediments, particularly during remediation. The on-site volume, toxicity and mobility of fill containing COPCs will be reduced by the placement of excavated PCB-impacted fill in excess of 10 ppm in an off-site disposal facility. As is the case with all other alternatives, the volume and toxicity of media impacted with PCB concentrations less than 10 ppm would gradually decrease through natural degradation and attenuation. The construction of a new shoreline bulkhead and the implementation of institutional goals will further reduce the mobility and toxicity of on-site COPCs.

4.2.2.6 Implementability

While excavation of impacted fill is a reliable option, the unique characteristics of this Site pose many challenges to the implementability of this remedial alternative. These unique characteristics have been explained in detail in **Sections 3.3.5.2** and **3.3.5.3** and within the Excavation Evaluation Summary Report (**Appendix B**). Since PCBs have been identified at depths approaching 40 feet below grade, excavating below the water table will require extensive sheeting and dewatering. Subsurface debris and structures will further increase the time and effort required to excavate impacted fill. There is potential for bottom heave during excavation in the area of the Marine Grey Silt Unit, which could endanger site workers and cause damage to nearby structures and property. The implementation of this alternative will require specialized material, equipment and labor. Currently, no viable excavation technologies exist which do not violate one or more of the Basic Principles developed for the Site to prevent further migration of contaminants during excavation. As described in the Excavation Evaluation Summary Report, deep excavation alternatives require either penetration of the Basal Sands Unit with shoring, pumping of the Basal Sands Unit to reduce artesian pressures in the Basal Sands Unit, or completing the excavation in a flooded condition. All of these excavation technologies will lead to the potential spread of contaminants into the presently uncontaminated Basal Sands aquifer. Due to the large volume of waste that will be generated during excavation and the lack of viable roads in the Village of Hastings, the transportation of waste via railroad is likely. The number of disposal facilities with rail capacity may be limited, and coordination with interstate rail carriers will be required.

Shallow excavation of lead hot spots, excavation of PCBs outside of the containment area, installation of the new shoreline bulkhead and installation of a multi-layered cap system are all considered to be readily implementable.

4.2.2.7 Cost

The estimated present worth, including capital and O&M, of this remedial alternative is $150,000,000. A detailed breakdown of this estimate is included in **Appendix D.**

4.2.3 Alternative 3: Excavation and Off-Site Disposal of All Fill Located Above the Water Table Exceeding TAGM Values and All PCB-Impacted Fill Located Below the Water Table ≥10 PPM. Excavation and Off-Site Disposal of Lead Hot Spots

This alternative would consist of excavation and off-site disposal of all subsurface fill located above the water table containing any COPCs exceeding any TAGM value and would also include excavation of all subsurface fill below the water table containing PCBs ≥ 10 ppm. Excavation and off-site disposal of lead hot spots and the construction of a new shoreline bulkhead are also included in this alternative. A detailed description of the alternative is presented in **Section 4.1.3**.

4.2.3.1 Overall Protection of Human Health and the Environment

The alternative provides overall protection of human health and the environment by:

- Preventing the following: 1) all current exposure risks to subsurface fill above RAOs, 2) future-use occupant exposure risks to subsurface fill above RAOs, and 3) short-term future-use construction exposure risks to air, fill, and fill water above RAOs;
- Preventing the transport of PCB impacted soil/sediment to the Hudson River (where applicable) by removing them by excavation; and
- Implementing institutional controls to prevent 1) future-use occupant contact with subsurface fill above remedial levels and 2) short-term future-use exposure, by construction workers, to impacted air, fill water, and surface and subsurface fill.

However, this alternative increases the short-term risk of cross contamination from the COPC in the Fill Unit to the uncontaminated Basal Sands Unit as a result of the deep excavations which would be conducted in both a flooded condition and with sheet piling that penetrated the Basal Sands Unit. This penetration and flooded condition would result in potential pathways for contaminant migration to the uncontaminated Basal Sands Aquifer Unit. This is a violation of all of the Basic Principles outlined in **Section 1.0**, and is undesirable due to the high risk of spreading contamination during the Site remediation, thereby increasing the present short-term and long-term risks at the Site.

4.2.3.2 Compliance with SCGs, ARARs and Other Regulations

This alternative would be consistent with RAO objectives through the excavation and off-site disposal of subsurface fill materials with contaminant levels exceeding any TAGM to the water table, PCB-impacted fill materials with concentrations greater than or equal to 10 ppm, and the placement of clean, imported soil in the excavated areas. Direct contact and migration of impacted media would be prevented, thereby achieving Site objectives.

4.2.3.3 Short-Term Effectiveness

Excavation could present a potential short-term impact to the community, workers or the environment. Catastrophic failures are always a potential risk when working with open excavations and shoring; particularly for deeper excavations adjacent to the river where hydraulic pressures would be higher. There are also risks in transporting hazardous waste by rail, truck or barge, that could potentially impact residential and/or environmentally sensitive areas. The use of personal protection equipment, possibly including dust control measures and respiratory protection would be necessary. Although the volatility of the COPCs is very low, air monitoring will also be necessary. Short term cross contamination of the Basal Sands Unit during construction is also possible due to the necessity of conducting deep excavations in a flooded state with sheet piling penetrating the Basal Sands Unit.

4.2.3.4 Long-Term Effectiveness and Permanence

The long-term risk of exposure for this alternative is very low. The potential risk of direct contact with, and migration of, impacted subsurface media exceeding RAO levels would be minimized by excavation and off-site disposal of impacted fill materials. Excavation would minimize the potential for the migration of these impacted materials to the Hudson River. The potential for driving contamination in the Fill Unit deeper into the Basal Sands Unit during deep excavation. Currently, as described in the Excavation Evaluation Summary Report (**Appendix B**), any excavation scenario implemented to this depth would require violation of one or more of the Basic Principles developed to prevent the further spread of contamination from the Site into deeper, presently uncontaminated areas (i.e., the Basal Sands Unit). This in turn would compromise the normal long-term effectiveness and permanence of excavation and potentially spread contamination to depths and areas where excavation becomes impossible to remedy. Institutional controls under the site-wide controls will specify environmental health and safety requirements for possible demolition and construction activities during site redevelopment. The volume and toxicity of remaining impacted fill with PCB concentrations less than 10 ppm would gradually decrease through natural degradation and attenuation.

4.2.3.5 Reduction in Mobility, Toxicity, and Volume

This alternative removes approximately 99% by mass of the presently existing PCB contamination from the Site. The inherent mobility, toxicity and volume of the impacted fill that would be excavated and removed from the Site would not change. Removal of fill material above the water table with contaminant concentrations greater than or equal to TAGM and PCB-impacted fill material with PCB concentrations exceeding 10 ppm would reduce on-site contaminant mobility, toxicity, and volume, by transferring the contamination to another site. However, the excavation technologies required to be used to achieve deep excavation could potentially increase the mobility of PCB-impacted sediments, particularly during remediation. Disposal would be conducted at a regulated facility with physical barriers to contaminant movement. These barriers would control mobility at the facility. As is the case with all other alternatives, the volume and toxicity of media impacted with PCB concentrations less than 10 ppm would gradually decrease through natural degradation and attenuation.

4.2.3.6 Implementability

Prevailing conditions at the Site would make the implementation of excavation difficult, particularly with increasing depth and proximity to the river. These conditions include the complex and dense network of subsurface utilities and structures, adjacent buildings, the shallow water table and the potential for flooding into an excavation from the river. Installation of sheet pile excavation cells would be required prior to excavation, and would require extensive shoring. Wooden pilings and buried bulkheads would have to be cut and removed from the excavation cells prior to bulk material excavation. A contractor experienced in excavation and transport would be used to complete this task. Currently, no viable excavation technologies exist which do not violate one or more of the Basic Principles developed for the Site to prevent further migration of contaminants during excavation. As described in the Excavation Evaluation Summary Report, deep excavation alternatives require either penetration of the Basal Sands Unit, pumping of the Basal Sands Unit, or working in a flooded excavation. All of these excavation technologies will lead to the potential spread of contaminants into the presently uncontaminated Basal Sands aquifer. There would be no technical limitations to the implementation of institutional controls.

4.2.3.7 Cost

The estimated present worth, including capital and O&M, of this remedial alternative is $225,000,000. A detailed breakdown of this estimate is included in **Appendix D.**

4.2.4 Alternative 4: Excavation and Off-Site Disposal of All PCB-Impacted Fill, Lead Hot Spots and Construction of a Multi-Layered Cap System Over the Entire Site

This alternative would consist of excavation and off-site disposal of all surface fill (i.e., 0 to 1 foot below grade) where PCB concentrations exceed 1 ppm and all subsurface fill where PCB concentrations equal or exceed 10 ppm. In addition to the excavation and off-site disposal of PCB-impacted fill as specified above, this alternative would also include excavation and off-site disposal of fill containing lead hot spots. A multi-layered cap system will be installed over the entire site and a new shoreline bulkhead will be constructed. A detailed description of the alternative is presented in **Section 4.1.4**.

4.2.4.1 Overall Protection of Human Health and the Environment

This alternative provides overall protection of human health and the environment by:

Eliminating the following: 1) all current exposures to surface and subsurface fill above PRGs; 2) future-use occupant exposures to subsurface fill above PRGs; and 3) short-term future-use construction exposures to air, fill, fill water above PRGs by removal and containment of this material and by implementing institutional controls; and preventing the transport of PCB impacted fill into the Hudson River (where applicable) by removing it by excavation and by constructing a new shoreline bulkhead.

This alternative and the associated deep excavation activities increase the short-term risk of cross contamination Basal Sands Unit. Deep excavations will require the excavation to be flooded and penetration of the Basal Sands Unit with multiple sheet pile sections. This penetration and flooded condition would open up additional pathways to contaminant migration during construction that could possibly contaminate the aquifer within the Basal Sands Unit. This is a violation of all of the Basic Principles outlined in **Section 1.0**, and is undesirable due to the high risk of spreading contamination during the Site remediation, thereby increasing the present short-term and long-term risks at the Site.

4.2.4.2 Compliance with SCGs, ARARs and Other Regulations

This alternative would eliminate exposures to fill and fill water exceeding SCGs through the removal and off-site disposal of fill exceeding the TAGM 4046 objectives for PCBs. Surface fill (i.e., 0 to 1 foot below grade) where PCB concentrations exceed 1 ppm and all subsurface fill where PCB concentrations exceed 10 ppm would be excavated. Because fill exceeding the (PCB content) criteria for hazardous waste in New York State would be removed, the site could be removed from the NYSDEC's Inactive Hazardous Sites Registry.

4.2.4.3 Short-Term Effectiveness

As with Alternatives 2 and 3, implementation of this alternative will increase short-term risks of exposure to site construction workers, surrounding communities, the River environment, and the groundwater underlying the Marine Grey Silt layer. Short-term risks to construction workers including vapor and dust inhalation can be reduced with the use of proper engineering controls such as soil wetting and the use of personal protective equipment. It may be necessary to perform air monitoring during implementation of this alternative. The construction of a soil cover system and a new shoreline bulkhead pose little to no short-term risk. Short term cross contamination of the Basal Sands Unit during construction is also possible due to the necessity of conducting deep excavations in a flooded state with sheet piling penetrating the Basal Sands Unit.

4.2.4.4 Long-Term Effectiveness and Permanence

Excavation and placement of PCB and lead-impacted fill in an off-site landfill is a permanent solution to effectively reduce the future potential exposure risks associated with this material. However, as described in the Excavation Evaluation Summary Report (**Appendix B**), any excavation scenario implemented to this depth would require violation of one or more of the Basic Principles developed to prevent the further spread of contamination from the Site into deeper, presently uncontaminated areas (i.e., the Basal Sands Unit) This in turn would compromise the normal long-term effectiveness and permanence of excavation and potentially spread contamination to depths and areas where excavation becomes impossible. Also, the dewatering activities associated with deep excavation have possible long term risks such as potential increase in PCB mobility through excavation dewatering discharge into the Hudson River. The installation of a multi-layered cap over the entire site will reduce potential human contact to lead and PAHs in surface fill. The implementation of institutional controls will reduce potential future risks at the site by specifying how future intrusive activities at the site will be enacted.

4.2.4.5 Reduction in Mobility, Toxicity, and Volume

This remedial alternative relies upon excavation of COPCs at the Site instead of treatment and removes approximately 99% by mass of the presently existing PCB contamination from the Site. A limited volume of PCB-impacted fill (10 ppm or less) will remain on-site in subsurface soils. There is no expected reduction in the volume, toxicity or mobility of the COPCs excavated and removed from the Site. However, the excavation technologies required to be used to achieve deep excavation could potentially increase the mobility of PCB-impacted sediments, particularly during remediation. The on-site volume, toxicity and mobility of fill containing COPCs will be reduced by the placement of excavated PCB-impacted fill greater than or equal to of 10 ppm in an off-site disposal facility. As is the case with all other alternatives, the volume and toxicity of media impacted with PCB concentrations less than 10 ppm would gradually decrease through natural degradation and attenuation. The construction of a new shoreline bulkhead and the implementation of institutional goals will further reduce the mobility and toxicity of on-site COPCs.

4.2.4.6 Implementability

While excavation of impacted fill is a reliable option, the unique characteristics of this Site pose many challenges to the implementability of this remedial alternative. These unique characteristics have been explained in detail in **Sections 3.3.5.2** and **3.3.5.3**. Since PCBs have been identified at depths approaching 40 feet below grade, excavating below the water table will require extensive sheeting, excavation in a flooded condition, and dewatering of excavation soils. Subsurface debris and structures will further increase the time and effort required to excavate impacted fill. There is also potential for bottom heave during excavation in the area of the Marine Grey Silt Unit, which could potentially endanger site workers and cause damage to nearby structures and property. Due to the complexity of the subsurface fill, the implementation of deep excavation will require specialized equipment and labor. Currently, no viable excavation technologies exist which do not violate one or more of the Basic Principles developed for the Site to prevent further migration of contaminants during excavation. As described in the Excavation Evaluation Summary Report (**Appendix B**), deep excavation alternatives require either penetration of the Basal Sands Unit, pumping of the Basal Sands Unit, or working in a flooded excavation. All of these excavation technologies will lead to the potential spread of contaminants into the presently uncontaminated Basal Sands aquifer.

Due to the large volume of waste that will be generated during excavation and the lack of viable roads in the Village of Hastings, the transportation of waste via railroad is likely. The number of disposal facilities with rail capacity may be limited, and coordination with interstate rail carriers will be required. Installation of the new shoreline bulkhead and the multi-layered cap system are both considered to be readily implementable.

4.2.4.7 Cost

The estimated present worth, including capital and O&M, of this remedial alternative is $167,000,000. A detailed breakdown of this estimate is included in **Appendix D.**

4.2.5 Alternative 5: Excavation and Off-Site Disposal of Fill Containing the "Rubbery Matrix" and Lead Hot Spots, Complete Containment of the Water Tower and Northwest Corner Areas, Excavation and Off-Site Disposal of Impacted Fill Located Outside the Limits of the Containment

This alternative would consist of a combination of excavation and containment technologies. This alternative would consist of a complete containment system around the Water Tower and Northwest Corner Areas, and the construction of a new shoreline bulkhead. Inside the proposed containment system, fill material containing the "rubbery matrix" would be excavated and disposed of off-site. Outside the proposed containment system, fill containing lead hot spots and fill material located above the water table containing COPCs above any TAGM value and all fill located below the water table containing PCBs $\geq$ 10 ppm would be excavated and disposed of off-site. A detailed description of the alternative is presented in **Section 4.1.5**.

4.2.5.1 Overall Protection of Human Health and the Environment

This alternative provides overall protection of human health and the environment by:

Eliminating the following: 1) all current exposures to surface and subsurface fill above PRGs; 2) future-use occupant exposures to subsurface fill above PRGs; and 3) short-term future-use construction exposures to air, fill, fill water above PRGs by removal and containment of this material and by implementing institutional controls; and preventing the transport of PCB impacted fill into the Hudson River (where applicable) by removing it by excavation, by constructing a new shoreline bulkhead, and by constructing a containment system in the Water Tower and Northwest Corner Areas.

However, this alternative increases the short-term risk of cross contamination impacts to the uncontaminated Basal Sands Unit aquifer due to deep excavations being conducted in both a flooded condition and with sheet piling that penetrated the Basal Sands Unit. This penetration and flooded condition would open up additional pathways for contaminant migration during construction that could contaminate the presently pristine Basal Sands Unit. This is a violation of all of the Basic Principles outlined in **Section 1.0** (**Appendix B**), and is undesirable due to the high risk of spreading contamination during the Site remediation, thereby increasing the present short-term and long-term risks at the Site.

4.2.5.2 Compliance with SCGs, ARARs and Other Regulations

This alternative eliminates exposures to fill and fill water exceeding SCGs through implementation of the following actions:

- Excavation and off-site disposal of fill containing the “Rubbery Matrix”, and
- Construction of a complete containment system for the Water Tower and Northwest Corner Areas, and
- Excavation and off-site disposal of subsurface fill located outside the area of containment and above the water table that contains lead hot spots and COPCs exceeding any TAGM value and all fill below the water table with PCBs greater than or equal to 10 ppm, and
- Installation of a new shoreline bulkhead, and
- Implementation of institutional controls restricting future use activities.

4.2.5.3 Short-Term Effectiveness

As with Alternatives 2, 3 and 4, implementation of this alternative will increase short-term risks of exposure to site construction workers, surrounding communities, the River environment, and the groundwater underlying the Marine Grey Silt layer. Short-term risks to construction workers including vapor and dust inhalation can be reduced with the use of proper engineering controls such as soil wetting and the use of personal protective equipment. It may be necessary to perform air monitoring during implementation of this alternative. The construction of a complete containment system and a new shoreline bulkhead pose little to no short-term risk. Short term cross contamination of the Basal Sands Unit during construction is also possible due to the necessity of conducting deep excavations in a flooded state with sheet piling penetrating the Basal Sands Unit.

4.2.5.4 Long-Term Effectiveness and Permanence

Excavation and placement of PCB and lead-impacted fill in an off-site landfill is a permanent solution to effectively reduce the future potential exposure risks associated with this material. However, the dewatering activities associated with deep excavation have possible long-term risks such as potential increase in PCB mobility through excavation dewatering discharge into the Hudson River. The potential for driving the contamination deeper into the soils also exists if penetration of the Basal Sands Unit during deep excavation occurs. Currently, as described in the Excavation Evaluation Summary Report (**Appendix B**), any excavation scenario implemented to this depth would require violation of one or more of the Basic Principles developed to prevent the further spread of contamination from the Site into deeper, presently uncontaminated areas (i.e., the Basal Sands Unit). This in turn would compromise the normal long-term effectiveness and permanence of excavation and potentially spread contamination to depths and areas where excavation becomes impossible. The installation of a complete containment system around the Water Tower and Northwest Corner Areas of the site will reduce potential human contact to PCBs in surface fill in those areas. The implementation of institutional controls will reduce potential future risks at the site by specifying how future intrusive activities at the site will be enacted.

4.2.5.5 Reduction in Mobility, Toxicity, and Volume

This remedial alternative relies upon excavation and containment of COPCs at the Site instead of treatment and removes approximately 98% by mass of the presently existing PCB contamination from the Site. A limited volume of PCB-impacted fill (10 ppm or less) will remain on-site in subsurface soils. There is no expected reduction in the volume, toxicity or mobility of the COPCs excavated and removed from the Site. However, the excavation technologies required to be used to achieve deep excavation could potentially increase the mobility of PCB-impacted fill, particularly during remediation. The on-site volume, toxicity and mobility of fill containing COPCs will be reduced by the placement of excavated PCB-impacted fill in excess of 10 ppm in an off-site disposal facility. The mobility of COPCs remaining in subsurface fill in the Water Tower and Northwest Corner Areas of the site will be greatly reduced by the installation of a complete containment system in those areas. As is the case with all other alternatives, the volume and toxicity of media impacted with PCB concentrations less than 10 ppm would gradually decrease through natural degradation and attenuation. The construction of a new shoreline bulkhead and the implementation of institutional controls will further reduce the mobility and toxicity of on-site COPCs.

4.2.5.6 Implementability

While excavation of impacted fill is a reliable option, the unique characteristics of this Site pose many challenges to the implementability of this remedial alternative. These unique characteristics have been explained in detail in **Sections 3.3.5.2** and **3.3.5.3**. Since PCBs have been identified at depths approaching 40 feet below grade, excavating below the water table will require extensive sheeting and dewatering. Subsurface debris and structures will further increase the time and effort required to excavate impacted fill. There is potential for bottom heave during excavation in the area of the Marine Grey Silt Unit, which could potentially endanger site workers and cause damage to nearby structures and property. Due to the complexity of the subsurface fill, the implementation of deep excavation will require specialized equipment and labor. Currently, no viable excavation technologies exist which do not violate one or more of the Basic Principles developed for the Site to prevent further migration of contaminants during excavation. As described in the Excavation Evaluation Summary Report (**Appendix B**), deep excavation alternatives require either penetration of the Basal Sands Unit, pumping of the Basal Sands Unit, or working in a flooded excavation. All of these excavation stabilization techniques will lead to the potential spread of contaminants into the presently uncontaminated Basal Sands aquifer. Due to the large volume of waste that will be generated during excavation and the lack of viable roads in the Village of Hastings, the transportation of waste via railroad is likely. The number of disposal facilities with rail capacity may be limited, and coordination with interstate rail carriers will be required.

Installation of the new shoreline bulkhead and the complete containment system are both considered to be readily implementable. Implementing institutional controls are also considered readily implementable.

4.2.5.7 Cost

The estimated present worth, including capital and O&M, of this remedial alternative is $165,000,000. A detailed breakdown of this estimate is included in **Appendix D.**

4.2.6 Alternative 6: Excavation and Off-Site Disposal of Fill Containing the "Rubbery Matrix" and Lead Hot Spots, Complete Containment of the Water Tower and Northwest Corner Areas, Construction of a Multi-Layered Cap over the Entire Site

This alternative would consist of excavation and off-site disposal of the material containing the "rubbery matrix" and lead hot spots, complete containment of the Water Tower and Northwest Corner Areas and constructing a multi-layered cap over the entire site. This alternative would also include implementing institutional controls to restrict future site activities at the site and constructing a new shoreline bulkhead. A detailed description of the alternative is presented in **Section 4.1.6**.

4.2.6.1 Overall Protection of Human Health and the Environment

This alternative provides overall protection of human health and the environment by:

Eliminating the following: 1) all current exposures to surface and subsurface fill above PRGs; 2) future-use occupant exposures to subsurface fill above PRGs; and 3) short-term future-use construction exposures to air, fill, fill water above PRGs by removal and containment of this material and by implementing institutional controls; and preventing the transport of PCB impacted fill into the Hudson River (where applicable) by removing it by excavation, by constructing a new shoreline bulkhead, by constructing a complete containment system for the Water Tower and Northwest Corner areas, and by constructing a multi-layered cap over the entire site.

However, this alternative increases the short-term risk of cross contamination impacts to the uncontaminated Basal Sands Unit due to the necessity of constructing deep excavations which would be conducted in both a flooded excavation and with sheet piling that penetrated the Basal Sands Unit. This penetration and flooded condition would result in additional pathways for contaminant migration during construction that could contaminate the Basal Sands Unit Aquifer. This is a violation of all of the Basic Principles outlined in **Section 1.0**, and is undesirable due to the high risk of spreading contamination during the Site remediation, thereby increasing the present short-term and long-term risks at the Site.

4.2.6.2 Compliance with SCGs, ARARs and Other Regulations

This alternative eliminates exposures to fill and fill water exceeding SCGs through implementation of the following actions:

- Excavation and off-site disposal of fill containing the "Rubbery Matrix" and lead hot spots, and
- Construction of a complete containment system for the Water Tower and Northwest Corner Areas, and
- Construction of a multi-layered cap over the entire site, and
- Installation of a new shoreline bulkhead, and
- Implementation of institutional controls restricting future use activities.

4.2.6.3 Short-Term Effectiveness

As with Alternatives 2, 3, 4, and 5, implementation of this alternative will increase short-term risks of exposure to site construction workers, surrounding communities, the Hudson River environment, and the groundwater underlying the Marine Grey Silt layer. Short-term risks to construction workers including vapor and dust inhalation can be reduced with the use of proper engineering controls such as soil wetting and the use of personal protective equipment. It may be necessary to perform air monitoring during implementation of this alternative. The construction of a multi-layered cap and a new shoreline bulkhead pose little to no short-term risk. Short term cross contamination of the Basal Sands Unit during construction is also possible due to the necessity of conducting deep excavations in a flooded state with sheet piling penetrating the Basal Sands Unit.

4.2.6.4 Long-Term Effectiveness and Permanence

Excavation and placement of PCB-impacted fill in an off-site landfill is a permanent solution to effectively reduce the future potential exposure risks associated with this material. However, the potential for promoting contamination to move deeper into the Basal Sands Unit during the installation of shoring necessary for completing deep excavations. In addition, deep excavations require flooding the excavations which may cause piping and channeling of contamination along the shoring and existing piles. Currently, as described in the Excavation Evaluation Summary Report (**Appendix B**), any excavation scenario implemented to this depth would require violation of one or more of the Basic Principles developed to prevent the further spread of contamination from the Site into deeper, presently uncontaminated areas (i.e., the Basal Sands Unit) This in turn would compromise the normal long-term effectiveness and permanence of excavation and potentially spread contamination to depths and areas where remediation via excavation becomes impossible. Also, the dewatering activities associated with deep excavation have possible long-term risks such as potential increase in PCB mobility through excavation dewatering discharge into the Hudson River. The installation of a complete containment system around the Water Tower and Northwest Corner Areas of the site and a multi-layered cap over the entire site will reduce potential human contact to COPCs remaining in surface fill in those areas. The implementation of institutional controls will further reduce potential future risks at the site by specifying how future intrusive activities at the site will be enacted.

4.2.6.5 Reduction in Mobility, Toxicity, and Volume

This remedial alternative relies upon excavation and containment of COPCs at the Site instead of treatment and removes approximately 97% by mass of the presently existing PCB contamination from the Site. A limited volume of PCB-impacted fill will remain on-site in subsurface soils. There is no expected reduction in the volume, toxicity or mobility of the COPCs excavated and removed from the Site. However, the excavation technologies required to be used to achieve deep excavation could potentially increase the mobility of PCB-impacted media, particularly during remediation. The on-site volume, toxicity and mobility of fill containing COPCs will be reduced by the placement of excavated fill containing the “rubbery matrix” and lead hot spots in an off-site disposal facility. The mobility of COPCs remaining in subsurface fill at the site will be greatly reduced by the installation of a complete containment system in the Water Tower and Northwest Corner Areas, and the installation of a multi-layered cap over the entire site. The construction of a new shoreline bulkhead and the implementation of institutional controls will further reduce the mobility and toxicity of on-site COPCs.

4.2.6.6 Implementability

While excavation of impacted fill is a reliable option, the unique characteristics of this Site pose many challenges to the implementability of this remedial alternative. These unique characteristics have been explained in detail in **Sections 3.3.5.2** and **3.3.5.3**. Due to the complexity of the subsurface fill, the implementation of deep excavation will require specialized equipment and labor. Currently, viable excavation technologies do not exist which do not violate one or more of the Basic Principles developed for the Site to prevent further migration of contaminants. As described in the Excavation Evaluation Summary Report, deep excavation alternatives require either penetration of the Basal Sands Unit, pumping of the Basal Sands Unit, or working in a flooded excavation. All of these excavation technologies will lead to the potential spread of contaminants into the presently uncontaminated Basal Sands Unit Aquifer.

Due to the large volume of waste that will be generated during excavation and the lack of viable roads in the Village of Hastings, the transportation of waste via railroad is likely. The number of disposal facilities with rail capacity may be limited, and coordination with interstate rail carriers will be required.

Installation of the complete containment system in the Water Tower and Northwest Corner areas may be complicated by the presence of underground obstructions. However, installation of the new shoreline bulkhead and a multi-layered cap over the entire site are both considered to be readily implementable.

4.2.6.7 Cost

The estimated present worth, including capital and O&M, of this remedial alternative is $132,000,000. A detailed breakdown of this estimate is included in **Appendix D.**

4.2.7 Alternative 7: Excavation and Off-Site Disposal of Shallow PCB-Impacted Fill (≥10 ppm) and Lead Hot Spots, Complete Containment of the Water Tower and Northwest Corner Areas, Construction of a Contact Barrier and Soil Cover System

This alternative was developed by Atlantic Richfield and primarily consists of on-site containment in the Northwest Corner and Water Tower Areas with shallow excavation and off-site disposal of PCB-impacted fill (≥ 10ppm) across the Site. Excavation and off-site disposal of lead hot spots and the construction of a new shore line bulkhead are also included in this alternative. A detailed description of the alternative is presented in **Section 4.1.7**.

4.2.7.1 Overall Protection of Human Health and the Environment

This alternative provides overall protection of human health and the environment by:

- Preventing the following: 1) all current exposure risks to subsurface fill above PRGs, 2) future-use occupant exposure risks to subsurface fill above PRGs, and 3) short-term future-use construction exposure risks to air, fill, and fill water above PRGs by removal and containment of this material and by implementing institutional controls; and
- Preventing the transport of PCB impacted fill to the Hudson River (where applicable) by removing it by excavation, by constructing a new shoreline bulkhead, and by constructing a containment system in the Water Tower and Northwest Corner Areas.

4.2.7.2 Compliance with SCGs, ARARs and Other Regulations

This alternative would be compliant with SCGs through the removal and off-site disposal of fill located above the groundwater table greater than or equal to the site-specific TAGM values for PCBs (10 ppm) and lead, hot spots, and containment of the remaining fill exceeding SCGs.

4.2.7.3 Short-Term Effectiveness

Significant short-term risks to the communities surrounding the transportation routes exists during the excavation and transportation of waste and clean fill by truck, rail, and barge. Risks associated with excavation above the water table are lower and more manageable than those associated with deeper excavations. Construction of a containment system, contact barrier and soil cover system, and shoreline bulkhead pose little to no short-term risk.

4.2.7.4 Long-Term Effectiveness and Permanence

This alternative would provide an effective long-term remedy for COPCs present in fill at the Site. The fill located above the groundwater table containing PCBs and lead hot spots would be removed and transported to a secure disposal facility. The excavation and disposal of PCB and lead-impacted fill in a permitted off-site facility would eliminate future potential exposure risks associated with this material. The containment system would be constructed using standard practices (vertical barriers designed for landfill cells and bulkhead as commonly used for shoreline protection) that have proven durable in similar applications. Implementation of institutional controls that limit obtrusive work below the contact barrier or within the limits of the containment system will further enhance the long-term effectiveness of this remedial alternative.

4.2.7.5 Reduction in Mobility, Toxicity, and Volume

This remedial alternative removes approximately 29% by mass of the presently existing PCB contamination and lead hot spots at the Site. Mobility of COPCs will be decreased by placement in a permitted off-site disposal facility, on-site containment, and construction of a new bulkhead. Construction of the contact barrier and soil cover system and the containment system will reduce the overall risk associated with toxicity by eliminating the potential for exposure to COPCs remaining on-site.

4.2.7.6 Implementability

Excavation of the shallow PCB and lead-impacted fill materials may be complicated by the complex network of subsurface structures at the site, but due to the shallow depth required, the proposed excavation can be readily accomplished. Transportation of the excavated material to the off-site disposal facility will require coordination with interstate agencies. Construction of the vertical components of the containment system and shoreline bulkhead may also be complicated by subsurface structures. Construction of the contact barrier and soil cover system will be a relatively straightforward task. The implementation of institutional controls envisioned (recording use limitation on the property deed and plot plan, posting activity restrictions, and registry reclassification) are implementable.

4.2.7.7 Cost

The estimated present worth, including capital and O&M, of this remedial alternative is $46,000,000. A detailed breakdown of this estimate is included in **Appendix D.**

4.2.8 Alternative 8: Containment of the Water Tower and Northwest Corner Areas, Excavation and Off-Site Disposal of PCB-Impacted Fill (≥10 ppm) and Lead Hot Spots Located Above the Water Table and Outside the Limits of the Containment and Construction of a Contact Barrier and Soil Cover System

This alternative was developed by Atlantic Richfield Company and primarily consists of on-site containment in the Water Tower and Northwest Corner Areas with limited excavation and off-site disposal of PCB-impacted fill (≥ 10 ppm) outside of the containment system in the central and southern portions of the Site. The excavation and off-site disposal of lead hot spots and the construction of a new shore line bulkhead are also included in this alternative. A detailed description of the alternative is presented in **Section 4.1.8**.

4.2.8.1 Overall Protection of Human Health and the Environment

This alternative provides overall protection of human health and the environment by:

- Eliminating the following: 1) all current exposures to subsurface fill above PRGs, 2) future-use occupant exposures to subsurface fill above PRGs, and 3) short-term future-use construction exposures to air, fill, and fill water above PRGs by removal and containment of this material and by implementing institutional controls; and
- Preventing the transport of PCB impacted fill to the Hudson River (where applicable) by removing it by excavation, by constructing a new shoreline bulkhead, and by constructing a containment system in the Water Tower and Northwest Corner Areas.

4.2.8.2 Compliance with SCGs, ARARs and Other Regulations

This alternative would eliminate exposures to fill and fill water exceeding SCGs through the removal and off-site disposal of fill located above the groundwater table greater than or equal to the site-specific TAGM values for PCBs (10 ppm) and lead containment of the remaining fill exceeding SCGs in the central and southern portions of the Site. Because fill exceeding the (PCB content) criteria for hazardous waste in New York State would be removed from the Central and Southern portions of the Site, these areas could be removed from NYSDEC's Inactive Hazardous Sites Registry. All fill exceeding SCGs in the Water Tower and Northwest Corner Areas of the Site would remain, but would be contained.

4.2.8.3 Short-Term Effectiveness

The potential for short-term risks to the communities surrounding the transportation routes exists during the excavation and transportation of waste and clean fill by truck, rail, and barge. Risks associated with excavation above the water table are much lower and more manageable than those associated with deeper excavations. However, construction of a containment system, contact barrier and soil cover system, and shoreline bulkhead pose little to no short-term risk.

4.2.8.4 Long-Term Effectiveness and Permanence

This alternative would provide an effective long-term remedy for COPCs present in fill at the Site. The fill located above the groundwater table containing PCBs in the central and southern portions of the Site would be removed and transported to a secure disposal facility. The excavation and disposal of this PCB-impacted fill and fill containing lead hot spots in a permitted off-site facility would eliminate future potential exposure risks associated with this material. The containment system would be constructed using standard practices (vertical barriers designed for landfill cells and bulkhead as commonly used for shoreline protection) that have proven durable in similar applications. Implementation of institutional controls that limit obtrusive work below the contact barrier or within the limits of the containment system will further enhance the long-term effectiveness of this remedial alternative.

4.2.8.5 Reduction in Mobility, Toxicity, and Volume

This remedial alternative removes approximately less than 1% by mass of the presently existing PCB contamination and lead hot spots at the Site. In order of relative impact, the mobility of COPCs will be decreased by the construction of a new bulkhead, on-site containment, and placement in a permitted offsite disposal facility. Construction of the contact barrier and soil cover system and the containment system will reduce the overall risk associated with toxicity by eliminating the potential for exposure to COPCs remaining on-site.

4.2.8.6 Implementability

Excavation of the shallow PCB and lead-impacted fill materials may be complicated by the complex network of subsurface structures at the site, but due to the shallow excavation depth, the proposed excavation is considered implementable. Transportation of the excavated material to the off-site disposal facility will require coordination with interstate agencies. Construction of the vertical components of the containment system and shoreline bulkhead may also be complicated by subsurface structures. Construction of the contact barrier and soil cover system will be a relatively straightforward task The implementation of institutional controls envisioned (recording use limitation on the property deed and plot plan, posting activity restrictions, and registry reclassification) are implementable.

4.2.8.7 Cost

The estimated present worth, including capital and O&M, of this remedial alternative is $33,000,000. A detailed breakdown of this estimate is included in **Appendix D.**

4.2.9 Alternative 10: Construction of a Contact Barrier and Soil Cover System Over the Entire Site, Excavation and Off-Site Disposal of Lead Hot Spots

This alternative was retained from the June 1998 Draft Feasibility Study Report; however, it now contains several modifications. This alternative primarily consists of on-site containment and construction of a contact barrier and soil cover system over the entire site but also includes excavation and off-site disposal of lead hot spots and the construction of a new shoreline bulk head. A more detailed description of this alternative is presented in **Section 4.1.10**.

4.2.9.1 Overall Protection of Human Health and the Environment

The alternative provides overall protection of human health and the environment by:

- Eliminating the following: 1) all current exposures to subsurface fill above PRGs; 2) future-use occupant exposures to subsurface fill above PRGs; and 3) short-term future-use construction exposures to air, fill, and fill water above PRGs by containment of this material and by implementing institutional controls;
- Preventing the transport of PCB impacted fill to the Hudson River (where applicable) by constructing a new shoreline bulkhead.

4.2.9.2 Compliance with SCGs, ARARs and Other Regulations

This alternative eliminates exposures to fill and fill water exceeding SCGs through implementation of the following actions:

- Construction of a contact barrier and soil cover system over the entire Site, and
- Installation of a new shoreline bulkhead that will reduce direct contact with, and migration of, impacted media at the Site.

4.2.9.3 Short-Term Effectiveness

Construction of a contact barrier and soil cover system, and shoreline bulkhead pose little to no short-term risk. Excavation and off-site disposal of shallow lead-impacted fill materials pose potential for short-term risks to the communities surrounding the transportation routes.

4.2.9.4 Long-Term Effectiveness and Permanence

This alternative would provide an effective long-term remedy for COPCs present in fill at the Site. The excavation and disposal of lead-impacted fill in a permitted off-site facility would eliminate future potential exposure risks associated with this material. Remaining contaminated fill at the Site would be contained using effective technologies. The long-term risk of potential future exposures to this material for this alternative would be minimal, and this alternative does not require deep excavation or dewatering, eliminating the potential releases to the River associated with these activities. Implementation of institutional controls that limit obtrusive work below the contact barrier would further enhance the long-term effectiveness of this alternative.

4.2.9.5 Reduction in Mobility, Toxicity, and Volume

This remedial alternative removes 0% by mass of the presently existing PCB contamination and removes fill material containing lead hot spots from the Site, however, COPC mobility will be permanently reduced after construction of the contact barrier and the shoreline bulkhead. Construction of the contact barrier and soil cover system will reduce the overall risk associated with toxicity by eliminating the potential for exposure to COPCs remaining on-site.

4.2.9.6 Implementability

Construction of the contact barrier and soil cover system will be a relatively routine task; however, the construction of the new shoreline bulkhead may be limited due to the presence of subsurface obstructions. The implementation of institutional controls envisioned (recording use limitations on the property deed and plot plan, posting activity restrictions, and registry reclassification) are implementable.

4.2.9.7 Cost

The estimated present worth, including capital and O&M, of this remedial alternative is $17,500,000. A detailed breakdown of this estimate is included in **Appendix D.**

4.2.10 Alternative 11: Complete Containment of the Water Tower and Northwest Corner Areas, Excavation at Multiple Depths (3, 9 and 12- feet bgs (with grout stabilization)) and Off-Site Disposal of Shallow PCB-Impacted Fill Located Within the Containment, Excavation and Off-Site Disposal of PCB-Impacted Fill (≥10 ppm) and Lead Hot Spots Located Outside the Limits of the Containment, Construction of a Contact Barrier and Soil Cover Over the Entire Site

This alternative consists of a combination of on-site containment and excavation and off-site disposal in the Water Tower and Northwest Corner Areas. The alternative also consists of the excavation and off-site disposal of PCB-impacted fill ≥10 ppm and fill containing lead hot spots located outside the limits of the containment. The construction of a contact barrier and soil cover system and a new shoreline bulkhead are also included in this alternative. A more detailed description of the alternative is presented in **Section 4.1.11**.

4.2.10.1 Overall Protection of Human Health and the Environment

The alternative provides overall protection of human health and the environment by:

- Eliminating the following: 1) all current exposures to subsurface fill above PRGs; 2) future use occupant exposures to subsurface fill above PRGs; and 3) short-term future use construction exposures to air, fill, and water above PRGs by containment of this material;
- Preventing the transport of PCB impacted fill to the Hudson River (where applicable) by constructing a new shoreline bulkhead.

4.2.10.2 Compliance with SCGs, ARARs and Other Regulations

This alternative eliminates exposures to fill and fill water exceeding SCGs through the following actions:

- Containment of the Water Tower and Northwest Corner Areas; and
- Removal and off-site disposal of PCB-impacted fill to varying depths within the limits of the containment; and
- Removal and off-site disposal of fill material containing PCB-impacted fill ≥10 ppm and fill containing lead hot spots located outside the limits of the containment; and
- Construction of a contact barrier and soil cover system over the entire site; and
- Construction of a new shoreline bulkhead.

4.2.10.3 Short-Term Effectiveness

The potential for short-term risks to the communities surrounding the transportation routes exists during the excavation and transportation of waste and clean fill by truck, rail and barge. Risks associated with limited excavation are lower and more manageable than those associated with deeper excavations. Construction of a containment system, contact barrier, soil cover system and shoreline bulkhead pose little to no short-term risk.

4.2.10.4 Long-Term Effectiveness and Permanence

This alternative would provide an effective long-term remedy for COPCs present in fill at the site. A portion of the PCB-impacted fill located inside the limits of the containment, and fill containing PCB-impacted fill ≥10 ppm and fill containing lead hot spots located outside the limits of the containment would be removed and transported to a secure disposal facility. The placement of this impacted fill material in a permitted off-site facility would eliminate future potential exposure risks associated with this material. The containment system would be constructed using standard practices (vertical barriers designed for landfill cells and bulkhead as commonly used for shoreline protection) that have proven durable in similar applications. The construction of a contact barrier and soil cover system across the entire site would further enhance the long-term effectiveness of this remedial alternative.

4.2.10.5 Reduction in Mobility, Toxicity, and Volume

This remedial alternative removes approximately 15% by mass of the presently existing PCB contamination and lead hot spots at the site. Mobility of COPCs would be decreased by placement in a permitted off-site disposal facility, on-site containment, and construction of a new bulkhead. Construction of the contact barrier and soil cover system and the containment system will reduce the overall risk associated with toxicity by eliminating the potential for exposure to COPCs remaining on-site.

4.2.10.6 Implementability

While there are risks and technical obstacles inherent with excavation, these risks are less challenging due to the somewhat limited depths of excavation included in this alternative. Specialized excavation equipment and labor would be required, however, excavation to the depths proposed in this alternative would be implementable. Transportation of excavated fill material to a permitted disposal facility would require coordination with interstate agencies. Installation of the vertical components of the containment system may be complicated by the presence of underground obstacles, but would be implementable. Construction of a contact barrier and soil cover system over the site would be readily implementable.

4.2.10.7 Cost

The estimated present worth, including O&M, of this remedial alternative is $52,500,000. A detailed breakdown of this alternative is included in **Appendix D**.

4.2.11 Alternative 12: Complete Containment of the Northwest Corner and Water Tower Areas, Excavation at 9-Foot and 12-Foot Depths (with grout stabilization) and Off-Site Disposal of PCB-Impacted Fill Located within the Containment; Off-Site Disposal of PCB-Impacted Fill (≥10 ppm) and Lead Hot Spots Located Outside the Containment; Construction of a Contact Barrier and Soil Cover System.

This alternative consists of a combination of on-site containment and excavation and off-site disposal in the Water Tower and Northwest Corner Areas. The alternative also consists of the excavation and off-site disposal of PCB-impacted fill ≥10 ppm and fill containing lead hot spots located outside the limits of the containment. The construction of a contact barrier and soil cover system and a new shoreline bulkhead are also included in this alternative. A more detailed description of the alternative is presented in **Section 4.1.12**.

4.2.11.1 Overall Protection of Human Health and the Environment

The alternative provides overall protection of human health and the environment by:

- Eliminating the following: 1) all current exposures to subsurface fill above PRGs; 2) future use occupant exposures to subsurface fill above PRGs; and 3) short-term future use construction exposures to air, fill, and water above PRGs by containment of this material;
- Preventing the transport of PCB impacted fill to the Hudson River (where applicable) by constructing a new shoreline bulkhead.

4.2.11.2 Compliance with SCGs, ARARs and Other Regulations

This alternative eliminates exposures to fill and fill water exceeding SCGs through the following actions:

- Containment of the Water Tower and Northwest Corner Areas; and
- Removal and off-site disposal of PCB-impacted fill to varying depths within the limits of the containment
- Removal and off-site disposal of fill material containing PCB-impacted fill ≥10 ppm and fill containing lead hot spots located outside the limits of the containment; and
- Construction of a contact barrier and soil cover system over the entire site; and
- Construction of a new shoreline bulkhead.

4.2.10.3 Short-Term Effectiveness

The potential for short-term risks to the communities surrounding the transportation routes exists during the excavation and transportation of waste and clean fill by truck, rail and barge. Risks associated with limited excavation are lower and more manageable than those associated with deeper excavations. Construction of a containment system, contact barrier, soil cover system and shoreline bulkhead pose little to no short-term risk.

4.2.11.4 Long-Term Effectiveness and Permanence

This alternative would provide an effective long-term remedy for COPCs present in fill at the site. A portion of the PCB-impacted fill located inside the limits of the containment, and fill containing PCB-impacted fill ≥10 ppm and fill containing lead hot spots located outside the limits of the containment would be removed and transported to a secure disposal facility. The placement of this impacted fill material in a permitted off-site facility would eliminate future potential exposure risks associated with this material. The containment system would be constructed using standard practices (vertical barriers designed for landfill cells and bulkhead as commonly used for shoreline protection) that have proven durable in similar applications. The construction of a contact barrier and soil cover system across the entire site would further enhance the long-term effectiveness of this remedial alternative.

4.2.11.5 Reduction in Mobility, Toxicity, and Volume

This remedial alternative removes approximately 52% by mass of the presently existing PCB contamination and lead hot spots at the site. Mobility of COPCs would be decreased by placement in a permitted off-site disposal facility, on-site containment, and construction of a new bulkhead. Construction of the contact barrier and soil cover system and the containment system will reduce the overall risk associated with toxicity by eliminating the potential for exposure to COPCs remaining on-site.

4.2.11.6 Implementability

While there are risks and technical obstacles inherent with excavation to the specified depths, these risks are less challenging due to the somewhat limited depths of excavation included in this alternative. Specialized excavation equipment and labor would be required, however, excavation to the depths proposed in this alternative would be implementable. Transportation of excavated fill material to a permitted disposal facility would require coordination with interstate agencies. Installation of the vertical components of the containment system may be complicated by the presence of underground obstacles, but would be implementable. Construction of a contact barrier and soil cover system over the site would be readily implementable.

4.2.11.7 Cost

The estimated present worth, including O&M, of this remedial alternative is $74,500,000. A detailed breakdown of this alternative is included in **Appendix D**.

4.3 Comparative Analysis

This section compares the relative performance of each of the eleven remedial alternatives retained for further detailed analysis using the specific evaluation criteria presented in **Section 4.2**. Comparisons are presented in a qualitative manner in order to identify substantive differences between alternatives. As with the detailed evaluation, the following criteria were used for comparative analysis:

1. Overall Protection of Human Health and the Environment
2. Compliance with SCGs, ARARs and Other Regulations
3. Short-Term Effectiveness
4. Long-Term Effectiveness
5. Reduction in Mobility, Toxicity, and Volume
6. Implementability

7. Cost

The qualitative comparison is outlined in the following sections. **Table 4-1** presents a summary of the alternative comparative analysis.

4.3.1 Overall Protection of Human Health and the Environment

The comparative evaluation of overall protection of human health and the environment evaluates attainment of PRGs, as well as the analysis of other criteria evaluated for each alternative (specifically short- and long-term effectiveness). The evaluation of this criteria focuses on such factors as the manner in which the remedial alternatives achieve protection over time, the degree to which site risks would be reduced, and the manner in which each source of COPCs would be eliminated, reduced, or controlled.

Alternative 1 is protective of human health and the environment under the current land use scenario. However, Alternative 1 would not provide adequate protection of human health and the environment under future land use scenarios because impacted fill exceeding PRGs would remain on-site and the existing control measures including limited access to the Site and strict security control may not be compatible with all future uses.

Alternatives 2, 3, 4, 5, and 6 may not be protective of human health and the environment due to the necessity of conducting deep excavations at the Site in such a manner that the Basic Principles are violated. Currently, any deep excavation scenario undertaken will involve breaking one or more of the Basic Principles and thus will greatly increase the chance of spreading contamination on-Site.

The remaining Alternatives 7 and 8 would effectively reduce potential human health exposure to fill exceeding PRGs and SCGs by the combination of applicable removal and disposal, containment, or barrier measures. Alternative 10 would accomplish the elimination of exposure pathways by containment and barrier measures alone. Alternatives 11 and 12 effectively reduce exposure pathways by removal of contaminated shallow soils and off site disposal, followed by placement of a clean cover. Short-term impacts will exist during construction during excavation and transportation of the wastes but are minimal and can be easily managed.

Short-term impacts to both human health and the environment during the implementation of Alternatives 8 and 10 are minimal and easily managed. Short-term impacts associated with Alternative 7 are significantly greater due to the transportation risks associated with this alternative. Alternatives 7, 8, 10, 11, and 12 would all be considered effective measures to protect against potential long-term human health risks and environmental impacts.

4.3.2 Compliance with SCGs, ARARs and Other Regulations

The comparative evaluation of the compliance of each alternative focuses on the following criteria:

- published NYSDEC Standards, Criteria, and Guidance (SCGs)
- other applicable federal relevant and appropriate requirements (ARARs).

Alternative 1, the no action alternative, currently prevents exposures to fill and fill water exceeding SCGs, but the control measures in place would not be compatible with future uses of the Site. Under Alternative 1, fill and fill water may potentially become available for direct contact at the Site if the land use changes.

All other alternatives would eliminate potential environmental exposures to fill and fill water exceeding SCGs and ARARs by either excavation and off-site disposal, construction of containment systems, construction of contact barriers, or combinations of these technologies. All remedial actions would be completed in a manner compliant with action-specific standards (i.e., RCRA, NYS SPDES, and other applicable criteria).

4.3.3 Short-Term Effectiveness

The short-term effectiveness comparison includes the evaluation of the relative potential for impacts to the nearby community, site worker exposures, environmental impacts, and the time frame for implementation of the alternatives.

The implementation of Alternative 1 would result in the least short-term impact since no action would be taken to disturb the impacted media at the Site. Alternatives 8 and 10 would result in minimal short-term impacts that are easily managed. The implementation of Alternatives 2 through 7 and 11 & 12 would result in significantly greater short-term impact due to the transportation risks associated with these alternatives.

4.3.4 Long-Term Effectiveness and Permanence

The comparative evaluation of long-term effectiveness focuses on the reduction in residual risk and adequacy and reliability of controls provided by each alternative.

Alternative 1 reduces the potential health and environmental exposure risks associated with the impacted fill and fill water at the Site through the implementation of restrictive control measures. Although natural attenuation and degradation may gradually reduce the volume and toxicity of impacted media at the Site, redevelopment could present an increased potential for exposures and associated risks to human health and the environment as the current restrictions to site access may not be compatible with these future users. During excavation remediation, Alternatives 2 through 6 have the potential for spreading contamination deeper into the Basal Sands Unit due to violation of the Basic Principles and therefore they may not yield a long-term remedial solution. Deep excavation could compromise the normal long-term effectiveness and permanence of excavation and potentially spread contamination to depths and areas where excavation becomes impossible. Alternative 10 would effectively reduce long-term risks by the construction of a contact barrier and containment system, but would allow only limited use of the Site. Alternatives 7, 8, 11, and 12 would effectively reduce long-term risks by a combination of excavation and off-site disposal, construction of containment systems, construction of contact barriers, and the implementation of institutional controls that define specific limitations on intrusive subsurface activities at the Site but allow a wider range of uses of the Site than are possible under the current control measures.

4.3.5 Reduction in Mobility, Toxicity, and Volume

The comparative evaluation of reduction of mobility, toxicity, and volume focuses on the ability of the alternative employed to address the impacted material on-site, the mass of material destroyed or treated, the irreversibility of the process employed, and the nature of the impacted materials after implementation of the alternative.

Alternative 1 would rely on natural attenuation and degradation to reduce volume and toxicity. Mobility of COPCs would continue to be minimal, due to the nature of the fill material and the COPCs impacting the site, the IRMs that have been completed or are underway, and the reconstruction of the bulkhead across the entire site.

Alternatives 2 through 6 rely on direct excavation and off-Site disposal to reduce volume and toxicity at the site. However, the excavation technologies required to be used to achieve deep excavation could potentially increase the mobility of PCBs, particularly during remediation.

Alternatives 7 & 8 and 11 & 12 would employ off-site disposal of impacted fill, contact barriers, and containment systems to reduce the volume and mobility of COPCs, while Alternative 10 would utilize contact barriers and containment systems to reduce the mobility of COPCs and thereby prevent future exposure to impacted media.

4.3.6 Implementability

The comparative evaluation of implementability focuses on the feasibility of construction and operation of each alternative, the administrative feasibility, the availability of required disposal facilities, technical and service personnel, and contractors.

Alternative 1 would be readily implementable at the Site. No construction other than repair of the bulkhead would be required to implement this alternative. Subsequently, technical feasibility and performance are not an issue.

Alternatives 2 through 6 are implementable at the Site from a geotechnical engineering perspective but are presently unable to be achieved to the necessary excavation depth without violation of one or more of the Site Basic Principles. All of the excavation technologies will lead to the potential spread of contaminants into the presently uncontaminated Basal Sands aquifer.

Alternatives 7, 8, 10, 11 and 12 are considered to be readily implementable, although some difficulties may be associated with the excavations proposed in Alternatives 7 & 8 and 11 & 12, and with the construction of containment systems. The "layering" of institutional controls including the creation of a special zoning district will require the cooperation of the Village of Hastings, but the result to the Village will include more beneficial use of the Site.

4.3.7 Cost

The comparative evaluation of the cost of remediation is based on the net present worth of each alternative. The total capital, annual O&M, and present worth costs of all alternatives are presented in **Appendix D**. The costs associated with Alternative 1 are approximately $17,000,000. Alternatives 2 through 6 all cost in excess of $130,00,000, and are the most expensive alternatives. The costs associated with Alternative 7 are approximately $46,000,000. and with Alternative 8 approximately $33,000,000. Alternative 10 would cost approximately $17,500,000. Alternatives 11 and 12 cost $52,500,000 and $74,500,000, respectively.

5.0 SELECTION OF PREFERRED ALTERNATIVE

5.1 Overview of Selected Alternative

The evaluation of proposed alternatives for remediation of the Site described in the previous sections of this report was completed in accordance with the procedures outlined in NYSDEC TAGM 4030, Selection of Remedial Actions for Inactive Hazardous Waste Sites (NYSDEC, 1990), as well as US EPA guidance for the completion of feasibility studies in accordance with CRECLA and the NCP (EPA, 1988). Based on the comparative analysis of alternatives described in **Section 4.3**, Alternative 11 (Complete Containment of the Water Tower and Northwest Corner Areas, Excavation at Multiple Depths (3, 9 and 12 feet bgs (with grout stabilization) and Off-Site Disposal of Shallow PCB-Impacted Fill Located Within the Containment, Excavation and Off-Site Disposal of PCB-Impacted Fill (≥10 ppm) and Lead Hot Spots Located Outside the Limits of the Containment, Construction of a Contact Barrier and Soil Cover Over the Entire Site) was selected as the alternative of choice for the Harbor-at-Hastings site.

This alternative will prevent future exposures to fill containing PCBs and other COPCs, and the rubbery-matrix PCB material (located in the Water Tower Area and Northwest Corner of the Site) by their removal to specified depths and placement of clean cover material. PCBs are present at depths of approximiately 40 feet and are immobile because they are bound to fill particles. Due to the depth of the PCBs, a formidable excavation effort would be associated with their removal, including significant risk and problems associated with shoring, possible excavation failure, and dewatering. In addition, deep excavations cannot be undertaken at the Site without violating one or more of the Basic Principles, developed from the conclusions of the Excavation Evaluation Summary Report (**Appendix B**), which could lead to the further spread of contamination at the Site. The deep excavation of PCBs and the associated risks will be avoided, and the excavation of PCBs to select depths and containment measures will prevent the spread of contaminants. The engineered containment system in the form of a vertical barrier (Waterloo Barrier©, sheet-pile wall, or slurry wall) around the PCB material will separate the PCBs from the adjacent central and southern portions of the Site and the Hudson River.

Following excavation, a clean cover backfill layer will be placed over the remaining wastes with a minimum of 24 inches of clean soil. (Ultimately, during development of the Site, up to several additional feet of clean fill must be placed over some portions of the Site to bring the Site above the 100-year flood plain and allow future construction on the Site. As the contours of this fill and final Site grading would be dependent on the final Site Development Plan, it was not factored into the evaluation of the effectiveness of this alternative). The subsurface barrier and soil cover combined with appropriate deed restrictions would prevent future contact with residual debris and fill materials (the Site has an extensive fill history dating back to the last century), and would permit any planned redevelopment of the central and southern portions of the Site as well as portions of the Northwest Corner and Water Tower Areas for residential and recreational usage in a manner fully protective of human health and the environment.

Alternative 11 was ranked highest in the detailed analysis because of its significant technical strengths relative to the evaluation criteria specified in the TAGM (4030). These criteria include:

- *Compliance with SCGs, ARARs and Other Regulations*: In the Water Tower and Northwest Corner Areas, removal of shallow contaminated soils would limit potential future migration or direct contact exposures with materials exceeding NYSDEC TAGM values. In the central and southern portions of the Site, fill exceeding the site-specific TAGM value for PCBs (10 ppm) would be removed for off-site disposal, and residual fill material exceeding TAGM values would be covered with a cover layer. The alternative would be implemented in manner compliant with all action-specific criteria.
- *Overall Protection of Human Health and the Environment:* This alternative would be fully protective of human health and the environment, as it would eliminate any existing exposure risks to subsurface fill exceeding preliminary remediation goals (PRGs), would prevent potential future exposure risks to subsurface fill/fill water exceeding PRGs developed for various reuse scenarios, and would prevent the transport of PCB impacted soil/sediment to the Hudson River. This would be accomplished by the removal of certain areas of PCB-contaminated fill material and the elimination of direct surface contact pathways.
- *Short-Term Effectiveness:* Excavating and transporting the limited volume of waste and clean fill described in this alternative by truck, rail, and barge would pose minimal short-term risk to the communities surrounding the Site and along the transportation route(s). The risks associated with the excavation envisioned for this alternative are minimal when compared to other alternatives evaluated within this FS. Construction of a containment system, contact barrier and soil cover system, and shoreline bulkhead pose little to no short-term risk.
- *Long-Term Effectiveness and Permanence:* The combination of surface and subsurface containment systems combined with the excavation and disposal of PCB-impacted fill in a permitted off-site facility would provide an effective long-term remedy for the Site. The implementation of institutional controls that restrict work below the cover layer or within the limits of the containment system would further enhance the long-term effectiveness of this alternative.
- *Reduction in Mobility, Toxicity, and Volume:* The mobility of residual constituents in fill and fill water on-site will be significantly decreased by the construction of a cover layer and an engineered subsurface containment system. The mobility of PCBs contained in fill material excavated from the Site would also be significantly reduced by placement of this material in a secure, off-site disposal facility.

- *Implementability:* This alternative may be considered readily implementable in terms of reliability in meeting the specified process efficiencies of performance goals; the reduced number of potential delays due to technical problems; and number of vendors available to provide competitive bids. Certain potential complications to soil excavation and construction of the vertical components of the containment system may occur as a result of the complex network of subsurface structures (footings, foundations, and piles at the Site). The magnitude of these potential problems would be less than for other alternatives considered that would involve deeper excavation, and these issues are considered manageable.
- *Cost:* This alternative is not the lowest-cost alternative, but is considered cost-effective relative to the effectiveness and permanence of the remedial solution that it would employ, and to the potential benefit(s) that may be derived by beneficial reuse of the Site.

5.2 Analyses of Rejected Alternatives

Alternative 1: No Action This alternative was retained throughout the Feasibility Study to provide a baseline against which other response actions can be compared. As the *No Action* alternative includes the reconstruction of the bulkhead across the entire Site, the IRMs currently completed or underway (the Building 14 sump closure, LNAPL recovery, Northwest Corner surface cover, southwest corner bulkhead and the removal of resinous material from the shoreline near Building 57), as well as access controls and institutional controls, there are currently no significant threats to health or the environment at the Site. However, this alternative was rejected as a final remedy because these actions essentially prohibit any alternate uses of the Site in the future, as they do not provide for adequate safeguards under potential future exposure pathways associated with recreational, commercial/industrial, or residential scenarios as contemplated in the Risk Assessment.

Alternative 2: Excavation and Off-Site Disposal of All PCB-Impacted Fill and Lead Hot Spots This and other associated deep excavation alternatives are effective in reducing the volume and potential contact routes of contamination at the Site but they all cause significant short and long-term effectiveness problems associated with the deep excavation technologies used. Deep excavation at the Site will require violation of one or more of the Basic Principles, potentially causing the spread of contamination into presently uncontaminated areas of the Site, including the groundwater aquifer located within the Basal Sands Unit. This potential was judged unacceptable due to the present relative immobility of the deep-seated PCBs, the likelihood of spreading contamination during remediation (due to violation of the Basic Principles discussed in **Section 1.0**), and the potential for risk to human health (construction workers) as a result of the potential for excavation failure. These deep excavation alternatives also pose significant short-term risks to communities due to the required transportation for off-site disposal of large amounts of contaminated soils. In addition, the cost of this alternative exceeds $145,000,000 and is much larger than other alternatives which generate lower risks.

Alternative 3: Excavation and Off-Site Disposal of All Fill Located Above the Water Table Exceeding TAGM Values and All PCB- Impacted Fill Located Below the Water Table ≥ 10 PPM, Excavation and Off-Site Disposal of Lead Hot Spots Similar to Alternative 2, this alternative was considered unacceptable due to its questionable short and long-term effectiveness, the likelihood of increasing contaminant mobility, the significant short-term risks introduced, and its associated high costs.

Alternative 4: Excavation and Off-Site Disposal of All PCB-Impacted Fill, Excavation and Off-Site Disposal of Lead Hot Spots and Construction of a Multi-Layered Cap System Over the Entire Site Similar to Alternative 2, this alternative was considered unacceptable due to its questionable short and long-term effectiveness, the likelihood of increasing contaminant mobility, the significant short-term risks introduced, and its associated high costs.

Alternative 5: Excavation and Off-Site Disposal of Fill Containing the "Rubbery Matrix" and Lead Hot Spots, Complete Containment of the Water Tower and Northwest Corner Areas, Excavation and Off-Site Disposal of Impacted Fill Located Outside the Limits of the Containment Similar to Alternative 2, this alternative was considered unacceptable due to its questionable short and long-term effectiveness, the likelihood of increasing contaminant mobility, the significant short-term risks introduced, and its associated high costs.

Alternative 6: Excavation and Off-Site Disposal of Fill Containing the "Rubbery Matrix" and Lead Hot Spots, Complete Containment of the Water Tower and Northwest Corner Areas, Construction of a Multi-Layered Cap over the Entire Site Similar to Alternative 2, this alternative was considered unacceptable due to its questionable short and long-term effectiveness, the likelihood of increasing contaminant mobility, the significant short-term risks introduced, and its associated high costs.

Alternative 7: Excavation and Off-Site Disposal of Shallow PCB-Impacted Fill (≥10 ppm) and Lead Hot Spots, Complete Containment of the Water Tower and Northwest Corner Areas, Construction of a Contact Barrier and Soil Cover System This alternative was rejected because the amount of productive, unimpacted area remaining after remediation is less than other alternatives. The remaining impacted areas after remediation also have associated impacts on future land use in terms of long-term effectiveness and reduction of risks. Creation of a contact barrier may require maintenance as Site activities may disturb the restricted areas. This can be dealt with from an institutional control basis, but an engineering control basis is preferred in order to minimize or eliminate these risks. The presence of shallow PCB contaminated soils below the contact barrier can cause long-term risk and effectiveness issues unless the barrier is properly maintained. It is preferred to remove the shallow soil contamination rather than leave it in-place as in this alternative.

Alternative 8: Containment of the Water Tower and Northwest Corner Areas, Excavation and Off-Site Disposal of PCB-Impacted Fill (≥10 ppm) and Lead Hot Spots Located Above the Water Table and Outside the Limits of the Containment and Construction of a Contact Barrier and Soil Cover System This alternative was rejected due to its relative ineffectiveness in reducing the volume of wastes and impacted area. This alternative also does not reduce restricted land use for redevelopment as effectively. The creation and maintenance of a soil cover system and its associated impacts on future land use are problematic in terms of long-term effectiveness and reduction of risks as Site activities may disturb the restricted areas. This can be dealt with from an institutional control basis, but an engineering control basis is preferred in order to minimize or eliminate these risks.

Alternative 10: Construction of a Contact Barrier and Soil Cover System over the Entire Site, Excavation and Off-Site Disposal of Lead Hot Spots This alternative is most reliable (in terms of meeting process objectives) and offers the lowest degree of short-term risk to the Hastings Community and the environment, as only a limited amount of excavation and offsite transport of impacted fill material is involved. The soil cover system would reliably prevent human contact with fill material; however, use limitations would remain on the entire Site. As the Site would remain in its entirety on the NYSDEC Inactive Hazardous Site Registry, no substantial change in use of the Site could occur until NYSDEC review and approval of proposed plans occurred. Although this alternative would be protective of human health and the environment subject to these Site limitations, it was not selected because it is not as effective as Alternative 11 in returning the Site to beneficial re-use.

Alternative 12: Complete Containment of the Northwest Corner and Water Tower Areas, Excavation at 9-Foot and 12-Foot Depths (with grout stabilization) and Off-Site Disposal of PCB-Impacted Fill Located within the Containment; Off-Site Disposal of PCB-Impacted Fill (≥10 ppm) and Lead Hot Spots Located Outside the Containment; Construction of a Contact Barrier and Soil Cover System This alternative provides the same level of protection regarding long-term effectiveness as Alternative 11, and restores the same areas of the Site to future use. However, Alternative 12 was rejected as a final remedy due to its higher costs and higher short-term community impact associated with excavation and transport of larger volumes of contaminated soils. Alternative 11 also provides equal protection to human health and the environment at a lower short-term risk to Site workers and the community.

5.3 Process Components of Selected Alternative

Major process components of the selected remedial alternative are described below:

- *Engineered Containment System:* In the Water Tower and Northwest Corner of the Site, PCB material and other impacted fill are present at significant depths below ground surface. The depth of this material (approximately 40 feet below grade, below the water table, adjacent to the Hudson River, and located within a setting characterized by such obstacles as old footings, foundations, and piles) poses a formidable challenge to its excavation and removal. Due to the already-immobile nature of the PCB material , enhancement of its immobile characteristic would be more readily implementable and reliable than excavation. Standard geoengineering designs and systems such as sheetpiling (the most likely technology along the Hudson River) or slurry wall systems are capable of controlling hydraulic and particulate flow within the subsurface.
- *Excavation and Treatment of Soils Exceeding Risk-Based PRGs and NYS TAGM Guidelines for PCBs:* Approximately 2,400 cubic yards of PCB-contaminated fill material lies within relatively close proximity to the ground surface in the central and southern portions of the Site. This material may be readily excavated and sent off-site for disposal, leaving only concentrations of other industrial and municipal residuals (ash, coal, clinker, and other debris) that are characteristic of urban fill throughout the Hudson Valley and much of the Northeastern portion of the United States.

  In addition, an approximate 44,500 cubic yards of PCB-contaminated fill material lies at depths which are accessible to moderate depth excavations (which do not violate any of the Basic Principles established for the Site). These soils are located within the Northwest Corner and Water Tower areas of the Site. Excavation of these contaminated soils to their full depth (approximately 40 feet BGS) is not achievable without violation of the Basic Principles described in **Section 1.0**, but significant volume and mass reduction of contaminated soils remaining on-site can be achieved. In addition, a layer of clean cover soil can be installed to isolate the contaminants and prevent any possible surface exposures. This material may be excavated and sent off-site for disposal, leaving contamination at depths that only deep construction excavations would normally reach.
- *Cover Soil:* Throughout the Site, remaining industrial and municipal residuals would be covered with a clean soil cover layer. This cover layer would be underlaid with an asphalt layer. The cover layer would then be covered with topsoil and revegetated. Ultimately, depending on the future development plans for the Site, it is likely that as many as several feet of additional cover soil may be added to certain portions of the Site, but this was not included in the evaluation of the alternative. Utility conduits could be designed into or above the surface contact barrier in most areas, relatively easily. These actions would provide a physically effective means of preventing potential future utility worker direct contact exposures to industrial and municipal residues in fill and fill water at the Site.
- *Institutional Controls:* Institutional controls would be included as part of this alternative, to ensure that the intent of the physical controls emplaced as part of the alternative is communicated to potential future land use planners or maintenance and repair organizations. While the central and southern portions of the Site could be constructed

(or modified later, as necessary) to incorporate such features as tree wells, utility conduits, footings, or pilings to accommodate a wide range of planned uses, access to the subsurface at the Water Tower and Northern Portions of the Site would need to be carefully controlled to prevent access by persons unaware or untrained in the specific requirements for work in this type of hazardous environment. Specific limitations on subsurface access or disturbance, redevelopment, or change-in-use of the Site must be placed on the deed and survey plan for this parcel prior to any potential transfer of its ownership, and must also transfer to all successors and assigns. Postings regarding appropriate activities or access to the Site would also be feasible and appropriate. The NYSDEC may be petitioned to reclassify the central and southern portions of the Site differently from the northern portion in the NYS Inactive Hazardous Registry. The reclassification would indicate the appropriate status and restrictions on change-in-use for each area after completion of the remedial action.

5.4 Remedial Design Basis

After incorporation of comments from the NYSDEC and modification of the Preliminary Remedial Action Plan (PRAP), the selected remedial alternative as described above will become the basis for the Remedial Design/Remedial Action for the project.

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TABLES

Table 1-1: Identification of Chemicals of Potential Concern in Fill Material Harbor-at-Hastings, Hastings-on-Hudson, New York			
Group	**Chemical[1]**	**CASRN**	**Concentration[2]**
SVOC	Indeno(I,2,3-cd)pyrene	193-39-5	1.34E+01
P/PCB	Aroclor-1254	11097-69-1	4.10E+03
P/PCB	Aroclor-1260	11096-82-5	1.77E+05
INORG	Arsenic	7440-38-2	1.30E+01
INORG	Beryllium	7440-41-7	5.04E-01
INORG	Copper	7440-50-8	2.2E+04
INORG	Lead	7439-92-1	3.4E+03
SVOC	Benzo(a)anthracene	56-55-3	1.68E+01
SVOC	Benzo(a)pyrene	50-32-8	1.45E+01
SVOC	Benzo(b)fluoranthene	205-99-2	1.57E+01
SVOC	Benzo(k)fluoranthene	207-08-9	1.70E+01
SVOC	Dibenz(a,h)anthracene	53-70-3	8.32E+00
CDD/F	2,3,7,8-TCDD Equivalent	1746-01-6	**8.3E-03**

Notes:

1. Chemicals detected in one or more fill samples are included in the list.

2. Concentration (in mg/kg) is the lower of the 95% UCL or maximum detected concentration (shown in bold).

Table 1-2: Identification of Chemicals of Potential Concern in Fill Water Harbor-at-Hastings, Hastins-on-Hudson, New York			
Group	**Chemical[1]**	**CASRN**	**Concentration[2]**
VOC	Chloroform	67-66-3	**2.0E-03**
VOC	1,1-Dichloroethane	75-34-3	7.1E-03
VOC	1,1-Dichloroethene	75-35-4	**2.0E-03**
VOC	1,1,1-Trichloroethane	71-55-6	3.2E-02
SVOC	Benzo(a)anthracene	56-55-3	**2.0E-03**
SVOC	Benzo(a)pyrene	50-32-8	**1.0E-03**
SVOC	Benzo(b)fluoranthene	205-99-2	**2.0E-03**
SVOC	Benzo(k)fluorathene	207-08-9	**2.0E-03**
SVOC	Carbazole	86-74-8	5.4E-03
SVOC	Chrysene	218-01-9	**2.0E-03**
SVOC	Dibenz(a,h)anthracene	53-70-3	**6.0E-04**
SVOC	Indeno(1,2,3-cd)pyrene	193-39-5	**2.0E-03**
P/PCB	Aroclor-1254[3]	11097-69-1	**5.4E-03**
P/PCB	Aroclor-1260[3]	11096-82-5	**2.7E-03**
INORG	Antimony	7440-36-0	1.2E-02
INORG	Arsenic	7440-38-2	2.2E-02
INORG	Cadmium	7440-43-9	**2.0E-02**
INORG	Chromium(total)[4]	7440-47-3	**6.3E-01**
INORG	Copper	7440-50-8	**1.1E+01**
INORG	Lead[5]	7439-92-1	**2.6E+00**
INORG	Manganese	7439-96-5	1.4E+00
INORG	Mercury[6]	7439-97-6	**1.8E-03**
INORG	Thallium	7440-28-0	**1.2E-02**
INORG	Zinc	7440-66-6	**3.5E+00**

Notes:
1. Chemicals detected in one or more fill water samples are included in the list.
2. Concentration (in mg/L) is the lower of the 95% UCL or maximum detected concentration (shown in bol
3. TOGS value for total PCBs is used as a surrogate TOGS value for Aroclor-1245 and Aroclor-1260.
4. Screening values for chromium VI are used as surrogate values for chromium (total).
5. The MCL for lead is used as a surrogate RBC for lead.
6. The RBC for mercuric chloride is used as a surrogate RBC for mercury.

Table 2-1: Standards, Criteria And Guidelines Evaluation				
Requirements/Criteria	**Citation**	**Description**	**Evaluation**	**Evaluation Comment**
FEDERAL				
Resource Conservation and Recovery Act (RCRA)	**40 U.S.C. 6901-6987**			
Identification and Listing of Hazardous Wastes	40 CFR Part 261-265	Outlines criteria determining whether solid waste is a hazardous waste after generation and is subject to regulation under 40 CFR Parts 260-266. Does not address cleanup action levels.	Applicable to removed media only.	These regulations would only apply to media removed from the Site as part of a remedial action.
Land Disposal Restrictions	40 CFR Part 268	Established constituent-specific standards to which hazardous wastes must be treated prior to land disposal. Only applies to newly generated solid wastes.	Applicable to removed media only.	These requirements would be applicable to media removed from the Site which are determined to be hazardous wastes that are land disposed off site as part of a remedial action.
Toxic Substances Control Act (TSCA)	**15 U.S.C. 2601 et seq.**			
PCB Disposal Policy	40 CFR Part 761.60	Sets disposal criteria for soils and debris greater than 50 ppm PCBs.	Applicable to removed media only.	Fill and debris greater than 50 ppm PCBs must go to TSCA landfill or incinerator.
PCB Spill Cleanup Policy	40 CFR Part 761.125	Specifies requirements for PCB spill cleanup for spills that occurred after May 1987.	Not Applicable.	These requirements for PCB spill cleanup do not apply specifically to historic activities but are frequently used as guidance.
Clean Air Act (CAA)	**42 U.S.C. 7401-7642**			
National Primary and Secondary Ambient Air Quality Standards	40 CFR Part 50	Establishes ambient air quality standards for protection of public health.	Applicable.	NAAQS may be applicable in evaluating whether there are air impacts at a site prior to remediation, or during long-term remediation programs. Due to the site conditions, air emissions would not be a significant issue.

Table 2-2

Remedial Action Objectives for Fill

Chemical of Potential Concern	SCGs/ARARs			Health Based Goals (PRGs)						Qualitative Remedial Action Objective
	TAGM 4046[1] Generic Soil Cleanup Values	TAGM 4046 Soil Cleanup Values for Groundwater Protection	Other ARARs	Recreational (Park) Scenario[12]		Commercial/Industrial Scenario[12]		Residential Scenario[12]		
				PRG at 10^{-5}	PRG at 10^{-6}	PRG at 10^{-5}	PRG at 10^{-6}	PRG at 10^{-5}	PRG at 10^{-6}	
PCB (Arochlor-1254)	Total PCBs: 1 ppm[2](surface)[3] 10 ppm (subsurface)[4]	Total PCBs: 50 - 530 ppm (subsurface)[10]	Total PCBs: 50 ppm (TSCA, 6NYCRR Part 371)	Aroclor -1254: 46 ppm	Aroclor -1254: 4.6 ppm	Aroclor -1254: 16 ppm	Aroclor -1254: 1.6 ppm	Aroclor -1254: 3.2 ppm	Aroclor -1254: 0.32 ppm	**All Human Receptors and Exposure Pathways:** shown. Health-based goals were developed in the Draft Human Health excess cancer risk of 1x10-5 or 1x10-6. Acceptable PRGs for these COPCs were determined for each exposure scenario in the Risk specific PRGs because they assume that all exposure scenarios **All Environmental Receptors:** Prevent the transport of COPCs exceeding appropriate quantitative criteria to the Hudson River, as dust or as contained in stormwater.
PCB (Arochlor-1260)	Total PCBs: 1 ppm (surface)[3] 10 ppm (subsurface)[4]	Total PCBs: 50 - 530 ppm (subsurface)[10]	Total PCBs: 50 ppm (TSCA, 6NYCRR Part 371)	Aroclor -1260: 46 ppm	Aroclor -1260: 4.6 ppm	Aroclor -1260: 29 ppm	Aroclor -1260: 2.9 ppm	Aroclor -1260: 3.2 ppm	Aroclor -1260: 0.32 ppm	
Benzo(a) Anthracene	0.224 ppm[5] or MDL[6]	30.6 ppm (subsurface)[11]		130 ppm	13 ppm	46 ppm	4.6 ppm	8.8 ppm	0.88 ppm	
Benzo(a) Pyrene	0.061 ppm[5] or MDL	112.2 ppm (subsurface)[11]		13 ppm	1.3 ppm	4.6 ppm	0.46 ppm	0.88 ppm	0.088 ppm	
Benzo(b) Fluoranthene	0.224 ppm[5] or MDL	11.22 ppm (subsurface)[11]		130 ppm	13 ppm	46 ppm	4.6 ppm	8.8 ppm	0.88 ppm	
Benzo(k) Fluoranthene	0.224 ppm[5] or MDL	11.22 ppm (surface)[11]								
Dibenz(a,h) Anthracene	0.014 ppm[5] or MDL	165,000 ppm (subsurface)[11]		13 ppm	1.3 ppm	4.6 ppm	0.46 ppm	0.88 ppm	0.088 ppm	
Indeno (1,2,3-cd)pyrene	3.2 ppm[7]	32.64 ppm (subsurface)[11]		130 ppm	13 ppm	46 ppm	4.6 ppm	8.8 ppm	0.88 ppm	
Arsenic	7.5 ppm or SB[8]	-								
Beryllium	0.16 ppm or SB	-								
Copper	25 ppm or SB	-								
Lead	200 - 500 ppm[9]	-		400 ppm[13]	400 ppm	1,000 ppm	1,000 ppm	400 ppm	400 ppm	
Dioxin (2,3,7,8-TCDD equiv.)	0.001 ppm	-								

NOTES:

[1] Division Technical and Administrative Guidance Memorandum (TAGM) 4046: Determination of Soil Cleanup Objectives and Cleanup Levels (1994)

[2] ppm parts per million (equivalent to milligrams per kilogram)

[3] Surface soil value for PCBs is from EPA Health Effect Summary Table.

[4] TAGM guidance value for subsurface PCBs is based on groundwater protection at a "generic site" soil total organic carbon content of 5%.

[5] TAGM guidance value derived from EPA Health Effect Summary Table.

[6] MDL: Method Detection Limit.

[7] TAGM guidance value is based on groundwater protection at a "generic site" soil total organic carbon content of 1%.

[8] SB: Site Background

[9] Range of site background concentrations for lead in TAGM 4046.

[10] Site-specific TAGM groundwater protection guidance value for PCB, adjusted for site subsurface soil TOC content and US EPA Kow values, as described in Appendix A.

[11] Site-specific TAGM groundwater protection guidance value adjusted for site subsurface soil TOC content, as described in TAGM 4046.

[12] COPC concentration that would meet risk criteria if present in upper two feet of soil.

13 EPA Residential Screening Value for Lead

Requirements/Criteria	Citation	Description	Evaluation	Evaluation Comment
Clean Water Act (CWA)	**33 U.S.C. 251-1376**			
Ambient Ground Water Quality Criteria Guidelines	40 CFR Part 141	Establishes maximum contaminant levels (MCLs) for treatment of groundwater for public potable water supplies.	Not Applicable.	Fill water and river water are non-potable water. These standards would only be applicable to groundwater in the Basal Sand Deposits, which is upgradient at the Site.
Safe Drinking Water Act (SDWA)	40 U.S.C.300			
National Primary Drinking Water Standards	40 CFR Part 141	Establishes maximum contaminant levels or MCLs, which are health-based standards for public water systems.	Not Applicable.	Fill water and river water are non-potable water. These standards would only be applicable to groundwater in the Basal Sand Deposits, which is upgradient at the Site.
Maximum-Contaminant Level Goals (MCLGs)	40 CFR Part 141.50-141.51	Non-enforceable health goals for public water systems.	Not Applicable.	Fill water and river water are non-potable water. These standards would only be applicable to groundwater in the Basal Sand Deposits, which is upgradient at the Site.
STATE				
New York State Environmental Conservation Law	**Chapter 10 - Articles 15, 17**			
New York State Pollution Discharge Elimination System	15 NYCRR 750-758	Defines permitting requirements for discharges.	Relevant and Appropriate.	The regulations would be applicable only for alternatives that include discharge to surface water.

Requirements/Criteria	Citation	Description	Evaluation	Evaluation Comment
Ambient Water Quality Standards and Guidance Values	6 NYCRR 700-705	Establishes quality standards for groundwater and incorporates federal MCLs and standards from other state regulations.	Applicable.	Fill water is not a source of potable water and contains constituents related to the quality of historic fill materials at the Site. Groundwater within the Basal Sand Deposits is at greater hydrostatic pressure (upward vertical gradient) than the fill water.
Ambient Water Quality Standards and Guidance Values	6 NYCRR 800-941	Establishes water quality criteria for the Hudson River.	Relevant and Appropriate.	These standards would only be applicable to the Hudson River.
Ambient Water Quality Standards and Guidance Values	TOGS 1.1.1	Establishes quality standards for groundwater in New York State and incorporates federal MCLs.	Applicable.	Fill water is not a source of potable water and contains constituents related to the quality of historic fill materials at the Site. Groundwater within the Basal Sand Deposits is at greater hydrostatic pressure (upward vertical gradient) than the fill water.
Technical Guidance for Screening Contaminated Sediments		Describes the methodology used by the Division of Fish and Wildlife and the Division of Marine Resources for establishing criteria for the purpose of identifying contaminated sediments.	Not Applicable.	Relevant for sedimentation control.
Groundwater Effluent Standards	6 NYCRR 700-705	Establishes effluent standards and/or limitations for discharges to Class GA groundwater.	Applicable but not relevant.	Discharges to groundwater are not being considered.
Use and Protection of Waters	6 NYCRR 608	Establishes permitting requirements for work conducted in and along the Hudson River.	Relevant and appropriate.	Applicable for work conducted in and along the Hudson River.
New York State Environmental Conservation Law	**Article 25**			

Requirements/Criteria	Citation	Description	Evaluation	Evaluation Comment
Tidal Wetlands Land Use Regulations	6 NYCRR 661	Establishes permitting requirements for work conducted in and along the Hudson River.	Relevant and appropriate.	Applicable for work conducted in and along the Hudson River.
New York State Environmental Conservation Law	**Article 27**			
Determination of Soil Clean-Up Objectives and Clean-Up Levels	TAGM HWR-94-4046	Establishes general clean-up goals for environmental media.	Applicable.	Widely used as a guidance document for calculating soil cleanup levels.
Identification and Listing of Hazardous Wastes	6 NYCRR 371	Outlines criteria determining whether solid waste is a hazardous waste and is subject to regulation under 6 NYCRR Parts 370-376.	Applicable.	Applies to material generated from the Site for off-site disposal and determined to be hazardous waste.
Solid Waste Management	7 NYCRR 360	Includes solid waste disposal requirements.	Applicable.	These regulations would only be applicable to the off site disposal of non-hazardous waste.
New York State Environmental Conservation Law	**Article 19**			
New York State Air Guide 1	6 NYCRR 750-758	Provides guidance for permitting emissions from new or existing sources.	Applicable but not relevant.	No air emissions are being considered.
Fugitive Dust Suppression and Particulate Monitoring Program at Inactive Hazardous Waste Sites	TAGM HWR 89-4031	Provides guidance for fugitive dust suppression and particulate monitoring at inactive hazardous waste sites.	Relevant and appropriate.	This guidance provides a basis for developing and implementing a fugitive dust suppression and particulate monitoring program as an element of a hazardous waste site’s health and safety program.

Table 2-3			
Remedial Action Objectives for Groundwater and Fill Water			
	SCGs/ARARs	**Health Based Goals (PRGs)**	
Chemical of Potential Concern (COPC)	**TOGS 1.1.11**	**Recreational (Park) Scenario; Commercial/Industrial Scenario; Residential Scenario**	**Qualitative Remedial Action Objective**
PCB (Arochlor-1254)	Total PCBs: .09 ppb[2]	A Draft Human Health Risk Assessment was prepared for the Harbor-at-Hastings site (ENVIRON Corporation, 2000). The Risk Assessment found that fill water does not contain concentrations of non-carcinogens that would exceed a hazard quotient of 1.0, or concentrations of carcinogens that represent a total excess cancer risk of $1x10^{-4}$. Dermal contact exposure of utilities maintenance workers was evaluated as a potentially complete exposure pathway. Because no concentrations of COPCs in fill water exceeded these risk-based criteria, site-specific health-based quantitative criteria (PRGs) were not developed.	**All Human Receptors and Exposure Pathways:** Prevent the incidental ingestion of, or direct contact with, fill water having concentrations of COPCs exceeding the appropriate quantitative criteria shown. The Draft Human Health Risk Assessment (ENVIRON Corporation, 2000) showed that no non-carcinogenic or carcinogenic COPCs on-site exceeded risk-based target criteria. TAGM criteria are shown for comparison. TAGM criteria are generally more conservative than site-specific PRGs because they assume that all exposure scenarios (including the development of a potable water supply on-site) are likely. **All Environmental Receptors:** Prevent the transport of COPCs exceeding appropriate quantitative criteria to the Hudson River, as dissolved phase constituent or as particulate.
PCB (Arochlor-1260)	Total PCBs: .09 ppb		
Chloroform	7 ppb		
1,1-Dichloroethane	5 ppb		
1,1-Dichloroethene	5 ppb		
1,1,1-Trichloroethane	5 ppb		
Benzo(a)Anthracene	0.002 ppb (GV)[3]		
Benzo(a)Pyrene	ND4		
Benzo(b)Fluoranthene	0.002 ppb (GV)		
Benzo(k)Fluoranthene	0.002 ppb (GV)		
Carbazole	NV[5]		
Chrysene	0.002 ppb (GV)		
Dibenz(a,h)Anthracene	NV		
Indeno(1,2,3-cd)pyrene	0.002 ppb (GV)		
Antimony	3 ppb		
Arsenic	25 ppb		
Cadmium	5 ppb		
Chromium	50 ppb		
Copper	200 ppb		
Lead	25 ppb		
Manganese	300 ppb		
Mercury	0.7 ppb		
Thallium	0.5 ppb (GV)		
Zinc	2,000 ppb (GV)		

NOTES

[1] Division of Water Technical and Operational Guidance Series (TOGs 1.1.1), Ambient Water Quality Standards and Guidance Values and

[2] ppb part per billion (equivalent to micrograms per liter)

[3] GV Guidance Value - no standard has been established.

[4] ND The groundwater standard for this COPC is no detectable concentration.

[5] NV No standard or guidance value is listed in New York regulations for this COPC.

Table 2-4		
Remedial Action Objectives for Surface Water		
Chemical of Potential Concern	**SCGs/ARARs** **TOGs 1.1.11**	**Qualitative Remedial Action Objective**
PCB (Arochlor-1254)	Total PCBs: 1 x 10-6 ppb (for human consumption of fish from saline waters) 1.2 x 10-4 ppb(for wildlife protection in saline waters)	
PCB (Arochlor-1260)	Total PCBs: 1 x 10-6 ppb (for human consumption of fish from saline waters) 1.2 x 10-4 ppb(for wildlife protection in saline waters)	listed.
Chloroform	No standard applies other than drinking water criteria.	
1,1-Dichloroethane	No standard applies other than drinking water criteria.	2. Applicable Action-Specific Standards and Guidance:
1,1-Dichloroethene	No standard applies other than drinking water criteria.	*Substantive conditions of New York State's General Permit
1,1,1-Trichloroethane	No standard applies other than drinking water criteria.	
Benzo(a)Anthracene	0.03 ppb (GV, for fish propagation in saline waters)	(Article 17, Titles 7 and 8).
Benzo(a)Pyrene	6 x 10-4 ppb (GV, for human consumption of fish from saline waters)	
Benzo(b)Fluoranthene	No standard applies other than drinking water criteria.	
Benzo(k)Fluoranthene	No standard applies other than drinking water criteria.	Waters (6NYCRR Part 608) and Tidal Wetlands Land Use
Carbazole	NV	(6NYCRR Part 661) permit programs (pertaining to work in
Chrysene	No standard applies other than drinking water criteria.	and around the Hudson River) would apply during the
Dibenz(a,h)Anthracene	NV	construction phase of the remediation project.
Indeno(1,2,3-cd)pyrene	No standard applies other than drinking water criteria.	
Antimony	No standard applies other than drinking water criteria.	
Arsenic	63 ppb (for fish propagation in saline waters)	
Cadmium	2.7 ppb (GV, for human consumption of fish from saline waters) 0.03 ppb (for fish propagation in saline waters)	
Chromium	0.03 ppb3 (for fish propagation in saline waters)	
Copper	3.4 ppb (for fish propagation in saline waters) 4.8 ppb (for fish survival in saline waters)	
Lead	8 ppb (for fish propagation in saline waters) 204 ppb (for fish survival in saline waters)	
Manganese	No standard applies other than drinking water criteria.	
Mercury	7 x 10-4 ppb (for human consumption of fish from saline waters) 0.0026 ppm (for wildlife protection in fresh or saline waters)	
Thallium	NV	
Zinc	66 ppb (for fish propagation in saline waters)	

NOTES

1. Ambient surface water quality criteria, standards and guida
Effluent Limitations. All values shown are
classification SD.

2. GV- Guidance Value - no standard has been established.

3. For hexavalent form.

ND - The standard is no detectable concentration.

NV - No standard or guidance value is listed for this compound.

Table 2-5

Remedial Action Objectives for PCB-Containing Materials

Chemical of Potential Concern	SCGs/ARARs: TAGM 4046[1] (Generic Values)	SCGs/ARARs: TAGM 4046[1] (Adjusted for Site- Specific TOC2)	SCGs/ARARs: Other ARARs	Health Based Goals (PRGs): Recreational (Park) Scenario[7]	Health Based Goals (PRGs): Commercial /Industrial Scenario[7]	Health Based Goals (PRGs): Residential Scenario[7]	Qualitative Remedial Action Objective
PCB (Arochlor-1254)	1 ppm[3] (surface)[4,5] 10 ppm (subsurface)[4] Total PCBs:	Total PCBs: 1 ppm (surface)[5] 53 ppm (subsurface)[6]	Total PCBs: 50 ppm (TSCA, 6NYCRR Part 371)	Aroclor -1254: 46 ppm	Aroclor -1254: 18 ppm	Aroclor -1254: 3.2 ppm	**All Human Receptors and Exposure Pathways:** future.
PCB (Arochlor-1260)	1 ppm (surface)[4] 10 ppm (subsurface)[4]	Total PCBs: 1 ppm (surface)[5] 53 ppm (subsurface)[6]	Total PCBs: 50 ppm (TSCA, 6NYCRR Part 371)	Aroclor -1260: 46 ppm	Aroclor -1260: 29 ppm	Aroclor -1260: 3.2 ppm	**All Environmental Receptors:** particulate or mobile liquid phase.

NOTES:

[1] Division Technical and Administrative Guidance Memorandum (TAGM) 4046: Determination of Soil Cleanup Objectives and Cleanup Levels (1994)

[2] TOC: Total Organic Carbon

[3] ppm parts per million (equivalent to milligrams per kilogram)

[4] TAGM guidance value at generic soil TOC content (5% for PCBs; 1% for all other constituents).

[5] Surface soil value for PCBs is from EPA Health Effect Summary Table.

[6] Site-specific TAGM guidance value for PCB, adjusted for site subsurface soil TOC content and US EPA K_{ow} values, as described in TAGM 4046.

[7] COPC concentration that would meet risk criteria if present in upper two feet of soil.

[8] Shading indicates values that will be utilized in the Feasibility Study

Table 2-6		
Remedial Action Objectives for Air		
Chemical of Potential Concern	**SCGs/ARARs TAGM 40311**	**Qualitative Remedial Action Objective**
Nuisance Dust, Mist, Aerosols	PM_{10}[2] < 150 ug/m^3(3)	Control and monitoring of fugitive dust emissions during construction activities will be performed in accordance with NYSDEC guidance (TAGM 4031). These measures include monitoring procedures employing real-time particulate monitors and visual observation, and dust suppression techniques such as applying water on haul roads, wetting excavation faces and equipment, covering materials during transport, limiting vehicle speeds to 10 mph, and limiting open excavation areas.

NOTES

[1] Division Technical and Administrative Guidance Memorandum (TAGM) 4031: Fugitive Dust Suppression and Particulate Monitoring at Inactive Hazardous Waste Sites(1989)

[2] PM10 Particles between 0.1 and 10 microns

[3] ug/m^3 microgram per cubic meter.

Table 3-1: Summary of Retained Technology Types and Process Options	
Harbor-at-Hastings, Hastings-on-Hudson, New York	
Remedial Technology Type	**Process Options Retained for Further Consideration**
No further action	Not applicable
Institutional controls	Access restrictions Notice of covenant on deed transfers Zoning restrictions
Contact barriers	Asphalt or concrete Steel or synthetic mats
Capping	Permeable soil Multi-layers liner Asphalt/concrete
Surface controls	Diversion channels, grading, revegetation
Vertical barriers	Sheet piling Slurry walls
Source removal	Shallow excavation Braced excavation above water table Braced excavation below water table
Ex-situ treatment	Ex-situ stabilization/solidification
Disposal	Off-site disposal as non-hazardous waste Off-site disposal as hazardous waste
In-situ treatment	In-situ stabilization/solidification

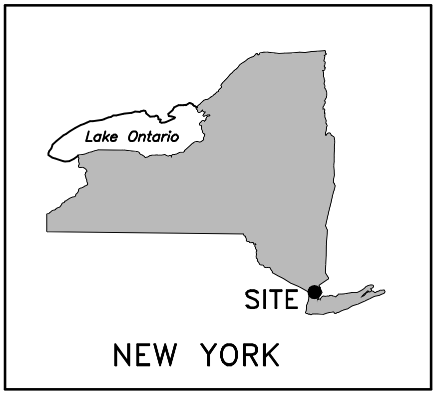
Table 3-2: Technology Evaluation Summary Harbor-at-Hastings, Hastings-on-Hudson, New York					
General Response Actions	**Remedial Technology Type**	**Process Options**	**Effectiveness**	**Implementability**	**Cost**
No Action	None	Not Applicable	Does not achieve remedial action objectives	Readily implementable	Negligible
Institutional Controls	Access Restrictions	Access Restrictions	Depends upon continued future implementation.	Readily implementable	Negligible
	Notice of Covenant on Deed Transfers	Notice of Covenant on Deed Transfers	Depends upon continued future implementation.	Appropriate legal actions required	Negligible
	Zoning Restrictions	Zoning Restrictions	Depends upon continued future implementation.	Approval of local government required	Negligible
Containment	Contact Barriers	Asphalt or Concrete	Highly effective	Highly implementable	Low capital and maintenance
		Steel or Synthetic Mats	Highly effective	Highly implementable	Low capital and maintenance
	Capping	Permeable Soil Cap	Effective, susceptible to cracking, but has self healing properties	Easily implementable, restricts future land use	Low capital and maintenance
		Multi-layered	Highly effective, least susceptible to cracking	Easily implementable, restricts future land use	High capital and moderate maintenance
	Surface Controls	Diversion Channels, Grading, Revegetation	Effective in preventing erosion	Implementable	Low capital and maintenance
	Vertical Barriers	Sheet Piling	Effective in preventing migration	Difficult to implement due to subsurface obstructions	Low capital and maintenance
		Slurry Walls	Effective in preventing migration	Difficult to implement due to subsurface obstructions	Low capital and maintenance
Source Removal	Source Removal	Source Removal	Effective in reducing on-site volume and toxicity, however, mobility may be increased during implementation of deeper source removal	Shallow source removal is implementable; deep source removal is difficult or impractical to implement due to site construction restraints	Moderate capital for shallow source removal; higher capital for deep source removal
Ex-Situ Treatment	Physical Processes	Ex-situ Stabilization/ Solidification	Effective, requires material segregation	Difficult to implement due to heterogeneous nature of fill material	Moderate capital; however, transportation and disposal costs increase due to increased volume
Disposal	Disposal	Off-site Disposal as Non-hazardous Waste	Effective, requires transportation	Nearest facility in Utah	Moderate transportation and disposal
		Off-site Disposal as Hazardous Waste	Effective, requires transportation	Nearest facility in Utah	High transportation and disposal
In-Situ Treatment	Physiochemical Processes	In-Situ Stabilization/ Solidification	Effective	Subsurface obstructions may present difficulties	Moderate capital

Table 4-1: Alternative Screening Summary Harbor-at-Hastings, Hastings-on-Hudson, New York							
Alternative No.	**Overall Protection of Human Health and the Environment**	**Compliance With SCGs, ARARs and Other Regulations**	**Short-Term Effectiveness**	**Long-Term Effectiveness and Permanence**	**Reduction in Mobility, Toxicity, and Volume**	**Implementability**	**Cost**
1	No reduction in potential risks to human health or the environment	Site cleanup objectives not achieved	No short-term risks to workers, the community or the environment as a result of construction activities	No reduction in long-term risk	Gradual reduction in colume and toxicity of impacted media; potential for off-site migration of COPCs is minimal	Implementable	$17,000,000
2	Elimination of potential risks to human health or the environment by removal of PCB contamination	Site cleanup objectives achieved	Significant short-term risks to workers, community or the environment as a result of construction activities	Long-term risks reduced, but still remain due to potential increase in PCB mobility due to construction activities	Reduction of on-site toxicity and volume of COPC-impacted fill; potential for PCB mobility to be increased during construction activities	Not implementable, breaks site Basic Principles	$150,000,000
3	Elimination of potential risks to human health or the environment by removal of PCB and TAGM contamination	Site cleanup objectives achieved	Significant short-term risks to workers, community or the environment as a result of construction activities	Long-term risks reduced, but still remain due to potential increase in PCB mobility due to construction activities	Reduction of on-site toxicity and volume of COPC-impacted fill; potential for PCB mobility to be increased during construction activities	Not implementable, breaks site Basic Principles	$225,000,000
4	Elimination of potential risks to human health or the environment by migration pathway elimination and removal of PCB contamination	Site cleanup objectives achieved	Significant short-term risks to workers, community or the environment as a result of construction activities	Long-term risks reduced, but still remain due to potential increase in PCB mobility due to construction activities; maintenance required for long-term effectiveness	Reduction of on-site toxicity and volume of COPC-impacted fill; potential for PCB mobility to be increased during construction activities	Not implementable, breaks site Basic Principles	$167,000,000
5	Reduction of potential risks to human health or the environment by removal of "rubbery matrix" and fill above water table; migration pathway elimination of remaining material	Site cleanup objectives achieved	Significant short-term risks to workers, community or the environment as a result of construction activities	Long-term risks reduced, but still remain due to potential increase in PCB mobility due to construction activities; maintenance required for long-term effectiveness	Reduction of on-site toxicity and volume of COPC-impacted fill; potential for PCB mobility to be increased during construction activities	Not implementable, breaks site Basic Principles	$165,000,000
6	Reduction of potential risks to human health or the environment by removal of "rubbery matrix"; migration pathway elimination of remaining material	Site cleanup objectives achieved	Significant short-term risks to workers, community or the environment as a result of construction activities	Long-term risks reduced, but still remain due to potential increase in PCB mobility due to construction activities; maintenance required for long-term effectiveness	Reduction of on-site toxicity and volume of COPC-impacted fill; potential for PCB mobility to be increased during construction activities	Not implementable, breaks site Basic Principles	$132,000,000

Table 4-1: Alternative Screening Summary Harbor-at-Hastings, Hastings-on-Hudson, New York							
Alternative No.	**Overall Protection of Human Health and the Environment**	**Compliance With SCGs, ARARs and Other Regulations**	**Short-Term Effectiveness**	**Long-Term Effectiveness and Permanence**	**Reduction in Mobility, Toxicity, and Volume**	**Implementability**	**Cost**
7	Reduction of potential risks to human health or the environment by removal of PCB fill >=10 ppm and migration pathway elimination of remaining material	Site cleanup objectives achieved	Moderate short-term risks to workers, community or the environment as a result of construction activities; however, lower than deep excavation alternatives	Long-term risks effectively reduced; maintenance required for long-term effectiveness	Slight reduction of on-site mobility, toxicity and volume of COPC-impacted fill	Implementable	$46,000,000
8	Reduction of potential risks to human health or the environment by removal of PCB fill >=10 ppm and migration pathway elimination of remaining material	Site cleanup objectives achieved	Minimal short-term risks to workers, community or the environment as a result of construction activities	Long-term risks effectively reduced; maintenance required for long-term effectiveness	Minimal reduction in on-site mobility, toxicity and volume of COPC-impacted fill	Implementable	$33,000,000
10	Reduction of potential risks to human health or the environment by removal of lead hot spots and migration pathway elimination of remaining material	Site cleanup objectives achieved	Minimal short-term risks to workers, community or the environment as a result of construction activities	Long-term risks effectively reduced; maintenance required for long-term effectiveness	Minimal reduction in on-site mobility, toxicity and volume of COPC-impacted fill	Implementable	$17,500,000
11	Reduction of potential risks to human health or the environment by removal of PCB fill >=10 ppm and migration pathway elimination of remaining material	Site cleanup objectives achieved	Moderate short-term risks to workers, community or the environment as a result of construction activities	Long-term risks effectively reduced; maintenance required for long-term effectiveness	Moderate reduction in on-site mobility, toxicity and volume of COPC-impacted fill	Implementable	$52,500,000
12	Reduction of potential risks to human health or the environment by removal of PCB fill >=10 ppm and migration pathway elimination of remaining material	Site cleanup objectives achieved	Moderate short-term risks to workers, community or the environment as a result of construction activities	Long-term risks effectively reduced; maintenance required for long-term effectiveness	Moderate reduction in on-site mobility, toxicity and volume of COPC-impacted fill	Implementable	$74,500,000

Note: Greyed areas indicate failure of alternative to meet screening criteria

FIGURES



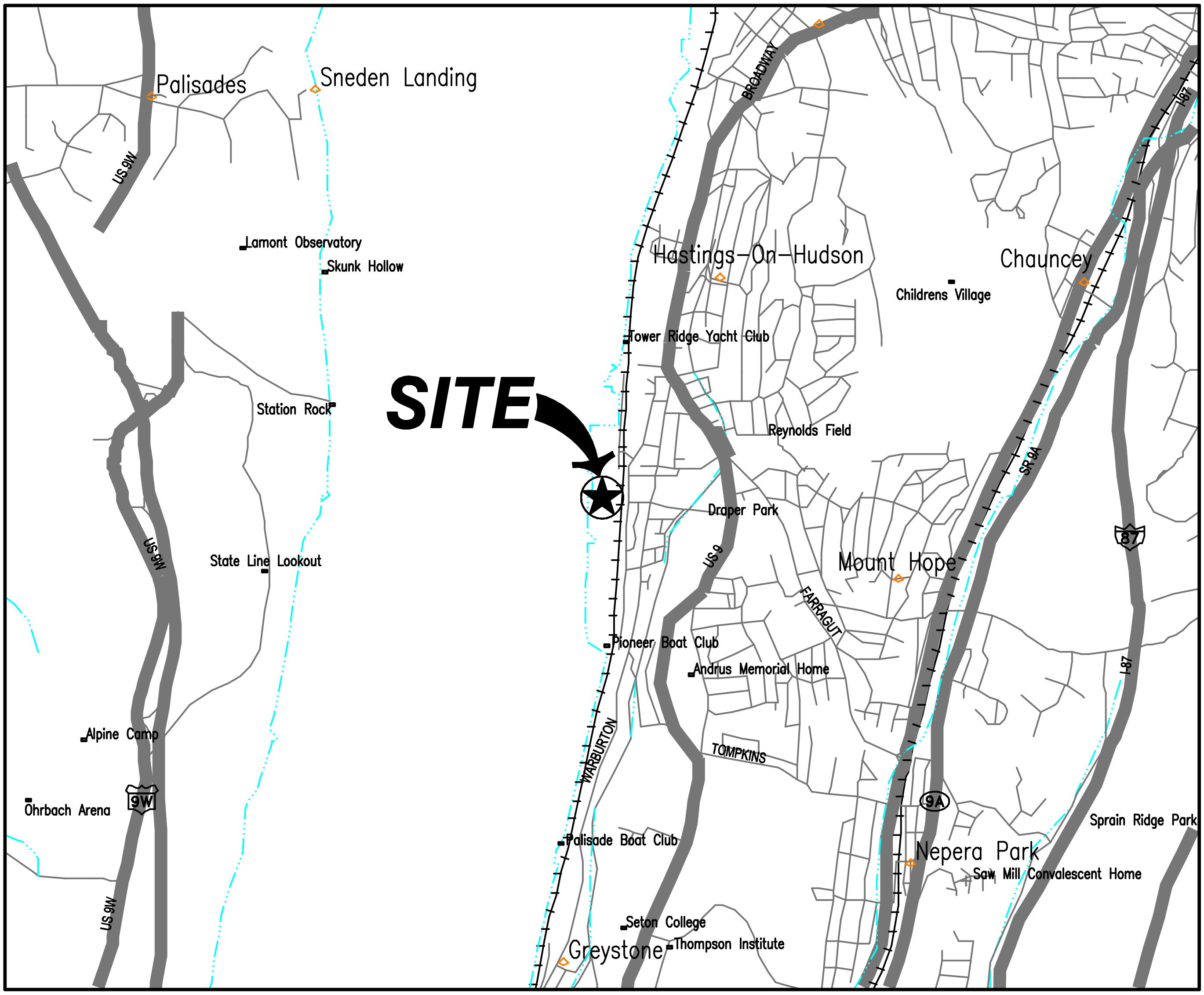


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FIGURE 1-1
SITE LOCATION MAP

HARBOR AT HASTINGS
HASTINGS-ON-HUDSON, NEW YORK

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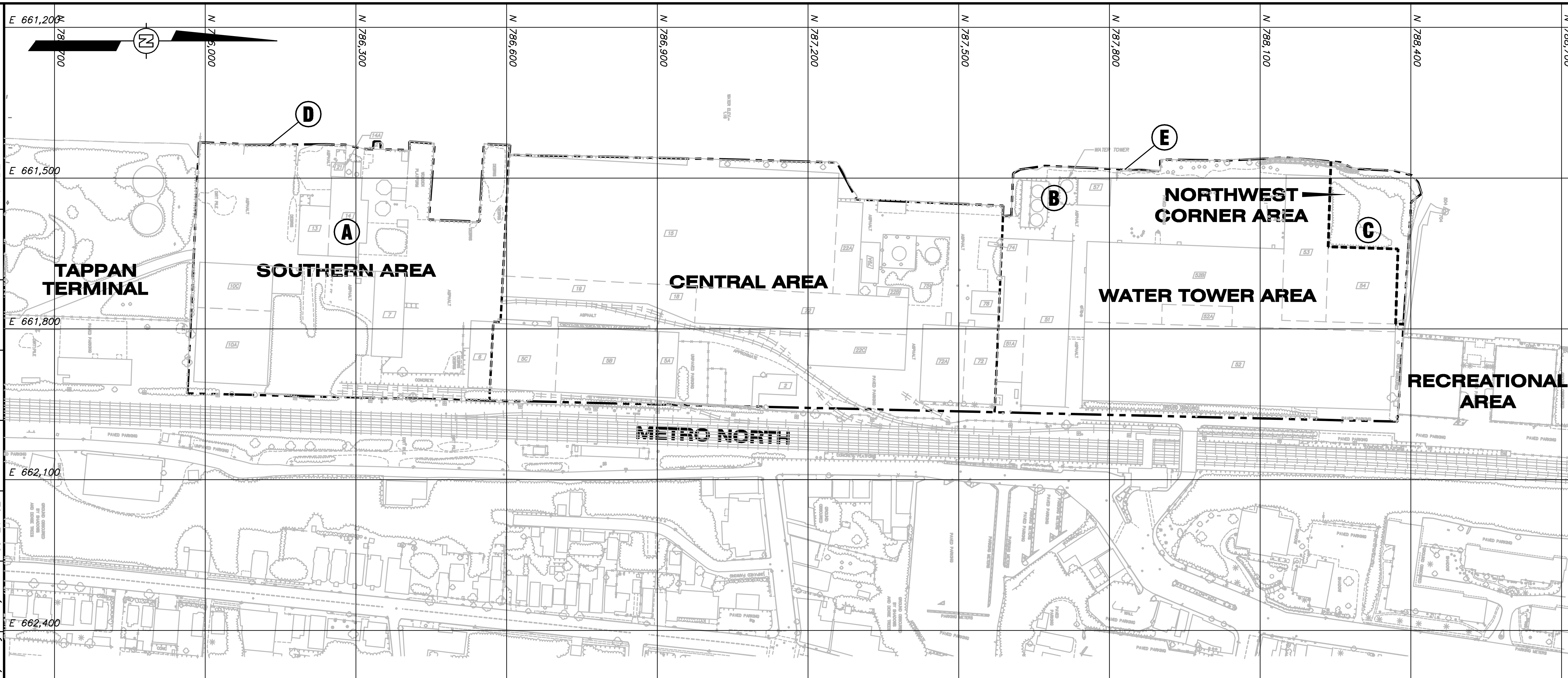

LEGEND:

15	BUILDING DESIGNATION
— - - —	APROXIMATE SITE BOUNDARY
- - - - - -	APROXIMATE SITE BOUNDARY
—— -5 ——	DEPTH TO CONTAMINATION CONTOUR

INTERIM REMEDIAL MEASURES

- (A) BUILDING 14 SUMP CLOSURE IRM
- (B) SEPARATE PHASE LIQUID RECOVERY IRM
- (C) NORTHWEST CORNER IRM
- (D) SOUTHWEST CORNER BULKHEAD IRM
- (E) BUILDING 57 SHORELINE IRM

SCALE

0 200 400 FEET

REFERENCES:

1. TOPOGRAPHY AND PLANIMETRICS PROVIDED BY GEOD PHOTOGRAMMETRIC SCIENCES SURVEY TECHNOLOGIES. MAPPED BY PHOTOGRAMMETRIC METHODS FROM AERIAL PHOTOGRAPHS TAKEN 12-08-1995. GRIDS BASED ON NEW YORK 1988 STATE PLANE COORDINATE SYSTEM. VERTICAL DATUM IS BASED ON NAD 1983. RI SAMPLE LOCATIONS SURVEYED BY GEOD.
2. EXISTING BUILDING DESIGNATIONS ARE BASED ON DOLPH ROTFELD ASSOCIATES FIGURE 4, DATED NOVEMBER 1996. BUILDING INTERIOR DIVISION LOCATIONS ARE APPROXIMATE ONLY.

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FIGURE 1-2

SITE AREA MAP
HARBOR AT HASTINGS
HASTINGS-ON-HUDSON, NEW YORK

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APPROVED BY

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OFFICE Pittsburgh/Albany

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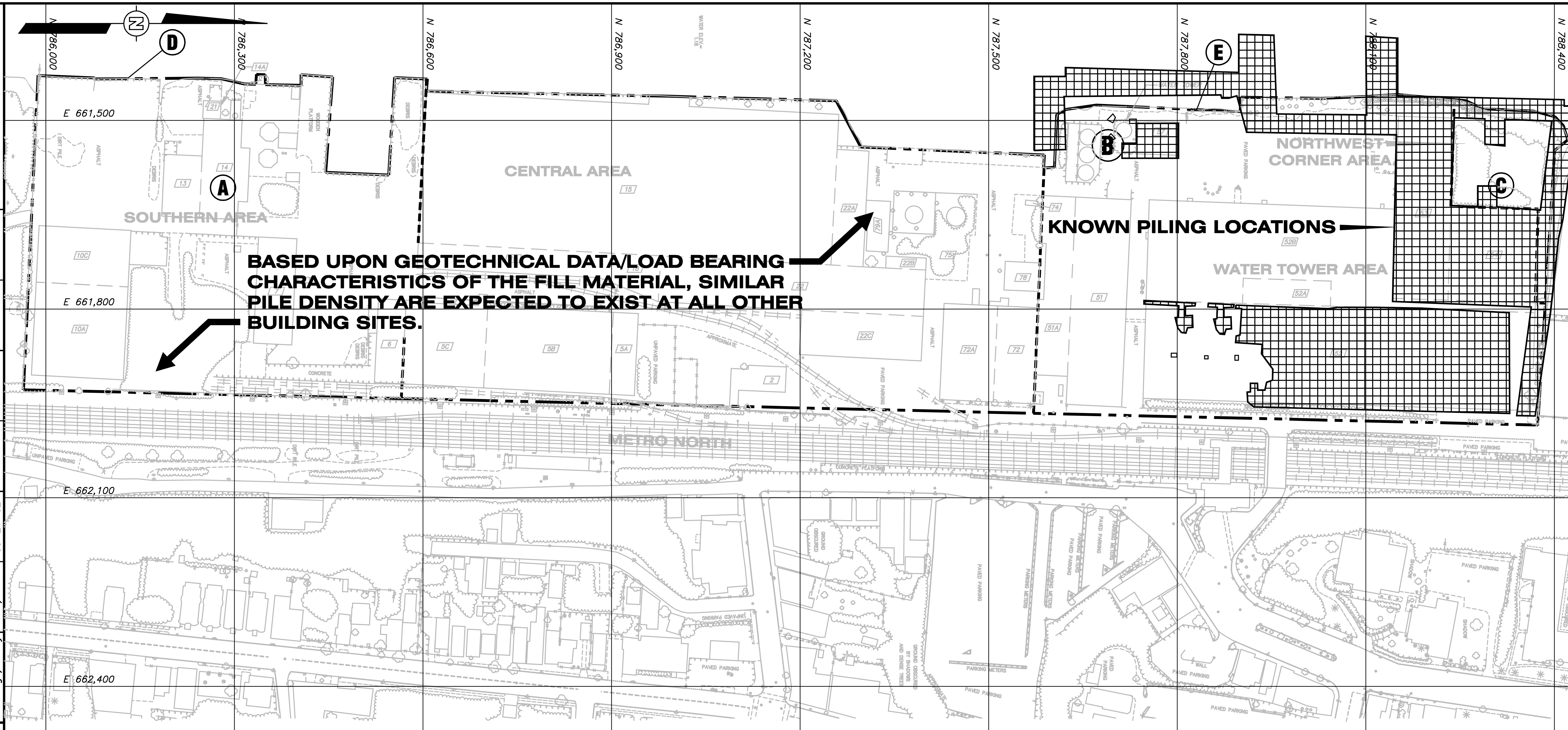

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2. EXISTING BUILDING DESIGNATIONS ARE BASED ON DOLPH ROTFELD ASSOCIATES FIGURE 4, DATED NOVEMBER 1996. BUILDING INTERIOR DIVISION LOCATIONS ARE APPROXIMATE ONLY.
3. FOR PILE LOCATIONS REFER TO FIGURE 4-6 HISTORICAL PILING MAP IN THE FINAL REMEDIAL INVESTIGATION REPORT DATED ? 2000.

LEGEND:

15	BUILDING DESIGNATION
— — —	APROXIMATE SITE BOUNDARY
- - - -	APROXIMATE SITE BOUNDARY
—5—	DEPTH TO CONTAMINATION CONTOUR
(grid pattern)	AREAS WHERE PILE LOCATIONS CONFIRMED BY AVAILABLE FACILITY AS-BUILT DRAWINGS BASED ON GEOTECHNICAL DATA/LOAD BEARING CHARACTERISTICS OF THE FILL MATERIAL, SIMILAR PILE DENSITY ARE EXPECTED TO EXIST AT ALL OTHER BUILDING SITES.

INTERIM REMEDIAL MEASURES:

- (A) BUILDING 14 SUMP CLOSURE IRM
- (B) SEPARATE PHASE LIQUID RECOVERY IRM
- (C) NORTHWEST CORNER IRM
- (D) SOUTHWEST CORNER BULKHEAD IRM
- (E) BUILDING 57 SHORELINE IRM

SCALE

0 160 320 FEET

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FIGURE 1-3

PILE LOCATION MAP
HARBOR AT HASTINGS
HASTINGS-ON-HUDSON, NEW YORK

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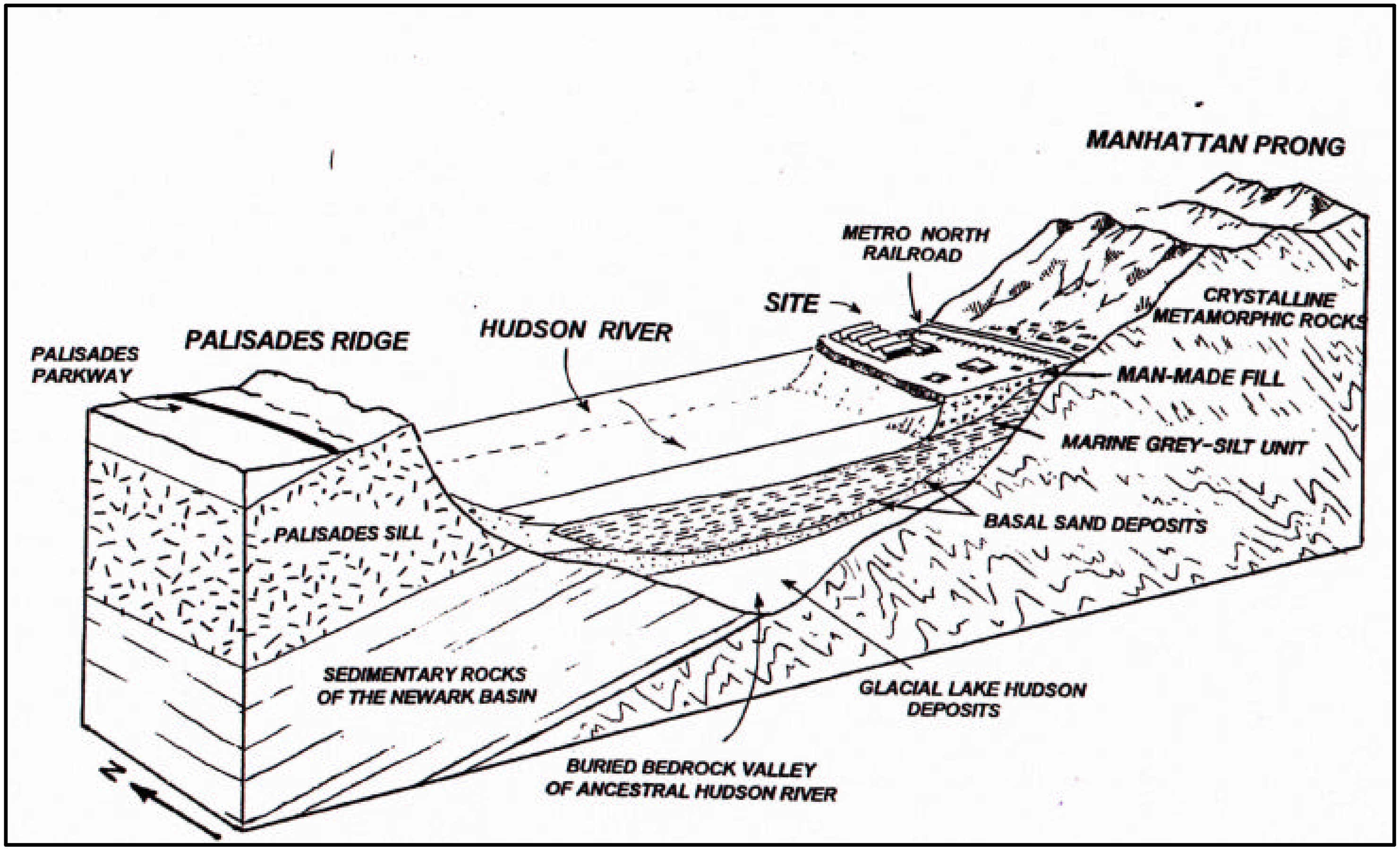

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FIGURE 1-4

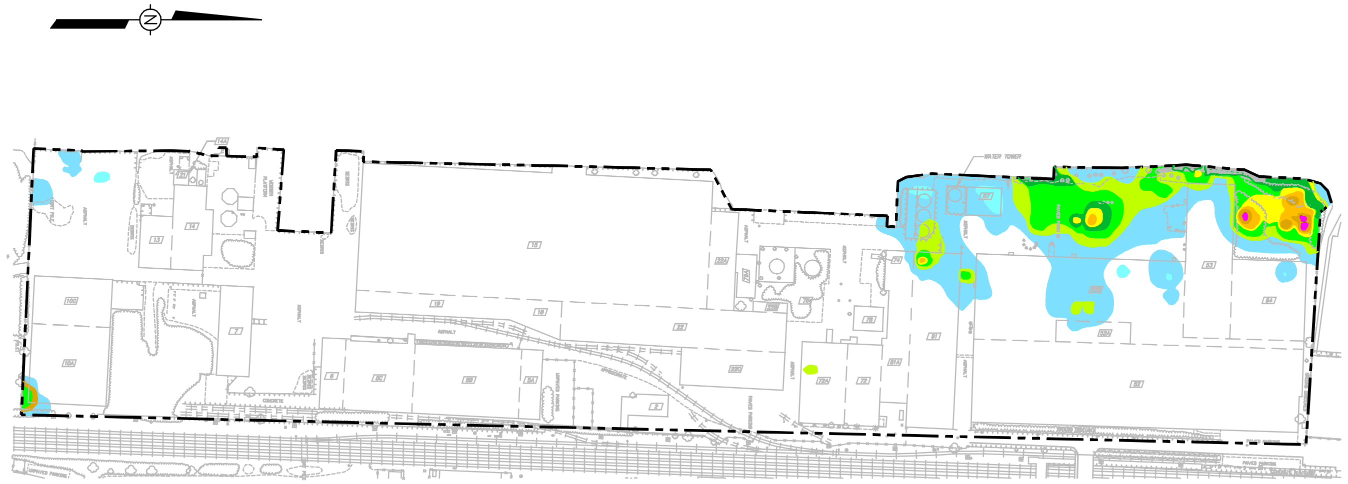
REGIONAL GEOLOGIC CROSS-SECTION

HARBOR AT HASTINGS
HASTINGS-ON-HUDSON, NEW YORK

REFERENCE:

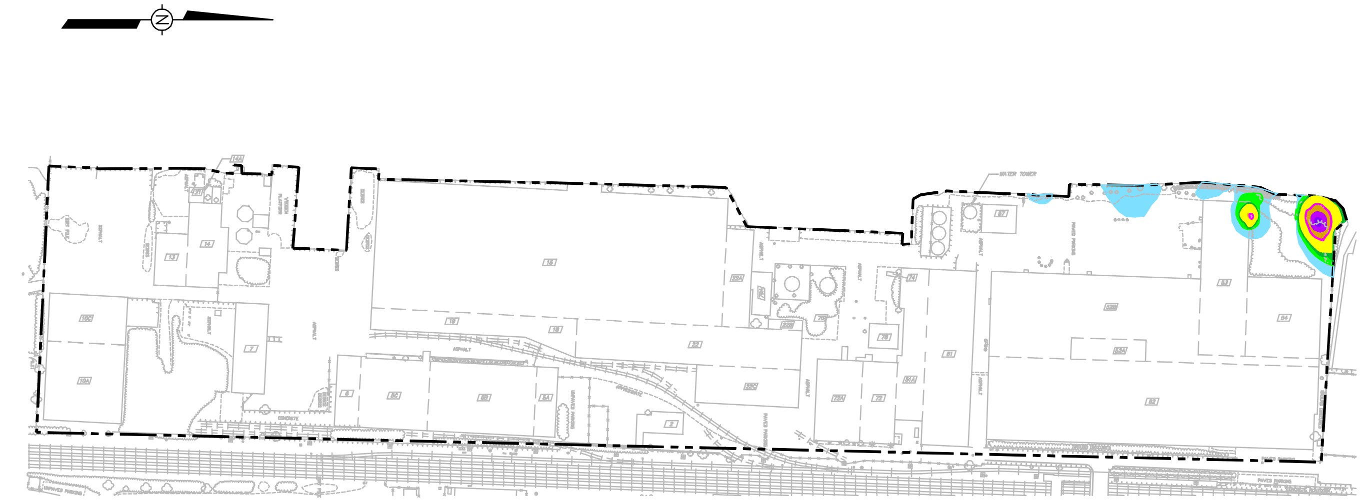
GOLDER ASSOCIATES

DRAWING NOT TO SCALE



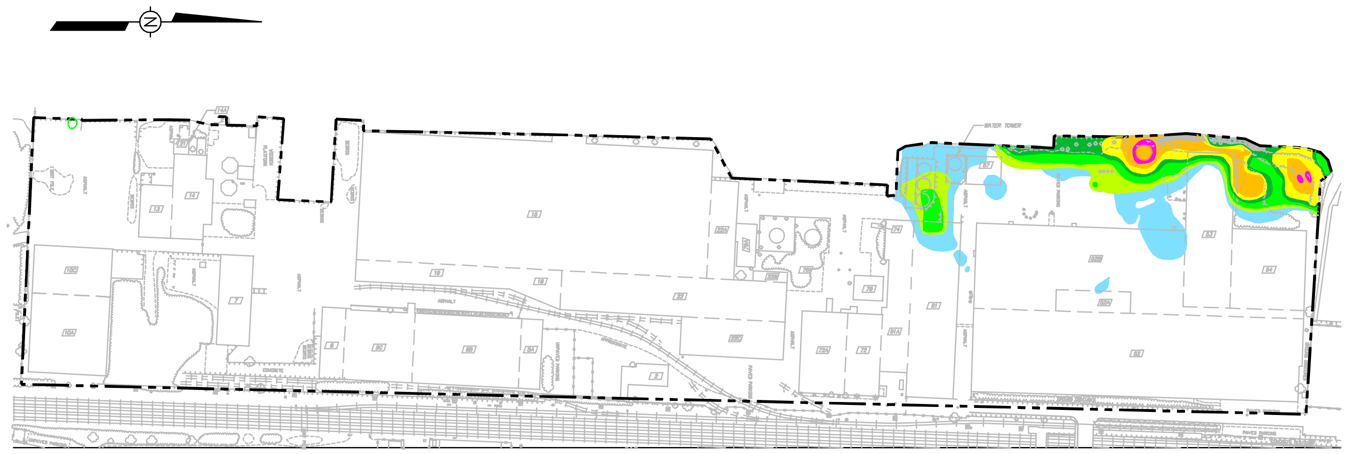
PCB CONCENTRATIONS > 1 mg/kg AT A DEPTH OF 1 FOOT

N. T. S.



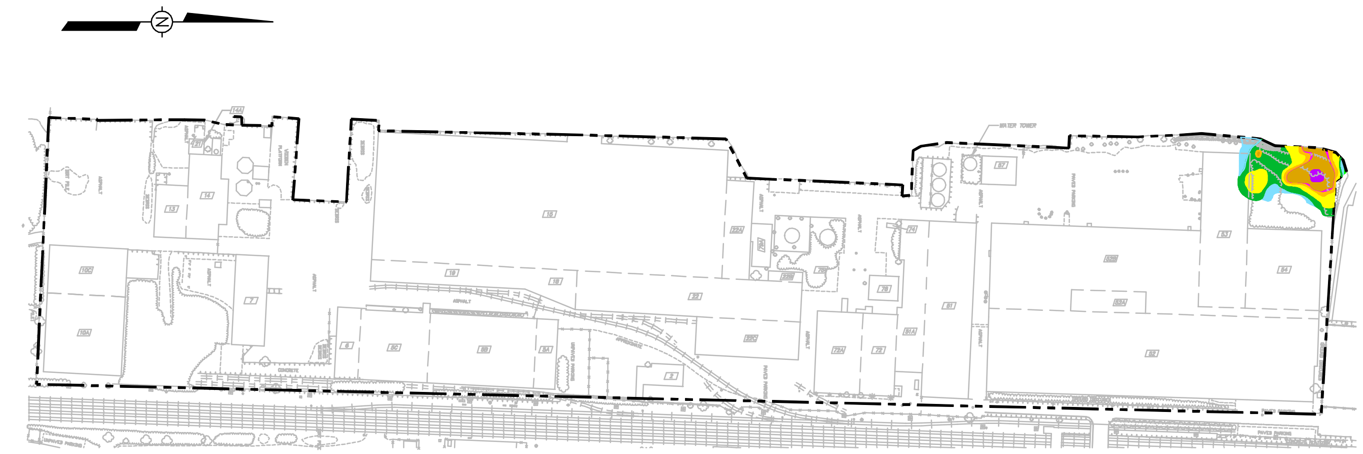
PCB CONCENTRATIONS > 10 mg/kg AT A DEPTH OF 20 FEET

N. T. S.



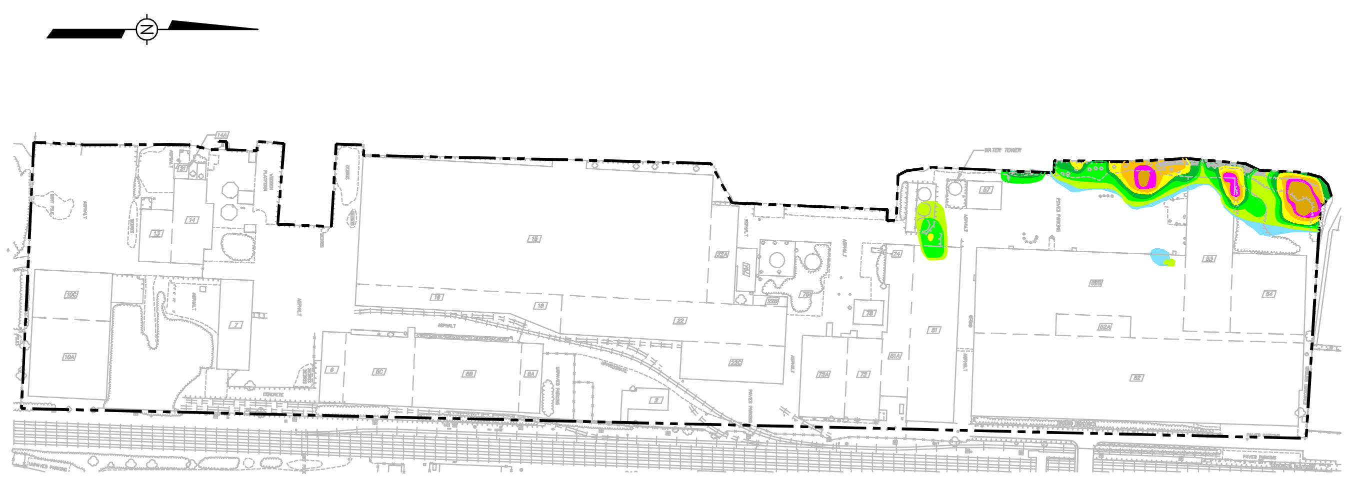
PCB CONCENTRATIONS > 10 mg/kg AT A DEPTH OF 6 FEET

N. T. S.



PCB CONCENTRATIONS > 10 mg/kg AT A DEPTH OF 30 FEET

N. T. S.



PCB CONCENTRATIONS > 10 mg/kg AT A DEPTH OF 10 FEET

N. T. S.

LEGEND:

DISPLAY: alogPCB_June00_1
UNITS: mg/kg

- 100000.0
- 50000.0
- 10000.0
- 5000.0
- 1000.0
- 500.0
- 250.0
- 100.0
- 50.0
- 10.0

REFERENCES:

1. TOPOGRAPHY AND PLANIMETRICS PROVIDED BY GEOD PHOTOGRAMMETRIC SCIENCES SURVEY TECHNOLOGIES. MAPPED BY PHOTOGRAMMETRIC METHODS FROM AERIAL PHOTOGRAPHS TAKEN 12–08–1995. GRIDS BASED ON NEW YORK 1988 STATE PLANE COORDINATE SYSTEM. VERTICAL DATUM IS BASED ON NAD 1983. RI SAMPLE LOCATIONS SURVEYED BY GEOD.
2. HISTORICAL SAMPLING LOCATIONS BASED ON DOLPH ROTFELD, FIGURE 4, DATED 1976, PARISH & WEINER, PLATE 2, DATED OCTOBER 1989 AND RETEC, FIGURE 2–8, DATED DECEMBER 1993. THESE LOCATIONS ARE APPROXIMATE ONLY, AS LAND SURVEYING DATA ARE NOT AVAILABLE.
3. EXISTING BUILDING DESIGNATIONS ARE BASED ON DOLPH ROTFELD ASSOCIATES FIGURE 4, DATED NOVEMBER 1996. BUILDING INTERIOR DIVISION LOCATIONS ARE APPROXIMATE ONLY.

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FIGURE 1–5
PCB CONCENTRATIONS EXCEEDING SITE SPECIFIC TAGM VALUES IN FILL
HARBOR AT HASTINGS
HASTINGS–ON–HUDSON, NEW YORK

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CHECKED BY

DRAWN BY MW/SSH 05–21–02

OFFICE Pittsburgh/Albany

Image:
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DRAWING NUMBER 806938B13

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CHECKED BY

DRAWN BY MW/SSH 05-21-02

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Image: .
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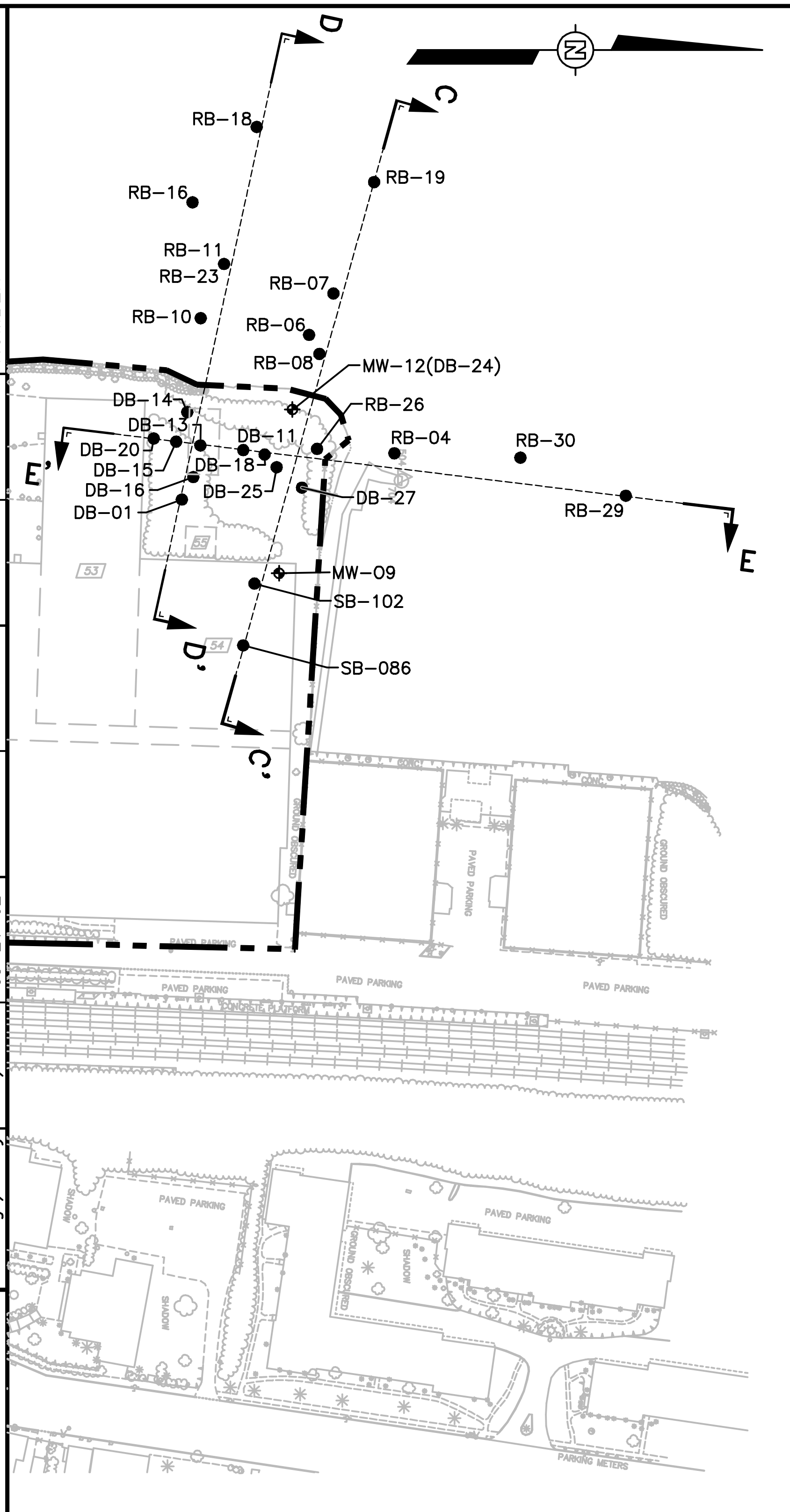
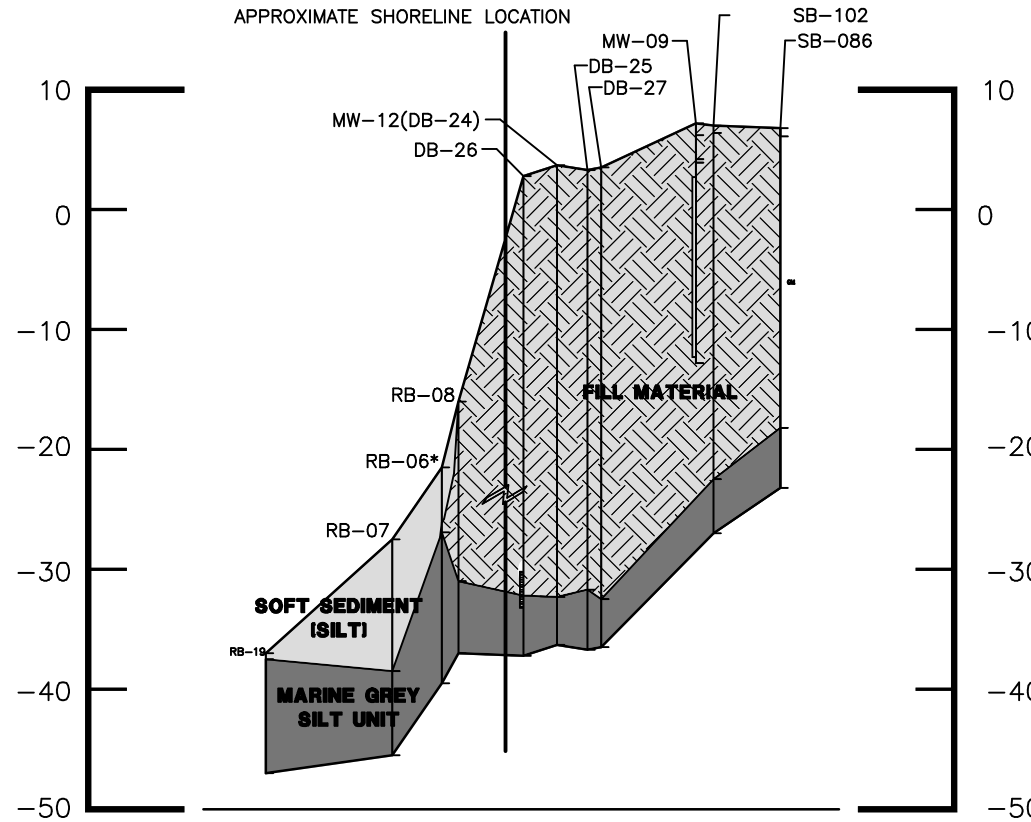
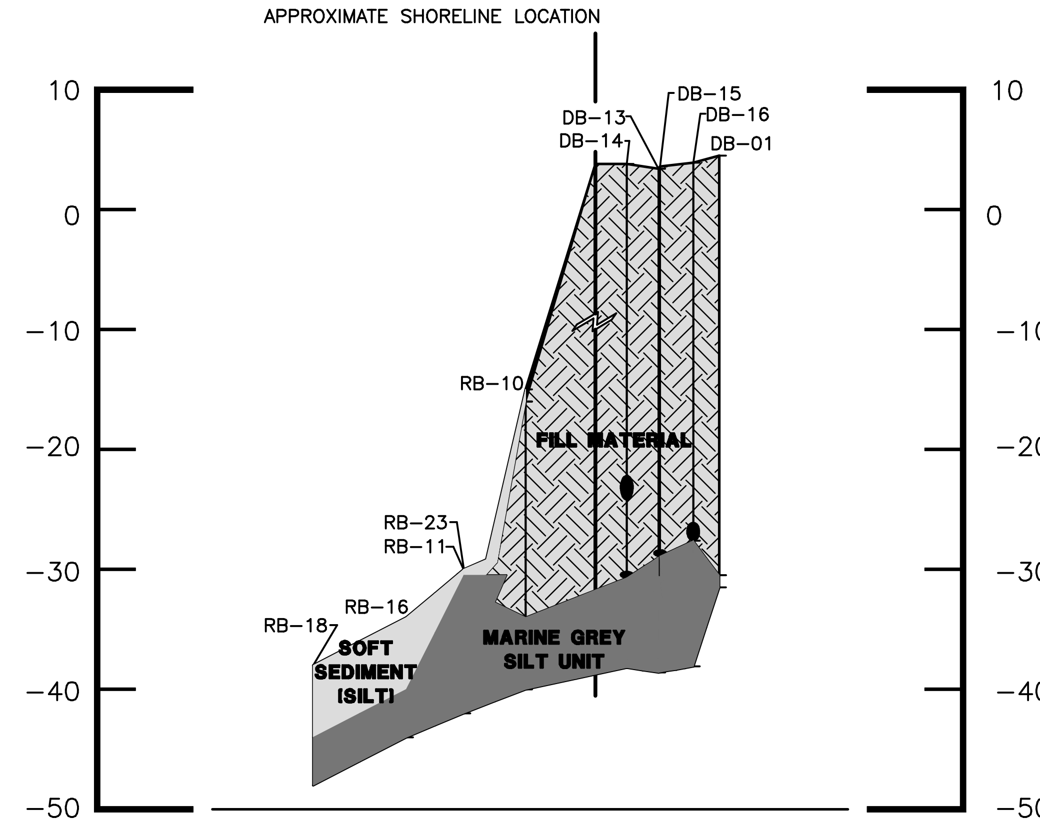


PLAN VIEW

SCALE 0 160 320 FEET



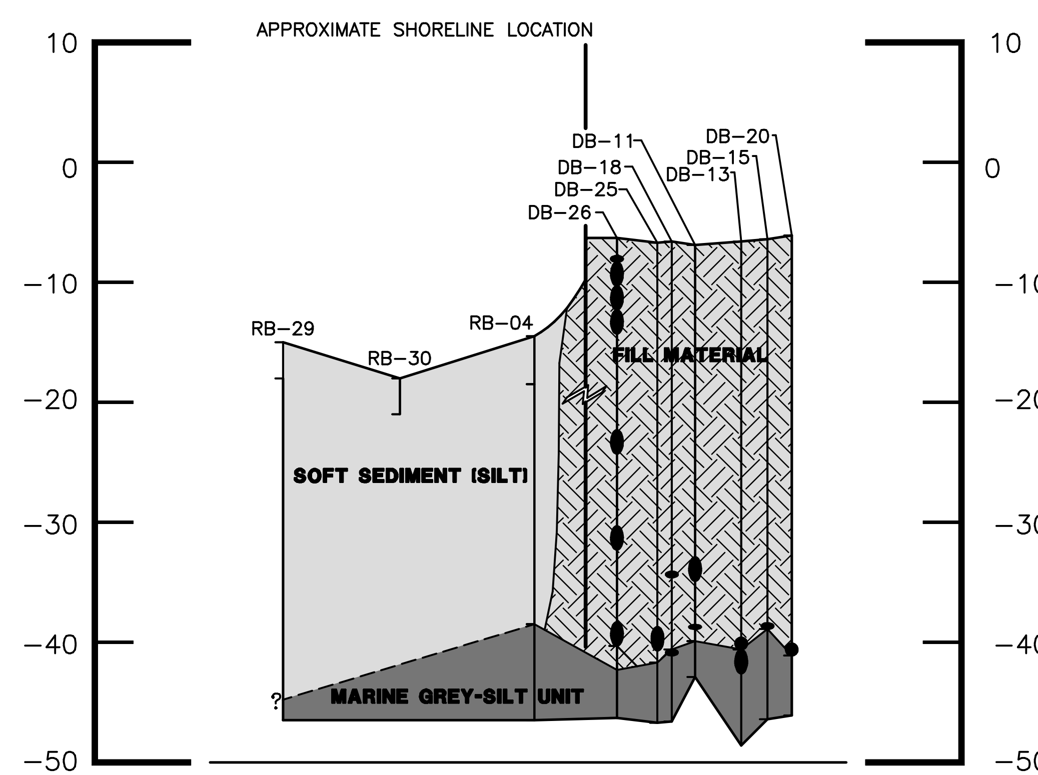
SECTION C – C'



SECTION D – D'

LEGEND:

[dashed outline]	FORMER BUILDIONG OUTLINE
15	BUILDING DESIGNATION
— - —	APROXIMATE SITE BOUNDARY
●	RUBBERY MATRIX DETECTED/OBSERVED
DB	FLUOR DANIEL GTI BORING
SB	FLUOR DANIEL GTI/IT CORPORATION BORING
MW	MONITORING WELL



SECTION E – E'

REFERENCES:

1. TOPOGRAPHY AND PLANIMETRICS PROVIDED BY GEOD PHOTOGRAMMETRIC SCIENCES SURVEY TECHNOLOGIES. MAPPED BY PHOTOGRAMMETRIC METHODS FROM AERIAL PHOTOGRAPHS TAKEN 12-08-1995. GRIDS BASED ON NEW YORK 1988 STATE PLANE COORDINATE SYSTEM. VERTICAL DATUM IS BASED ON NAD 1983. RI SAMPLE LOCATIONS SURVEYED BY GEOD.
2. EXISTING BUILDING DESIGNATIONS ARE BASED ON DOLPH ROTFELD ASSOCIATES FIGURE 4, DATED NOVEMBER 1996. BUILDING INTERIOR DIVISION LOCATIONS ARE APPROXIMATE ONLY.

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FIGURE 1-6

CROSS-SECTIONS AT NORTHWEST CORNER
HARBOR AT HASTINGS
HASTINGS-ON-HUDSON, NEW YORK

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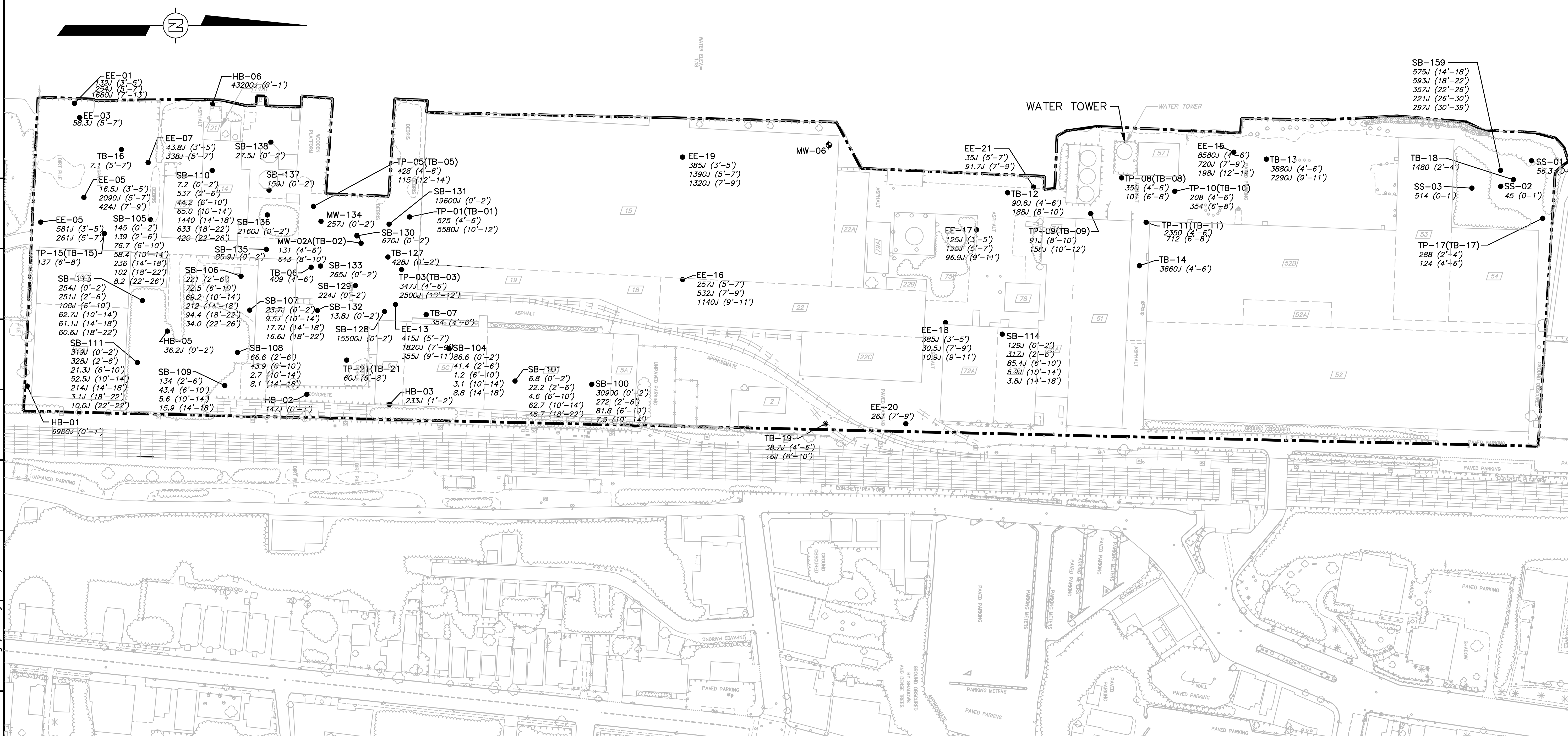

LEGEND:

(dash-dot line)	APPROXIMATE SITE BOUNDARY
15	BUILDING DESIGNATION
(dashed box)	FORMER BUILDING OR STRUCTURE
HB-03●	SOIL BORING
224J (0'-2')	RESULTS IN mg/kg (SAMPLE DEPTH RANGE IN FEET)
R	DATA REJECTED DURING VALIDATION
J	ESTIMATED VALUE
mg/kg	MILLIGRAMS PER KILOGRAM
MW-04	MONITORING WELL

EE	ELDON ENVIRONMENTAL BORING
EEW	ELDON ENVIRONMENTAL WELL
HB	ELDON ENVIRONMENTAL HAND BORING
(MP)MW	MALCOLM PIRNIE WELL
B	DOLPH ROTFELD BORING
SB	FLUOR DANIEL GTI/IT CORPORATION BORING
DB	FLUOR DANIEL GTI BORING
TP(TB)	GOLDER PIEZOMETER
TB	GOLDER BORING

REFERENCES:

1. TOPOGRAPHY AND PLANIMETRICS PROVIDED BY GEOD PHOTOGRAMMETRIC SCIENCES SURVEY TECHNOLOGIES. MAPPED BY PHOTOGRAMMETRIC METHODS FROM AERIAL PHOTOGRAPHS TAKEN 12-08-1995. GRIDS BASED ON NEW YORK 1988 STATE PLANE COORDINATE SYSTEM. VERTICAL DATUM IS BASED ON NAD 1983. RI SAMPLE LOCATIONS SURVEYED BY GEOD.
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3. EXISTING BUILDING DESIGNATIONS ARE BASED ON DOLPH ROTFELD ASSOCIATES FIGURE 4, DATED NOVEMBER 1996. BUILDING INTERIOR DIVISION LOCATIONS ARE APPROXIMATE ONLY.

SCALE 0 80 160 240 FEET

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FIGURE 1-7

LEAD CONCENTRATIONS IN FILL/SILT SAMPLES

HARBOR AT HASTINGS
HASTINGS-ON-HUDSON, NEW YORK

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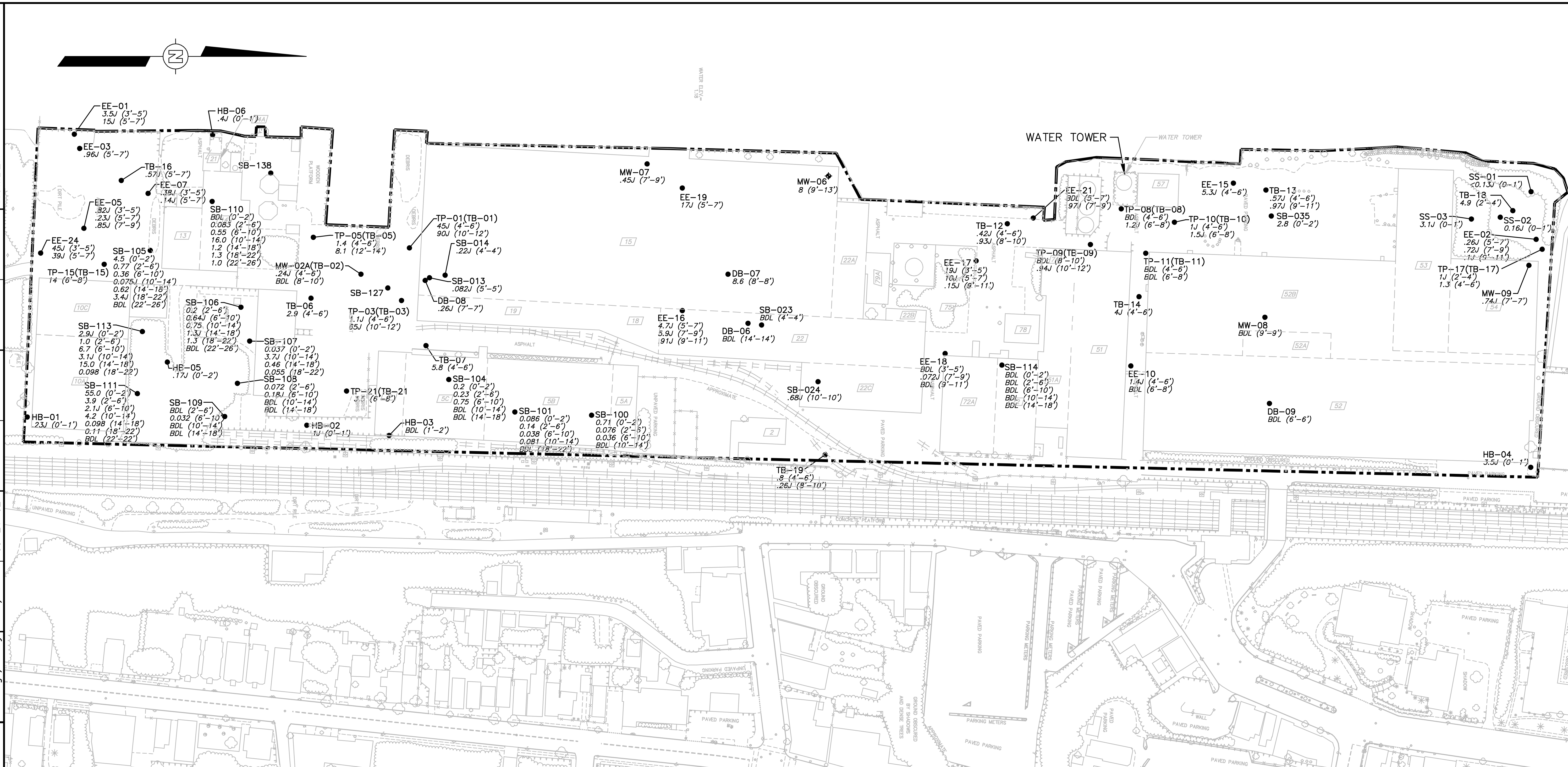

LEGEND:

(dash-dot line)	APPROXIMATE SITE BOUNDARY	EE	ELDON ENVIRONMENTAL BORING
15	BUILDING DESIGNATION	EEW	ELDON ENVIRONMENTAL WELL
(dashed box)	FORMER BUILDING OR STRUCTURE	HB	ELDON ENVIRONMENTAL HAND BORING
HB-03●	SOIL BORING	(MP)MW	MALCOLM PIRNIE WELL
BDL (1'-2')	RESULTS IN mg/kg (SAMPLE DEPTH RANGE IN FEET)	B	DOLPH ROTFELD BORING
R	DATA REJECTED DURING VALIDATION	SB	FLUOR DANIEL GTI/IT CORPORATION BORING
J	ESTIMATED VALUE	DB	FLUOR DANIEL GTI BORING
mg/kg	MILLIGRAMS PER KILOGRAM	TP(TB)	GOLDER PIEZOMETER
MW-04	MONITORING WELL	TB	GOLDER BORING

REFERENCES:

1. TOPOGRAPHY AND PLANIMETRICS PROVIDED BY GEOD PHOTOGRAMMETRIC SCIENCES SURVEY TECHNOLOGIES. MAPPED BY PHOTOGRAMMETRIC METHODS FROM AERIAL PHOTOGRAPHS TAKEN 12-08-1995. GRIDS BASED ON NEW YORK 1988 STATE PLANE COORDINATE SYSTEM. VERTICAL DATUM IS BASED ON NAD 1983. RI SAMPLE LOCATIONS SURVEYED BY GEOD.
2. HISTORICAL SAMPLING LOCATIONS BASED ON DOLPH ROTFELD, FIGURE 4, DATED 1976, PARISH & WEINER, PLATE 2, DATED OCTOBER 1989 AND RETEC, FIGURE 2-8, DATED DECEMBER 1993. THESE LOCATIONS ARE APPROXIMATE ONLY, AS LAND SURVEYING DATA ARE NOT AVAILABLE.
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SCALE 0 80 160 240 FEET

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FIGURE 1-8
BENZO (A) PYRENE CONCENTRATIONS IN FILL/SILT SAMPLES
HARBOR AT HASTINGS
HASTINGS-ON-HUDSON, NEW YORK

DRAWING NUMBER	806938-D7
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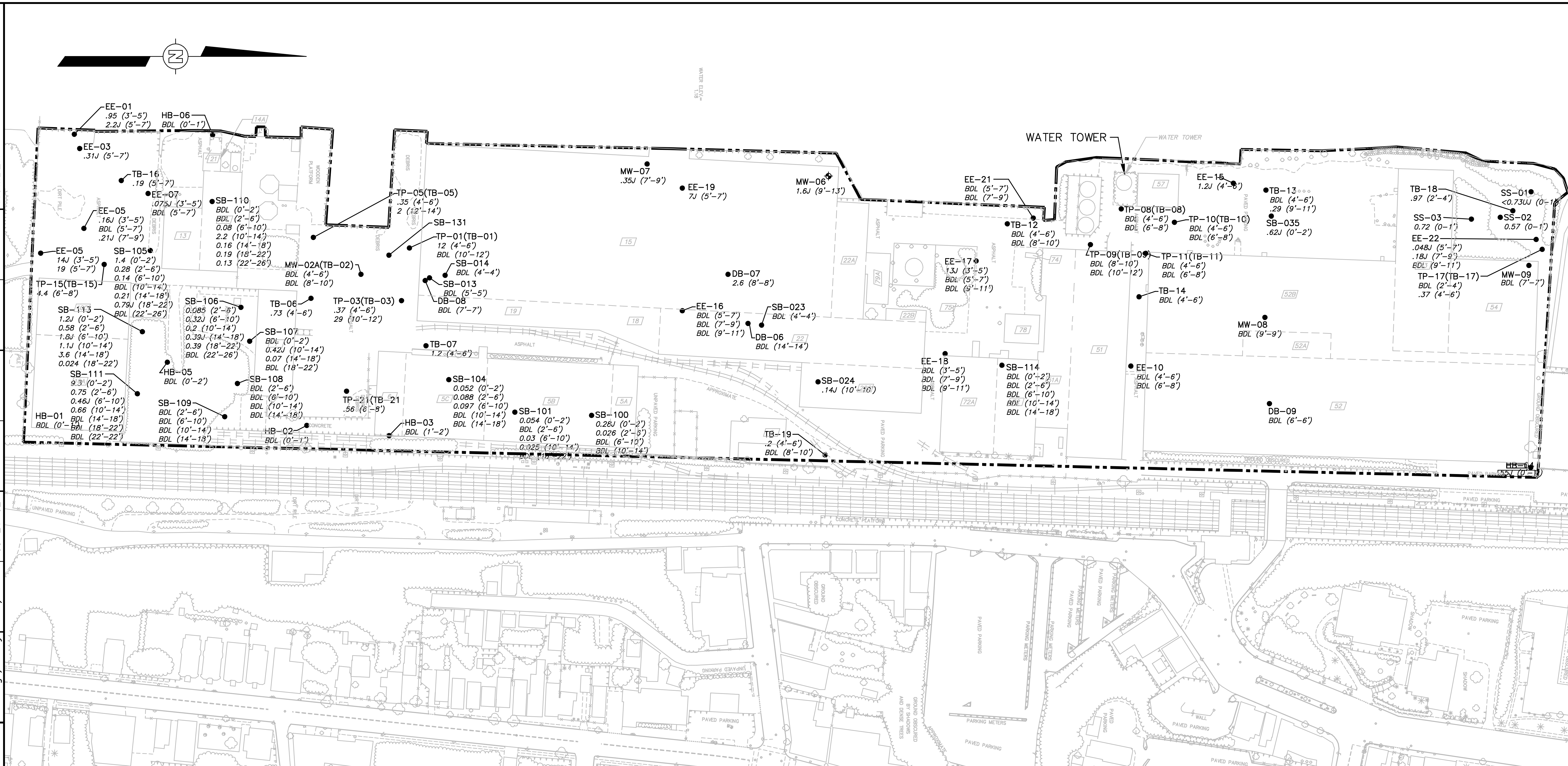
CHECKED BY	
DRAWN BY	MW/SSH 05-21-02
OFFICE	Pittsburgh/Albany



LEGEND:

— · — · —	APPROXIMATE SITE BOUNDARY	EE	ELDON ENVIRONMENTAL BORING
15	BUILDING DESIGNATION	EEW	ELDON ENVIRONMENTAL WELL
(dashed box)	FORMER BUILDING OR STRUCTURE	HB	ELDON ENVIRONMENTAL HAND BORING
HB-03●	SOIL BORING	(MP)MW	MALCOLM PIRNIE WELL
BDL (0'-2')	RESULTS IN mg/kg (SAMPLE DEPTH RANGE IN FEET)	B	DOLPH ROTFELD BORING
R	DATA REJECTED DURING VALIDATION	SB	FLUOR DANIEL GTI/IT CORPORATION BORING
J	ESTIMATED VALUE	DB	FLUOR DANIEL GTI BORING
mg/kg	MILLIGRAMS PER KILOGRAM	TP(TB)	GOLDER PIEZOMETER
MW-06	MONITORING WELL	TB	GOLDER BORING

SCALE 0 80 160 240 FEET

REFERENCES:

1. TOPOGRAPHY AND PLANIMETRICS PROVIDED BY GEOD PHOTOGRAMMETRIC SCIENCES SURVEY TECHNOLOGIES. MAPPED BY PHOTOGRAMMETRIC METHODS FROM AERIAL PHOTOGRAPHS TAKEN 12-08-1995. GRIDS BASED ON NEW YORK 1988 STATE PLANE COORDINATE SYSTEM. VERTICAL DATUM IS BASED ON NAD 1983. RI SAMPLE LOCATIONS SURVEYED BY GEOD.
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3. EXISTING BUILDING DESIGNATIONS ARE BASED ON DOLPH ROTFELD ASSOCIATES FIGURE 4, DATED NOVEMBER 1996. BUILDING INTERIOR DIVISION LOCATIONS ARE APPROXIMATE ONLY.

Image: Xref: TOPO-1

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Format Revised: 11/23/99

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FIGURE 1-9
DIBENZO (A,H) ANTHRACENE CONCENTRATIONS IN FILL/SILT SAMPLES
HARBOR AT HASTINGS
HASTINGS-ON-HUDSON, NEW YORK

* PRGS FOR LEAD BASED UPON EPA SCREENING LEVELS, NOT RISK FACTORS

REFERENCE:
DRAWING SOURCE: DRAFT HUMAN HEALTH RISK ASSESSMENT
ENVIRON CORPORATION, AUGUST 2000.

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FIGURE 2–1
AREAS EXCEEDING PRGS AT 1E–5 RISK AND HQ OF 1: PARK SCENARIO
HARBOR AT HASTINGS
HASTINGS–ON HUDSON, NEW YORK

* PRGS FOR LEAD BASED UPON EPA SCREENING LEVELS, NOT RISK FACTORS

REFERENCE:
DRAWING SOURCE: DRAFT HUMAN HEALTH RISK ASSESSMENT
ENVIRON CORPORATION, AUGUST 2000.

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FIGURE 2–2
AREAS EXCEEDING PRGS AT 1E–5 RISK AND HQ OF 1: COMMERCIAL/INDUSTRIAL SCENARIO
HARBOR AT HASTINGS
HASTINGS–ON HUDSON, NEW YORK

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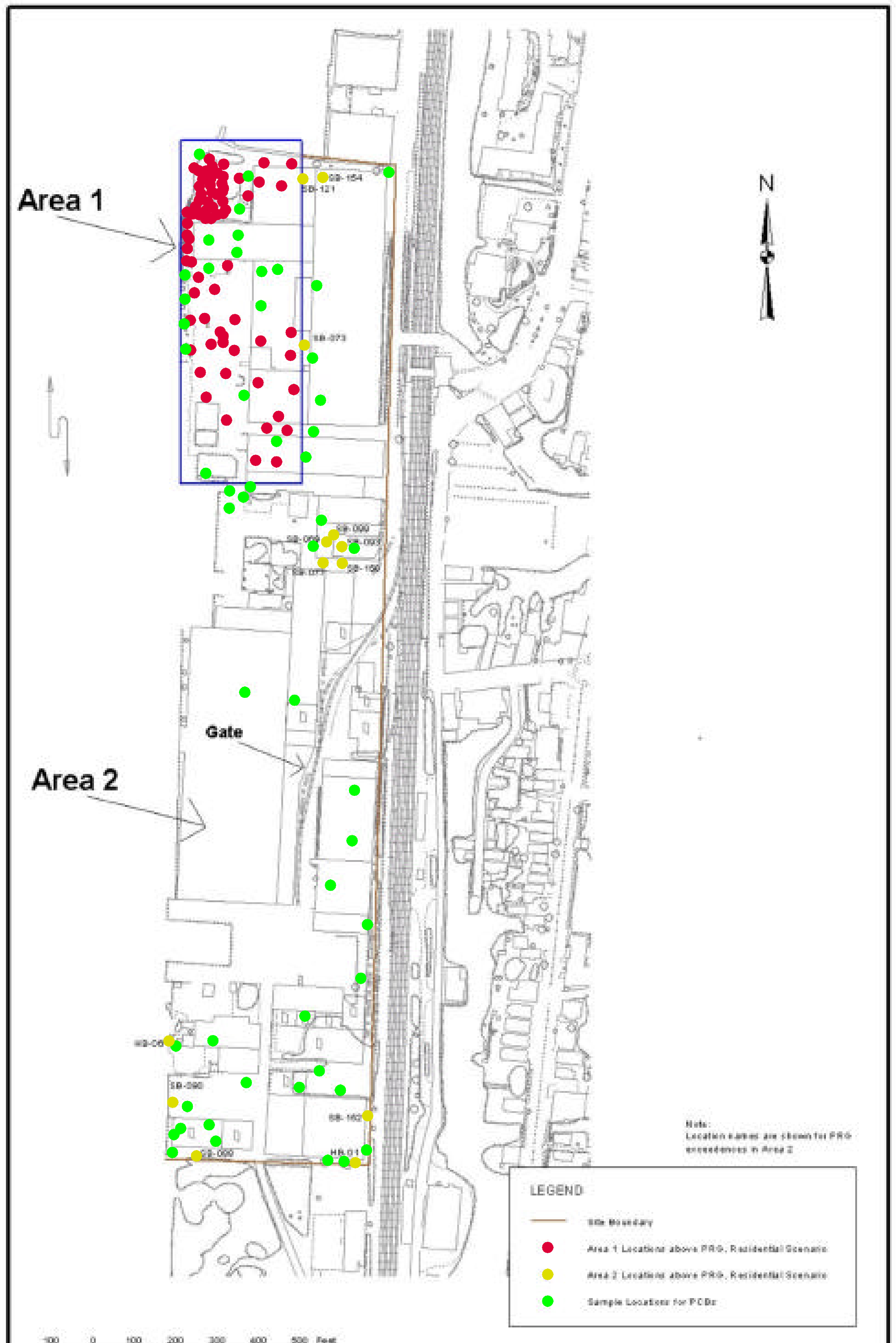
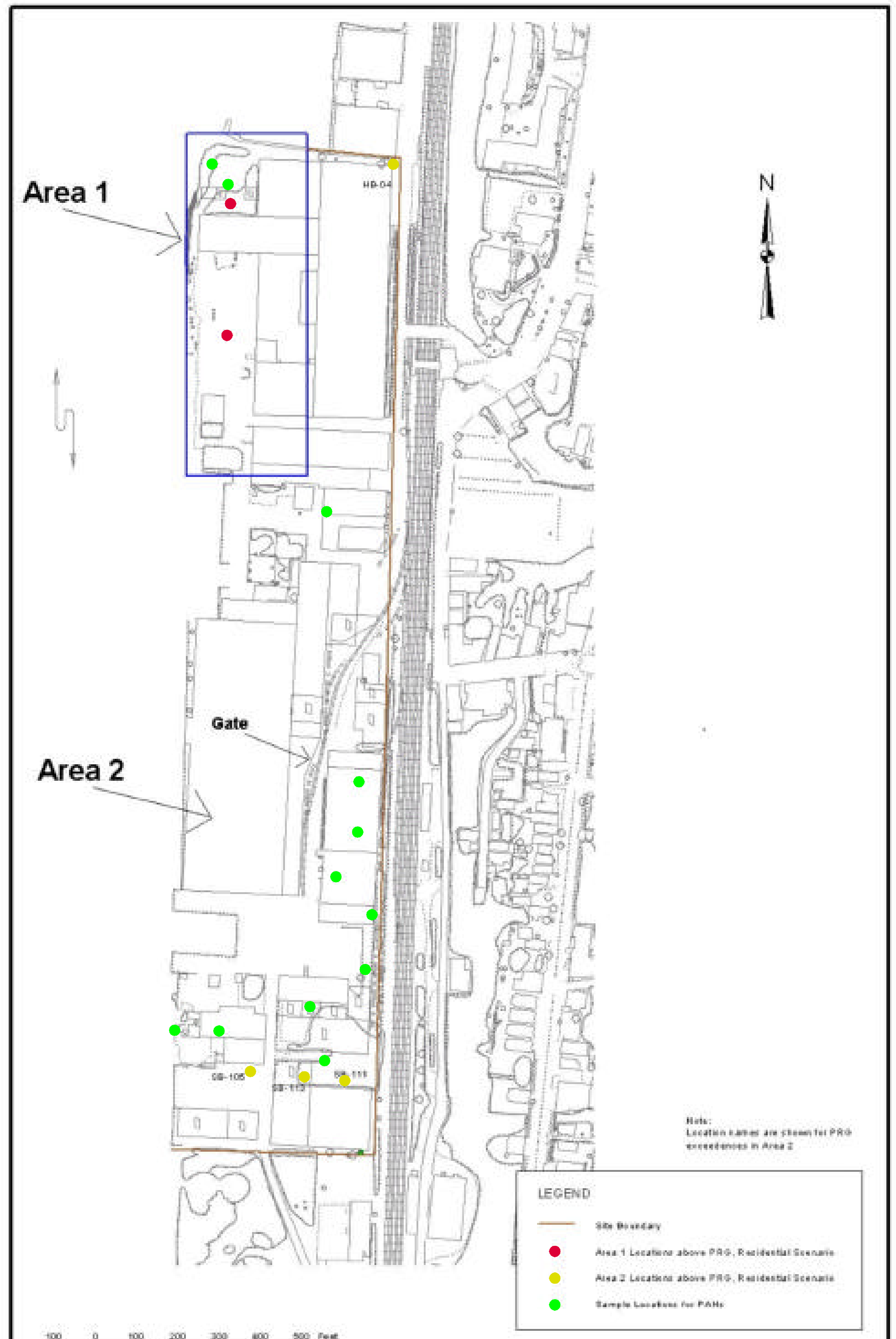
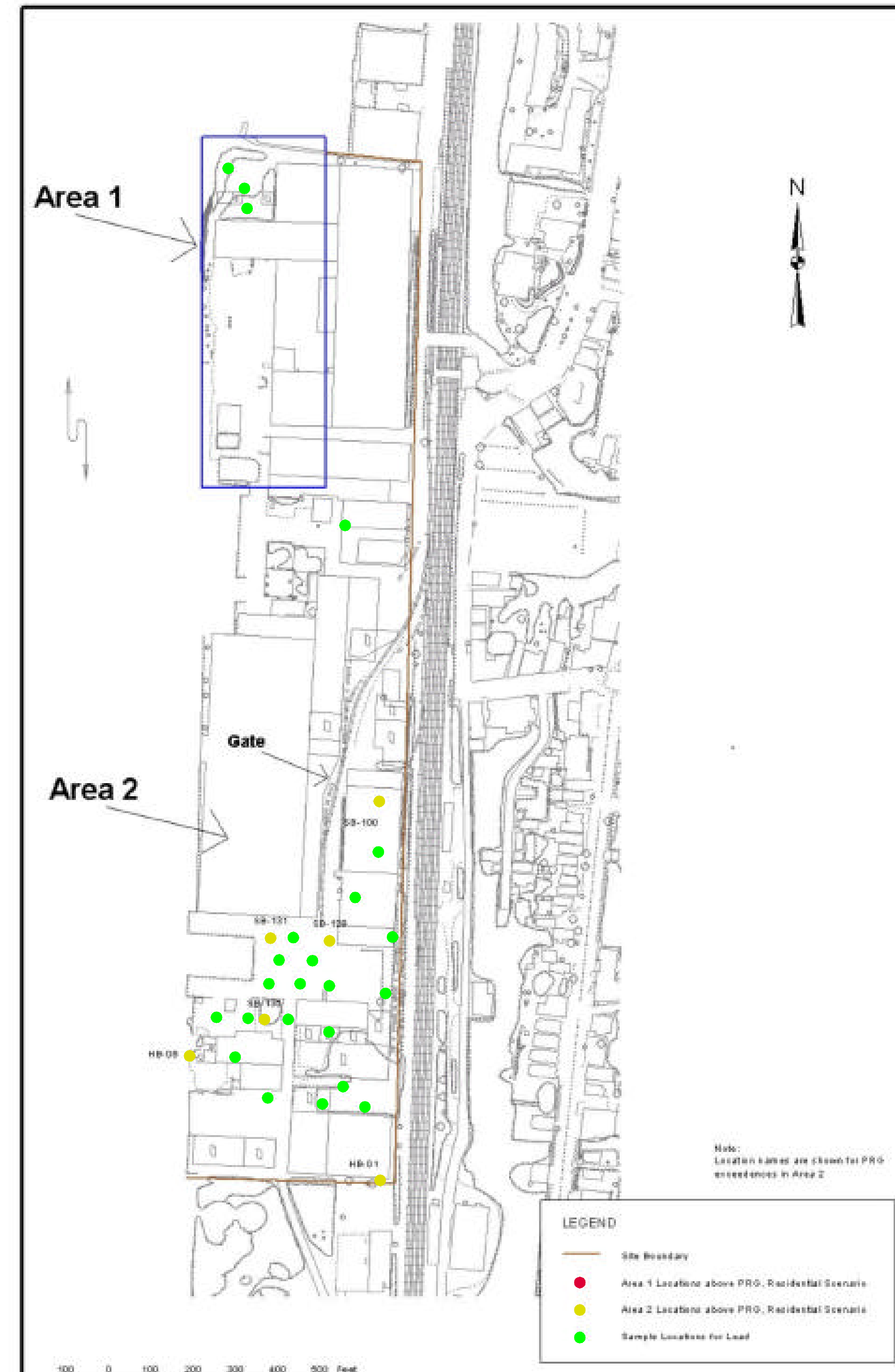


ENVIRON | Locations Exceeding PRG for PCBs, Residential Scenario
Harbor-at-Hastings, Hastings-on-Hudson, NY | Figure 5-3A



ENVIRON | Locations Exceeding PRG for PAHs, Residential Scenario
Harbor-at-Hastings, Hastings-on-Hudson, NY | Figure 5-3B



ENVIRON | Locations Exceeding PRG for Lead*, Residential Scenario
Harbor-at-Hastings, Hastings-on-Hudson, NY | Figure 5-3C

* PRGS FOR LEAD BASED UPON EPA SCREENING LEVELS, NOT RISK FACTORS

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FIGURE 2–3
AREAS EXCEEDING PRGS AT 1E–5 RISK AND HQ OF 1: RESIDENTIAL SCENARIO
HARBOR AT HASTINGS
HASTINGS–ON HUDSON, NEW YORK

REFERENCE:
DRAWING SOURCE: DRAFT HUMAN HEALTH RISK ASSESSMENT ENVIRON CORPORATION, AUGUST 2000.

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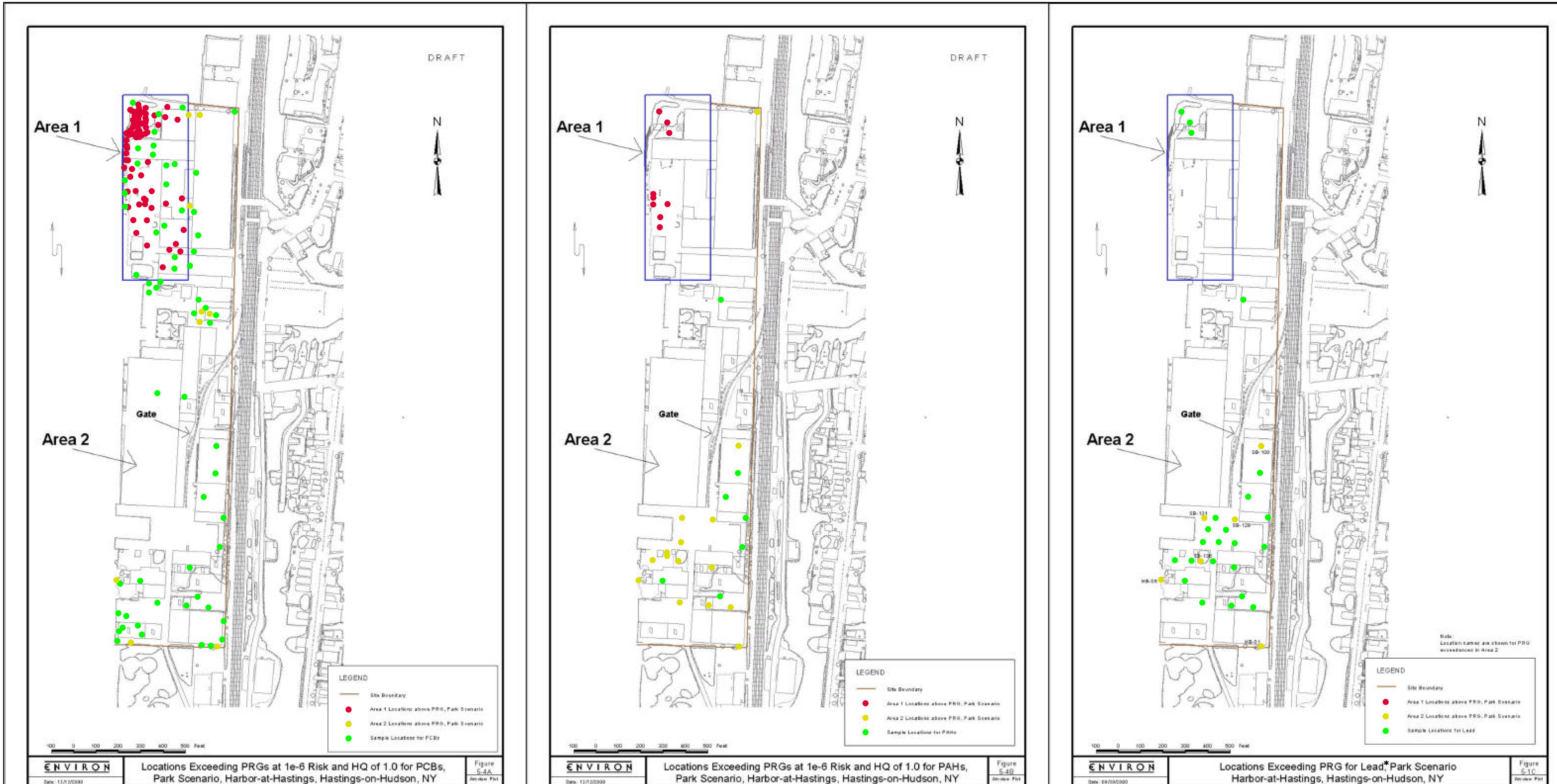

* PRGS FOR LEAD BASED UPON EPA SCREENING LEVELS, NOT RISK FACTORS

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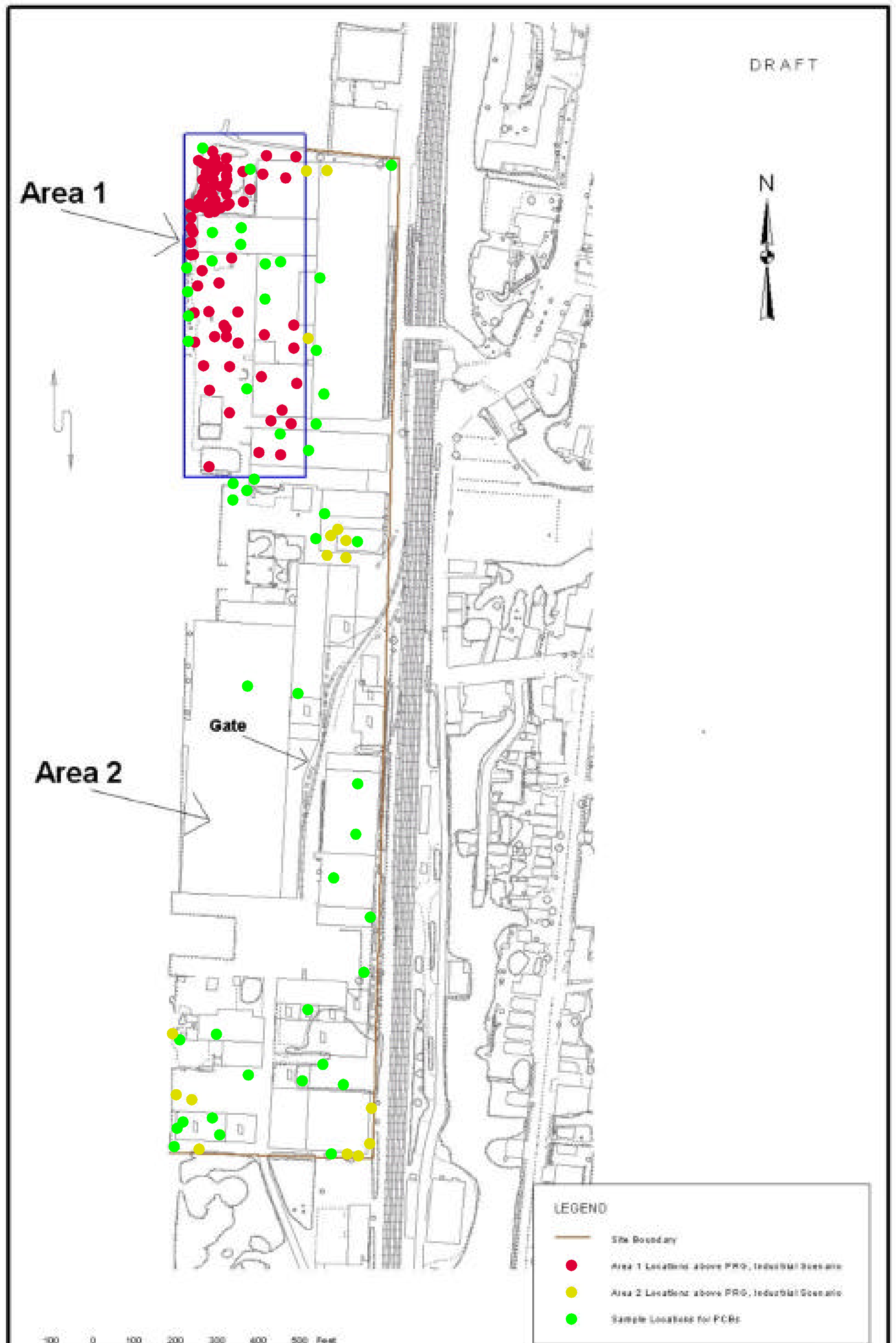
FIGURE 2–4
AREAS EXCEEDING PRGS AT 1E–6 RISK AND HQ OF 1: PARK SCENARIO
HARBOR AT HASTINGS
HASTINGS–ON HUDSON, NEW YORK

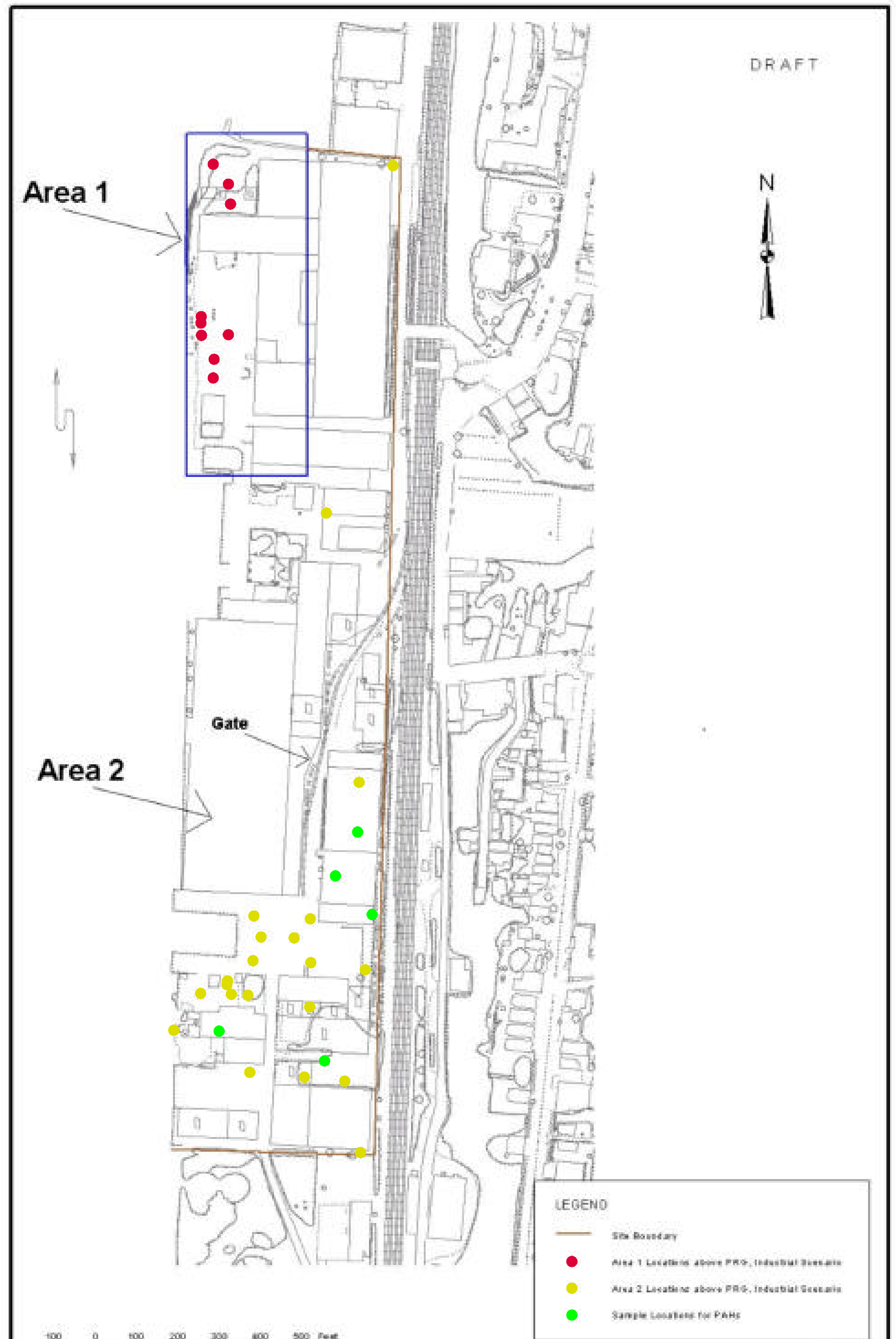
REFERENCE:
DRAWING SOURCE: DRAFT HUMAN HEALTH RISK ASSESSMENT ENVIRON CORPORATION, AUGUST 2000.



ENVIRON
Date: 12/12/2000

Locations Exceeding PRGs at 1e-6 Risk and HQ of 1.0 for PCBs, Commercial/Industrial Scenario, Harbor-at-Hastings, Hastings-on-Hudson, NY

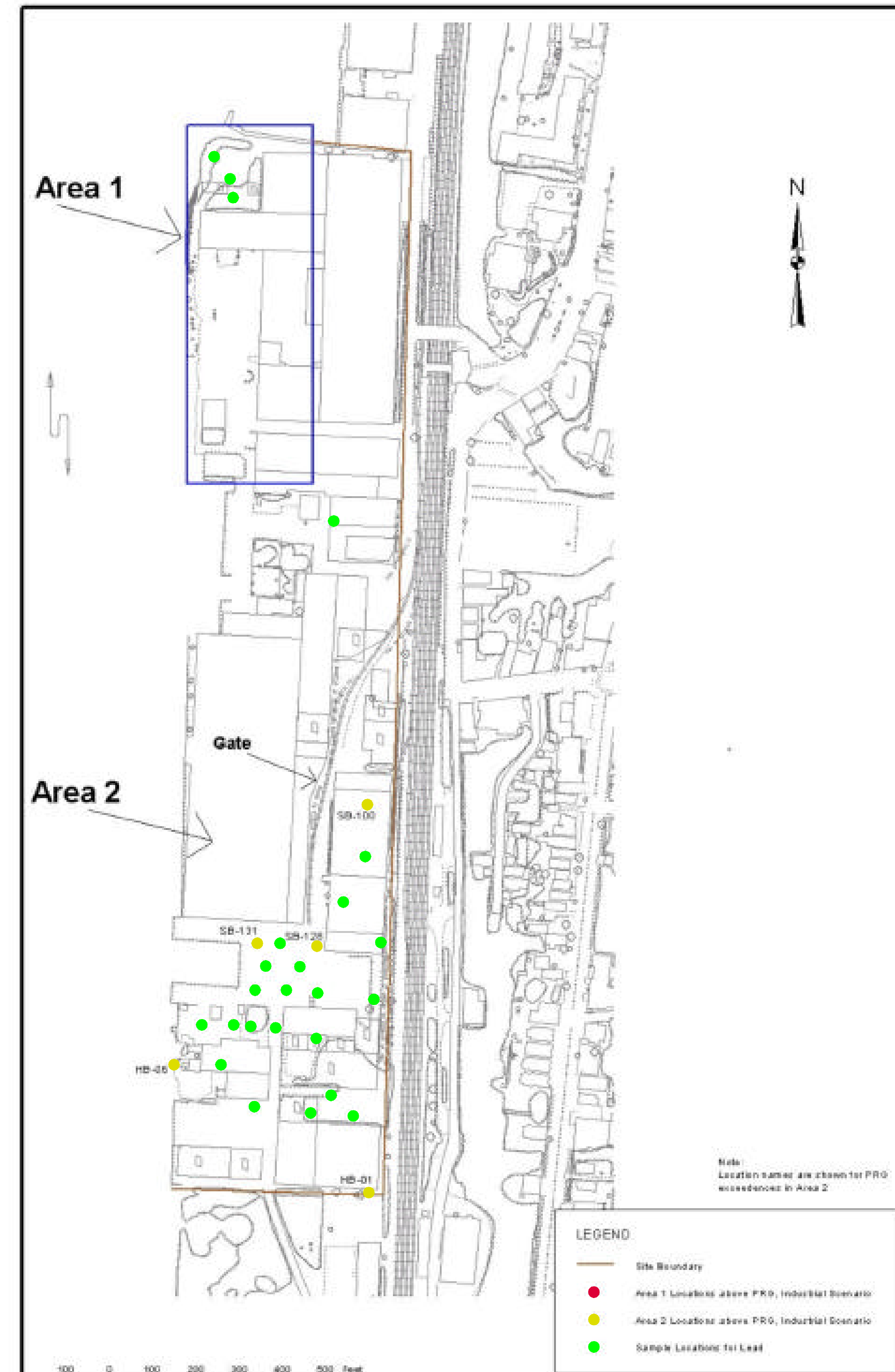
Figure 5-5A
Review Plot



ENVIRON
Date: 12/12/2000

Locations Exceeding PRGs at 1e-6 Risk and HQ of 1.0 for PAHs, Commercial/Industrial Scenario, Harbor-at-Hastings, Hastings-on-Hudson, NY

Figure 5-5B
Review Plot



ENVIRON

Locations Exceeding PRG for Lead,* Commercial/Industrial Scenario Harbor-at-Hastings, Hastings-on-Hudson, NY

Figure 5-2C
Review Plot

* PRGS FOR LEAD BASED UPON EPA SCREENING LEVELS, NOT RISK FACTORS

REFERENCE:
DRAWING SOURCE: DRAFT HUMAN HEALTH RISK ASSESSMENT
ENVIRON CORPORATION, AUGUST 2000.

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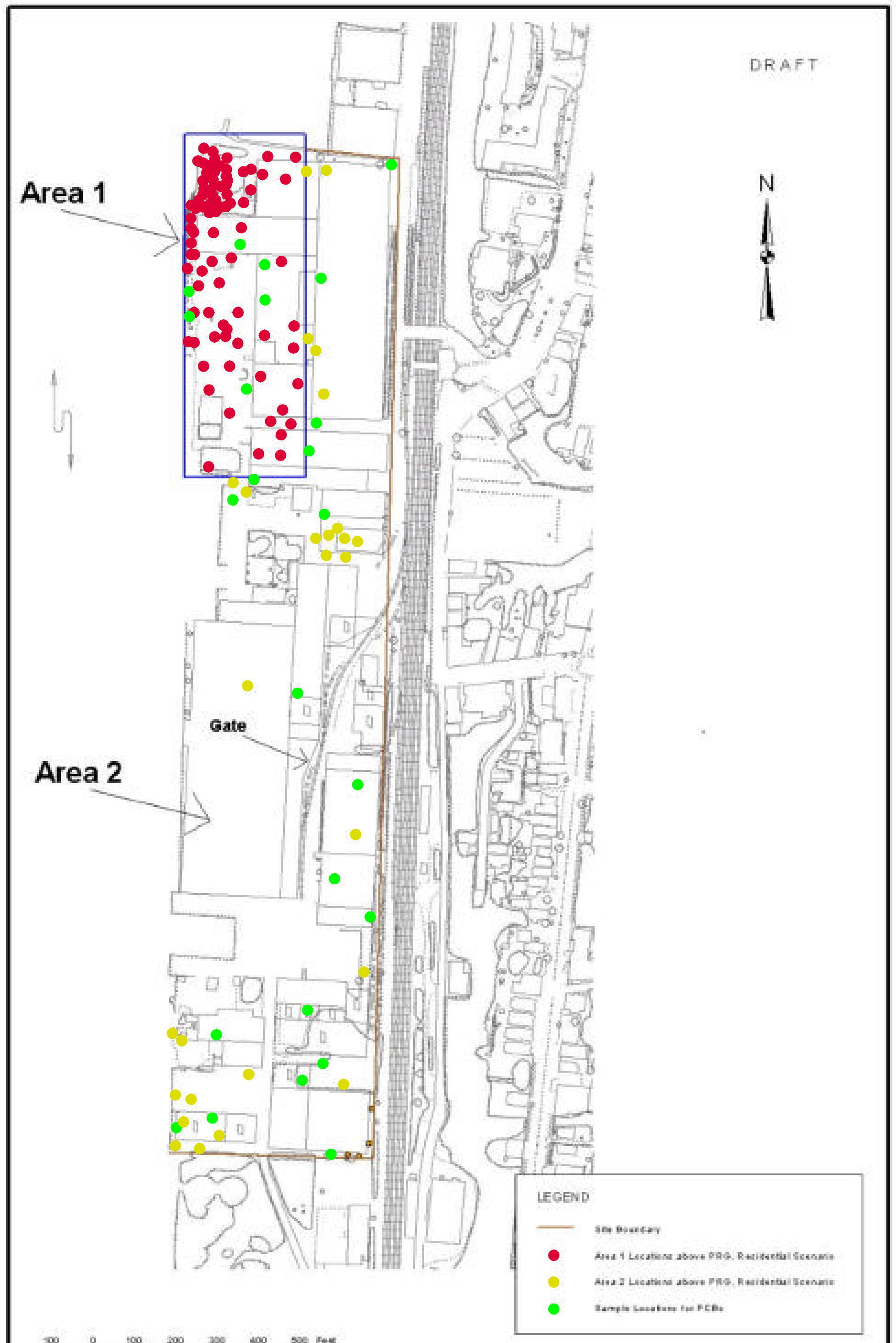
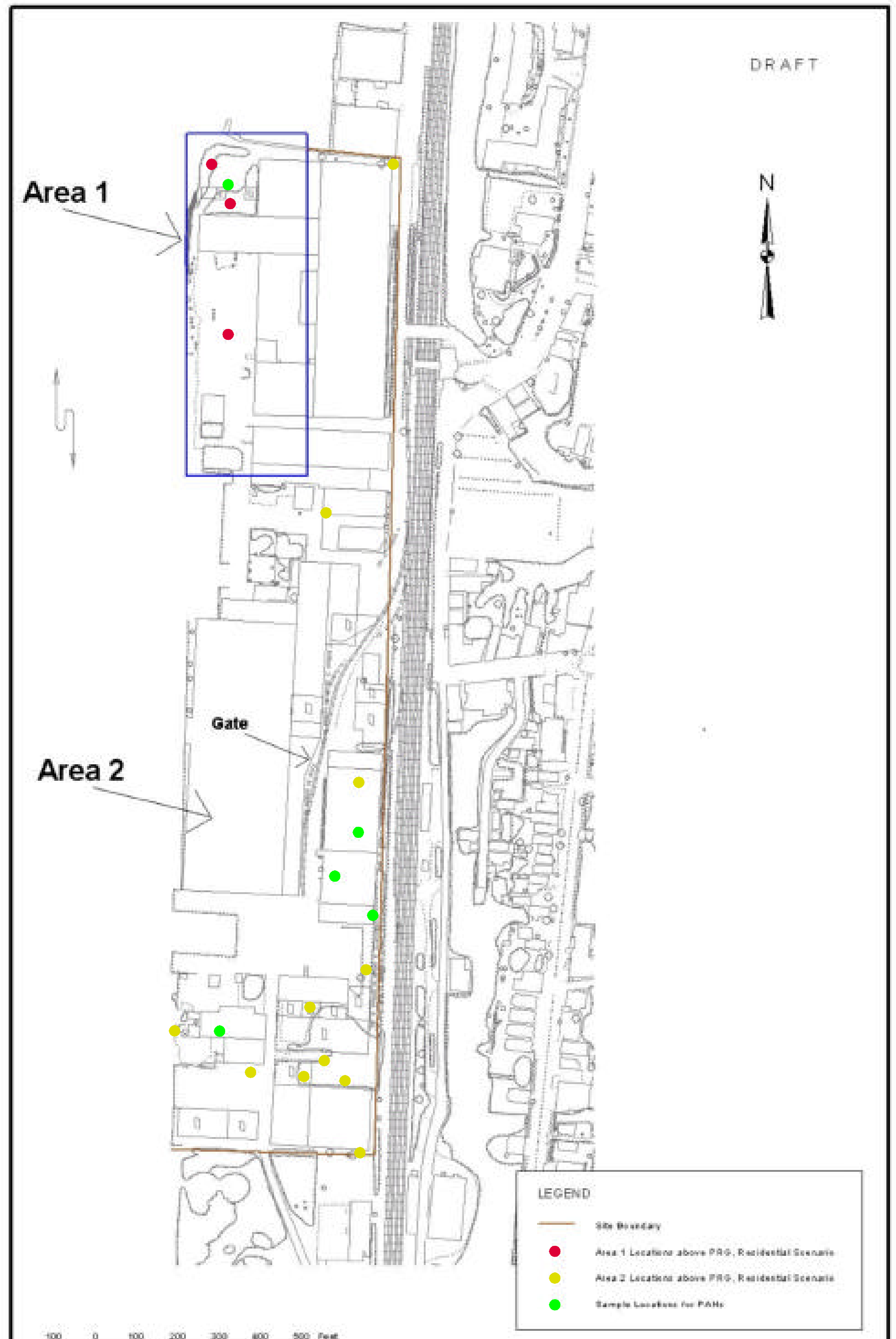
FIGURE 2–5
AREAS EXCEEDING PRGS AT 1E–6 RISK AND HQ OF 1: COMMERCIAL/INDUSTRIAL SCENARIO
HARBOR AT HASTINGS
HASTINGS–ON HUDSON, NEW YORK



ENVIRON

Locations Exceeding PRGs at 1e-6 Risk and HQ of 1.0 for PCBs, Residential Scenario, Harbor-at-Hastings, Hastings-on-Hudson, NY

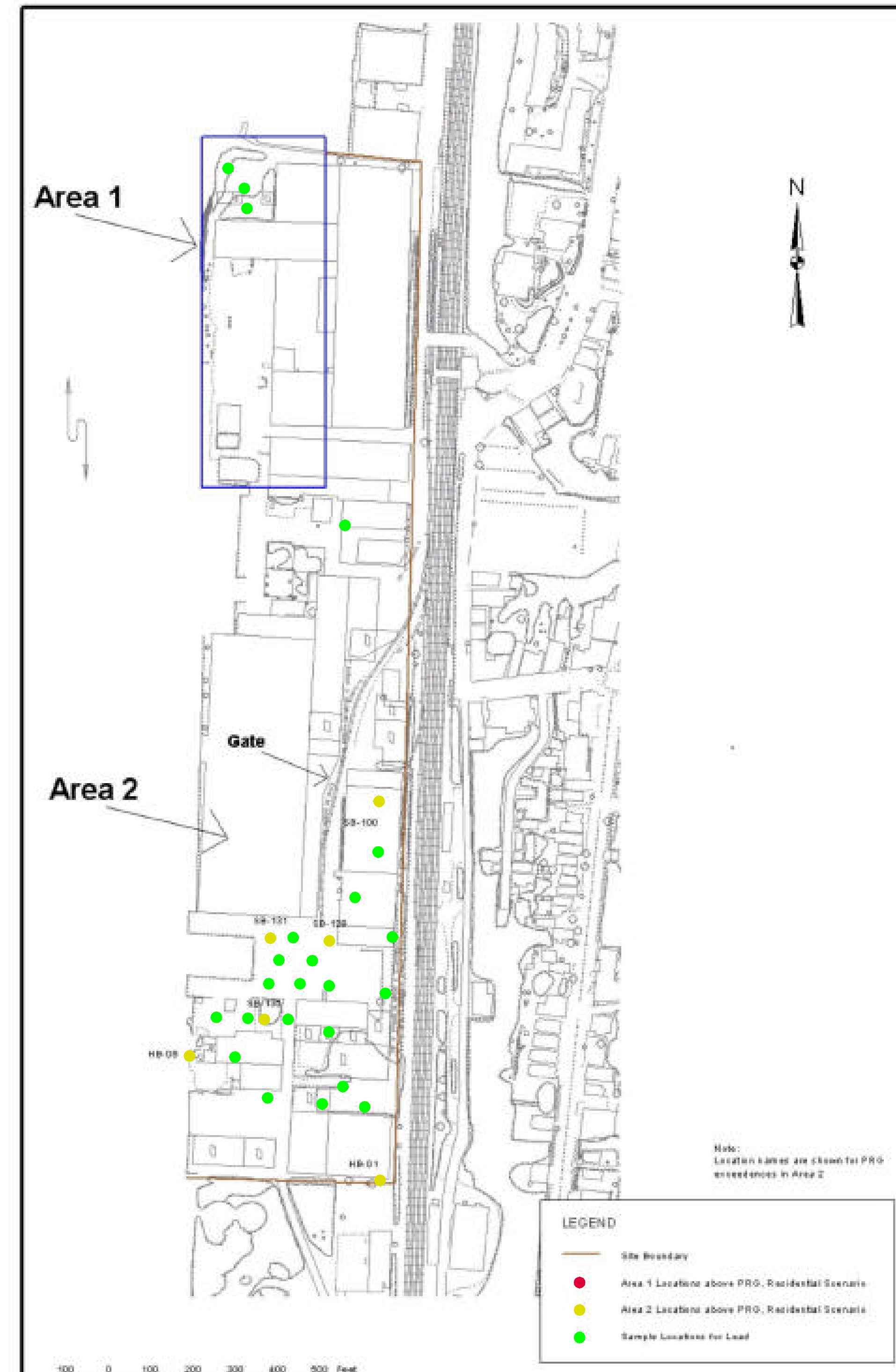
Figure 5-6A



ENVIRON

Locations Exceeding PRGs at 1e-6 Risk and HQ of 1.0 for PAHs, Residential Scenario, Harbor-at-Hastings, Hastings-on-Hudson, NY

Figure 5-6B



ENVIRON

Locations Exceeding PRG for Lead,* Residential Scenario Harbor-at-Hastings, Hastings-on-Hudson, NY

Figure 5-3C

* PRGS FOR LEAD BASED UPON EPA SCREENING LEVELS, NOT RISK FACTORS

REFERENCE:

DRAWING SOURCE: DRAFT HUMAN HEALTH RISK ASSESSMENT ENVIRON CORPORATION, AUGUST 2000.

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FIGURE 2–6
AREAS EXCEEDING PRGS AT 1E–6 RISK AND HQ OF 1: RESIDENTIAL SCENARIO
HARBOR AT HASTINGS
HASTINGS–ON HUDSON, NEW YORK

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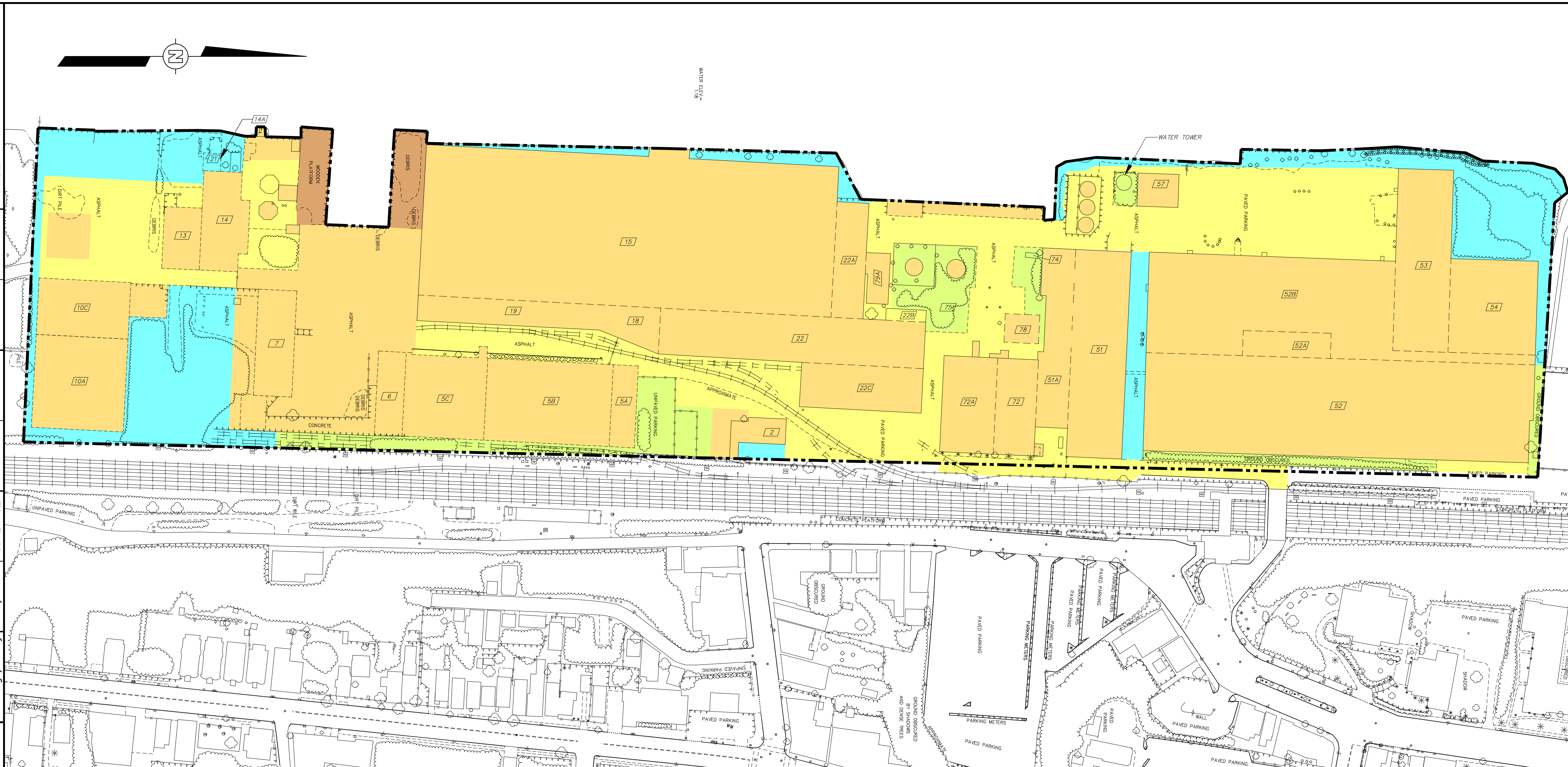

LEGEND:

APPROXIMATE SITE BOUNDARY

15 BUILDING DESIGNATION

FORMER BUILDING OR STRUCTURE

ASPHALT

CONCRETE

EXPOSED–FILL

GRAVEL/ROCK

WOOD

SCALE

0 80 160 240 FEET

REFERENCES:

1. TOPOGRAPHY AND PLANIMETRICS PROVIDED BY GEOD PHOTOGRAMMETRIC SCIENCES SURVEY TECHNOLOGIES. MAPPED BY PHOTOGRAMMETRIC METHODS FROM AERIAL PHOTOGRAPHS TAKEN 12–08–1995. GRIDS BASED ON NEW YORK 1988 STATE PLANE COORDINATE SYSTEM. VERTICAL DATUM IS BASED ON NAD 1983. RI SAMPLE LOCATIONS SURVEYED BY GEOD.
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FIGURE 3–1

EXISTING SURFACE CONDITIONS

HARBOR AT HASTINGS

HASTINGS–ON–HUDSON, NEW YORK

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REFERENCES:

1.) TOPOGRAPHY AND PLANIMETRICS PROVIDED BY GEOD PHOTOGRAMMETRIC SCIENCES SURVEY TECHNOLOGIES. MAPPED BY PHOTOGRAMMETRIC METHODS FROM AERIAL PHOTOGRAPHS TAKEN 12-08-1995. GRIDS BASED ON NEW YORK 1988 STATE PLANE COORDINATE SYSTEM. VERTICAL DATUM IS BASED ON NAD 1983. RI SAMPLE LOCATIONS SURVEYED BY GEOD.

2.) HISTORICAL SAMPLING LOCATIONS BASED ON DOLPH ROTFELD, FIGURE 4, DATED 1976, PARISH & WEINER, PLATE 2, DATED OCTOBER 1989 AND RETEC, FIGURE 2-8, DATED DECEMBER 1993. THESE LOCATIONS ARE APPROXIMATE ONLY, AS LAND SURVEYING DATA ARE NOT AVAILABLE.

3.) EXISTING BUILDING DESIGNATIONS ARE BASED ON DOLPH ROTFELD ASSOCIATES FIGURE 4, DATED NOVEMBER 1996. BUILDING INTERIOR DIVISION LOCATIONS ARE APPROXIMATE ONLY.

LEGEND:

- **A** - COBBLESTONE, BLACKTOP, CONCRETE (FAIR)
- **A'** - MOSTLY BLACKTOP NEAR BUILDING (GOOD)
- **B** - BLACKTOP (GOOD-FAIR)
- **C** - EXPOSED SURFACE (POOR)
- **D** - MOSTLY CRUSHED STONE (FAIR-POOR) AND CONCRETE
- **E** - CONCRETE (GOOD)
- **F** - LARGE GRAVEL AND CRUSHED STONE
- **G** - BLACKTOP (GOOD)
- **H** - BLACKTOP ALONG FENCE (POOR)
- **I** - CONCRETE AND BLACKTOP (FAIR)
- **J** - BLACKTOP, EXPOSED SURFACE, CONCRETE (FAIR-POOR)
- **K** - EXPOSED SURFACE, SOME CONCRETE (POOR)
- **L** - MOSTLY CONCRETE (GOOD-FAIR)
- **M** - CONCRETE (GOOD)
- **N** - CONCRETE (GOOD)
- **O** - CONCRETE (FAIR)
- **P** - CONCRETE, EXPOSED SURFACE (FAIR)
- **Q** - BLACKTOP AND CONCRETE (FAIR-POOR)
- POOR - MANY CRACKS/LARGE HOLES
- FAIR - SOME CRACKS/SMALL HOLES
- GOOD - FEW CRACKS/NO HOLES
- EXCELLENT - NO CRACKS/NO HOLES

PHOTOGRAPH NUMBER AND DIRECTION OF CAMERA WHEN PHOTO WAS TAKEN

PHOTOGRAPH OF SITE SURFACE CONDITIONS

APPROXIMATE SITE BOUNDARY

APPROXIMATELY 1,160,026 SQ FT INCLUDING BUILDING FOOTAGE
APPROXIMATELY 500,211 SQ FT OCCUPIED BY BUILDINGS
APPROXIMATELY 659,815 SQ FT PROPERTY LESS BUILDING FOOTAGE

8' GROUND SURFACE ELEVATION CONTOUR IN FEET DASHED WHERE INFERRED

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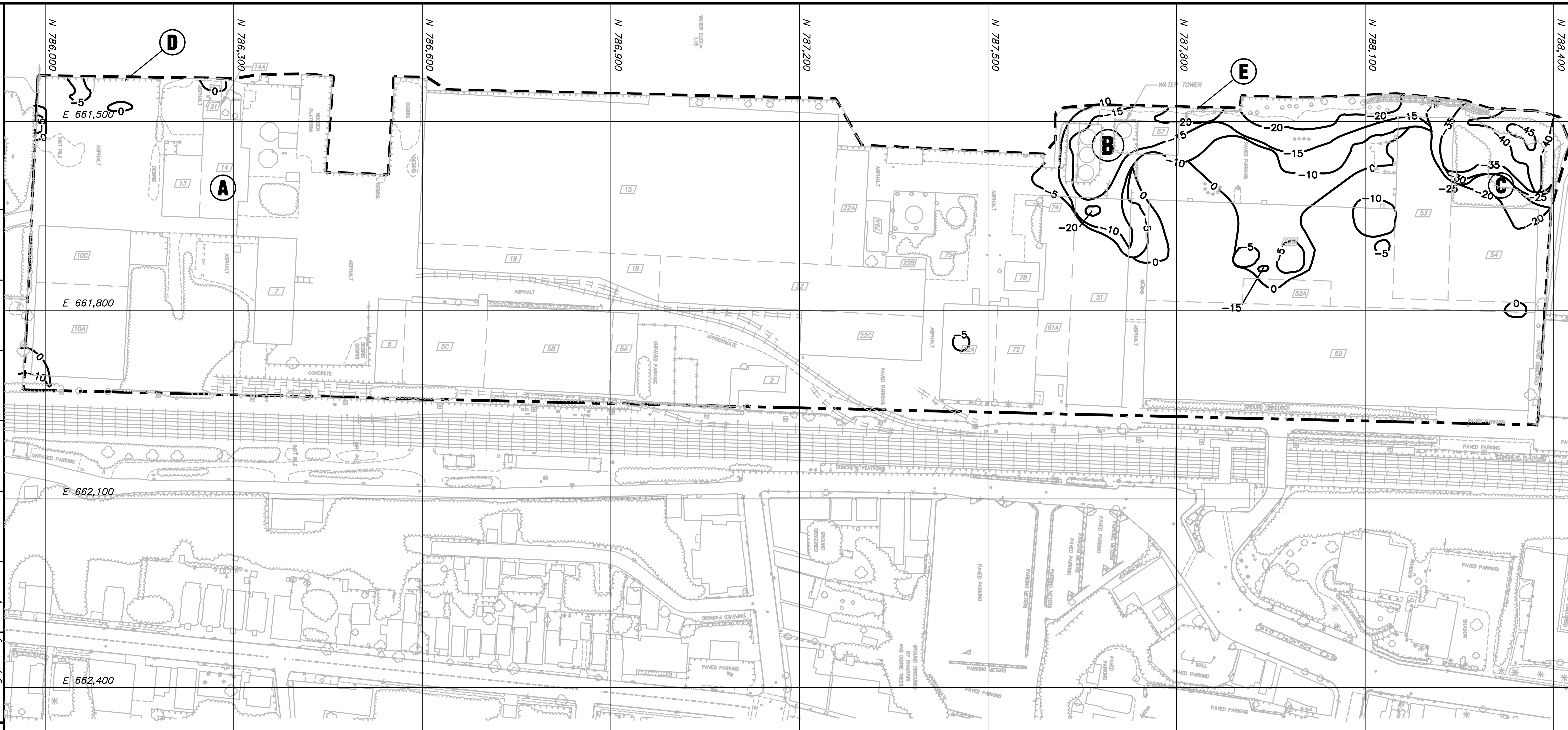
FIGURE 3-2
PHOTOGRAPHIC LOG OF EXISTING SURFACE CONDITIONS
HARBOR AT HASTINGS
HASTINGS-ON HUDSON, NEW YORK



LEGEND:

15	BUILDING DESIGNATION
━ ‒ ‒ ━	APROXIMATE SITE BOUNDARY
━ ━ ━ ━	BULKHEAD
── -5 ──	DEPTH TO CONTAMINATION CONTOUR

INTERIM REMEDIAL MEASURES

(A)	BUILDING 14 SUMP CLOSURE IRM
(B)	SEPARATE PHASE LIQUID RECOVERY IRM
(C)	NORTHWEST CORNER IRM
(D)	SOUTHWEST CORNER BULKHEAD IRM
(E)	BUILDING 57 SHORELINE IRM

REFERENCES:

1. TOPOGRAPHY AND PLANIMETRICS PROVIDED BY GEOD PHOTOGRAMMETRIC SCIENCES SURVEY TECHNOLOGIES. MAPPED BY PHOTOGRAMMETRIC METHODS FROM AERIAL PHOTOGRAPHS TAKEN 12-08-1995. GRIDS BASED ON NEW YORK 1988 STATE PLANE COORDINATE SYSTEM. VERTICAL DATUM IS BASED ON NAD 1983. RI SAMPLE LOCATIONS SURVEYED BY GEOD.
2. EXISTING BUILDING DESIGNATIONS ARE BASED ON DOLPH ROTFELD ASSOCIATES FIGURE 4, DATED NOVEMBER 1996. BUILDING INTERIOR DIVISION LOCATIONS ARE APPROXIMATE ONLY.

SCALE

0 160 320 FEET

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COMPANY

FIGURE 4-1

REMEDIAL ALTERNATIVE NO. 1
HARBOR AT HASTINGS
HASTINGS-ON-HUDSON, NEW YORK

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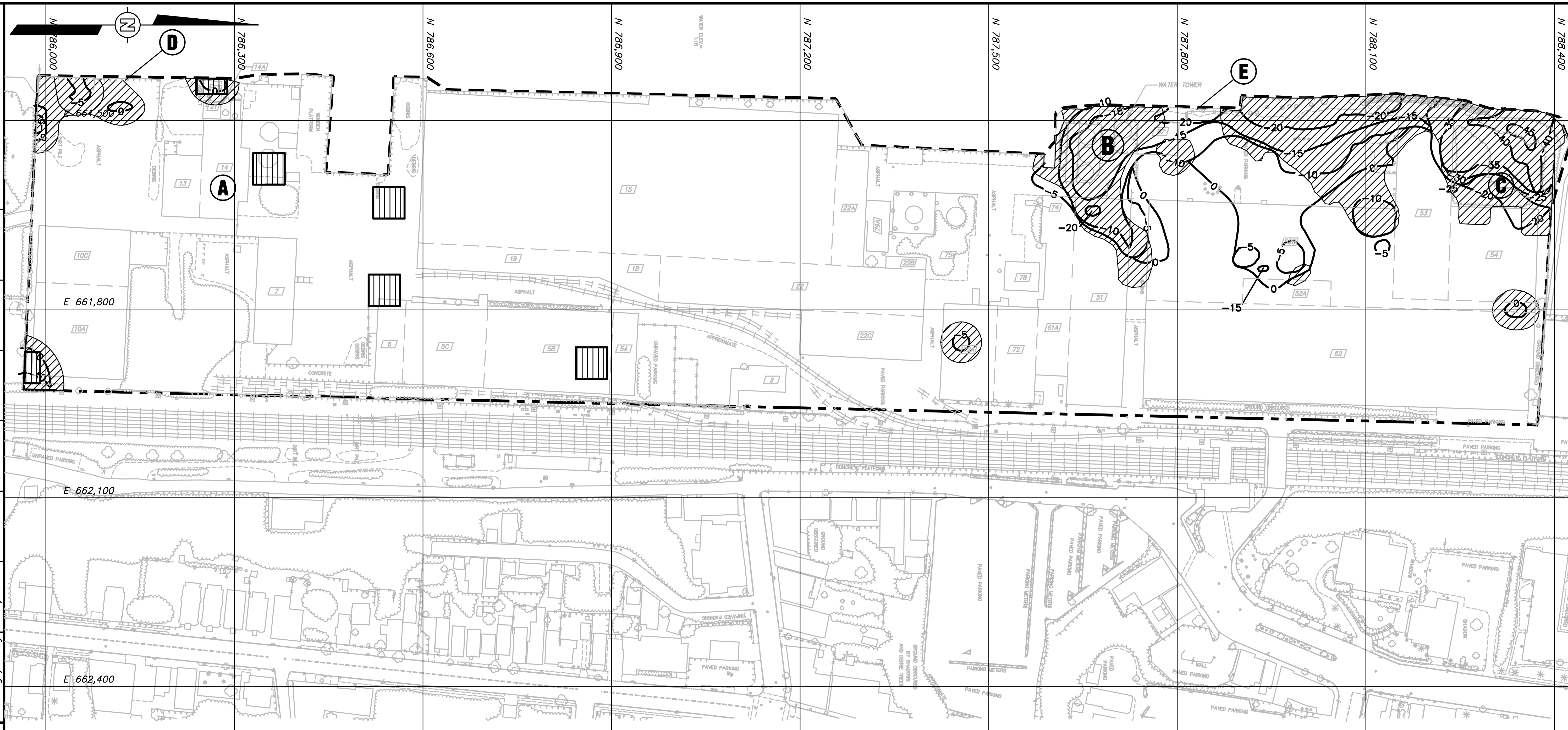

LEGEND:

15	BUILDING DESIGNATION
— - —	APROXIMATE SITE BOUNDARY
— — —	BULKHEAD
—-5—	DEPTH TO CONTAMINATION CONTOUR
(hatched)	EXCAVATION FOR DISPOSAL (>10 PPM)
(vertical lines)	EXCAVATION FOR DISPOSAL (LEAD HOT SPOTS)

INTERIM REMEDIAL MEASURES

A	BUILDING 14 SUMP CLOSURE IRM
B	SEPARATE PHASE LIQUID RECOVERY IRM
C	NORTHWEST CORNER IRM
D	SOUTHWEST CORNER BULKHEAD IRM
E	BUILDING 57 SHORELINE IRM

SCALE

0 160 320 FEET

REFERENCES:

1. TOPOGRAPHY AND PLANIMETRICS PROVIDED BY GEOD PHOTOGRAMMETRIC SCIENCES SURVEY TECHNOLOGIES. MAPPED BY PHOTOGRAMMETRIC METHODS FROM AERIAL PHOTOGRAPHS TAKEN 12-08-1995. GRIDS BASED ON NEW YORK 1988 STATE PLANE COORDINATE SYSTEM. VERTICAL DATUM IS BASED ON NAD 1983. RI SAMPLE LOCATIONS SURVEYED BY GEOD.
2. EXISTING BUILDING DESIGNATIONS ARE BASED ON DOLPH ROTFELD ASSOCIATES FIGURE 4, DATED NOVEMBER 1996. BUILDING INTERIOR DIVISION LOCATIONS ARE APPROXIMATE ONLY.

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FIGURE 4-2

REMEDIAL ALTERNATIVE NO. 2

HARBOR AT HASTINGS

HASTINGS-ON-HUDSON, NEW YORK

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Format Revised: 12/15/99

LEGEND:

15	BUILDING DESIGNATION
— - - —	APROXIMATE SITE BOUNDARY
— — — —	BULKHEAD
—— -5 ——	DEPTH TO CONTAMINATION CONTOUR
(hatched)	EXCAVATION FOR DISPOSAL (≥10 PPM)
(stippled)	EXCAVATION TO WATER TABLE
(vertical lines)	EXCAVATION FOR DISPOSAL (LEAD HOT SPOTS)

INTERIM REMEDIAL MEASURES

- Ⓐ BUILDING 14 SUMP CLOSURE IRM
- Ⓑ SEPARATE PHASE LIQUID RECOVERY IRM
- Ⓒ NORTHWEST CORNER IRM
- Ⓓ SOUTHWEST CORNER BULKHEAD IRM
- Ⓔ BUILDING 57 SHORELINE IRM

SCALE

0 160 320 FEET

REFERENCES:

1. TOPOGRAPHY AND PLANIMETRICS PROVIDED BY GEOD PHOTOGRAMMETRIC SCIENCES SURVEY TECHNOLOGIES. MAPPED BY PHOTOGRAMMETRIC METHODS FROM AERIAL PHOTOGRAPHS TAKEN 12-08-1995. GRIDS BASED ON NEW YORK 1988 STATE PLANE COORDINATE SYSTEM. VERTICAL DATUM IS BASED ON NAD 1983. RI SAMPLE LOCATIONS SURVEYED BY GEOD.
2. EXISTING BUILDING DESIGNATIONS ARE BASED ON DOLPH ROTFELD ASSOCIATES FIGURE 4, DATED NOVEMBER 1996. BUILDING INTERIOR DIVISION LOCATIONS ARE APPROXIMATE ONLY.

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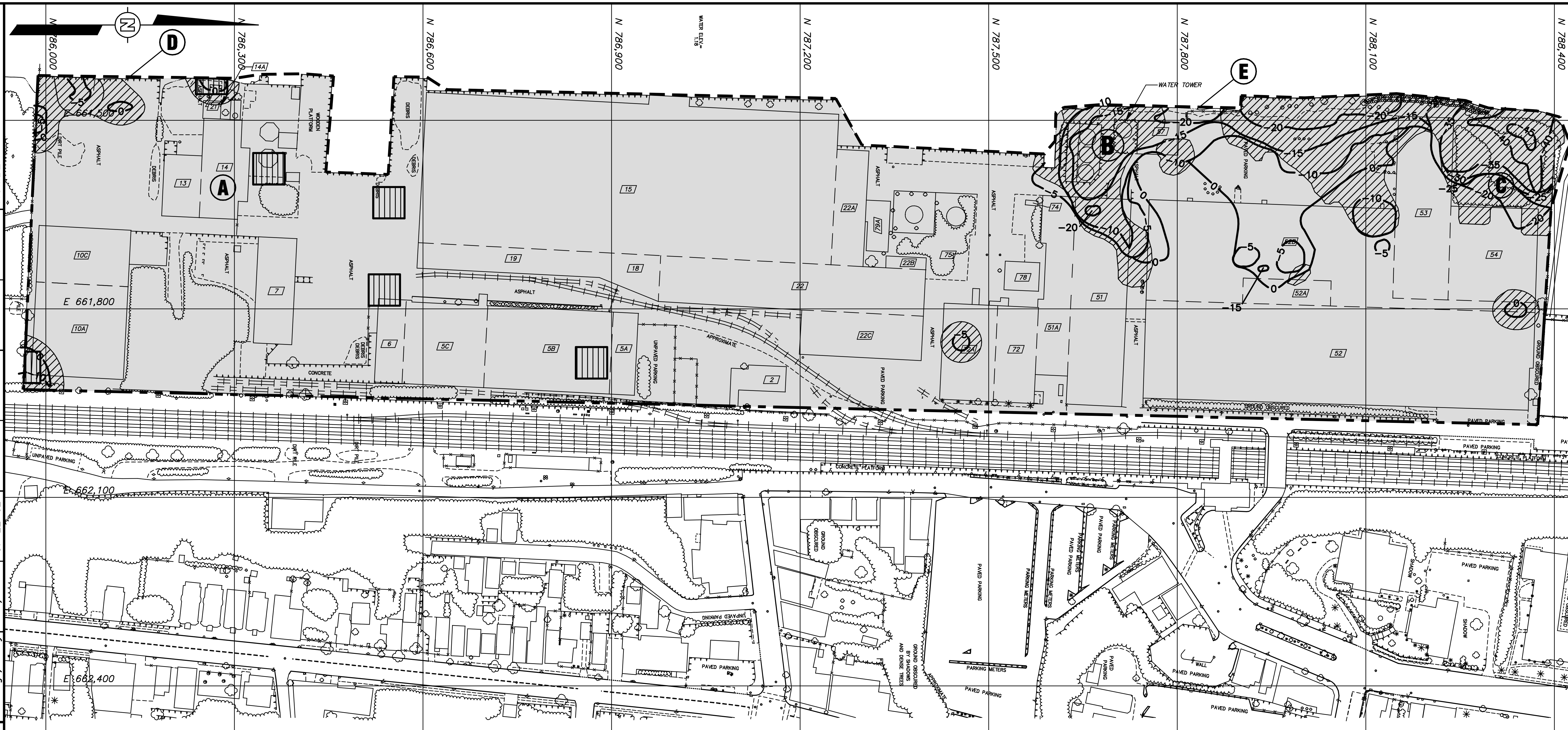
FIGURE 4-3

REMEDIAL ALTERNATIVE NO. 3
HARBOR AT HASTINGS
HASTINGS-ON-HUDSON, NEW YORK



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REFERENCES:

1. TOPOGRAPHY AND PLANIMETRICS PROVIDED BY GEOD PHOTOGRAMMETRIC SCIENCES SURVEY TECHNOLOGIES. MAPPED BY PHOTOGRAMMETRIC METHODS FROM AERIAL PHOTOGRAPHS TAKEN 12-08-1995. GRIDS BASED ON NEW YORK 1988 STATE PLANE COORDINATE SYSTEM. VERTICAL DATUM IS BASED ON NAD 1983. RI SAMPLE LOCATIONS SURVEYED BY GEOD.
2. EXISTING BUILDING DESIGNATIONS ARE BASED ON DOLPH ROTFELD ASSOCIATES FIGURE 4, DATED NOVEMBER 1996. BUILDING INTERIOR DIVISION LOCATIONS ARE APPROXIMATE ONLY.

LEGEND:

- 15 — BUILDING DESIGNATION
- APROXIMATE SITE BOUNDARY
- BULKHEAD
- -5 — DEPTH TO CONTAMINATION CONTOUR
- EXCAVATION FOR DISPOSAL (≥10 PPM)
- PART 360 CAP
- EXCAVATION FOR DISPOSAL (LEAD HOT SPOTS)

INTERIM REMEDIAL MEASURES

- (A) BUILDING 14 SUMP CLOSURE IRM
- (B) SEPARATE PHASE LIQUID RECOVERY IRM
- (C) NORTHWEST CORNER IRM
- (D) SOUTHWEST CORNER BULKHEAD IRM
- (E) BUILDING 57 SHORELINE IRM

SCALE

0 160 320 FEET

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FIGURE 4-4

REMEDIAL ALTERNATIVE NO. 4
HARBOR AT HASTINGS
HASTINGS-ON-HUDSON, NEW YORK

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LEGEND:

- 15 — BUILDING DESIGNATION
- APROXIMATE SITE BOUNDARY
- BULKHEAD
- −5 — DEPTH TO CONTAMINATION CONTOUR
- SLURRY TRENCH
- EXCAVATION FOR DISPOSAL (≥10 PPM)
- EXCAVATION TO WATER TABLE
- PART 360 CAP
- EXCAVATION OF RUBBERY MATRIX
- EXCAVATION FOR DISPOSAL (LEAD HOT SPOTS)

INTERIM REMEDIAL MEASURES

- A — BUILDING 14 SUMP CLOSURE IRM
- B — SEPARATE PHASE LIQUID RECOVERY IRM
- C — NORTHWEST CORNER IRM
- D — SOUTHWEST CORNER BULKHEAD IRM
- E — BUILDING 57 SHORELINE IRM

SCALE

0 160 320 FEET

REFERENCES:

1. TOPOGRAPHY AND PLANIMETRICS PROVIDED BY GEOD PHOTOGRAMMETRIC SCIENCES SURVEY TECHNOLOGIES. MAPPED BY PHOTOGRAMMETRIC METHODS FROM AERIAL PHOTOGRAPHS TAKEN 12-08-1995. GRIDS BASED ON NEW YORK 1988 STATE PLANE COORDINATE SYSTEM. VERTICAL DATUM IS BASED ON NAD 1983. RI SAMPLE LOCATIONS SURVEYED BY GEOD.
2. EXISTING BUILDING DESIGNATIONS ARE BASED ON DOLPH ROTFELD ASSOCIATES FIGURE 4, DATED NOVEMBER 1996. BUILDING INTERIOR DIVISION LOCATIONS ARE APPROXIMATE ONLY.

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FIGURE 4-5

REMEDIAL ALTERNATIVE NO. 5
HARBOR AT HASTINGS
HASTINGS-ON-HUDSON, NEW YORK

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LEGEND:

15	BUILDING DESIGNATION
— - —	APROXIMATE SITE BOUNDARY
— — —	BULKHEAD
—-5—	DEPTH TO CONTAMINATION CONTOUR
—o—	SLURRY TRENCH
(vertical hatch)	EXCAVATION FOR DISPOSAL (LEAD HOT SPOTS)
(diagonal hatch)	EXCAVATION OF RUBBERY MATRIX
(grey fill)	PART 360 CAP

INTERIM REMEDIAL MEASURES

A	BUILDING 14 SUMP CLOSURE IRM
B	SEPARATE PHASE LIQUID RECOVERY IRM
C	NORTHWEST CORNER IRM
D	SOUTHWEST CORNER BULKHEAD IRM
E	BUILDING 57 SHORELINE IRM

SCALE

0 160 320 FEET

REFERENCES:

1. TOPOGRAPHY AND PLANIMETRICS PROVIDED BY GEOD PHOTOGRAMMETRIC SCIENCES SURVEY TECHNOLOGIES. MAPPED BY PHOTOGRAMMETRIC METHODS FROM AERIAL PHOTOGRAPHS TAKEN 12-08-1995. GRIDS BASED ON NEW YORK 1988 STATE PLANE COORDINATE SYSTEM. VERTICAL DATUM IS BASED ON NAD 1983. RI SAMPLE LOCATIONS SURVEYED BY GEOD.
2. EXISTING BUILDING DESIGNATIONS ARE BASED ON DOLPH ROTFELD ASSOCIATES FIGURE 4, DATED NOVEMBER 1996. BUILDING INTERIOR DIVISION LOCATIONS ARE APPROXIMATE ONLY.

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FIGURE 4-6

REMEDIAL ALTERNATIVE NO. 6
HARBOR AT HASTINGS
HASTINGS-ON-HUDSON, NEW YORK

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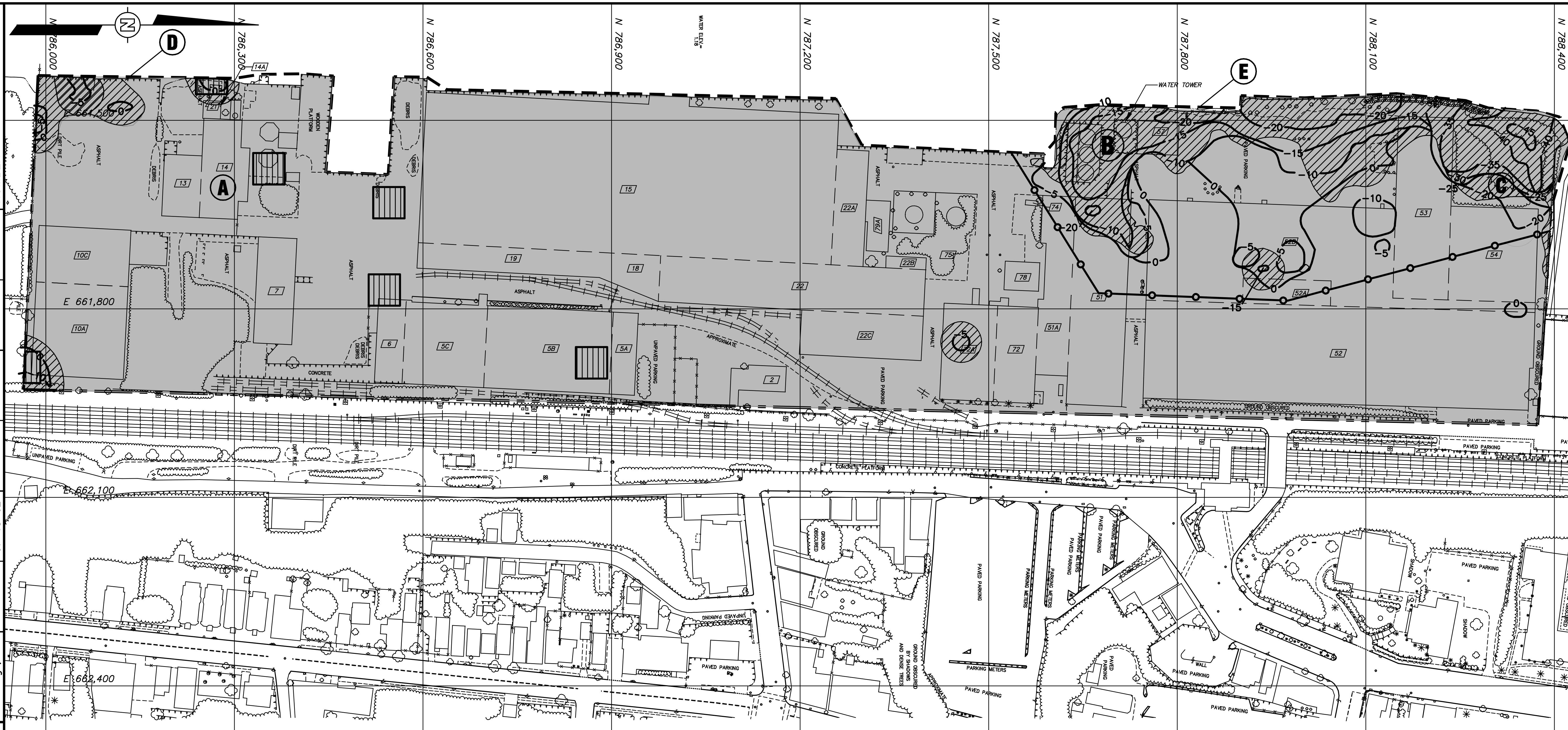

LEGEND:

15	BUILDING DESIGNATION
— - —	APROXIMATE SITE BOUNDARY
— — —	BULKHEAD
—5—	DEPTH TO CONTAMINATION CONTOUR
—o—	SLURRY TRENCH
(diagonal hatch)	EXCAVATION FOR DISPOSAL (≥ 10 PPM LIMITED TO THE ELEVATION OF THE GROUNDWATER TABLE)
(vertical hatch)	EXCAVATION FOR DISPOSAL (LEAD HOT SPOTS)
(shaded)	CONTACT BARRIER AND SOIL COVER

INTERIM REMEDIAL MEASURES

A	BUILDING 14 SUMP CLOSURE IRM
B	SEPARATE PHASE LIQUID RECOVERY IRM
C	NORTHWEST CORNER IRM
D	SOUTHWEST CORNER BULKHEAD IRM
E	BUILDING 57 SHORELINE IRM

SCALE

0 160 320 FEET

REFERENCES:

1. TOPOGRAPHY AND PLANIMETRICS PROVIDED BY GEOD PHOTOGRAMMETRIC SCIENCES SURVEY TECHNOLOGIES. MAPPED BY PHOTOGRAMMETRIC METHODS FROM AERIAL PHOTOGRAPHS TAKEN 12-08-1995. GRIDS BASED ON NEW YORK 1988 STATE PLANE COORDINATE SYSTEM. VERTICAL DATUM IS BASED ON NAD 1983. RI SAMPLE LOCATIONS SURVEYED BY GEOD.
2. EXISTING BUILDING DESIGNATIONS ARE BASED ON DOLPH ROTFELD ASSOCIATES FIGURE 4, DATED NOVEMBER 1996. BUILDING INTERIOR DIVISION LOCATIONS ARE APPROXIMATE ONLY.

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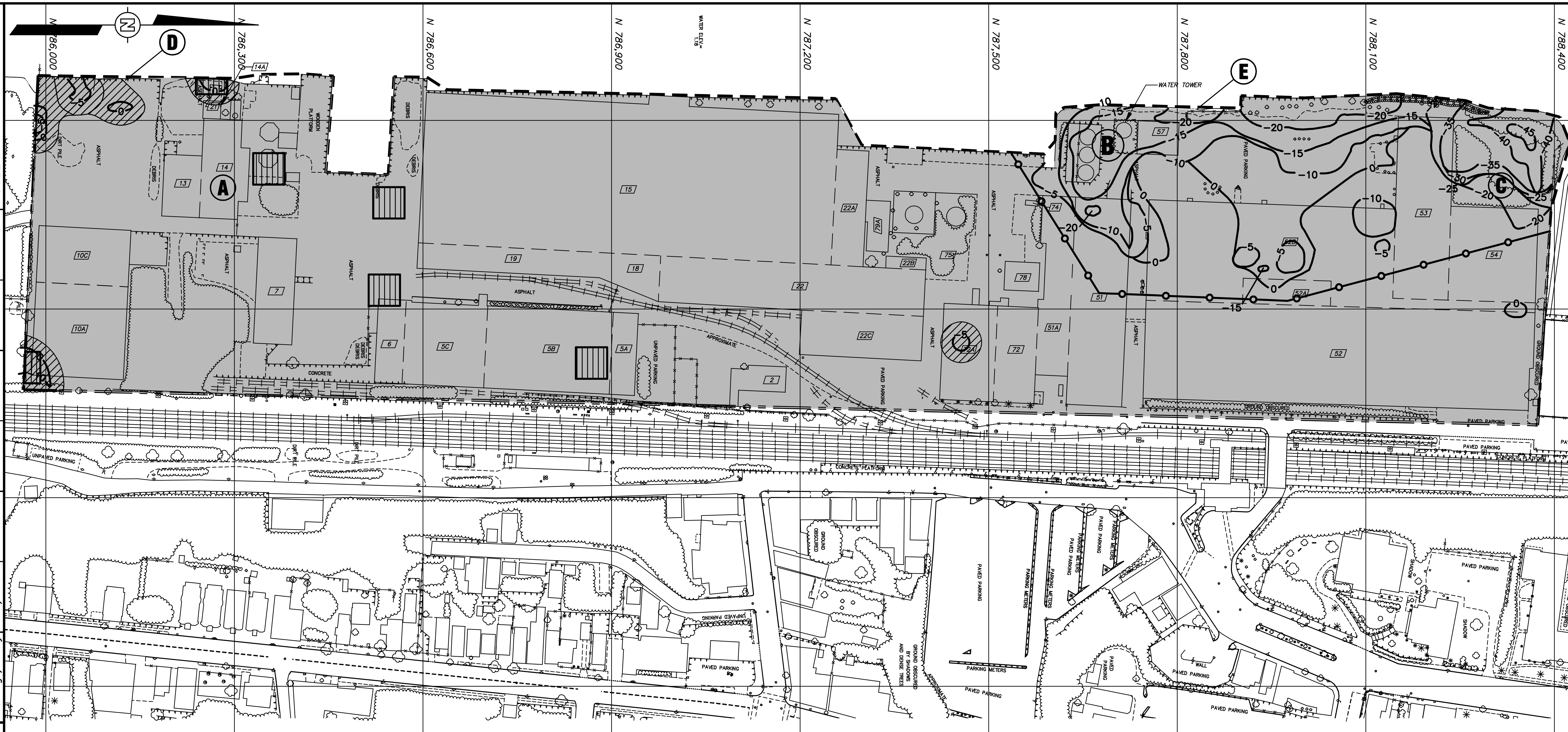
FIGURE 4-7

REMEDIAL ALTERNATIVE NO. 7
HARBOR AT HASTINGS
HASTINGS-ON-HUDSON, NEW YORK



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LEGEND:

15	BUILDING DESIGNATION
— - —	APROXIMATE SITE BOUNDARY
— — —	BULKHEAD
—-5—	DEPTH TO CONTAMINATION CONTOUR
—o—	SLURRY TRENCH
	CONTACT BARRIER AND SOIL COVER
	EXCAVATION FOR DISPOSAL (LEAD HOT SPOTS)
	EXCAVATION FOR DISPOSAL (>THAN 10 PPM)

INTERIM REMEDIAL MEASURES

A	BUILDING 14 SUMP CLOSURE IRM
B	SEPARATE PHASE LIQUID RECOVERY IRM
C	NORTHWEST CORNER IRM
D	SOUTHWEST CORNER BULKHEAD IRM
E	BUILDING 57 SHORELINE IRM

REFERENCES:

1. TOPOGRAPHY AND PLANIMETRICS PROVIDED BY GEOD PHOTOGRAMMETRIC SCIENCES SURVEY TECHNOLOGIES. MAPPED BY PHOTOGRAMMETRIC METHODS FROM AERIAL PHOTOGRAPHS TAKEN 12-08-1995. GRIDS BASED ON NEW YORK 1988 STATE PLANE COORDINATE SYSTEM. VERTICAL DATUM IS BASED ON NAD 1983. RI SAMPLE LOCATIONS SURVEYED BY GEOD.
2. EXISTING BUILDING DESIGNATIONS ARE BASED ON DOLPH ROTFELD ASSOCIATES FIGURE 4, DATED NOVEMBER 1996. BUILDING INTERIOR DIVISION LOCATIONS ARE APPROXIMATE ONLY.

SCALE

0 160 320 FEET

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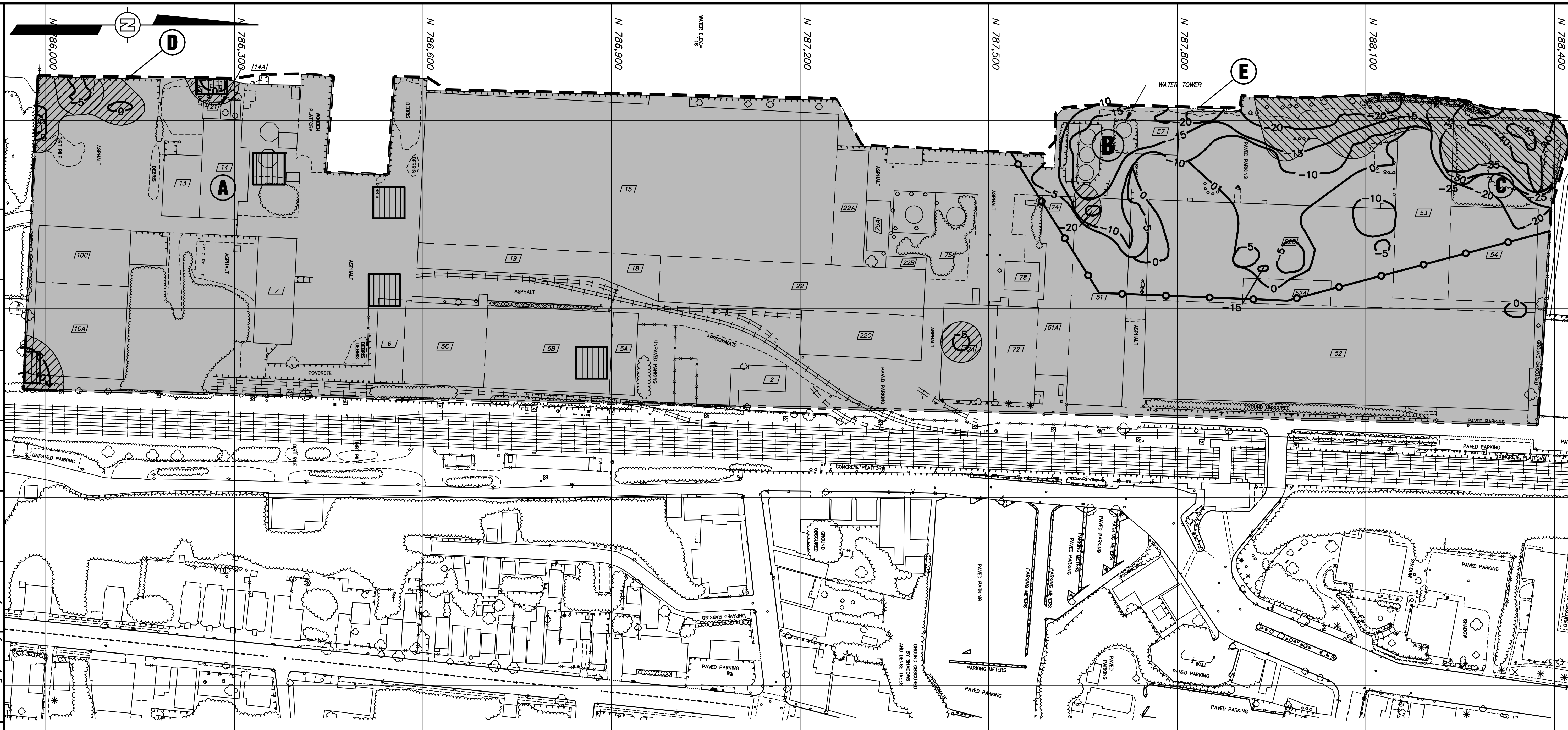
FIGURE 4-8

REMEDIAL ALTERNATIVE NO. 8
HARBOR AT HASTINGS
HASTINGS-ON-HUDSON, NEW YORK



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LEGEND:

15	BUILDING DESIGNATION
— - —	APROXIMATE SITE BOUNDARY
— — —	BULKHEAD
—-5—	DEPTH TO CONTAMINATION CONTOUR
—o—	SLURRY TRENCH
(gray fill)	CONTACT BARRIER AND SOIL COVER
(vertical hatch)	EXCAVATION FOR DISPOSAL (LEAD HOT SPOTS)
(diagonal hatch)	EXCAVATION FOR DISPOSAL (>THAN 10 PPM)
(diagonal hatch, gray)	IN SITU STABILIZATION OF LIQUID RUBBERY MATRIX

INTERIM REMEDIAL MEASURES

- A BUILDING 14 SUMP CLOSURE IRM
- B SEPARATE PHASE LIQUID RECOVERY IRM
- C NORTHWEST CORNER IRM
- D SOUTHWEST CORNER BULKHEAD IRM
- E BUILDING 57 SHORELINE IRM

SCALE

0 160 320 FEET

REFERENCES:

1. TOPOGRAPHY AND PLANIMETRICS PROVIDED BY GEOD PHOTOGRAMMETRIC SCIENCES SURVEY TECHNOLOGIES. MAPPED BY PHOTOGRAMMETRIC METHODS FROM AERIAL PHOTOGRAPHS TAKEN 12-08-1995. GRIDS BASED ON NEW YORK 1988 STATE PLANE COORDINATE SYSTEM. VERTICAL DATUM IS BASED ON NAD 1983. RI SAMPLE LOCATIONS SURVEYED BY GEOD.
2. EXISTING BUILDING DESIGNATIONS ARE BASED ON DOLPH ROTFELD ASSOCIATES FIGURE 4, DATED NOVEMBER 1996. BUILDING INTERIOR DIVISION LOCATIONS ARE APPROXIMATE ONLY.

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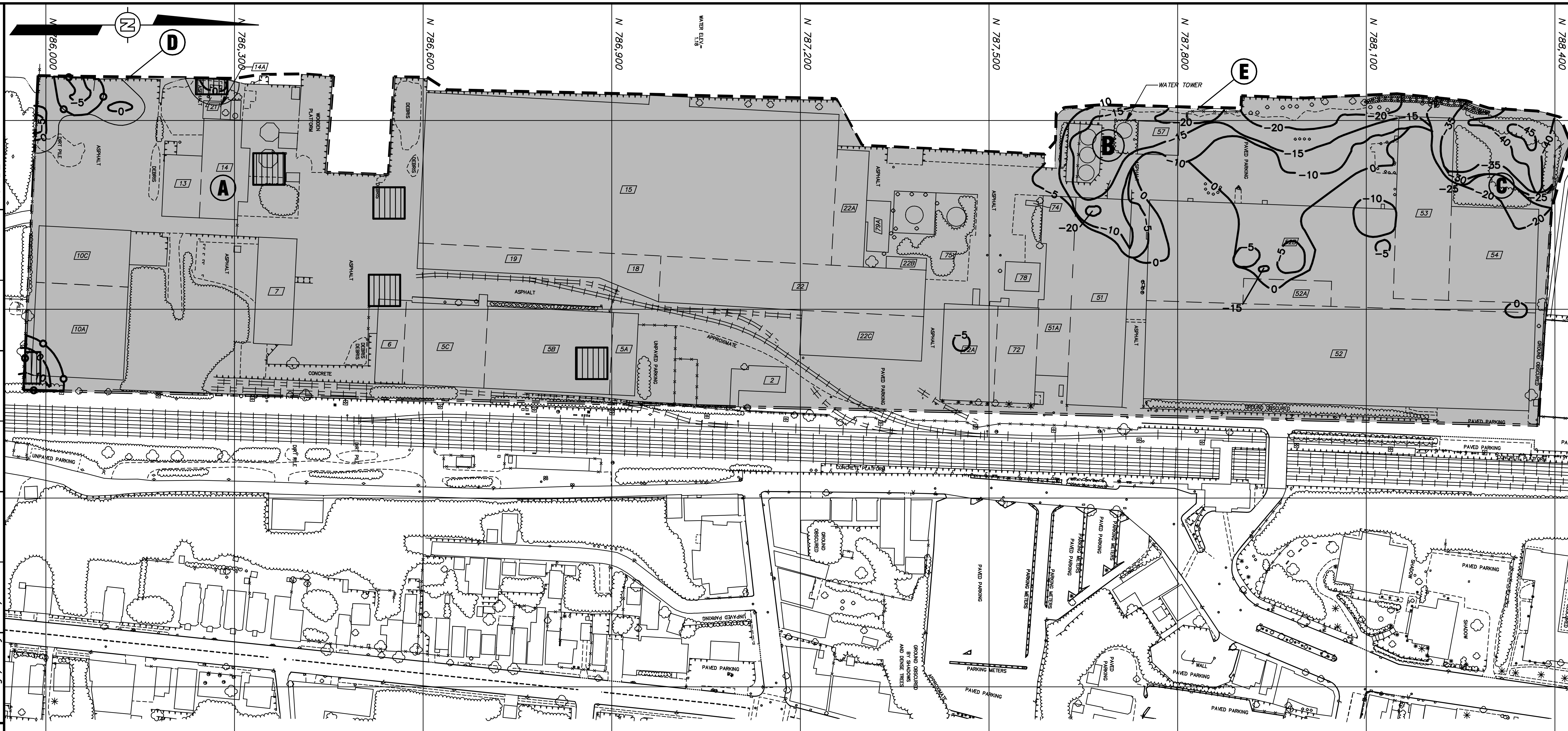
FIGURE 4-9

REMEDIAL ALTERNATIVE NO. 9
HARBOR AT HASTINGS
HASTINGS-ON-HUDSON, NEW YORK



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Format Revised: 12/15/99

LEGEND:

15	BUILDING DESIGNATION
— - —	APROXIMATE SITE BOUNDARY
— — —	BULKHEAD
—5—	DEPTH TO CONTAMINATION CONTOUR
(shaded)	CONTACT BARRIER AND SOIL COVER
(hatched)	EXCAVATION FOR DISPOSAL (LEAD HOT SPOTS)

INTERIM REMEDIAL MEASURES

A	BUILDING 14 SUMP CLOSURE IRM
B	SEPARATE PHASE LIQUID RECOVERY IRM
C	NORTHWEST CORNER IRM
D	SOUTHWEST CORNER BULKHEAD IRM
E	BUILDING 57 SHORELINE IRM

REFERENCES:

1. TOPOGRAPHY AND PLANIMETRICS PROVIDED BY GEOD PHOTOGRAMMETRIC SCIENCES SURVEY TECHNOLOGIES. MAPPED BY PHOTOGRAMMETRIC METHODS FROM AERIAL PHOTOGRAPHS TAKEN 12-08-1995. GRIDS BASED ON NEW YORK 1988 STATE PLANE COORDINATE SYSTEM. VERTICAL DATUM IS BASED ON NAD 1983. RI SAMPLE LOCATIONS SURVEYED BY GEOD.
2. EXISTING BUILDING DESIGNATIONS ARE BASED ON DOLPH ROTFELD ASSOCIATES FIGURE 4, DATED NOVEMBER 1996. BUILDING INTERIOR DIVISION LOCATIONS ARE APPROXIMATE ONLY.

SCALE

0 160 320 FEET

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FIGURE 4-10

REMEDIAL ALTERNATIVE NO. 10
HARBOR AT HASTINGS
HASTINGS-ON-HUDSON, NEW YORK

LEGEND:

15	BUILDING DESIGNATION
— - —	APROXIMATE SITE BOUNDARY
— — —	BULKHEAD
—-5—	DEPTH TO CONTAMINATION CONTOUR
—o—o—	CONTAINMENT WALL
	CONTACT BARRIER AND SOIL COVER
	EXCAVATION FOR DISPOSAL (LEAD HOT SPOTS)
	EXCAVATION FOR DISPOSAL (3-FOOT AREA)
	EXCAVATION FOR DISPOSAL (9-FOOT AREA)
	EXCAVATION FOR DISPOSAL (12-FOOT AREA)
	EXCAVATION OF PCBS ⩾ 10 PPM FOR DISPOSAL

INTERIM REMEDIAL MEASURES

A	BUILDING 14 SUMP CLOSURE IRM
B	SEPARATE PHASE LIQUID RECOVERY IRM
C	NORTHWEST CORNER IRM
D	SOUTHWEST CORNER BULKHEAD IRM
E	BUILDING 57 SHORELINE IRM

S C A L E

0 160 320 FEET

REFERENCES:

1. TOPOGRAPHY AND PLANIMETRICS PROVIDED BY GEOD PHOTOGRAMMETRIC SCIENCES SURVEY TECHNOLOGIES. MAPPED BY PHOTOGRAMMETRIC METHODS FROM AERIAL PHOTOGRAPHS TAKEN 12-08-1995. GRIDS BASED ON NEW YORK 1988 STATE PLANE COORDINATE SYSTEM. VERTICAL DATUM IS BASED ON NAD 1983. RI SAMPLE LOCATIONS SURVEYED BY GEOD.
2. EXISTING BUILDING DESIGNATIONS ARE BASED ON DOLPH ROTFELD ASSOCIATES FIGURE 4, DATED NOVEMBER 1996. BUILDING INTERIOR DIVISION LOCATIONS ARE APPROXIMATE ONLY.

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FIGURE 4-11

REMEDIAL ALTERNATIVE NO. 11
HARBOR AT HASTINGS
HASTINGS-ON-HUDSON, NEW YORK

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Format Revised: 12/15/99

LEGEND:

- 15 — BUILDING DESIGNATION
- APROXIMATE SITE BOUNDARY
- BULKHEAD
- —5— DEPTH TO CONTAMINATION CONTOUR
- CONTAINMENT WALL
- CONTACT BARRIER AND SOIL COVER
- EXCAVATION FOR DISPOSAL (LEAD HOT SPOTS)
- EXCAVATION FOR DISPOSAL (9–FOOT AREA)
- EXCAVATION FOR DISPOSAL (12–FOOT AREA)
- EXCAVATION OF PCBS ⩾ 10 PPM

INTERIM REMEDIAL MEASURES

- (A) BUILDING 14 SUMP CLOSURE IRM
- (B) SEPARATE PHASE LIQUID RECOVERY IRM
- (C) NORTHWEST CORNER IRM
- (D) SOUTHWEST CORNER BULKHEAD IRM
- (E) BUILDING 57 SHORELINE IRM

SCALE

0 160 320 FEET

REFERENCES:

1. TOPOGRAPHY AND PLANIMETRICS PROVIDED BY GEOD PHOTOGRAMMETRIC SCIENCES SURVEY TECHNOLOGIES. MAPPED BY PHOTOGRAMMETRIC METHODS FROM AERIAL PHOTOGRAPHS TAKEN 12–08–1995. GRIDS BASED ON NEW YORK 1988 STATE PLANE COORDINATE SYSTEM. VERTICAL DATUM IS BASED ON NAD 1983. RI SAMPLE LOCATIONS SURVEYED BY GEOD.
2. EXISTING BUILDING DESIGNATIONS ARE BASED ON DOLPH ROTFELD ASSOCIATES FIGURE 4, DATED NOVEMBER 1996. BUILDING INTERIOR DIVISION LOCATIONS ARE APPROXIMATE ONLY.

Shaw E & I, Inc.

ATLANTIC RICHFIELD COMPANY

FIGURE 4–12

REMEDIAL ALTERNATIVE NO. 12

HARBOR AT HASTINGS

HASTINGS–ON–HUDSON, NEW YORK

DRAWING NUMBER 806938–B16A

APPROVED BY

CHECKED BY

DRAWN BY MW/SSH 7/9/02

OFFICE Pittsburgh/Albany

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APPENDIX A

DERIVATION OF SITE-SPECIFIC PCB CLEAN-UP CRITERIA USING NYSDEC TAGM-4046

APPENDIX A

DERIVATION OF SITE-SPECIFIC
PCB CLEAN-UP CRITERIA USING NYSDEC TAGM 4046

The selection of remedial actions at hazardous waste sites in New York State is made by evaluating seven criteria, as described in NYSDEC guidance contained in the Technical and Administrative Guidance Memorandum - Selection of Remedial Actions at Hazardous Waste Sites, HWR-90-4030 (TAGM 4030). The use of these criteria recognizes the different approaches that various alternatives employ to restore and remediate hazardous waste sites, and supports the selection of the best remedy for the unique and site-specific conditions.

One of these evaluation criteria is the manner in which the proposed remedial alternative complies with New York State Standards, Criteria, and Guidance (SCGs). For soils, SCGs are defined by the criteria listed in NYSDEC Technical and Administrative Guidance Memorandum - Determination of Soil Cleanup Objectives and Cleanup Levels, HWR-94-4046 (TAGM 4046). Where site data can be used in the development of site-specific criteria for soils, these criteria should be developed in accordance with the procedures outlined in TAGM 4046. This Appendix was prepared to document the development of these criteria for polychlorinated biphenyls (PCBs) at the Harbor-at-Hastings site, in accordance with the TAGM 4046 guidance.

For PCBs in surface soils, Appendix A, Table 3 of TAGM 4046 contains a recommended soil cleanup goal of 1.0 ppm. This surface soil cleanup goal is a USEPA Health Based value, which USEPA has established as a level that is protective of potential exposures to PCBs in soil under unrestricted land use. This value is retained as the SCG criteria for surface soils, although as shown in the human health risk assessment (ENVIRON 2000), higher concentration limits for surface soils would be appropriate for certain land uses (e.g., commercial/industrial, park).

The determination of the SCG cleanup criteria for subsurface soils, in accordance with TAGM 4046, is a two-step process.

Step 1

In step one, an allowable soil concentration, C_s, is calculated using a Water-Soil Equilibrium Partition Theory model:

$$C_s = f_{oc} \times K_{oc} \times C_w \qquad (1)$$

Where: C_s = allowable soil concentration, expressed in the same units as the water standard

f_{oc} = fraction of organic carbon of the soil medium

K_{oc} = partition coefficient between water and the soil media

C_w = appropriate water quality value

TAGM 4046 states that K_{oc} values should be obtained from Exhibit A-1 of the USEPA Superfund Public Health Evaluation Manual (EPA/540/1-86/060). The K_{oc} value for PCB presented in Exhibit A-1 of the USEPA Superfund Public Health Evaluation Manual is 530,000 ml/g. Attachment A-1 of this appendix contains Exhibit A-1 of the USEPA Superfund Public Health Evaluation Manual. NYSDEC TAGM 4046 uses a value of 0.1 μg/L for the PCB water quality value, C_w, as derived from TOGS 1.1.1. This value is intended for the protection of potential exposures to PCBs in groundwater that is used as a drinking water supply. However, the shallow saturated zone at this site is not a current or reasonably expected future drinking water supply. Instead, exposures to the shallow saturated zone and subsurface soil are more likely to be associated with potential exposures of utilities construction workers who might contact these media during subsurface work, as evaluated in the human health risk assessment (ENVIRON 2000). The risk assessment calculations show that PCBs concentrations significantly higher (10-fold or more) than 0.1 ug/L would be protective of these potential exposures. A site-specific value of 0.10 was used for f_{oc}. Substituting these values into equation (1) yields an allowable soil concentration, C_s, equal to 5.3 ppm.

Step 2

In step two, a dilution attenuation factor (DAF) is applied to the allowable soil concentration, C_s, to obtain the soil cleanup criteria. The application of the DAF is intended to account for the mechanisms that occur during transport. These mechanisms include volatility, sorption and desorption, leaching and diffusion, transformation and degradation, and change in concentration of contaminants after reaching and/or mixing with the water surface. When the contaminated soil is located in the unsaturated zone above the water table, TAGM 4046 applies a DAF of 100 to the allowable soil concentration to determine the soil cleanup criteria. Using the NYSDEC TAGM 4046 default DAF value yields a subsurface soil SCG criteria of 530 ppm.

However, TAGM 4046 states that when the contamination is close to the groundwater table[1] (<3' to 5') or below the groundwater table, caution should be used when using the DAF of 100, implying that the DAF of 100 is not valid under these circumstances. The USEPA has selected a default DAF equal to 10 for determining soil-screening levels (*Soil Screening Guidance: Technical Background Document*, USEPA, EPA/540/R95/128, July 1996). The EPA default DAF was determined to be protective of human health from exposure through a groundwater transport pathway from a 30-acre source area. The EPA made several conservative assumptions in developing their default DAF. These assumptions (emphasized with *italics*) and their implications regarding attenuation at the Harbor-at-Hastings site include:

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[1] It is AERL's position that the water in saturated manmade fill underlying the Site can be differentiated from the groundwater contained in natural geologic sediments. This discussion of an alternate DAF value is included to solely address the qualification noted in the TAGM 4046.

- *The source concentration is considered to be infinite.* This implies that there are no degradation mechanisms acting upon the source. Although there is no direct evidence of degradation at the site, site operations involving the manufacture of PCBs ceased during the mid- 1970's; therefore, the source is finite.

- *Adsorption is linear and reversible and the system is at equilibrium with respect to adsorption.* These assumptions are inherently conservative for the reasons discussed in the EPA's Soil Screening Guidance, especially when considering the high fraction of organic carbon in the fill material at the Harbor-at-Hastings site.

- *Solubility limit is ignored.* Equation 1 assumes that the partitioning of PCBs from soil to water is always proportional to the PCBs concentration in soil. However, the concentration of PCBs in water is limited by its solubility, so that partitioning of PCBs from soil to water actually cannot occur beyond the solubility limit regardless of how high the concentrations of PCBs are in the soil.

- *Soil contamination extends to the water table.* This assumption is valid in the northwest corner of the site, where PCBs are present from grade to the depth of the marine silt; however, for the remainder of the site, PCBs are generally found at shallow depths (less that six feet). Therefore, with the exception of the northwest corner, vadose zone attenuation processes may occur.

Applying the EPA's conservative DAF of 10 yields a PCB subsurface soil SCG criteria of 53 ppm. The human health risk assessment (ENVIRON 2000) showed that concentrations higher than 53 ppm still would be protective of potential site-specific exposures to PCBs in subsurface soil. The conservative nature of this value is confirmed by data that show that dissolved fill water concentrations of PCBs are generally below TOGS guidance, even though soil PCB concentrations below the fill water table exceed 53 ppm by several orders of magnitude.

Summary

This Appendix derives a site-specific PCB SCG criteria for subsurface soils at the Harbor-at-Hastings site by using very conservative assumptions and by following the procedures outlined in TAGM 4046. Following the procedures outlined in TAGM 4046 and using a DAF of 100 yields a PCB soil cleanup criteria of 530 ppm. Using the EPA default DAF of 10 yields a PCB soil cleanup criteria of 53 ppm. Therefore, the site-specific PCB cleanup criteria for subsurface soils should be between 53 and 530 ppm.

Attachment A-1

Exhibit A-1
USEPA Superfund Public Health Evaluation Manual
(EPA/540/1-86/060)

ATTACHMENT A-1

Date

EXHIBIT A-1

PHYSICAL, CHEMICAL, AND FATE DATA

Chemical Name	CAS #	Mole Weight (g/mole)	Water Solubility (mg/l)	S*	Vapor Pressure (mm Hg)	S*	Henry's Law Constant (atm-m3/mol)	Koc (ml/g
Acenaphthene	83-32-9	154	3.42E+00	C	1.55E-03	C	9.20E-05	460
Acenaphthylene	208-96-8	152	3.93E+00	C	2.90E-02	C	1.48E-03	250
Acetone	67-64-1	58	1.00E+06	#	2.70E+02	J	2.06E-05	2.
Acetonitrile	75-05-8	41	1.00E+06	#	7.40E+01	F	4.00E-06	2.
2-Acetylaminofluorene	53-96-3	223	6.50E+00	B			NA	160
Acrylic Acid	79-10-7	72	1.00E+06	#	4.00E+00	F		
Acrylonitrile	107-13-1	53	7.90E+04	C	1.00E+02	C	8.84E-05	0.8
Aflatoxin B1	1162-65-8	312					NA	
Aldicarb	116-06-3	190						
Aldrin	309-00-2	365	1.80E-01	C	6.00E-06	C	1.60E-05	9600
Allyl Alcohol	107-18-6	58	5.10E+05	B	2.46E+01	B	3.69E-06	3.
Aluminum Phosphide	20859-73-8	58						
4-Aminobiphenyl	92-67-1	169	8.42E+02	B	6.00E-05	B	1.59E-08	10
Amitrole	61-82-5	84	2.80E+05	B			NA	4.
Ammonia	7664-41-7	17	5.30E+05	F	7.60E+03	F	3.21E-04	3.
Anthracene	120-12-7	178	4.50E-02	A	1.95E-04	A	1.02E-03	1400
Antimony and Compounds	7440-36-0	122			1.00E+00	N	NA	
Arsenic and Compounds	7440-38-2	75			0.00E+00	E	NA	
Asbestos	1332-21-4	NA	NA		NA		NA	N
Auramine	2465-27-2	267	2.10E+00	B			NA	290
Azaserine	115-02-6	173	1.36E+05	B			NA	6.
Aziridine	151-56-4	43	2.66E+06	B	2.55E+02	B	5.43E-06	1.
Barium and Compounds	7440-39-3	137					NA	
Benefin	1861-40-1	335						
Benzene	71-43-2	78	1.75E+03	A	9.52E+01	A	5.59E-03	8
Benzidine	92-87-5	184	4.00E+02	C	5.00E-04	C	3.03E-07	10.
Benz(a)anthracene	56-55-3	228	5.70E-03	C	2.20E-08	C	1.16E-06	138000
Benz(c)acridine	225-51-4	229	1.40E+01	B			NA	100
Benzo(a)pyrene	50-32-8	252	1.20E-03	A	5.60E-09	A	1.55E-06	550000
Benzo(b)fluoranthene	205-99-2	252	1.40E-02	C	5.00E-07	C	1.19E-05	55000
Benzo(ghi)perylene	191-24-2	276	7.00E-04	A	1.03E-10	A	5.34E-08	160000
Benzo(k)fluoranthene	207-08-9	252	4.30E-03	C	5.10E-07	C	3.94E-05	55000
Benzotrichloride	98-07-7	195						
Benzyl Chloride	100-44-7	127	3.30E+03	F	1.00E+00	E	5.06E-05	5
Beryllium and Compounds	7440-41-7	9			0.00E+00	E	NA	
1,1-Biphenyl	92-52-4	154						
Bis(2-chloroethyl)ether	111-44-4	143	1.02E+04	C	7.10E-01	C	1.31E-05	13.
Bis(2-chloroisopropyl)ether	108-60-1	171	1.70E+03	C	8.50E-01	C	1.13E-04	6
Bis(chloromethyl)ether	542-88-1	115	2.20E+04	C	3.00E+01	C	2.06E-04	1.
Bis(2-ethylhexyl)phthalate (DEHP)	117-81-7	391						
Bromomethane	74-83-9	95						
Bromoxynil Octanoate	1689-99-2	403						
1,3-Butadiene	106-99-0	54	7.35E+02	F	1.84E+03	F	1.78E-01	12
n-Butanol	71-36-3	74						
Butylphthalyl Butylglycolate	85-70-1	336						
Cacodylic Acid	75-60-5	138	8.30E+05	F			NA	2.
Cadmium and Compounds	7740-43-9	112			0.00E+00	E	NA	
Captan	133-06-2	301	5.00E-01	E	6.00E-05	E	4.75E-05	640
Carbaryl	63-25-2	201	4.00E+01	E	5.00E-03	E		
Carbon Disulfide	75-15-0	76	2.94E+03	E	3.60E+02	E	1.23E-02	5
Carbon Tetrachloride	56-23-5	154	7.57E+02	A	9.00E+01	A	2.41E-02	11
Chlordane	57-74-9	410	5.60E-01	A	1.00E-05	A	9.63E-06	14000
Chlorobenzene	108-90-7	113	4.66E+02	A	1.17E+01	A	3.72E-03	33
Chlorobenzilate	510-15-6	325	2.19E+01	B	1.20E-06	B	2.34E-08	80
Chlorodibromomethane	124-48-1	208			1.50E+01	D	NA	

EXHIBIT -1
(Continued)

PHYSICAL, CHEMICAL, AND FATE DATA

Chemical Name	CAS #	Mole Weight (g/mole)	Water Solubility (mg/l)	S*	Vapor Pressure (mm Hg)	S*	Henry's Law Constant (atm-m3/mol)	Koc (ml/g)
Chloroform	67-66-3	119	8.20E+03	A	1.51E+02	A	2.87E-03	31
Chloromethyl Methyl Ether	107-30-2	81					NA	
4-Chloro-o-toluidine Hydrochloride	3165-93-3	142					NA	
Chromium III and Compounds	7440-47-3	52			0.00E+00	E	NA	
Chromium VI and Compounds	7440-47-3	52			0.00E+00	E	NA	
Chrysene	218-01-9	228	1.80E-03	A	6.30E-09	A	1.05E-06	200000
Copper and Compounds	7440-50-8	64			0.00E+00	G	NA	
Creosote	8001-58-9	NA					NA	
Cresol	1319-77-3	108	3.10E+04	E	2.40E-01	J	1.10E-06	500
Crotonaldehyde	123-73-9	70						
Cyanides	57-12-5	NA					NA	
-- Barium Cyanide	542-62-1	189						
-- Calcium Cyanide	502-01-8	92						
-- Copper Cyanide	544-92-3	90						
-- Cyanogen	460-19-5	52	2.50E+05	K				
-- Cyanogen Chloride	506-77-4	61	2.50E+03	F	1.00E+03	J		
-- Hydrogen Cyanide	74-90-8	27	1.00E+06	#	6.20E+02	E		
-- Nickel Cyanide	557-19-7	182						
-- Potassium Cyanide	151-50-8	65	5.00E+05	K				
-- Potassium Silver Cyanide	506-61-6	199						
-- Silver Cyanide	506-64-9	134						
-- Sodium Cyanide	143-33-9	49	8.20E+05	H				
-- Zinc Cyanide	557-21-1	117						
Cyclophosphamide	50-18-0	261	1.31E+09	B			NA	0.042
Dalapon	75-99-0	143						
DDD	72-54-8	320	1.00E-01	C	1.89E-06	C	7.96E-06	770000
DDE	72-55-9	318	4.00E-02	C	6.50E-06	C	6.80E-05	4400000
DDT	50-29-3	355	5.00E-03	A	5.50E-06	A	5.13E-04	243000
Decabromodiphenyl Ether	1163-19-5	959						
Diallate	2303-16-4	274	1.40E+01	B	6.40E-03	B	1.65E-04	1000
2,4-Diaminotoluene	95-80-7	122	4.77E+04	B	3.80E-05	B	1.28E-10	12
1,2,7,8-Dibenzopyrene	189-55-9	305	1.10E-01	B			NA	1200
Dibenz(a,h)anthracene	53-70-3	278	5.00E-04	C	1.00E-10	C	7.33E-08	3300000
1,2-Dibromo-3-chloropropane	96-12-8	236	1.00E+03	B	1.00E+00	B	3.11E-04	98
Dibutylnitrosamine	924-16-3	152					NA	
Dibutyl Phthalate	84-74-2	278	1.30E+01	C	1.00E-05	C	2.82E-07	170000
1,2-Dichlorobenzene	95-50-1	147	1.00E+02	C	1.00E+00	C	1.93E-03	1700
1,3-Dichlorobenzene	541-73-1	147	1.23E+02	C	2.28E+00	C	3.59E-03	1700
1,4-Dichlorobenzene	106-46-7	147	7.90E+01	C	1.18E+00	C	2.89E-03	1700
3,3'-Dichlorobenzidine	91-94-1	253	4.00E+00	C	1.00E-05	C	8.33E-07	1553
Dichlorodifluoromethane	75-71-8	121	2.80E+02	C	4.87E+03			58
1,1-Dichloroethane	75-34-3	99	5.50E+03	A	1.82E+02	A	4.31E-03	30
1,2-Dichloroethane (EDC)	107-06-2	99	8.52E+03	A	6.40E+01	A	9.78E-04	14
1,1-Dichloroethylene	75-35-4	97	2.25E+03	A	6.00E+02	A	3.40E-02	65
1,2-Dichloroethylene (trans)	540-59-0	97	6.30E+03	A	3.24E+02	A	6.56E-03	59
1,2-Dichloroethylene (cis)	540-59-0	97	3.50E+03	A	2.08E+02	A	7.58E-03	49
Dichloromethane	75-09-2	85	2.00E+04	C	3.62E+02	C	2.03E-03	8.8
2,4-Dichlorophenol	120-83-2	163	4.60E+03	C	5.90E-02	C	2.75E-06	380
2,4-Dichlorophenoxyacetic Acid (2,4-D)	94-75-7	221	6.20E+02	F	4.00E-01	F	1.88E-04	20
4-(2,4-Dichlorophenoxy)butyric Acid (2,4-DB)	94-82-6							
Dichlorophenylarsine	696-28-6	223					NA	
1,2-Dichloropropane	78-87-5	113	2.70E+03	C	4.20E+01	C	2.31E-03	51

ATTACHMENT A-1

Date Prepare

EXHIBIT A-1
(Continued)

PHYSICAL, CHEMICAL, AND FATE DATA

Chemical Name	CAS #	Mole Weight (g/mole)	Water Solubility (mg/l)	S*	Vapor Pressure (mm Hg)	S*	Henry's Law Constant (atm-m3/mol)	Koc (ml/g)	S*
1,3-Dichloropropene	542-75-6	111	2.80E+03	C	2.50E+01	C	1.30E-03	48	C
Dieldrin	60-57-1	381	1.95E-01	C	1.78E-07	C	4.58E-07	1700	C
Diepoxybutane	1464-53-5	86					NA		
Diethanolnitrosamine	1116-54-7	134					NA		
Diethyl Arsine	692-42-2	134	4.17E+02	B	3.50E+01	B	1.48E-02	160	&
1,2-Diethylhydrazine	1615-80-1	88	2.88E+07	B			NA	0.3	&
Diethylnitrosamine	55-18-5	102			5.00E+00	F	NA		
Diethyl Phthalate	84-66-2	222	8.96E+02	C	3.50E-03	C	1.14E-06	142	C
Diethylstilbestrol (DES)	56-53-1	268	9.60E-03	B			NA	28	&
Dihydrosafrole	94-58-6	164	1.50E+03	B			NA	78	&
Dimethoate	60-51-5	229	2.50E+04	J	2.50E-02	J			
3,3'-Dimethoxybenzidine	119-90-4	244					NA		
Dimethylamine	124-40-3	45	1.00E+06	F	1.52E+03	F	9.02E-05	2.2	&
Dimethyl Sulfate	77-78-1	126	3.24E+05	B	6.80E-01	B	3.48E-07	4.1	&
Dimethyl Terephthalate	120-61-6	194							
Dimethylaminoazobenzene	60-11-7	225	1.36E+01	B	3.30E-07	B	7.19E-09	1000	&
7,12-Dimethylbenz(a)anthracene	57-97-6	256	4.40E-03	B			NA	476000	C
3,3'-Dimethylbenzidine	119-93-7	212							
Dimethylcarbamoyl Chloride	79-44-7	108	1.44E+07	B	1.95E+00	B	1.92E-08	0.5	&
1,1-Dimethylhydrazine	57-14-4	60	1.24E+08	B	1.57E+02	B	1.00E-07	0.2	&
1,2-Dimethylhydrazine	540-73-8	60					NA		
Dimethylnitrosamine	62-75-9	74	1.00E+06	#	8.10E+00	C	7.90E-07	0.1	C
1,3-Dinitrobenzene	99-65-0	168	4.70E+02	J			NA	150	&
4,6-Dinitro-o-cresol	534-52-1	198	2.90E+02	C	5.00E-02	C	4.49E-05	240	C
2,4-Dinitrophenol	51-28-5	184	5.60E+03	C	1.49E-05	C	6.45E-10	16.6	C
2,3-Dinitrotoluene	602-01-7	182	3.10E+03	B			NA	53	&
2,4-Dinitrotoluene	121-14-2	182	2.40E+02	C	5.10E-03	C	5.09E-06	45	C
2,5-Dinitrotoluene	619-15-8	182	1.32E+03	B			NA	84	&
2,6-Dinitrotoluene	606-20-2	182	1.32E+03	B	1.80E-02	C	3.27E-06	92	C
3,4-Dinitrotoluene	610-39-9	182	1.08E+03	B			NA	94	&
Dinoseb	88-85-7	240	5.00E+01	J					
1,4-Dioxane	123-91-1	88	4.31E+05	B	3.99E+01	B	1.07E-05	3.5	&
N,N-Diphenylamine	122-39-4	169	5.76E+01	B	3.80E-05	B	1.47E-07	470	&
1,2-Diphenylhydrazine	122-66-7	184	1.84E+03	C	2.60E-05	C	3.42E-09	418	C
Dipropylnitrosamine	621-64-7	130	9.90E+03	C	4.00E-01	C	6.92E-06	15	C
Disulfoton	298-04-4	274							
Endosulfan	115-29-7	407							
Epichlorohydrin	106-89-8	93	6.00E+04	J	1.57E+01	B	3.19E-05	10	&
Ethanol	64-17-5	46	1.00E+06	#	7.40E+02	G	4.48E-05	2.2	&
Ethyl Acetate	141-78-6	88							
Ethyl Methanesulfonate	62-50-0	124	3.69E+05	B	2.06E-01	B	9.12E-08	3.8	&
Ethylbenzene	100-41-4	106	1.52E+02	A	7.00E+00	A	6.43E-03	1100	C
Ethyl-4,4'-dichlorobenzilate	510-15-6	352							
Ethylene Dibromide (EDB)	106-93-4	188	4.30E+03	J	1.17E+01	B	6.73E-04	44	G
Ethylene Oxide	75-21-8	44	1.00E+06	B	1.31E+03	B	7.56E-05	2.2	&
Ethylenethiourea	96-45-7	102	2.00E+03	F			NA	67	&
1-Ethyl-nitrosourea	759-73-9	117	3.31E+08	B			NA	0.1	&
Ethylphthalyl Ethyl Glycolate	84-72-0	280							
Ferric Dextran	9004-66-4	7500					NA		
Fluoranthene	206-44-0	202	2.06E-01	A	5.00E-06	A	6.46E-06	38000	C
Fluorene	86-73-7	116	1.69E+00	C	7.10E-04	C	6.42E-05	7300	C
Fluorides	7782-41-4	NA					NA		
Fluridone	59756-60-4	329							
[illegible]	50-00-0	30	4.00E+05	K	1.00E+01	F	9.87E-07	3.6	&

ATTACHMENT A-1

Date Prepared:

EXHIBIT A-1
(Continued)

PHYSICAL, CHEMICAL, AND FATE DATA

Chemical Name	CAS #	Mole Weight (g/mole)	Water Solubility (mg/l)	S*	Vapor Pressure (mm Hg)	S*	Henry's Law Constant (atm-m3/mol)	Koc (ml/g)	S*	Log Kow
Formic Acid	64-18-6	46	1.00E+06		4.00E+01	E				-0.
Furan	110-00-9	68								
Glycidaldehyde	765-34-4	72	1.70E+08	B	1.97E+01	B	1.10E-08	0.1	&	-1.
Glycol Ethers	NA	NA					NA			
-- Diethylene Glycol, Monoethyl Ether	111-90-0	134								
-- 2-Ethoxyethanol	110-80-5	90	1.00E+06	F						0.
-- Ethylene Glycol, Monobutyl Ether	111-76-2	118	1.00E+06	F						0
-- 2-Methoxyethanol	109-86-4	76	1.00E+06	K						
-- Propylene Glycol, Monoethyl Ether	52125-53-8	104								
-- Propylene Glycol, Monomethyl Ether	107-98-2	90								
Heptachlor	76-44-8	374	1.80E-01	C	3.00E-04	C	8.19E-04	12000	C	4
Heptachlor Epoxide	1024-57-3	389	3.50E-01	C	3.00E-04	C	4.39E-04	220	C	2
Hexachlorobenzene	118-74-1	285	6.00E-03	A	1.09E-05	A	6.81E-04	3900	C	5
Hexachlorobutadiene	87-68-3	261	1.50E-01	A	2.00E+00	A	4.57E+00	29000	C	4
Hexachlorocyclopentadiene	77-47-4	273	2.10E+00	A	8.00E-02	A	1.37E-02	4800	C	5
alpha-Hexachlorocyclohexane (HCCH)	319-84-6	291	1.63E+00	C	2.50E-05	C	5.87E-06	3800	C	3
beta-HCCH	319-85-7	291	2.40E-01	C	2.80E-07	C	4.47E-07	3800	C	3
gamma-HCCH (Lindane)	58-89-9	291	7.80E+00	C	1.60E-04	C	7.85E-06	1080	G	3
delta-HCCH	319-86-8	291	3.14E+01	C	1.70E-05	C	2.07E-07	6600	C	4
Hexachloroethane	67-72-1	237	5.00E+01	C	4.00E-01	C	2.49E-03	20000	C	4
Hexachlorophene	70-30-4	407	4.00E-03	F			NA	91000	&	7
Hydrazine	302-01-1	32	3.41E+08	B	1.40E+01	B	1.73E-09	0.1	&	-3
Hydrogen Sulfide	7783-06-4	34	4.13E+03	K						
Indeno(1,2,3-cd)pyrene	193-39-5	276	5.30E-04	C	1.00E-10	C	6.86E-08	1600000	C	6
Iodomethane	77-88-4	142	1.40E+04	J	4.00E+02	J	5.34E-03	23	&	1
Iron and Compounds	15438-31-0	56					NA			
Isobutanol	78-83-1	74								
Isoprene	78-79-5	68			4.00E+02	E	NA			
Isosafrole	120-58-1	168	1.09E+03	B	1.60E-08	B	3.25E-12	93	&	2
Isophorone	78-59-1	138								
Isopropalin	33820-53-0	309								
Kepone	143-50-0	491	9.90E-03	B			NA	55000	&	2
Lasiocarpine	303-34-4	412	1.60E+03	B			NA	76	&	0
Lead and Compounds (Inorganic)	7439-92-1	207			0.00E+00	E	NA			
Linuron	330-55-2	249								
Malathion	121-75-7	330	1.45E+02	E	4.00E-05	E				2
Manganese and Compounds	7439-96-5	55					NA			
Melphalan	148-82-3	305								
Mercury and Compounds (Alkyl)	7439-97-6						NA			
Mercury and Compounds (Inorganic)	7439-97-6	201			2.00E-03	E	NA			
Mercury Fulminate	628-86-4	285								
Methanol	67-56-1	32								
Methyl Chloride	74-87-3	50	6.50E+03	C	4.31E+03	B	4.40E-02	35	&	[illegible]
Methyl Ethyl Ketone	78-93-3	72	2.68E+05	A	7.75E+01	A	2.74E-05	4.5	&	[illegible]
Methyl Ethyl Ketone Peroxide	1338-23-4	176								
Methyl Isobutyl Ketone	108-10-1	100								
Methyl Methacrylate	80-62-6	100	2.00E+01	F	3.70E+01	E	2.43E-01	840	&	[illegible]
Methyl Parathion	298-00-0	263	6.00E+01	E	9.70E-06	E	5.59E-08	460	&	1
2-Methyl-4-chlorophenoxyacetic Acid	94-74-6	201								
2(2-Methyl)-4-Chlorophenoxy-		--								

ATTACHMENT A-1

EXHIBIT A-1
(Continued)

PHYSICAL, CHEMICAL, AND FATE DATA

Chemical Name	CAS #	Mole Weight (g/mole)	Water Solubility (mg/l)	S*	Vapor Pressure (mm Hg)	S*	Henry's Law Constant (atm-m3/mol)	Koc (ml/g)	S*	L K
3-Methylcholanthrene	56-49-3	268					NA			
4,4'-Methylene-bis-2-chloroaniline	101-14-4	267					NA			
Methylnitrosourea	684-93-5	103	6.89E+08	B			NA	0.1	&	-
Methylthiouracil	56-04-2	142					NA			
Methylvinylnitrosamine	4549-40-0	86	7.60E+05	B	1.23E+01	B	1.83E-06	2.5	&	-
N-Methyl-N'-nitro-N-nitrosoguanadin	70-25-7	147					NA			
Mitomycin C	50-07-7	334					NA			
Mustard Gas	505-60-2	159	8.00E+02	B	1.70E-01	B	4.45E-05	110	&	
1-Napthylamine	134-32-7	143	2.35E+03	B	6.50E-05	B	5.21E-09	61	&	
2-Napthylamine	91-59-8	143	5.86E+02	B	2.56E-04	B	8.23E-08	130	&	
Nickel and Compounds	7440-02-0	59			0.00E+00	D	NA			
Nitric Oxide	10102-43-9	30								
Nitrobenzene	98-95-3	123	1.90E+03	C	1.50E-01	B		36	C	
Nitrogen Dioxide	10102-44-0	46								
Nitrosomethylurethane	615-53-2	132					NA			
N-Nitrosopiperidine	100-75-4	114	1.90E+06	B	1.40E-01	B	1.11E-08	1.5	&	-
N-Nitrosopyrrolidine	930-55-2	100	7.00E+06	B	1.10E-01	B	2.07E-09	0.8	&	-
5-Nitro-o-toluidine	99-55-8	152					NA			
Osmium Tetroxide	20816-12-0	254								
Pentachlorobenzene	608-93-5	250	1.35E-01	F			NA	13000	&	
Pentachloronitrobenzene	82-68-8	295	7.11E-02	B	1.13E-04	B	6.18E-04	19000	&	
Pentachlorophenol	87-86-5	266	1.40E+01	C	1.10E-04	C	2.75E-06	53000	C	
Phenacetin	62-44-2	179					NA			
Phenanthrene	85-01-8	178	1.00E+00	A	6.80E-04	A	1.59E-04	14000	C	
Phenobarbital	50-06-6	232	1.00E+03	B			NA	98	&	-
Phenol	108-95-2	94	9.30E+04	A	3.41E-01	A	4.54E-07	14.2	C	
Phenylalanine Mustard	148-82-3	305					NA			
m-Phenylenediamine	108-45-2	108								
Phenyl Mercuric Acetate	62-38-4	337	1.67E+03	K						
Phosphine	7803-51-2	34								
Polychlorinated Biphenyls (PCBs)	1336-36-3	328	3.10E-02	C	7.70E-05	C	1.07E-03	530000	C	
Propane Sultone	1120-71-4	122					NA			
Propyleniminе	75-55-8	57	9.44E+05	B	1.41E+02	B	1.12E-05	2.3	&	-
Pyrene	129-00-0	202	1.32E-01	A	2.50E-06	A	5.04E-06	38000	C	
Pyridine	110-86-1	79	1.00E+06	F	2.00E+01	F				
Saccharin	81-07-2	183					NA			
Safrole	94-59-7	162	1.50E+03	B	9.10E-04	B	1.29E-07	78	&	
Selenium and Compounds	7782-49-2	79			0.00E+00	E	NA			
-- Selenious Acid	7783-00-8	129								
-- Selenourea	630-10-4	123								
-- Thallium Selenite	12039-52-0	488								
Silver and Compounds	7440-22-4	108			0.00E+00	D	NA			
Sodium Diethyldithiocarbamate	148-18-5	171								
Streptozocin	18883-66-4	457					NA			
Strychnine	57-24-9	334	1.56E+02	E						
Styrene	100-42-5	104								
1,2,4,5-Tetrachlorobenzene	95-94-3	216	6.00E+00	F			NA	1600	&	
2,3,7,8-TCDD (Dioxin)	1746-01-6	322	2.00E-04	A	1.70E-06	A	3.60E-03	3300000	C	
1,1,1,2-Tetrachloroethane	630-20-6	168	2.90E+03	J	5.00E+00	J	3.81E-04	54	&	
1,1,2,2-Tetrachloroethane	79-34-5	168	2.90E+03	A	5.00E+00	A	3.81E-04	118	C	
Tetrachloroethylene	127-18-4	166	1.50E+02	A	1.78E+01	A	2.59E-02	364	C	
2,3,4,6-Tetrachlorophenol	58-90-2	232	1.00E+03	F			NA	98	&	
2,3,5,6-Tetrachloroterephthalate										

EXHIBIT A-1
(Continued)

PHYSICAL, CHEMICAL, AND FATE DATA

Chemical Name	CAS #	Mole Weight (g/mole)	Water Solubility (mg/l)	S*	Vapor Pressure (mm Hg)	S*	Henry's Law Constant (atm-m3/mol)	Koc (ml/
Tetraethyl Lead	78-00-2	323	8.00E-01	J	1.50E-01	J	7.97E-02	49
Thallium and Compounds	7440-28-0	204			0.00E+00	E		
-- Thallium Acetate	563-68-8	263						
-- Thallium Carbonate	6533-73-9	469						
-- Thallium Chloride	7791-12-0	240	2.90E+03	E	0.00E+00	E		
-- Thallium Nitrate	10102-45-1	266						
-- Thallic Oxide	1314-32-5	457						
-- Thallium Sulfate	7446-18-6	505	2.00E+02	E	0.00E+00	E		
Thioacetamide	62-55-5	75					NA	
Thiourea	62-56-6	76	1.72E+06	B			NA	1
o-Tolidine	119-93-7	212	7.35E+01	B			NA	4
Toluene	108-88-3	92	5.35E+02	A	2.81E+01	A	6.37E-03	3
o-Toluidine Hydrochloride	636-21-5	144	1.50E+04	J	1.00E-01	J	9.39E-07	
Toxaphene	8001-35-2	414	5.00E-01	C	4.00E-01	C	4.36E-01	9
Tribromomethane (Bromoform)	75-25-2	253	3.01E+03	C	5.00E+00	C	5.52E-04	1
1,2,4-Trichlorobenzene	120-82-1	181	3.00E+01	C	2.90E-01	C	2.31E-03	92
1,1,1-Trichloroethane	71-55-6	133	1.50E+03	A	1.23E+02	A	1.44E-02	1
1,1,2-Trichloroethane	79-00-5	133	4.50E+03	A	3.00E+01	A	1.17E-03	
Trichloroethylene	79-01-6	131	1.10E+03	A	5.79E+01	A	9.10E-03	1
Trichlorfon	52-68-6	257	1.54E+05	E	7.80E-06	E	1.71E-11	6
Trichloromonofluoromethane	75-69-4	137	1.10E+03	C	6.67E+02	C		1
2,4,5-Trichlorophenol	95-95-4	197	1.19E+03	A	1.00E+00	A	2.18E-04	
2,4,6-Trichlorophenol	88-06-2	197	8.00E+02	A	1.20E-02	A	3.90E-06	20
2,4,5-Trichlorophenoxyacetic Acid	93-76-5	255						
1,2,3-Trichloropropane	96-18-4	147						
1,1,2-Trichloro-1,2,2,-trifluoroethane	76-13-1	187	1.00E+01	F	2.70E+02	F		
Tris(2,3-dibromopropyl)phosphate	126-72-7	698	1.20E+02	B			NA	[illegible]
Trinitrotoluene (TNT)	118-96-7	227						
Trypan Blue	72-57-1	961					NA	
Uracil Mustard	66-75-1	252	6.41E+02	B			NA	[illegible]
Uranium and Compounds	7440-61-1	238					NA	
Urethane	51-79-6	89					NA	
Vanadium and Compounds	7440-62-2	51					NA	
Vinyl Chloride	75-01-4	63	2.67E+03	A	2.66E+03	A	8.19E-02	
Warfarin	81-81-2	308						
o-Xylene	95-47-6	106	1.75E+02	F	1.00E+01	E		
m-Xylene	108-38-3	106	1.30E+02	F	1.00E+01	F		
p-Xylene	106-42-3	106	1.98E+02	F	1.00E+01	F		
Xylene (mixed)	1330-20-7	106	1.98E+02	F	1.00E+01	F	7.04E-03	[illegible]
Zinc and Compounds	7440-66-6	65			0.00E+00	D	NA	
-- Zinc Phosphide	1314-84-7	258						
Zineb	12122-67-7	276						

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* Letters denote the source of the data, as listed in Section 3.1.
# Solubility of 1,000,000 mg/l assigned because of reported "infinite solubility" in the lite
& Koc estimated by the following equation: log Koc = (-0.55*logS) + 3.64 (Note: S in mg/l).

APPENDIX B

EXCAVATION EVALUATION SUMMARY REPORT

APPENDIX B

EXCAVATION EVALUATION SUMMARY REPORT

Shaw Environmental & Infrastructure, Inc.

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Shaw The Shaw Group Inc.™

EXCAVATION EVALUATION SUMMARY REPORT
OPERABLE UNIT #1
HARBOR AT HASTINGS SITE
HASTINGS ON HUDSON, NEW YORK

Shaw E & I Project 803132
Haley & Aldrich Inc. Project 28612

September 5, 2002

Prepared for:

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1.0 INTRODUCTION

Shaw Environmental & Infrastructure, Inc. (Shaw E & I), formerly IT Corporation, Inc., and Haley & Aldrich, Inc. have developed this report to evaluate the feasibility and risk associated with excavation of PCB-impacted fill at the Harbor At Hastings Site (Site) located in Hastings-On-Hudson, New York. The remediation of PCBs located at depths significantly below the water table adjacent to an active fluvial environment is one of the most difficult remedial activities that can be undertaken. In such cases, the only viable remedial option to reduce the volume of PCBs is to excavate the impacted materials. Accordingly, the ability to excavate PCB-impacted material is dependent on the limitations imposed by the site conditions and the nature and extent of PCBs at a particular site. Furthermore, it is of utmost importance that excavation activities do not promote PCB migration to un-impacted resources during the remediation process.

This report describes the Site conditions as they relate to the nature of PCB contamination and constraints on construction that control the selection of excavation methods for removal of PCB impacted materials from below the water table at the Harbor-At-Hastings Site. The evaluations discussed in this report were conducted to provide a basis for the selection of an excavation alternative in the Feasibility Study Report prepared for the Site.

1.1 Background on Early Evaluations of Excavation Methods

Deep excavation options were considered for remediation at the Site as presented to the New York State Department of Environmental Conservation (NYSDEC), in the January 30, 2001 Final Draft Feasibility Study *Final Draft Feasibility Study, Harbor at Hastings Site, IT Corporation, Inc., January 30, 2001* (Draft FS). The Draft FS concluded that a deep excavation at the Site was not the most feasible remedial alternative because of subsurface constraints including the proximity of the Site to the Hudson River, the presence of very weak soils, the presence of a very shallow water table and other related issues. Although not recommended, the deep excavation remedial options assessments (excavation approach) presented in the Draft FS evaluated several methods to achieve deep excavations. The Draft FS evaluated the removal of impacted fill material from below the water table from within flooded steel sheet pile cells. Fill from below the water table was proposed to be excavated in a flooded condition (no in-situ de-watering) due to the concerns with potential excavation failure as a result of hydraulic pressure from the Hudson River and the underlying Basal Sands Unit.

Due to the significant risks associated with deep excavation and the ability to effectively contain and prevent exposures to PCBs by alternative remedial measures, the Draft FS recommended: the containment of the Water Tower and Northwest Corner Areas; excavation and off-site disposal of PCB impacted fill located outside the limits of the containment area; and construction of a contact barrier and soil cover system.

On May 30, 2001 the Atlantic Richfield Company received Comments on the Draft FS from the NYSDEC. In the comments, the NYSDEC requested that Atlantic Richfield Company further evaluate the feasibility of deep excavation alternatives for removal of impacted fill material at the Site. In response to the NYSDEC request, Atlantic Richfield Company and Shaw E&I evaluated numerous deep excavation alternatives looking specifically at the engineering approach and feasibility of implementing excavation of PCB impacted fill material from significant depths below the water table (i.e. remedial alternatives 2, 3, 4, 5, 6 presented in the Draft FS). Due to difficult Site conditions including the proximity of the Hudson River, the shallow fill water table elevation, the presence of a deep underlying groundwater aquifer, and the potential for excavation depths approaching 40 feet below grade, Atlantic Richfield Company elected to convene a panel of technical experts specializing in such complex site conditions to evaluate the implementability of deep excavation at the Site.

Specifically the technical experts were invited to attend a Peer Review Meeting to:

- Review and comment on conceptual excavation approaches and cost estimates utilized during the development of remedial alternatives in the Draft FS,
- Determine the best-proven technologies or methods that could be utilized to remove PCB impacted fill,
- Identify any significant technical concerns associated with excavation of PCBs, and identify the depth of excavation where such technical difficulties are expected, and
- Evaluate existing geotechnical data to determine if additional data would be necessary to complete an evaluation of deep excavation at the Site.

The technical review meeting was held in Albany, New York on July 31 and August 1, 2001. The meeting was comprised of representatives from Atlantic Richfield Company, Shaw E&I, and a panel of technical experts specializing in deep excavation and shoring. The technical experts who participated included the following specialists:

- Joe Burke, P.E., Principal Engineer, SPEC Consulting, L.L.C.
- Stephen Olko, Principal, Olko Engineering
- Ancil Taylor, President, BEAN Environmental Dredging

- George Filz, PhD, P.E., Virginia Polytechnical Institute (on July 31 only)
- Mark Hawley, Ph.D., Senior Science Advisor, Environ Corporation
- Mike Crystal, Manager Dewatering Operations, Sevenson Environmental Services, Inc.
- Paul Thomson, Vice President, Sevenson Environmental Services, Inc.

Prior to the Peer Review Meeting, each of the technical experts was provided a data package summarizing the findings presented in the Remedial Investigation (RI) Report, *Remedial Investigation Report, Harbor At Hastings, IT Corporation, Inc., October 27, 2000*. At the beginning of the meeting, the RI data were reviewed and the conceptual excavation approach used during the development of excavation alternatives within the Draft FS was presented to the technical experts. The technical experts were asked to provide technical input regarding the Draft FS excavation approach to determine if the approach is a feasible means of removing deep impacted fill from the Water Tower Area and the Northwest Corner of the Site.

The Peer Review meeting resulted in identification of engineering issues associated with deep excavation alternatives and environmental and safety risks directly associated with those alternatives. The technical review did not include a full assessment of short and long term environmental costs and benefits of excavation, nor did it fully evaluate excavation activities against FS criteria. These evaluations will be presented in the revised FS Report that is currently scheduled for completion in 2002.

2.0 PEER REVIEW TEAM MEETING RESULTS AND RECOMMENDATIONS

The results of the technical expert review and the Peer Review Meeting are as follows:

1. The technical experts believed that completing deep flooded excavations within excavation support structures is possible, but difficult and expensive and may also present substantial additional environmental risk. However, the maximum depth of de-watered and flooded excavations could not be determined without additional Site data and engineering evaluations.
2. The technical experts highly recommended performing excavations in a de-watered state if possible. They concluded that reasons for not implementing flooded excavations were substantial and included:
    - Suspension of contaminants in water removed within the excavation will require treatment;

- Suspension of contaminants in the water remaining in the excavation would re-introduce contaminants to backfill material;
- Installation of sheet pile bracing and execution of other excavation activities within a flooded excavation will be extremely difficult because constructors would be unable to visually inspect the complex excavation shoring and bracing activities, and it would be impossible to view existing subsurface structures;
- Constructors would be unable to collect accurate end point samples and there would remain uncertainty in evaluating the extent of contaminated fill removed.

The technical experts concluded that a de-watered excavation would eliminate many of these hurdles, and they recommended that de-watered excavation activities be implemented rather than flooded excavations.

3. Although the technical experts considered other excavation options for the removal of deep PCBs, they remained significantly concerned about the potential for excavation failure (particularly as excavation depth increased) as a result of hydrostatic uplift of the bottom of the excavation (upwelling of groundwater from the Basal Sands Units due to artesian pressure) and piping (as a result of fill water and groundwater pressure and channeling).
4. The technical experts recommended that additional hydrogeologic and geotechnical data be collected to evaluate the specific depth at which excavation instability would become paramount. In particular, the experts explained that to fully understand the risk of excavation failure, documentation of groundwater elevations and pressures within the Basal Sands Unit is necessary. They recommended that these data be collected and evaluated to determine if artesian conditions exist which would cause instability of the bottom of the excavations. They also recommended that additional geotechnical data be collected from the Fill Unit, the Marine Grey Silt Unit and the Basal Sands Unit to provide basic data needed in structural evaluations of excavation support structures.

A more detailed explanation of the rationale for undertaking all excavation activities in a de-watered state is described in **Section 5.0** of this report and includes considerations that are in addition to those listed above.

Based on the recommendations of the technical experts, additional geotechnical information was required to determine the potential for bottom heave, piping, and consolidation to affect the necessary excavation support structures. In response to this requirement, Atlantic Richfield Company and Shaw E&I designed a Hydrogeologic and Geotechnical Investigation to collect the required data, *Hydrogeologic/Geotechnical Investigation Work Plan, August 24, 2001*. The investigation activities associated with collection of these data was undertaken in September and October 2001 as presented in **Section 3.0** of the report. The primary goal of this work was to collect the required data necessary to identify the depth at which a deep de-watered excavation could be safely undertaken.

3.0 HYDROGEOLOGIC/GEOTECHNICAL INVESTIGATION SUMMARY

The hydrogeologic/geotechnical investigation was completed in September and October 2001, as reported in the details of the Peer Review Report, dated November 30, 2001. The results of these investigations are presented below. The investigation consisted of the installation and sampling of three shallow monitoring wells in the Fill Unit and three deep monitoring wells in the Basal Sands Unit. The deep and shallow wells were installed side by side to form one monitoring well couplet in the North West Corner (MW-15A/MW-15B) and two monitoring well couplets in the Water Tower Area (MW-13A/MW-13B and MW-14A/MW-14B). These monitoring well locations are shown on **Figure 1, Cross Section A-A'**. The monitoring well construction details are presented in **Attachment A**.

The shallow wells (MW-13B, MW-14B and MW-15B) were installed in the Fill Unit to a depth of 30 feet using hollow stem auger drilling techniques. Each shallow well was constructed using 2-inch diameter PVC pipe and screened between 3 and 30 feet below ground surface as shown in **Table 1**.

The deep wells (MW-13A, MW-14A and MW-15A) were installed into the deep Basal Sands Unit aquifer using several drilling techniques to reach depths up to 90 feet below ground surface. The deep wells were constructed using 6-inch diameter PVC pipe and a 15 foot length of well screen installed in the Basal Sands Unit as shown in **Table 1**. To prevent the migration of contaminants from the Fill Unit to the lower geologic units during the installation of the deep wells, a 10-inch diameter casing was set and sealed with grout approximately 10 to 15 feet into the Marine Grey Silt Unit. Drilling was continued within the casing and geotechnical samples were collected from the Marine Grey Silt Unit and the Basal Sands Units using drive and wash drilling techniques. After the collection of all necessary geotechnical samples using both split spoon samplers and thin-walled shelby tubes, the deep wells were installed and sealed in the Basal Sands Unit using mud rotary drilling techniques.

3.1 GROUNDWATER/FILL WATER LEVEL MONITORING

On October 1, 2001, groundwater and fill water levels were measured in monitoring wells MW-13A, MW-13B, MW-14A, MW-14B, MW-15A and MW-15B. The water levels were monitored in October 2001 during a complete tidal cycle to evaluate the influence of the river on the hydrostatic condition of the two water bearing units. The water levels and elevations are presented in **Table 1**. During this initial gauging event, the water level in deep well MW-14A was determined to be above grade at high tide. On October 9, 2001, the casing elevation at MW-14A was raised and additional water level measurements were collected at high tide to better characterize the maximum water level elevation at this well location. The water levels measured on October 9 are presented in **Table 2**. Historic groundwater gauging data from the RI Report for additional deep wells located on the southern end of the Site were also evaluated.

3.2 Hydrology

The groundwater elevation data and fill water elevation data collected during the hydrogeological/geotechnical investigation confirms that artesian conditions exist in the Basal Sands Unit across the Site, as reported in the RI Report. It is noted that the hydrogeologic and geologic conditions in the areas of MW-14A and MW-1B are similar. MW-14A is located near the shoreline in the north end of the Water Tower Area and MW-1B is located near the shoreline in the Southwest Corner of the Site. The areas of MW-14A and MW-1B have similar ground surface elevations (< 0.1 foot differential), flowing artesian conditions, and a similar thickness of the Fill, Marine Grey Silt, and Basal Sands Units.

Review of the historic gauging data within the RI Report also identifies a groundwater elevation in the Basal Sands Unit at MW-1B of 4.55 feet (approximately 1.33 feet above ground surface) in February 1996. Monitoring well MW-14A had a groundwater elevation of 3.59 feet (approximately 0.37 feet above ground surface) in October 2001 (which was during a near drought weather cycle). Based on the hydrogeologic and geologic similiarities at each of the well locations and proximity to the Hudson River, there appears to be a potential for seasonal variation in artesian conditions on the Site. Based on the data collected at monitoring wells MW-13A, MW-14A, MW-15A, MW-1B and MW-3B there is evidence that the degree of artesian conditions also varies depending on the area of the Site where monitoring is performed.

At all well locations, the hydraulic head is higher in the Basal Sands Unit than in the corresponding wells set in the Fill Unit. A maximum head difference of 2.52 feet was measured between the Fill water and the groundwater in the Basal Sands Unit in monitoring well MW-13. It was also confirmed that the Fill water table and the groundwater table on the north and south ends of the Site are affected by the tidal cycle and the elevation of the Hudson River. On October 1, 2001 the tides within the Hudson River changed the river elevation by approximately 3.50 feet. The corresponding maximum groundwater table fluctuation in the Basal Sands Unit between low and high tide was 1.58 ft in MW-13A on the same date. For the Fill Unit, the maximum water table fluctuation was 2.7 feet in MW-14B. Based on the apparent connection between the Hudson River and Site groundwater, it is concluded that flood conditions within the Hudson River could result in a significant increase in artesian conditions at the Site.

3.3 Geology and Site Stratigraphy

As presented in **Figure 1, Cross Section A-A'**, the geological model of the Site presented in the RI was confirmed during the hydrogeological/geotechnical investigation. The thickness of the Fill, Marine Grey Silt and the Basal Sands Units increases from east to west across the Site. The Fill Unit is a heterogeneous industrial fill composed of silts, sands, ash, brick, slag, cinders, glass, gravel and wood. Many retrieved samples showed the Fill to have significant amount of ash. The thickness of the Fill Unit ranges between 34 feet (MW-15) and 17 feet (MW-14). The upper 5 to 10 feet Fill Unit, while composed of the same materials as the lower portion, is more heavily consolidated, likely due to construction and industrial use of the Site. Based on the available data the Marine Grey Silt Unit, which acts as a natural barrier (confining layer) between the Fill Unit and the underlying Basal Sands Unit, ranges in thickness between 26 feet (MW-15) and 39 feet (MW-14) and is generally thicker in the Water Tower Area and Northwest Corner. However, the thickness of the Marine Grey Silt Unit is not well defined due to the limited number of borings that have penetrated into the Basal Sands Unit. The Basal Sands Unit was generally encountered between 52 feet and 60 feet below ground surface. Soil classifications for the soil strata are presented in **Table 3**.

3.4 Geotechnical Properties

During the RI field activities 150 soil borings were advanced in the Water Tower Area and the Northwest corner. Soil sampling and Standard Penetration Tests (SPT) were completed via split spoon sampling at some of the borings. Soil descriptions/classifications were performed at each of the borings and 30 of the soil borings utilized continuous sampling techniques and SPT to characterize the entire thickness of the Fill Unit and the top of the Marine Grey Silt Unit. The data revealed that the Lower Fill Unit is extremely loose and weak, and quite variable in composition with average SPT N-values of 2.8 blows/foot, however many SPT N-values were 0 blows/ft.

During the Hydrogeologic/Geologic Investigation, multiple soil samples were collected from the Fill Unit, the Marine Grey Silt Unit and the Basal Sands Unit and analyzed for various geotechnical parameters. To fully characterize the strength and overall stability of the Fill Unit and the Marine Grey Silt Unit, the field and laboratory geotechnical data collected at MW-13, MW-14, MW-15 and other historic boring locations were carefully reviewed and evaluated. During drilling activities conducted as part of the RI and the Hydrogeologic/Geologic Investigation, it was noted that the Lower Fill Unit and Marine Grey Silt Unit were extremely soft and weak. Often the lower Fill Unit (greater than 10 feet below ground surface) was so soft and loose that the weight of the drilling rods and the weight of the hammer were capable of simply pushing sampling tools to the required sampling depths without any drops of the hammer. Consideration of the field data along with the laboratory data indicates that the Lower Fill Unit and the Marine Grey Silt Unit are extremely soft, have low shear strengths and will provide little support to excavation shoring. As noted in **Section 3.3**, standard penetration resistance measurements and geologic data both indicate that the Upper Fill Unit is denser and more consolidated than the Lower Fill Unit, presumably due to compaction by industrial uses of the property. This difference was incorporated into the geotechnical design evaluations discussed herein by treating the Upper and Lower Fill Units as distinct units.

The geotechnical parameters used to evaluate the excavation alternatives are summarized on **Tables 3 and 4**. The geotechnical laboratory data reports are presented in **Attachment B**. Geotechnical design input parameters were developed statistically from the field and laboratory geotechnical data. Unit weights for each of the geologic units were obtained by mathematically averaging the laboratory derived unit weights for each geologic unit and by researched correlations for soils of similar N-values, composition and constituents. The strength parameters, (cohesion and friction angle) were generally obtained using the U.S. ACE 33 percentile method for geotechnical design shear strength method (U.S. ACE, 1994), as noted on **Table 4**. Cohesion in the Fill and Basal Sands Units were set at zero, as is usual practice due to the granular nature of these units. The friction angle for the Marine Grey Silt Unit was also set at 0 due to cohesive and plastic nature of the soils, which is reflected by the extremely low friction angles obtained from the unconsolidated undrained shear strength test.

4.0 FACTORS AFFECTING EXCAVATION

The two significant factors affecting excavation at the Site are the nature of PCB contamination and the geotechnical and hydrogeologic conditions that are constraints on deep excavation. It is important to note that these two factors are not independent of one another. In other words, potential excavation issues such as hydrostatic uplift and piping not only affect the excavation depth and the method of excavation, but they also have a significant influence on the potential for contaminant remobilization at this Site. Accordingly, any excavation method selected must be evaluated in light of not only the physical conditions, but must also consider the potential effect the method will have on contaminant remobilization.

A significant factor affecting excavation activities at the Site is the nature of PCB contamination, particularly those below the water table. As indicated in the RI Report, PCBs have been detected as a highly viscous dense non-aqueous phase liquid (DNAPL) and as a semi-solid. In one boring the DNAPL PCB was described as less viscous but still highly viscous compared to water. The DNAPL PCB was encountered at the Fill-Marine Grey Silt interface indicating the material migrated downward until the Marine Grey Silt Unit was encountered where the reduced pore size of the Marine Grey Silt Unit halted further downward migration. Based on the significant testing that was undertaken during the RI, it is apparent that the PCB migration has stabilized under current conditions. This finding is consistent with significant research on DNAPL materials at contaminated sites that suggest DNAPL will migrate downward under gravity until their downward movement is halted by a change in pore size of the formation, a change in the properties of the DNAPL and/or other controlling hydraulic conditions. Once the downward and lateral migration ceases, these materials remain in place under equilibrium conditions.

A significant concern at this Site (as well as at other sites containing DNAPL), is disruption of this equilibrium thereby causing re-mobilization of contamination. The potential for this condition is particularly onerous at the Harbor At Hastings Site since the underlying Basal Sands Unit, which contains a primary groundwater aquifer system, has not been impacted by Site activities to date. Significant care must be taken in remedial technology selection and during remediation to minimize the potential for PCB re-mobilization. The remedial alternative selection process must insure that the selected alternative does not have the potential to cause PCBs and other site related constituents to migrate downward into the Basal Sand Unit. In the event that contaminants entered the aquifer there is significant risk of wide spread contaminant migration via natural groundwater flow conditions in this highly permeable formation. Any selected remedial alternative must prevent the deleterious impact of spreading contamination to the uncontaminated Basal Sands Unit.

As part of this study, excavation was evaluated in light of the potential for remobilization of PCBs at the Site. In particular, the following were considered with respect to changing equilibrium conditions as part of excavation:

1. The presence of hundreds of existing wood piles installed into the Basal Sands Unit. The existing piles will require removal to at least the bottom of the excavation. The method and depth of pile removal will require significant care to minimize the lateral movement of the piles and thereby minimize the potential for

creation of preferential migration pathways (i.e. increasing the "pore size opening" adjacent to the piles).

2. The ability to locate and view the existing piles to minimize the disturbance of these structures during excavation. Again, disturbance of the wood piles will increase the potential for downward PCB migration along opened "pore space" into the uncontaminated Basal Sands Unit. This issue is particularly important with respect to construction in a flooded excavation.

3. The potential deleterious effect of lowering the hydraulic head/water level in the Basal Sands Unit or increasing the hydraulic head in the Fill or a combination of the two. The head relationship that currently exists provides buoyancy to the PCB located at the Fill – Marine Silt interface. Either raising the head in the Fill or lowering the head in the Basal Sands Unit to increase excavation depth could decrease PCB buoyancy thereby re-mobilizing PCB downward to the Basal Sands Unit.

4. The potential for re-mobilization to occur if excavation support structures are installed into the Basal Sands Unit. The installation of excavation support structures into the Basal Sands Unit may drive contaminants downward and/or provide a preferential pathway for downward PCB migration through increasing the "pore size opening" along the support structure-soil interface.

As stated above, it is also imperative that any construction activity be implementable and undertaken in a manner that is safe to human health and the environment. The evaluation criteria for the excavation alternatives must be reviewed with respect to Site contaminant issues so that deep excavation activities will be protective of the environment. These criteria include: the appropriate design of excavation support structures, maintaining excavation bottom stability and protecting neighboring structures.

Since the peer review meeting, Atlantic Richfield Company has considered other construction-related factors including the potential to remobilize PCBs thereby contaminating currently uncontaminated areas of the Site (**Sections 4.0, 5.0, 6.0**). The following sections describe excavation at the Site in light of these considerations. **Section 5.0** provides an in-depth evaluation of the excavation alternatives with respect to constructability issues. **Section 6.0** describes the Site conditions that affect the constructability of any excavation while considering the geotechnical and hydrogeologic conditions at the Site and the potential for contaminant re-mobilization.

5.0 CONSTRUCTABILITY ASSESSMENT

The ability to complete excavations to depth at the Site requires the evaluation of several constructability issues. These issues relate to the ability to excavate in a safe and cost effective manner while protecting the Basal Sands Unit groundwater system. These constructability issues include the following:

- Flooded excavations and the resultant need to work in the "blind";
- Existing wood piles and foundation elements located in the excavation;
- Installing sheet piles at a site with significant subsurface obstructions; and
- The use of jet grouting at a site with significant subsurface obstructions.

5.1 Flooded Excavations

There are significant constructability issues associated with a flooded excavation including the following:

<u>Geotechnical Considerations</u>

- As discussed in **Section 3.4**, the Fill Unit and Marine Grey Silt Unit are loose and very weak. Extensive lateral bracing will be needed to support sheet piles and the sides of the excavations. In a flooded excavation it is not possible to visually inspect the complex excavation shoring and bracing activities or view existing subsurface structures. The installation of lateral excavation support bracing underwater is always difficult and slow, but when the water is clouded by excavation activities to the point of almost zero visibility, the task will be nearly impossible. All underwater work must be completed by experienced divers, who would be working in PCB contaminated water, posing significant safety concerns.
- Bracing installation will be particularly slow if sheet piling is not installed straight and vertical because extensive blocking will be required. After the bracing is installed, the deeper excavation would have to be conducted using a clamshell excavator or equivalent due to the limited open spaces between strut braces and around the existing woodpiles.

Environmental Considerations

- Excavation activities will suspend contaminants in the water of the flooded cell. Contaminants in water removed with the excavated fill would require treatment and the water remaining in the excavation would potentially re-introduce contaminants to backfill material.
- Accurate end point sampling would be difficult and there would be uncertainty in evaluating the extent of contaminated fill removed.
- The excavation would be undertaken "in the blind" due to the extreme turbidity that would be created during excavation. It is likely that nearly every dip of the backhoe bucket or clamshell would disturb unseen wood piles, which could cause lateral movement of the piles thereby opening preferential water and contaminant pathways.
- There is an increased likelihood of hydraulic head reversal causing a downward flow of contaminated water toward the Basal Sands Unit. The water level in the flooded excavation necessary to counterbalance the hydrostatic uplift force from the Basal Sands Unit would have to maintain a net positive head of 1 to 4 feet above ground surface to counteract the higher artesian conditions encountered in the Basal Sands Unit. This in turn would create a driving head of downward pressure along the interface of the sheet pile and the disturbed Marine Grey Silt Unit along wood piles. The amount of downward pressure would fluctuate due to the proximity of the Site to the Hudson River. Tidal influences cause a 4 foot shift in river water level to occur twice daily, and the change in tides have been observed to cause fluctuations in Basal Sands Unit groundwater level. It is not practicable to raise and lower the water levels within the excavation while continuously monitoring changes in head in the Basal Sands Unit. Therefore some level of downward driving hydraulic gradient would exist in a flooded excavation, and it is likely that water with suspended contaminants would flow down through the Marine Grey Silt, creating the potential to cross-contaminate the underlying Basal Sands Unit. The need to excavate around wood piles underwater and the potential for opening flowpaths along the piles when they are disturbed by excavating equipment can exacerbate this condition.

Based on the above, it is concluded that flooded excavations significantly increase the risk of contaminant migration into the Basal Sands Unit, and this risk has eliminated flooded excavations from further consideration as a safe and reasonable excavation support method.

5.2 Existing Wood Piles and Foundation Elements

There are hundreds of wood piles existing in the subsurface across the Site. These piles penetrate the Basal Sands Unit, which is the competent load bearing stratum for building foundations. Some indications of pile locations are available on design drawings. **Figure 2** depicts locations of the deep pile foundations that are thought to exist within the Site boundaries. The majority of the piles shown on the drawing are approximately 5 feet apart from center-to-center. It is noted, however, that actual 'as-built' locations often differ from the design plans. Furthermore, there are structures for which no drawings are available, some of these structures have been removed. Therefore, it is unlikely that predetermination of the positions and spacing between wood piles is possible. Also, the nature of pile caps can not be reliably predicted. The above facts are the basis for the following:

Environmental Considerations

- Since there is no reliable method for back-grouting the pile holes concurrent with, or immediately following, pile extraction, pulling the woodpiles is not considered viable. It is likely that if piles were extracted, preferential pathways for groundwater flow and contaminant migration would result, which may allow PCBs to migrate into the Basal Sands Units aquifer..
- Excavations around such existing wood piles will cause some amount of disturbance of the wood piles as the excavator attempts to remove surrounding contaminated soil. The amount of disturbance of the existing piles must be kept at a minimum to reduce the likelihood of creating a preferential pathway for contaminant migration during construction. In addition, it is expected that the possibility of wood pile movement will increase with depth during the excavation process.

It is anticipated that excavation can be undertaken only after carefully digging around each pile, and cutting off each pile in 2 to 4 ft. lengths. The cutting process would be performed with a tree cutting device that would be mounted on an excavator. At close pile spacing, it may not be practical to use backhoes for excavation. Rather, to continue excavation through and below the piles, a clamshell bucket operated from a crane would be needed. Using this excavation method the pile cutting process would further slow and complicate the excavation.

Based on the above, it is concluded that excavation can be undertaken despite the existence of existing wood piles and other foundation structures. However, it is critical that extreme care be taken in identifying the location of existing piles and that the piles are not disturbed during pile cutting and excavation activities.

5.3 Installing Sheet Piling

As discussed elsewhere herein, the methodology developed for removing the subsurface contamination will require installation of steel sheet pile support structures, with lateral bracing in the form of struts and walers. However, with limited knowledge of the locations of wood piles, bulkheads, wharves and retaining walls, it is likely that installing sheet piles will be a time-consuming and tedious effort because these existing buried structures will obstruct pile installation. The area within 100 to 150 ft. of the present bulkhead should be considered to contain remnants of former wharves composed of timber crib walls, long ago buried under miscellaneous fill. Battered piles (inclined) are also known to have been used to provide lateral support at some bulkheads. The excavations required to implement the remediation would undoubtedly encounter all of these historic water front structures making construction of the excavation support structure along the former bulkheads difficult at best.

Geotechnical Considerations

The following considerations will be required during construction:

- It will be necessary to develop schemes to probe to shallow depth and identify obstructions, and remove those of shallow extent. In the cases where the obstructions in the form of deep pile foundations and wharf piles cannot be removed it will be necessary to relocate the steel sheet pile wall.
- Not all obstructions will be identified prior to sheet pile installations. In this case, it is expected that sheet piles will achieve only part of their intended depths due to encountering obstructions and it is likely that certain sections of sheet piles will have to be pulled out and reinstalled.
- The sheet pile walls will likely not be installed as straight lines, making the subsequent installation of walers and bracing struts a much more complicated process with the need to install separate blocking to sheets that are not flush to the waler.

Environmental Considerations

- The contaminated nature of the Fill will necessitate thorough decontamination of each pulled sheet pile that encounters an unmovable obstruction.
- For deep excavations (greater than about 9 ft.), the sheet piling would need to penetrate through the very soft Marine Grey Silt and into the Basal Sands Unit to develop the required soil passive restraint to laterally support the bottom of the sheets. However the potential for re-mobilization of DNAPL PCBs during installation of sheet pile is likely in this scenario and thus would adversely impact the Basal Sands Unit aquifer. Therefore, the sheet piles should not be driven into the Basal Sand, but to achieve the needed soil lateral restraint without penetrating the Basal Sands Unit, jet grouting in the lower Fill would be necessary.

Based on the above, it is concluded that sheet pile installed above the Basal Sands Unit for excavation support will be difficult and time consuming, but is implementable with perseverance. It is also concluded that driving sheet pile into the Basal Sands Unit is not an option for excavation at this Site. However, to create the necessary lateral restraint within the excavation a continuous layer of jet grout would have to be installed, as described below and further discussed in **Section 5.4**.

5.4 Jet Grouting

One excavation shoring support option considered in this evaluation is to use jet grouting within the toe of the sheet pile cell. Jet grouting is a process whereby a water-cement grout is injected outward from a drill pipe into in-situ soils using high pressure jets. The high pressures (on the order of 4000 to 8000 psi) of grout cut outward through the soil, liquefying it into a soil-grout mixture. Jet grouting has significant benefit at this Site because it can provide adequate excavation support in lieu of deep bracing therefore eliminating the need to install sheet pile into the Basal Sands Unit. However, the following are major considerations regarding the application of jet grouting at the Site:

<u>Geotechnical Considerations</u>

- The effectiveness of jet grouting at the Site will be limited by the presence of the existing woodpile foundations and bulkheads. These structures will form a barrier to the installation of the jet grout. This results in a 'shadow' of ungrouted soil behind each wood pile. There will likely be enough continuity developed to provide lateral sheet pile support, but jet grouting will not form an impermeable barrier to upward flow of artesian water. The shadowing effect inhibits the application of jet grouting to protect against hydrostatic uplift instability.
- Jet grouting in the granular Fill Unit will create fairly strong grout, but in the Marine Grey Silt Unit, the strength of the grout will be substantially less. The anticipated grout column diameter will also vary between soil types, potentially 4 to 6 ft. or more in the granular Fill and 3 to 4.5 ft. in the Marine Grey Silt. The erodable nature of the sandy soils creates larger diameter columns than in the cohesive/plastic silty soils. Accordingly, the design of jet grouting program to increase excavation support should consider the effective use of jet grouting in the Fill only.

<u>Environmental Considerations</u>

- Since the Fill Unit is saturated, an equivalent amount of soil/water will be returned to the ground surface because of displacement during the grouting process. These soil/water/grout spoils will be contaminated with PCBs and would require disposal.

- The process of jet grouting, with high pressures and large volume flow can cause ground (soil) fracturing or ground heave. These fractures provide a potential contaminant transport route from the subsurface to ground surface which would require control.

Based on the above, the following is concluded with respect to jet grouting implementation at the Site:

- Due to the significant number of subsurface structures (woodpiles, etc.), the use of jet grout to provide effective sheet pile lateral support is subject to uncertainty and will require unusually extensive efforts.
- Jet grouting can be used for sheet pile support but will not provide excavation bottom stability against hydrostatic uplift.
- Jet grouting effectiveness and implementability will be limited to the Fill Unit due to the substantially low strengths attainable in the Marine Grey Silt.
- Care must be taken to manage the environmental impacts of jet grouting and related waste handling.

6.0 EXCAVATION EVALUATION

The Site conditions described in **Sections 3.0, 4.0 and 5.0** provide the basis for evaluating the critical excavation design issues at the Site. The four design issues or modes of excavation failures that become more likely to occur as excavations are advanced to greater depths at the Site are: (a) hydrostatic uplift as pressures below the excavation cause buoyant effects; (b) piping that may result from internal soil erosion and quicksand conditions; (c) means to structurally support the sides of excavations with sheet piling; and (d) possible settlement of the ground around the excavation. Each of these design issues is addressed in this section of the report, with some initial comments presented to explain the mechanics of the issue. The soil properties that were used have been derived from available data and subsurface explorations, as discussed in **Section 3.0**. Each of the excavation scenarios assessed consider the remedial excavations to be completed in the dry, as explained in **Section 5.0**.

6.1 Hydrostatic Uplift

Geotechnical Considerations

Hydrostatic uplift occurs when the upward force of hydrostatic pressure in a confined aquifer becomes greater than the weight of the remaining soil at the base of the excavation. Such an uplift condition would occur at the Site when the weight of soil remaining between the bottom of an excavation and the top of Basal Sands Unit becomes less than the force of groundwater pressure in that aquifer. If the force of groundwater pressure in the Basal Sands Unit were to become greater than the soil weight, and other resisting forces, the block of silt and fill could become buoyant and literally float upward. With uplift, cracks may open through the Marine Grey Silt that would produce open pathways for water to flow between the Basal Sands Unit and the Fill Unit. However, before flotation, the ability of the soil to support the sheet piling would be substantially reduced, and large, inward lateral sheet pile deflections or collapse could occur. Such conditions would be catastrophic to the remedial excavation and pose significant safety risks. Therefore, it is imperative that buoyancy or uplift be prevented, and that there is sufficient weight in the Fill/Marine Grey Silt at the base of the excavation to provide for an adequate margin of safety.

The degree of safety against uplift is the ratio of (a) a numerator consisting of the soil total weight and the perimeter adhesion of the soil to the sheet pile, to (b) a denominator consisting of the hydrostatic uplifting force caused by the groundwater pressure acting in the Basal Sands Unit. The Factor of Safety is defined as:

$$\text{Factor of Safety} = \frac{\text{Resisting Forces (i.e., weight of soil block and perimeter adhesion)}}{\text{Driving Forces (i.e., force of the uplifting hydrostatic pressure)}}$$

The soil total weight is simply the dead weight of the soil block above the aquifer. The adhesion is the amount of force developed by the soil in 'sticking' to the sides of the excavation support system. For trial analyses to determine the impact of perimeter adhesion, only one third of the soil strength was applied as adhesion to account for soil disturbance due to sheet pile driving. For a 50 foot square excavation, the adhesion would amount to adding less than 2 feet of soil dead load, and the effect could not be relied on to be evenly distributed across the excavation because the downward acting adhesion would only be at the perimeter but the 6 to 11 ft. pressure acts upward across the entire excavated area. Thus, further assessments did not include perimeter adhesion. In application, the equation used to calculate the Factor of Safety is as follows:

$$FS = \frac{\gamma_{TO}(D_O)}{\gamma_w(H_w)} = \frac{\gamma_{TF}(D_{OF}) + \gamma_{Tmgs}(D_{Omgs})}{\gamma_w(H_w)}$$

Where:

FS = Factor of Safety (Dimensionless) = 1.3

γ_{TO} = Total average unit weight of the overburden (lb/cu.ft)

D_o = Depth of overburden (ft)

γ_w = Unit weight of water (lb/cu.ft)

H_w = Confined aquifer head in Basal Sands Unit (ft)

γ_{TF} = Total unit weight of the fill (lb/cu.ft)

γ_{Tmgs} = Total unit weight of the Marine Grey Silt (lb/cu.ft)

D_{OF}= Depth of the overburden fill (ft)

D_{Omgs} = Depth of the overburden Marine Grey Silt (ft)

The Factor of Safety applied must reflect both the degree of uncertainty in ground parameters (soil properties, groundwater pressure and soil layer thicknesses), and the consequences of failure (safety of workers, potential contaminant migration and aquifer contamination). The soil stratigraphy, hydrogeologic conditions, and soil properties have been shown from the test borings drilled to date to vary considerably at the Site. The relative impact of variations in parameters on Factor of Safety has been assessed by a sensitivity analysis (calculations included in **Attachment C**).

The variations in parameters and conditions applied in the sensitivity analysis were derived from evaluation of conditions determined from the three test borings made in October 2001, information from historic borings at the site, and judgements on possible variations of hydrostatic uplift pressure in the Basal Sands Unit. In general, when reasonable combinations of parameter variations were applied, the Factor of Safety changed by 0.20 to 0.28.

The parameters having greatest impact were hydrostatic pressure in the Basal Sands Unit and the location of the stratigraphic interface between the Marine Grey Silt and the Basal Sands Unit. As indicated in **Section 3.0**, the two observations of groundwater levels in the Basal Sands Unit (in February 1996 and October 2001) indicated that variations in hydrostatic uplift pressure will occur due to both seasonal variations and site location. A seven foot variation was therefore applied in the sensitivity analysis, being twice the observed differences and expected to reflect spring snow-melt and run-off conditions, which have not been measured. To reflect the data available on the depth to interface between the Marine Grey Silt and the Basal Sands Unit, a seven foot variation was applied. Finally, the unit weight of the Marine Grey Silt (which makes up the majority of the soil block resisting uplift) was varied from 110 pcf as presented in **Section 3.0**, to 105 pcf, and then decreased further to 100 pcf.

Although the reasonable combinations of parameter variations caused the Factor of Safety to vary by 0.20 to 0.28, there could be more extreme combinations of parameter changes representing more worst case scenarios. The calculation summaries in **Attachment C** demonstrates that if these variables deviate to these more critical conditions (but still within the ranges from those determined by the three test borings), the calculated Factor of Safety is reduced by as much as 0.34. Because it is considered unlikely that all parameters would become worst case at the same time 1.3 was adopted as a working Factor of Safety against hydrostatic uplift. However, the risk would remain that at a design Factor of Safety of 1.3, it may potentially approach 1.0 or or less.

The analyses in **Attachment C** show that for dry excavations, the deepest that excavations can be made while maintaining the Factor of Safety of 1.3 is 12 feet below ground surface. The calculated depths of excavation for Factor of Safety equal to 1.3 are 11.6, 12.2, and 12.6 feet for borings MW-13A, MW-14A, and MW-15A, respectively. Therefore, the 12 foot excavation depth is adopted as a limiting condition for dry excavation.

Environmental Considerations

A significant consequence of experiencing an uplift condition would be the formation of cracks in the cohesive Marine Grey Silt, particularly around existing wood piles or new sheet piles. These open pathways would allow water to move through the Marine Grey Silt, and open the possibility for migration of contamination from the Fill Unit to the Basal Sands Unit. Accordingly, bottom heave must be avoided to reduce the potential for downward contaminant migration into the Basal Sands Unit.

A common method used to deepen excavations at sites that have high hydrostatic pressures in an aquifer underlying soft soils is to reduce the hydrostatic head in the aquifer. This construction excavation/dewatering technique is not viable for this Site due to the potential for contaminant remobilization if the head were to be lowered in the Basal Sands Unit. As discussed in **Section 4.0**, the hydraulic head in the Basal Sands provides “buoyancy” to PCBs located at the Fill – Marine Grey Silt interface. Engineered changes in this hydraulic condition reverse the pressure (from upward to downward) and may cause the PCB product to remobilize and thereby contaminate the Basal Sands Unit aquifer.

Another technique to overcome hydrostatic uplift, alone or in combination with lowering the head in the Basal Sands Unit, would be to flood the excavation or in other words raise the hydraulic head in the excavation. This activity, alone or in combination with lowering the head in the Basal Sands Unit, could disturb the equilibrium conditions and potentially remobilize PCBs. In addition, this technique carries with it all of the constructability problems of a flooded excavation as identified in **Section 5.1**.

Both of these options to overcome hydrostatic uplift are simply not acceptable because of the potential for cross contamination from the Fill Unit to the groundwater resource in the Basal Sands Unit.

Also as previously discussed, jet grouting as a means to prevent hydrostatic uplift is not an option because of the inability to create a uniform grout bottom to the excavation due to the presence of the multiple existing wood piles and the resultant shadowing effect during grout injection.

6.2 Piping and "Quick Conditions"

Piping is another type of soil/water flow failure that can occur when a soil is subject to an aggravated hydraulic condition. Piping is sometimes manifested as internal erosion, and sometimes causes local quicksand conditions. It must always be avoided in excavations because it represents a fully buoyant condition in which soil particles are floated upward by water flowing through the pores of the subsurface soils. The "quick" condition is caused by the upward velocity of water flowing through the soil, rather than the water pressure that causes the hydraulic uplift condition discussed above. If the seepage forces caused by the flowing water reach a critical condition, then soil particles can be eroded away. The actual manifestation of piping is at first a small boiling up of water carrying soil particles. If not quickly treated by rapidly backfilling with a thick layer of crushed stone or other very pervious soil, then the piping zone will quickly spread out to form a large zone of piping and quicksand. Such piping will often follow the interface between soil and structural elements, such as the sheet piling that support the sides of the excavation. The existing woodpiles, if disturbed, can also yield a preferential pathway for seepage.

Geotechnical Considerations

Piping resistance is offered by the depth (or thickness) of granular soil through which water flows, and the hydraulic energy dissipated. The Factor of Safety is the ratio of the soil's buoyant unit weight to the uplifting force of the water that flows up through pores in the Fill. The force is determined by dividing the distance of flow into the hydraulic head (the energy of the water) dissipated in that distance, and multiplying that ratio by the unit weight of water to derive the uplifting force of the water. The Marine Grey Silt Unit is much less pervious than the Fill, and would normally be considered to be a barrier to water flow that would cause piping. However, it is quite likely that during excavation, pathways for water flow through some depth of the Marine Grey Silt Unit will be opened along either the existing wood piles or the sheet piling. Such pathways would form when the wood piles are disturbed by excavating equipment or when sheared off as discussed in **Section 4.0**. The ramification of this would be to open a linear void along the pile and, if formed through the full thickness of the Marine Grey Silt, that void would provide a direct flow pathway from the Fill to the Basal Sands Unit . Once a pathway occurs, piping could develop rapidly as the trapped hydraulic pressure in the Basal Sands Unit would be provided ready access to the Fill by flowing through the new pathway along the disturbed wood pile or the side of steel sheeting. Since the soil that boils up will quickly loose its strength, the spread of the piping condition could lead to excavation support system failure.

The Factor of Safety against piping should be a minimum of 1.5 for the temporary conditions of the remediation excavations. If it can be assumed that the granular lower Fill would always stay in contact with the wood piles (and the sheet piling of the excavation support system), then the depth of Fill between the bottom of the excavation and the top of the Marine Grey Silt should always be at least 50% greater than the hydraulic energy difference between the Basal Sands Unit and the bottom of excavation. Therefore, there should always be at least 25 ft. of Fill between the Marine Grey Silt and the bottom of excavation. This would mean leaving an unusually thick soil block to reliably prevent piping in worst case situation. The low unit weight of the Fill (91 pcf) makes flotation easier to occur, and limits dry excavation depths to about 6 ft. However, if dry excavations are advanced to 12 ft. depth, there will be just 15 ft., 16 ft., and 19 ft. of Fill between the bottom of excavation and the top of the Marine Grey Silt, as measured in Borings MW-13A, MW-14A, and MW-15A, respectively. In these cases there would not be enough Fill to balance the hydraulic energy, let alone enough to provide any appreciable margin of safety (see Calculations in **Attachment C**).

Therefore, piping may be expected to develop in some locations when wood piles are disturbed enough during the dry excavations below a depth of about 10 ft to open pathways through the Marine Grey Silt. Since there are numerous wood piles distributed throughout the Site, and deeper excavations would increase the likelihood of developing piping conditions, one might want to further limit dry excavations to only those shallower depths at which piping would not develop if a complete pathway through the Marine Grey Silt were to open. However, it is recognized that piping will initially be a localized failure as opposed to the more massive uplift failure expected if hydrostatic uplift were to occur. As such, a piping condition usually can be mitigated by rapidly placing a mound of crushed stone or sand over the area. Such occurrence would certainly present clear need to re-evaluate future excavation depths and practices.

Environmental Considerations

The most significant environmental concern with piping is the potential for a change in pore opening size along the pipe. This change in pore opening size causes a decrease in the pore entry pressure thereby allowing suspended soil particles with PCBs or PCB DNAPL to potentially mobilize.

6.3 Sheet Pile Design Evaluation

An essential element necessary to complete deep excavations is adequate lateral excavation support structures. Steel sheet pile walls and bracing support structures are adequate to support excavations at the Site. However unsupported excavations could not practically be performed to any significant depth below the water table due to proximity of the river, the low soil strength, the high trapped artesian hydraulic head in the Basal Sands Unit, and the large number of wood piles in place. The following assumptions and information were utilized in evaluating the use of sheet pile for excavation support:

- A Coulomb pressure model was used to calculate lateral soil pressures, with and without soil to sheet pile friction/adhesion.
- Widely accepted classical sheet pile design methods were used for sheet pile analysis.
- Surface surcharge loading due to construction activity, material handling and stockpiling, and truck hauling traffic taken equal to 400 pounds per square foot (which is a standard practice).
- Groundwater level in the Fill Unit was assumed to be at ground surface.
- PZ-27 sheeting was used as the preferred sheet pile section, but the heavier section of AZ-48 was also used when additional structural capacity was required. PZ-27 is a commonly available steel sheet pile section. The AZ-48 is the strongest commercially available steel sheet pile, but its availability is sometimes limited.
- Sheet pile toe penetration is limited to a total depth no greater than 5 feet above the top of the Basal Sands Unit. This depth was established to prevent compromising the Marine Grey Silt Unit and maintain its important function as a confining layer that prevents downward migration of PCBs into the underlying Basal Sands Unit.
- The sheet pile design was conducted using *SPW-911 version 2.0, Sheet Pile Design Software* (Pile Buck, Inc.).

Geotechnical Considerations

The sheet piling support system needed to complete excavations requires two structural bracing levels to advance the excavations to the 12 ft. depth limit dictated by the hydrostatic pressure uplift and piping conditions at the Site. The loose Fill and very soft Marine Grey Silt provide little positive support for the sheet piling. The steel sheeting must hold back the full hydrostatic and soil pressure that will be acting from outside the excavation. To do so, the sheet piles must be embedded into the Marine Grey Silt Unit to act as a cut-off structure against groundwater flow from the exterior Fill water system. This leads to a difficult excavation support situation because the Marine Grey Silt is so weak that it does not provide any net internal resistance to the toe of the sheet pile walls. Therefore, for deeper excavations to be supported by internal bracing, jet grouting below the base of the excavation will be required to provide the needed lateral support at the toe of the sheet piles.

The maximum depth for sheet pile installation was determined by applying the following criteria:

- Sufficient sheet pile penetration to provide adequate lateral restraint in front of the sheet piles and prevent inward movement and rotation of toe (but not deeper than 5 ft. above the Basal Sand Unit).
- Allowable bending moment for the respective sheet pile – e.g. limited to 62,842 ft-lb/ft for PZ-27 (f_s = 25 ksi) steel sheet pile, and 185,820 ft-lb/ft for AZ-48 (f_s = 25 ksi) steel sheet pile.

The following summarizes the results of the assessment and analyses performed relative to support of excavations:

Shallow excavations can be made down to the Fill Water Table without sheet piling. The Fill Water Table is located between 0 to 3 ft. below existing ground surface at the Water Tower and Northwest Corner areas of the Site. These excavations will have sloping sides at perhaps 3 feet horizontal to 1 foot vertical. When excavations are advanced deeper than approximately 3 ft., lateral support of the excavation is required to prevent side slope collapse. Also without sheet piling, open excavations that extend below the Fill water table would collect a large quantity of contaminated seepage water and may pose substantial health risk to workers in the excavation. In addition, excavation to greater depths below the fill water table without sheet piling would present the potential for catastrophic excavation failure via side wall collapse.

Therefore advancing excavations to depths below the water table will require sheet pile for side wall support. If no bracing is installed to support the sheet piling, then excavations with cantilevered sheet piling in the Fill can be made to depths of approximately 4 ft. to 5 ft. Even the higher strength sheet piling is quickly over-powered by the poor soil conditions, (due to inadequate toe support). This will prevent excavation using unbraced sheeting to depths greater than 5 ft. (just less than half of the 12 ft. available depth based on hydrostatic uplift considerations). To achieve deeper excavations in the dry, internal bracing must be installed.

With one level of internal bracing installed at the 3.6 to 4.2 ft. depth, the dry excavation can be advanced to 5.8 ft. to 8.3 ft. at the range of soil profiles determined for the three borings. The evaluation indicates that as the excavation is deepened, the loss of the interior support provided by the Fill is aggravated by the very weak Marine Grey Silt which leads quickly to sheet pile toe support failure. While the calculations show that the installation of a second level of bracing at a depth 5.3 to 7.8 ft. would permit continuing the excavation to a depth of 6.3 to 8.7 ft., the actual installation of two levels of structural steel for bracing the sheet pile walls would be very difficult given their close vertical proximity.

Therefore, to make excavations deeper than allowed by two levels of bracing, it would be necessary to install a layer of jet grout between 15 to 19 ft. in the lower fill to support the toe of the sheet pile walls. The jet grout must solidify to create a stiff layer of soil-cement. With the toe of the sheet piles stiffly supported below the desired excavation grade, the calculations indicate that dry excavations could be carried down to a depth of 15 ft. below ground surface with the support of this 4 ft. thick layer of jet grout. However it is important to note that the depth of excavation continues to be limited to 12 ft. by hydrostatic uplift conditions.

Attachment C contains the design calculations associated with the above analyses.

Environmental Considerations

There are no environmental issues associated with sheet pile installation scenarios described above, based on the following:

- Sheet piles will not be driven deeper than five feet above the top of the Basal Sands Unit.
- Flooded excavations are excluded from consideration.
- Sheets that are refused by obstructions prior to achieving their target installation depth will have to be decontaminated prior to re-installation.

6.4 Consolidation of Marine Grey Silt Unit

Excavation dewatering can result in consolidation and settlement of the Marine Grey Silt Unit due to increased effective stresses. Consolidation of the Marine Grey Silt Unit was evaluated with respect to these increased effective stresses. Based on these evaluations, it was determined that if the proposed excavation dewatering operations were done before excavation, then there could potentially be as much as 0.66 feet of consolidation of the Marine Grey Silt Unit. This evaluation was performed as a worst case scenario, taking into account consolidation caused by de-watering only. The evaluation did not consider the effect of removing fill after de-watering, which would decrease the effective stresses and likely negate most of the magnitude of the potential consolidation.

Since consolidation is time dependent, a rate of consolidation analysis was performed and it was determined that the time required to achieve 50-percent of the total consolidation was approximately 0.75 years. Because the time required to complete any single excavation cell is significantly less than 0.75 years, consolidation due to de-watering is not considered to be a limiting design constraint, although a thorough evaluation of potential consolidation would be required at the time of final design.

7.0 EXCAVATION EVALUATION SUMMARY

The ability to complete an excavation at a particular location is defined by the physical properties of the subsurface, the excavation depth, the excavation method, engineering controls such as excavation lateral support and de-watering, and by considering environmental risks associated with the excavation itself. The Harbor at Hastings Site exhibits many unique conditions and physical properties associated with the Site as a result of its land mass being created with riverfront backfill. The physical nature of the Site and these conditions limit the types of excavations which can be performed safely without causing risk to human health and the environment.

Within **Section 5.0** and **Section 6.0** potential excavation failure modes and the ability to construct an excavation at the Site were evaluated. Based upon these evaluations, the feasibility of excavating fill material to increasing depths was reviewed. It is important to note that potential excavation failure via the noted failure modes would be particularly damaging to the environment at the Harbor At Hastings Site. Unlike other sites not located in an environmentally sensitive setting, excavation failure at the Site presents an imminent risk of cross contamination between the Fill Unit and the deeper Basal Sands Unit, which contains the groundwater aquifer. Excavation failure also presents a significant safety risk.

7.1 Basic Principles

As described throughout this report, the two underlying ***fundamentals*** that control the choice of excavation method and excavation depth at the Site are:

1. Excavation must be completed in a manner that does not spread contamination to resources beneath or adjacent to the Site that are currently not impacted by past Site activities. The resource that is of utmost concern is the Basal Sands Unit and the groundwater system/aquifer located within the unit. Complying with this fundamental allows the remedial excavation to be undertaken in a manner that is protective of the aquifer and the environment.
2. Excavation must be undertaken in a manner protective of human health. Worker health and safety must be the primary criterion for excavation method selection. Complying with this fundamental allows the remedial excavation to be undertaken in a manner that is protective of human health.

Conformance with the above fundamentals is essential to the successful remediation of the Site.

The underlying fundamentals described above provide the foundation for excavation method selection and excavation depth determination as described throughout this document. In keeping with these fundamentals, three "Basic Principles" become obvious for governing excavation method selection and the resulting excavation depth requirements. These basic principles are:

1. All excavations must be undertaken in the dry. Flooded excavations violate both ***fundamentals*** described above.
2. There will be no pumping of Basal Sands Unit groundwater for hydrostatic head relief. Pumping groundwater from the Basal Sands Unit to provide hydrostatic head relief would violate the first ***fundamental*** stated above.
3. There will be no penetration of the Basal Sands Unit including penetration by excavation support structures, and no woodpile extractions. If excavation support extended into the Basal Sands Unit, it would violate the first ***fundamental*** stated above.

The combined affect of the three Basic Prinicples on excavation are as follows:

1. Excavation depth is limited to a maximum of 12 feet, the depth at which hydrostatic uplift from an unaltered Site hydrostatic head condition would fail a dry excavation. Excavation support structures, regardless of depth of installation, have no influence on controlling hydrostatic uplift.
2. Excavation depth may be further limited to 9 feet or the depth at which excavation support (sheet pile) failure occurs if the sheet piles are not supported by grout. As noted in **Section 5.4**, the use of jet grout may not be implementable at this Site.
3. Excavation to a depth of 6 to 9 feet can be undertaken using braced sheet piles that are only installed into the Marine Grey Silt Unit. Excavation to a depth of 12 feet can be undertaken using sheet pile installed into the Marine Grey Silt as long as the sheet pile is supported by jet grout (see item 2, above).
4. No penetration of the Basal Sands Unit is necessary by excavation support structures to support excavation to depths of 9 or 12 feet, providing that jet grout is used to establish rigid lateral support in the lower fill.
5. Throughout excavations deeper than 6 ft., careful attention must be directed toward the potential onset of piping.

The following discussion summarizes excavation at the Site. **Table 5** summarizes each type of excavation, the maximum depth attained by each, and the shoring requirements. The maximum depth of excavation was determined by evaluating the results of the analysis described in **Sections 5.0 and 6.0.**

<u>Shallow Excavation</u>

Shallow excavations are limited to the approximate depth of the water table and generally will not require shoring with the exception of shore line protection. While the water table is generally found at depths ranging from 0 to 8 feet below grade across the entire Site, the water table was identified between 0 to 3 feet below grade in the primary areas of concern for this remediation task (i.e. the Water Tower Area and the Northwest Corner). Shallow excavations may be possible to depths slightly below the water table if excavation sloping and benching are performed.

Technical challenges associated with completing shallow excavations include, but are not limited to, protection of surface structures that may create a hazard (ie; building foundations, utilities, etc.), locating and removing subsurface obstructions, locating and routing of underground utilities and sloping and benching systems. Although each of these challenges would need to be addressed in the final design, shallow excavation is clearly implementable and the risks to workers and the environment are manageable.

Deeper Excavations

Deeper excavations are defined as those that are advanced below the water table and require sheeting with necessary shoring and bracing. Based on the weak nature of the Fill Unit/Marine Grey Silt Unit and the hydrogeologic conditions associated with the Hudson River, the Fill water system, and the artesian groundwater system, the degree of difficulty associated with completing deep excavations at the Harbor At Hastings Site increases substantially with each foot of increasing excavation depth. Deeper excavation designs are limited by the maximum permitted depth of the required sheet piling to five feet above the Basal Sands Unit in order to mitigate potential piping and cross contamination conditions.

Deeper excavations were evaluated based on the stratigraphic data collected from each boring location and the design parameters summarized in **Table 4** and in **Attachment C**. A deeper excavation can be performed to a practical maximum depth of approximately 6 to 9 feet below grade with sheeting driven down deep into the Marine Grey Silt, but not into the Basal Sand Unit. The maximum depth of excavation at all locations was limited by the weak and soft existing soil. If grouting is used to enhance sheet pile toe stability, a deeper excavation depth is possible, but is limited to approximately 12 feet below grade at which depth hydrostatic uplift becomes the controlling limitation to the excavation depth.

In addition to the challenges associated with shallow excavation, deeper excavations will require de-watering procedures to control and remove soil water and precipitation. Deeper excavation will also require the implementation of site worker health and safety policies applicable to shored excavations. Also as noted, as deeper excavations are advanced, historic Site records indicate that wooden piles will be encountered. The wooden piles extend to the Basal Sands Unit and will require cutting at various depths to advance the excavation. The placement and advancement of steel sheeting is also likely to be inhibited by the presence of piles and subsurface obstructions. The implementation of grout stabilization of the base of the sheet pile cells to prevent the inward movement of the toe of the sheeting will also be technically challenging, and can only be safely completed in the Fill Unit due to its granular nature. These challenges are a result of the nature of the Fill and Marine Grey Silt Units and potential incomplete installation of the grout columns due to the presence of woodpiles and other shadowing structures.

The implementation of the deeper excavation at the Site, although extremely complex due to the previously noted Site conditions, likely can be completed to the specified depths. However it is essential that the ability to visually inspect various excavation activities be maintained. Most critically, visual inspection and observation of the placement of bracing, pile cutting/removal and actual Fill removal from the sheet pile cells is imperative to the completion of the excavation without adverse impacts to worker safety or the environment.

8.0 CONCLUSION

It is not feasible to excavate the full extent of PCB contamination at the Site using shoring and bracing methods without posing an unacceptable risk to human health and the environment. The Harbor-At-Hastings Site is composed of very loose man-made Fill, underlaid by very soft, weak, native subsurface conditions. Contrary to most formations, the soils remain soft and weak with depth. The Site's Fill Unit also contains elevated levels of PCBs that are currently stable and essentially immobile. The PCBs and other constituents in the Fill Unit are separated from the regional Basal Sands Unit aquifer by the overlying Marine Grey Silt Unit aquitard. The integrity of this aquitard is currently sound and prevents downward movement of contaminants. Deep excavation or excavation failure will develop migration pathways within the aquitard and enable contaminants to impact the underlying aquifer in the Basal Sand Unit. The results of the engineering analyses and the further considerations for environmental risks at the Site that are described in this report are summarized below.

Three Basic Principles governing excavation at the Site have been developed as a result of the investigation and evaluation described herein and include:

1. All excavations must be undertaken in the dry in order to effectively manage the excavation process, maintain clean backfill materials and protect human health and the environment.
2. There will be no pumping of Basal Sands Unit groundwater for hydrostatic head relief in order to protect the environment from exacerbation of contamination.
3. There will be no penetration of the Basal Sands Unit including penetration by excavation support structures in order to protect the environment from exacerbation of contamination.

These Basic Principles must be adhered to as a whole to undertake successful excavation at the Site and provide the basis for the following construction constraints:

- Sheet piles will be driven no deeper than the Marine Grey Silt Unit with adequate separation between this unit and the Basal Sands Unit.

- Existing piles will not be removed from the excavation; instead they will require cutting to the depth of excavation.
- The maximum excavation depth will be controlled by the depth at which bottom failure from hydrostatic uplift occurs in a dry excavation.
- Significant care must be taken to minimize the disturbance of the existing structures during excavation.

In the de-watered excavation case, without the use of special and extensive jet grouting, the maximum depth of excavation is limited by structural failure of the soils and the toe of the sheet pile cell. Such ground failure occurs because the Fill Unit and Marine Grey Silt Unit are extremely soft and weak and provide little support to the embedded portion of sheet pile cells. When the maximum depth to which the sheet pile cells are installed is restricted to the Marine Grey Silt (i.e. limited to five feet above the Basal Sands Unit: to prevent cross contamination), excavation of the supporting fill material from within the cells ultimately results in a condition where the cell collapses inward. Deeper de-watered excavation can be performed beyond a depth of 9 feet only when the soils and the toe of the sheet piles are strengthened by jet grouting. Extending sheeting down to penetrate deep into the Basal Sand Unit could also prevent such sheet pile instability from occurring, but it would likely cross-contaminate the Basal Sands Unit with PCBs, and would violate one of the three Basic Principles developed in **Section 7.0**.

When the toe of the sheet pile is supported by a jet grout layer, the maximum depth of a de-watered excavation could be extended down to 12 feet below ground surface. At a depth of 12 feet the excavation is limited by conditions related to hydrostatic uplift forces. Also, at these depths, piping of water upwelling from the Basal Sands Unit along pathways through the Marine Grey Silt (pathways opened as consequence of the construction) can cause local instabilities and transport contamination.

Excavations at significant depths below the water table in a highly active river environment will expose workers to the forces of the Hudson River, the artesian conditions of the Basal Sand Unit and the extremely weak properties of the Harbor-At-Hastings land mass. These could potentially cause sheet pile failure and result in a catastrophic loss of life.

Based on the severe impacts associated with excavation failure, the maximum depth of excavation should not be extended deeper than 12 ft., and the excavation should only be made under dry conditions, with sides fully supported by braced steel sheet pile systems.

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TABLES

Table 1
GROUNDWATER TABLE ELEVATION
October 1, 2001
Harbor at Hastings Site

Well ID	Screened Interval (ft BGS)	Top of Casing Elevation (ft - NAVD)	Ground Elevation (ft - NAVD)	Groundwater Elevation / Time of Monitoring									
				8:30		9:00		10:00 (high tide)		11:00		12:00	
				GW Level (ft BGS)	GW Elev (ft - NAVD)	GW Level (ft - BGS)	GW Elev (ft - NAVD)	GW Level (ft - BGS)	GW Elev (ft - NAVD)	GW Level (ft - BGS)	GW Elev (ft - NAVD)	GW Level (ft - BGS)	GW Ele (ft - NAV
MW-13A	75-90	5.02	5.29	1.16	3.86	0.9	4.12	0.66	4.36	0.63	4.39	1.1	3.92
MW-13B	5-25'	5.09	5.4	3.5	1.59	3.43	1.66	3.32	1.77	3.22	1.87	3.18	1.91
MW-14A	75-90	3.01	3.37	0.1	2.91	< 0	>3.37	< 0	>3.37	< 0	>3.37	0	3.01
MW-14B	3-20'	2.92	3.29	0.68	2.24	0.3	2.62	< 0	>3.29	-0.1	3.02	0.61	2.31
MW-15A	71-86'	8.3	6.62	4.78	3.52	4.41	3.89	4.09	4.21	4.09	4.21	4.32	3.98
MW-15B	5-30'	9.02	6.8	7.46	1.56	7.39	1.63	7.22	1.8	7.22	1.8	7.21	1.81

Notes: BGS: Below Ground Surface TOC: Top of PVC Casing
High tide at 10:00 and 22:00, Low tide at 16:15
NAVD: North American Datum of 1988
Negative GW level indicate that water level is above TOC elevation (flowing artesian condition)

Well ID	Screened Interval (ft BGS)	Top of Casing Elevation (ft)	Ground Elevation (ft)	Groundwater Elevation / Time of Monitoring									
				17:00 (low tide)		18:00		19:00		20:00		21:00	
				GW Level (ft - BGS)	GW Elev (ft - NAVD)	GW Level (ft - BGS)	GW Elev (ft - NAVD)	GW Level (ft - BGS)	GW Elev (ft - NAVD)	GW Level (ft - BGS)	GW Elev (ft - NAVD)	GW Level (ft - BGS)	GW Ele (ft - NAV
MW-13A	75-90	5.02	5.29	2.21	2.81	2.05	2.97	1.75	3.27	1.48	3.54	1.11	3.91
MW-13B	5-25'	5.09	5.4	3.48	1.61	3.53	1.56	3.55	1.54	3.51	1.58	3.47	1.62
MW-14A	75-90	3.01	3.37	0.86	2.15	0.58	2.43	0	3.01	between	[3.01 - 3.37	< 0	> 3.37
MW-14B	3-20'	2.92	3.29	2.6	0.32	2.48	0.44	1.98	0.94	1.58	1.34	0.89	2.03
MW-15A	71-86'	8.3	6.62	5.6	2.7	5.62	2.68	4.91	3.39	4.75	3.55	4.4	3.9
MW-15B	5-30'	9.02	6.8	7.68	1.34	7.41	1.61	7.58	1.44	7.54	1.48	7.42	1.6

Notes: BGS: Below Ground Surface TOC: Top of PVC Casing
High tide at 10:00 and 22:00, Low tide at 16:15
NAVD: North American Datum of 1988
Negative GW level indicate that water level is above TOC elevation (flowing artesian condition)

TABLE 2
GROUNDWATER TABLE ELEVATION
October 9, 2001
Harbor at Hastings Site

Well ID	Screened Interval (ft BGS)	TOC Elevation (ft-NAVD)	Ground Elevation (ft-NAVD)	Groundwater Elevation / Time of Monitoring: 13:15 GW Level (ft - BGS)	13:15 GW Elev (ft - NAVD)	14:15 GW Level (ft - BGS)	14:15 GW Elev (ft - NAVD)	14:45 GW Level (ft - BGS)	14:45 GW Elev (ft - NAVD)	15:15 GW Level (ft - BGS)	15:15 GW Elev (ft - NAVD)	16:00 GW Level (ft - BGS)	16:00 GW Elev (ft - NAVD)
MW-13A	75-90	5.02	5.29	2.43	2.59	2.19	2.83	1.82	3.2	1.71	3.31	1.63	3.39
MW-13B	5-25'	5.09	5.4	4.73	0.36	4.69	0.4	4.62	0.47	4.6	0.49	4.56	0.53
MW-14A	75-90	3.01	3.37	0.7	2.31	-0.37	3.38	-0.54	3.55	-0.58	3.59	-0.58	3.59
MW-14B	3-20'	2.92	3.29	3.19	-0.27	2.63	0.29	2.31	0.61	2.04	0.88	1.92	1
MW-15A	71-86'	8.3	6.62	5.93	2.37	5.32	2.98	5.17	3.13	5.08	3.22	5.09	3.21
MW-15B	5-30'	9.02	6.8	8.72	0.3	8.64	0.38	8.6	0.42	8.56	0.46	8.54	0.48

Notes: BGS: Below Ground surface TOC: Top of Casing (PVC)
GW Level: Groundwater level measured from the TOC
GW Elev: Groundwater elevation referenced to the NAVD ' 88 system.
Negative GW level indicate that water level is above TOC elevation (flowing artesian condition)
NAVD: North American Datum of 1988

	Depth (1) (ft BGS)	Well ID	USC class (2)	LL (3)	PL	[illegible] (7)	Cc (8)	Cv (8) [illegible]	Gravel (9) (%)	Sand (9) (%)	Silt/Clay (9) (%)
Fill	20 - 22'	MW-13	GM	NP	NP		-	-	46.3	41.3	12.4
	24 - 26'	MW-15	GM	NP	NP		-	-	39.8	37.5	22.8
Transition	19-21'	MW-14	MH	51	35		-	-	0	13.9	86.1
Marine Silt	30 - 32'	MW-13	CL	32	23		0.35	0.0105	3.9	42.3	53.8
	40 - 42'	MW-13	CL	40	26		0.43	0.008	13.1	12	75
	50 - 52'	MW-13	SM	21	19		0.37	0.05	0.8	49.6	49.7
	34 - 36'	MW-14	CL	36	24		0.44	0.015	1.4	23.7	74.9
	40 - 42'	MW-14	ML	28	27		0.48	0.0125	0	27	73
	48 - 50'	MW-14	CL	28	20		0.54	0.04	-	-	-
	36 - 38'	MW-15	ML	32	26		-	-	0	11.1	88.9
	44 - 46'	MW-15	SM	NP	NP		0.4	0.0075	-	-	-
	54 - 56'	MW-15	ML	23	22		0.45	0.0225	-	-	-
Basal Sand	58-60'	MW-13	SM	NP	NP		-	-	2.8	78.9	18.4
	75 - 76'	MW-13	SM	NP	NP		-	-	10.5	55.5	34
	76 - 77'	MW-13	ML	23	24		-	-	0	16.4	83.6
	82.9 - 83'	MW-13	ML	24	22		-	-	0	3.9	96.1
	86.4 - 86.6'	MW-13	SM	NP	NP		-		0	87.4	12.6
	60 - 62'	MW-14	SM	NP	NP		-	-	2.6	75.4	22
	79 - 80'	MW-14	SP-SM	NP	NP		-	-	34.3	60.2	5.5
	80 - 81'	MW-14	ML	NP	NP		-	-	0	41.7	58.3
	70 - 72'	MW-15	SP	18	NP		-	-	2.2	67.7	30.1
	76 - 80	MW-15	ML	21	18		-	-	0	48.6	51.4

Notes:
(1): ft BGS = feet below ground surface
(2): Unified Soil Classification System according to ASTM D 248
(3): Atterberg Limits according to ASTM D4318 (LL = Liquid Limi
(4): Total/Dry Unit Weight EM-1110-2-1906, Appendix II (pcf = p
(5): Moisture content by ASTM D 2216 (% = percent)
(6): Cohesion and friction angle from unconsolidated undrained t
(7): Cohesion and friction angle from direct shear test
(8): One dimensional consolidation according to ASTM D2435 (s
(9): Particle Size Analysis ASTM D422 (% = percent)

Table 4
SUMMARY OF GEOTECHNICAL INPUT PARAMETERS
Harbor at Hastings Site

Geologic Unit	Depth (1)	Total Unit Weight (2)	Submerged Unit Weight (3)	Cohesion (4)	Friction Angle (5)
Upper Fill	0 to 10 feet	91 pcf	29 pcf	0 psi	31°
Lower Fill	10 to 30 feet	91 pcf	29 pcf	0 psi	25°
Fill -- Silt Transition (6)	17 to 30 feet	96 pcf	33 pcf	2.72 psi	0°
Marine Grey Silt	30 to 52 feet	110 pcf	50 pcf	1.55 psi (7)	0°
Grey Basal Sand	52 to 75 feet	110 pcf	62 pcf	0 psi	28°
Reddish-Brown Basal Sand	75 feet +	110 pcf	62 pcf	0 psi	35°

Notes:

(1) Measured as feet below ground surface. Generalized from geotechnical borings.

(2) In pounds per cubic foot (pcf). Calculated as arithmetic average of geotechnical samples obtained from relevant geologic unit, and by published correlations.

(3) In pounds per cubic foot (pcf).

(4) In pounds per square inch (psi). Calculated using U.S. ACE 33% geotechnical design shear strength method from geotechnical samples obtained from relevant geologic unit.

(5) Calculated using U.S. ACE 33% geotechnical design shear strength method from blow count data obtained from relevant geologic unit, and by published correlations.

(6) Mixed transition zone present only in MW-14B.

(7) Average strength of 2.84 psi also investigated, but it has little impact on sheet pile design.

Table 5
SUMMARY OF EXCAVATION AND SHORING REQUIREMENTS
Harbor at Hastings Site

Excavation Type	Maximum Depth (1)	Shoring Description (1)
Shallow (unsupported)	0-3 (i.e. Down to groundwater table)(2)	No shoring required.
Moderate – Depth De-watered (without Bracing	4 to 5 ft.	Sheet pile cell, cantilevered so no internal bracing. Sheet piles driven min. 35 ft.
Deeper – De-watered (without Jet Grout)	6 to 9 ft.	Sheet pile cell with internal bracing and sheet piles driven min. 35 feet.
Deeper – De-watered (with Jet Grout)	12(3)	Sheet pile cell with internal bracing and sheet piles driven min. 35 feet.
Deeper – De-watered (with thick Jet Grout)	>20(4)	Sheet pile cell with internal bracing and shoring driven up to 51 feet. (5)

Notes:

(1) The maximum depth of excavation and length of sheetpile in feet below ground surface.

(2) The maximum depth of a shallow excavation is approximately equal to the elevation of the groundwater table, which is found at depths of 0 to 3 feet in the Water Tower and Northwest Corner Areas. Shallow excavations may be possible to depths slightly below the water table if flattened excavation side slopes and/or benching are performed.

(3) Depth limited by Hydrostatic uplift criteria.

(4) Although, excavation support walls could be made stable for 20' deep dry excavation12 ft. thick jet grout below excavation bottom to support toe of sheet pile wall, the excavation depth is limited to 12 ft. by Hydrostatic uplift criteria.

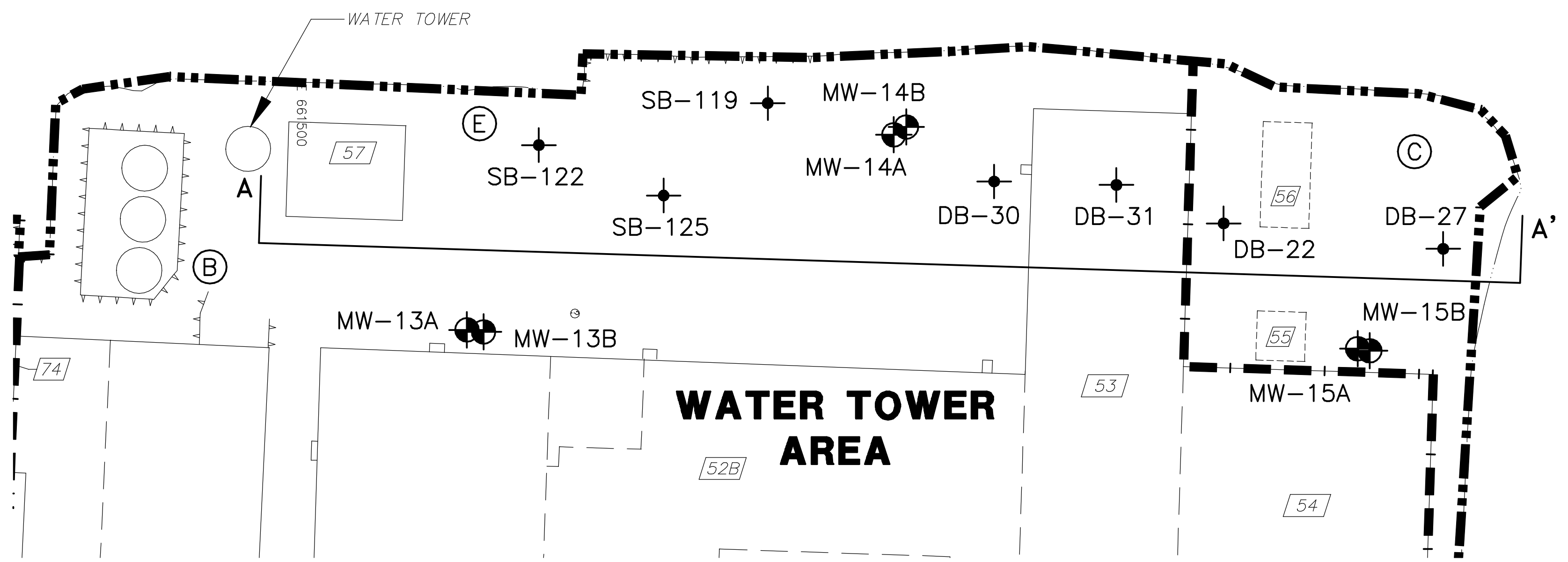
(5) Sheet pile depth may not penetrate closer than 5 ft. above Basal Sand Unit.

FIGURES

DRAWING NUMBER 829945B3
APPROVED BY ---
CHECKED BY ---
DRAWN BY JC/SSH 10/18/01
OFFICE NORW/ALB
X-REF 9-20-01
LAYOUT/VIEW Site17x11

N

SCALE
0 100 200 FEET



LEGEND:

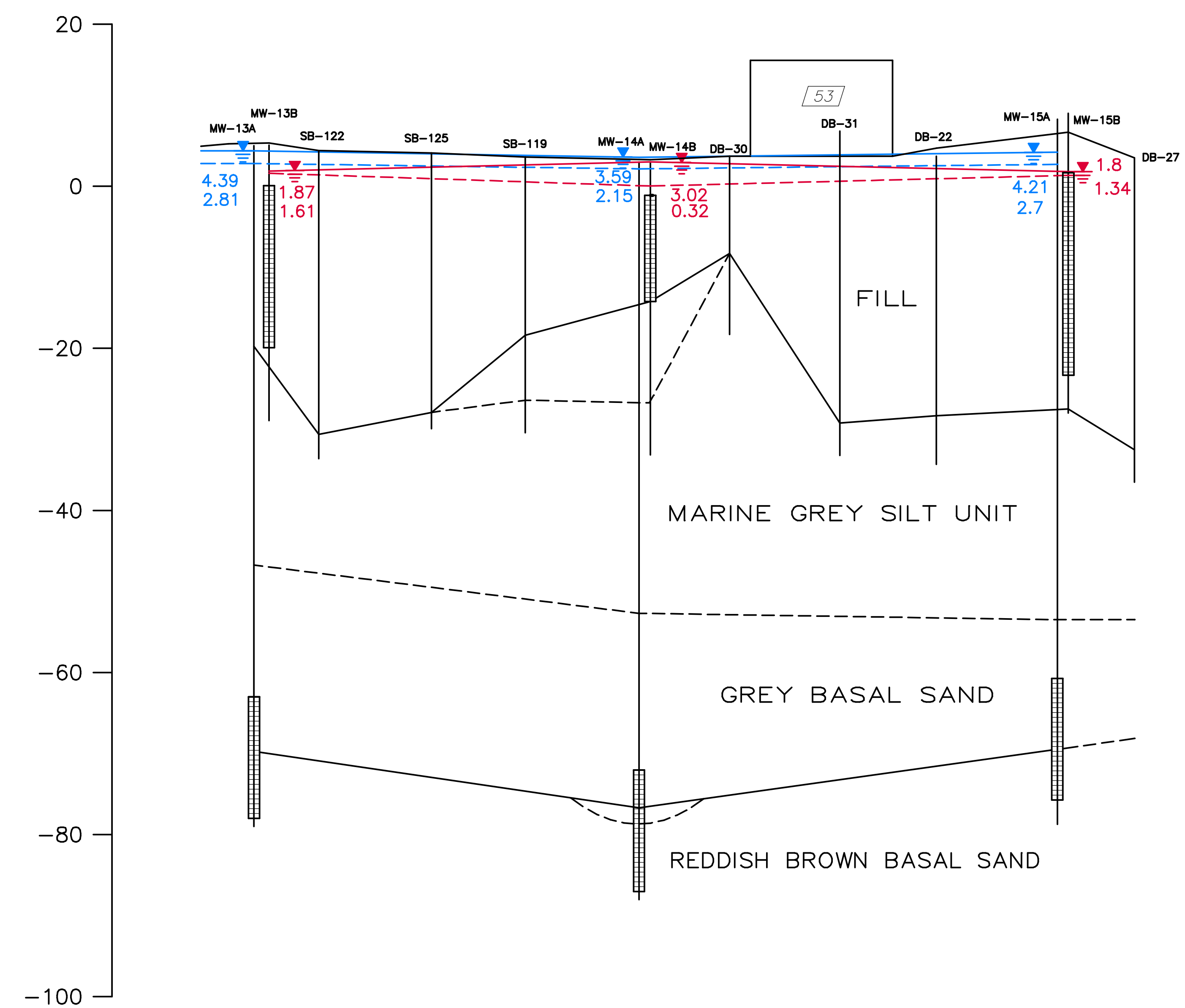
- HISTORICAL BOREHOLE LOCATION
- MONITORING WELL LOCATION
- BUILDING DESIGNATION
- APPROXIMATE SITE BOUNDARY
- SITE AREA BOUNDARY
- HIGHEST GROUNDWATER ELEVATION IN BASAL SAND UNIT (11:00, OCTOBER 1, 2001)
- LOWEST GROUNDWATER ELEVATION IN BASAL SAND UNIT (17:00, OCTOBER 1, 2001)
- HIGHEST GROUNDWATER ELEVATION IN FILL UNIT (11:00, OCTOBER 1, 2001)
- LOWEST GROUNDWATER ELEVATION IN FILL UNIT (17:00, OCTOBER 1, 2001)
- 4.35 : WATER TABLE ELEVATION IN FEET
- FORMER BUILDING OUTLINE

INTERIM REMEDIAL MEASURES

- (B) SEPARATE PHASE LIQUID RECOVERY IRM
- (C) NORTHWEST CONER IRM
- (E) BUILDING 57 IRM

VERTICAL SCALE
0 20 40 FEET

HORIZONTAL SCALE
0 100 200 FEET



NOTE:

THE MOST ELEVATED GROUNDWATER ELEVATION WERE MEASURED ON OCTOBER 1, 2001 WITH THE EXCEPTION OF MW-14A WHICH WAS MEASURED OCTOBER 9, 2001 DUE TO ARTESIAN CONDITION

REFERENCES:

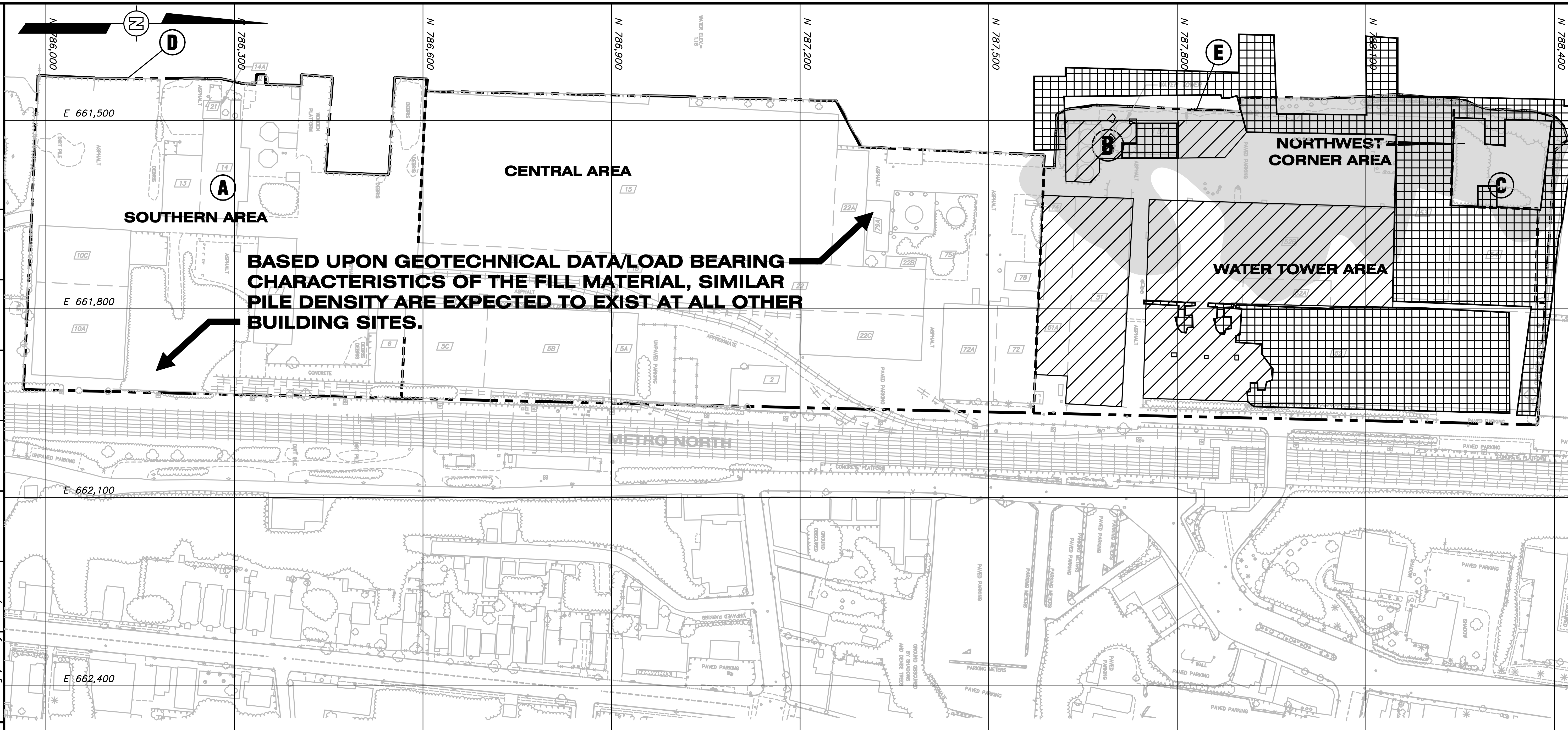
1.) TOPOGRAPHY AND PLANIMETRICS PROVIDED BY GEOD PHOTOGRAMMETRIC SCIENCES SURVEY TECHNOLOGIES. MAPPED BY PHOTOGRAMMETRIC METHODS FROM AERIAL PHOTOGRAPHS TAKEN 12-08-1995. GRIDS BASED ON NEW YORK 1988 STATE PLANE COORDINATE SYSTEM. VERTICAL DATUM IS BASED ON NAD 1983. RI SAMPLE LOCATIONS SURVEYED BY GEOD.
2.) HISTORICAL SAMPLING LOCATIONS BASED ON DOLPH ROTFELD, FIGURE 4, DATED 1976, PARISH & WEINER, PLATE 2, DATED OCTOBER 1989 AND RETEC, FIGURE 2-8, DATED DECEMBER 1993. THESE LOCATIONS ARE APPROXIMATE ONLY, AS LAND SURVEYING DATA ARE NOT AVAILABLE.
3.) EXISTING BUILDING DESIGNATIONS ARE BASED ON DOLPH ROTFELD ASSOCIATES FIGURE 4, DATED NOVEMBER 1996. BUILDING INTERIOR DIVISION LOCATIONS ARE APPROXIMATE ONLY.

Shaw E & I, Inc.

ATLANTIC RICHFIELD COMPANY

FIGURE 1

CROSS-SECTION A-A'
HARBOR AT HASTINGS
HASTINGS-ON-HUDSON, NEW YORK



DRAWING 806938B14

APPROVED BY

CHECKED BY

DRAWN BY MW/SSH 07-01-02

OFFICE Pittsburgh/Albany

Image: . Xref: TOPO-1

L:\project\806938\806938B14.dwg
Plot Date/Time: 07/03/02 02:14pm
Format Revised: 12/15/99

REFERENCES:

1. TOPOGRAPHY AND PLANIMETRICS PROVIDED BY GEOD PHOTOGRAMMETRIC SCIENCES SURVEY TECHNOLOGIES. MAPPED BY PHOTOGRAMMETRIC METHODS FROM AERIAL PHOTOGRAPHS TAKEN 12-08-1995. GRIDS BASED ON NEW YORK 1988 STATE PLANE COORDINATE SYSTEM. VERTICAL DATUM IS BASED ON NAD 1983. RI SAMPLE LOCATIONS SURVEYED BY GEOD.
2. EXISTING BUILDING DESIGNATIONS ARE BASED ON DOLPH ROTFELD ASSOCIATES FIGURE 4, DATED NOVEMBER 1996. BUILDING INTERIOR DIVISION LOCATIONS ARE APPROXIMATE ONLY.
3. FOR PILE LOCATIONS REFER TO FIGURE 4-6 HISTORICAL PILING MAP IN THE FINAL REMEDIAL INVESTIGATION REPORT DATED ? 2000.

LEGEND:

15	BUILDING DESIGNATION
— — —	APROXIMATE SITE BOUNDARY
- - - -	APROXIMATE SITE BOUNDARY
—5—	DEPTH TO CONTAMINATION CONTOUR
(grid pattern)	AREAS WHERE PILE LOCATIONS CONFIRMED BY AVAILABLE FACILITY AS-BUILT DRAWINGS BASED ON GEOTECHNICAL DATA/LOAD BEARING CHARACTERISTICS OF THE FILL MATERIAL, SIMILAR PILE DENSITY ARE EXPECTED TO EXIST AT ALL OTHER BUILDING SITES.

INTERIM REMEDIAL MEASURES:

A	BUILDING 14 SUMP CLOSURE IRM
B	SEPARATE PHASE LIQUID RECOVERY IRM
C	NORTHWEST CORNER IRM
D	SOUTHWEST CORNER BULKHEAD IRM
E	BUILDING 57 SHORELINE IRM

(grey shading)	PROPOSED AREAS INCLUDED IN PCB EXCAVATION (≥ 10 mg/kg)
(hatching)	AREAS WHERE PILE LOCATIONS ANTICIPATED BASED ON FORMER/CURRENT BUILDING LOCATIONS

SCALE 0 160 320 FEET

Shaw Shaw E & I, Inc.

ATLANTIC RICHFIELD COMPANY

FIGURE 2
WATER TOWER/NORTHWEST CORNER AREA PILE LOCATION MAP
HARBOR AT HASTINGS
HASTINGS-ON-HUDSON, NEW YORK

ATTACHMENT A

MONITORING WELL INSTALATION LOGS

INTERNATIONAL TECHNOLOGY CORPORATION

Drilling Log

Monitoring Well **MW-13A**

Project *Arco Hastings* Owner *Arco*

Location *Hastings-on-Hudson, New York* Proj. No. *823752*

Surface Elev. *NA* Total Hole Depth *84.0 ft.* North ______ East ______

Top of Casing *NA* Water Level Initial *NA* Static *NA* Diameter *12 in.*

Screen: Dia *6 in.* Length *15 ft.* Type/Size *Sched. 40 PVC/0.020 in.*

Casing: Dia *6 in.* Length *68 ft.* Type *Sched. 40 PVC*

Fill Material ______ Rig/Core *Schramm*

Drill Co. *ADT, Inc.* Method *Mud Rotary/Drive and Wash*

Driller *Derrek* Log By *Drew Graham* Date *9/17/01* Permit # *NA*

Checked By *Julie Bergeron* License No. ______

COMMENTS

Depth (ft.)	Well Completion	PID (ppm)	Sample ID % Recovery	Blow Count Recovery	Graphic Log	USCS Class.	Description (Color, Texture, Structure) Geologic descriptions are based on ASTM Standard D 2487-93 and the USCS.
0						GM	FILL MATERIAL: brown to black, gravel, brick, concrete, organic material, brown silt, saturated.
5							
10							
15							
20							
25			10%	3 1 2 1		CH	GREY MARINE SILT: grey, moist silt, thin layers of fine grained silty sand, trace shells.
			30%	1 1 1 1			
30							
35							
40							

Continued Next Page

INTERNATIONAL TECHNOLOGY CORPORATION

Drilling Log

Monitoring Well **MW-13A**

Project: *Arco Hastings* Owner: *Arco*

Location: *Hastings-on-Hudson, New York* Proj. No. *823752*

Depth (ft.)	PID (ppm)	Sample ID % Recovery	Blow Count Recovery	USCS Class.	Description (Color, Texture, Structure) Geologic descriptions are based on ASTM Standard D 2487-93 and the USCS.
40				CH	*Continued*
48–50		50%	2 2 2 4	CH	
52		100%	Push/24	SP	BASAL SANDS: dark grey to black, alternating layers of medium to fine grained silty sand, sandy silt an dclayey silt with traces of shell fragments.
54–55		30%	1/10 3/2 18 16	SP	
56–57		80%	7 2 2 4	SP	
58–60		100%	1 1 3 4	SP	
70		20%	1 2 2 5	SP	Trace of cobbles.
75			Push 4 8 16	SM	Reddish brown alternating layers of fine grained silty sand, clayey silt, and fine grained sand.
81–83		100%	9 15 22 32	SM	
85–87			9 27 30 35		
90					

INTERNATIONAL TECHNOLOGY CORPORATION

Drilling Log

Monitoring Well MW-13B

Project *Arco Hastings* Owner *Arco*

Location *Hastings-on-Hudson, New York* Proj. No. *823752*

Surface Elev. *NA* Total Hole Depth *34.0 ft.* North ____ East ____

Top of Casing *NA* Water Level Initial *NA* Static *NA* Diameter *8.25 in.*

Screen: Dia *2 in.* Length *20 ft.* Type/Size *Sched. 40 PVC/0.020 in.*

Casing: Dia *2 in.* Length *5 ft.* Type *Sched. 40 PVC*

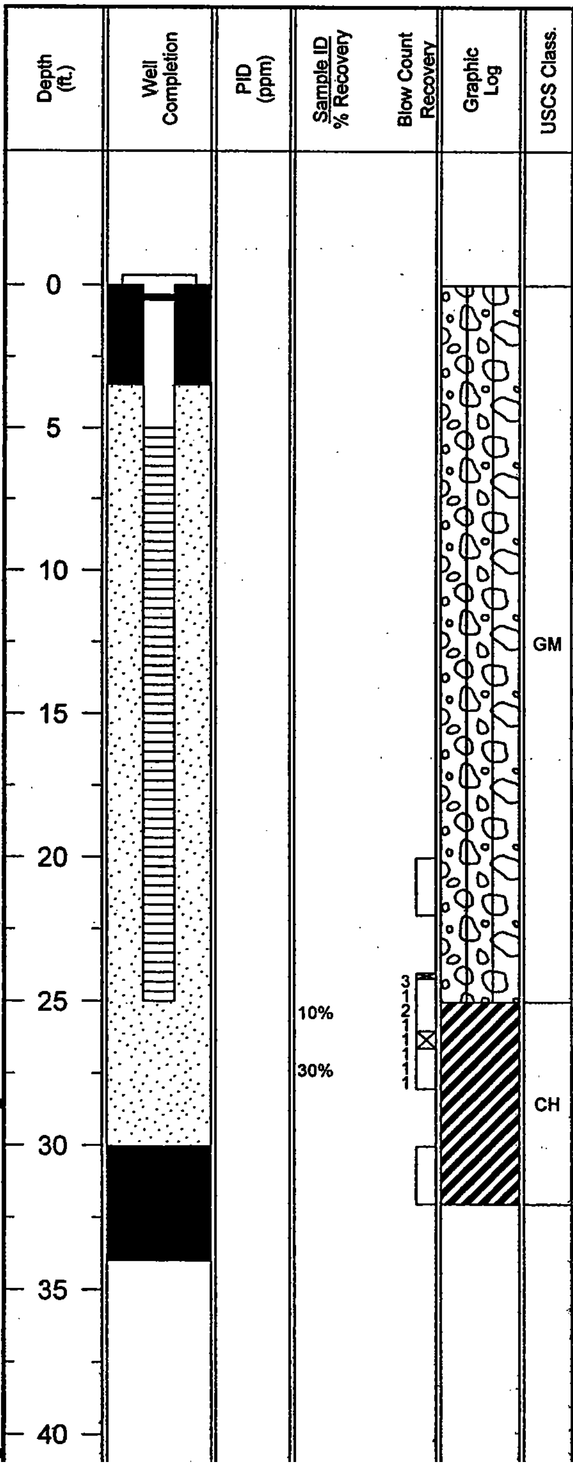
Fill Material ____ Rig/Core *CME*

Drill Co. *ADT, Inc.* Method *HSA*

Driller *Les* Log By *Drew Graham* Date *8/27/01* Permit # *NA*

Checked By *Julie Bergeron* License No. ____

COMMENTS



Description

(Color, Texture, Structure)

Geologic descriptions are based on ASTM Standard D 2487-93 and the USCS.

Depth (ft.)	Description
0 – 25	FILL MATERIAL: brown to black, gravel, brick, concrete, organic material, brown silt, saturated.
25 – 32	GREY MARINE SILT: grey, moist silt, thin layers of fine grained silty sand, trace shells.

INTERNATIONAL TECHNOLOGY CORPORATION

Drilling Log

Monitoring Well MW-14A

Project *Arco Hastings* Owner *Arco*

Location *Hastings-on-Hudson, New York* Proj. No. *823752*

Surface Elev. *NA* Total Hole Depth *91.0 ft.* North ______ East ______

Top of Casing *NA* Water Level Initial *NA* Static *NA* Diameter *12 in.*

Screen: Dia *6 in.* Length *15 ft.* Type/Size *Sched. 40 PVC/0.020 in.*

Casing: Dia *6 in.* Length *75 ft.* Type *Sched. 40 PVC*

Fill Material ______ Rig/Core *Schramm*

Drill Co. *ADT, Inc.* Method *Mud Rotary/Drive and Wash*

Driller *Derrek* Log By *Drew Graham* Date *9/19/01* Permit # *NA*

Checked By *Julie Bergeron* License No. ______

COMMENTS

Depth (ft.)	Well Completion	PID (ppm)	Sample ID / % Recovery	Blow Count / Recovery	Graphic Log	USCS Class.	Description (Color, Texture, Structure) Geologic descriptions are based on ASTM Standard D 2487-93 and the USCS.
0							FILL: brown to black, gravel, brick fragments, copper wire, saturated.
5							
10			5%	8 12 15 30		GM	
15							
			10%	2 1/12 1			SILT: black, organic silt, leaf fragments embedded in silt, saturated, soft.
20			50%	Push			
25			95%	1/18		CH	
			95%	1 1 1 1 1			
30			100%	Push 1/12 1			
			100%	Push/12 1 1			GRAY MARINE SILT: grey silt, thin layers of fine grained silty sand, trace shells.
			100%	Push 2 1 1			
35						CH	
40							

Continued Next Page

INTERNATIONAL TECHNOLOGY CORPORATION

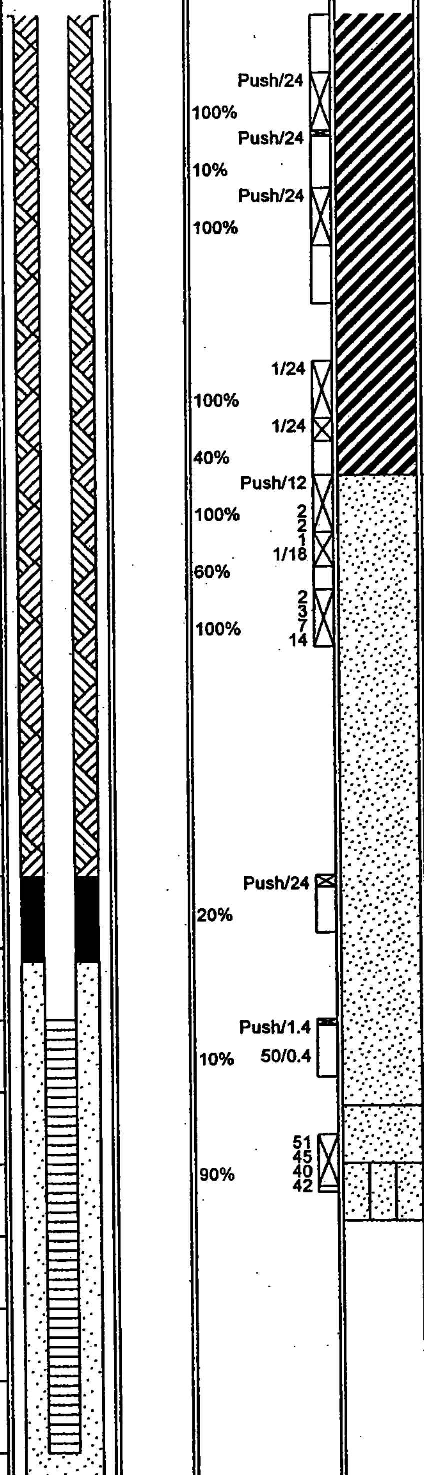
Drilling Log

Monitoring Well **MW-14A**

Project: Arco Hastings Owner: Arco

Location: Hastings-on-Hudson, New York Proj. No. 823752

Depth (ft.)	Sample ID % Recovery	Blow Count Recovery	USCS Class.	Description (Color, Texture, Structure) Geologic descriptions are based on ASTM Standard D 2487-93 and the USCS.
40				*Continued*
	100%	Push/24	CH	
45	10%	Push/24		
	100%	Push/24		
50				
	100%	1/24		
55	40%	1/24		
	100%	Push/12	SP	BASAL SANDS: dark grey alternating layers of silty sand and sandy silt, trace of shell fragments.
	60%	2 2 1 1/18		
60	100%	2 3 7 14		
65				
70	20%	Push/24		
75	10%	Push/1.4 50/0.4		
			SP	Gravelly sand, trace silt.
80	90%	51 45 40 42	SM	Reddish brown, silty sand.
85				
90				



INTERNATIONAL TECHNOLOGY CORPORATION

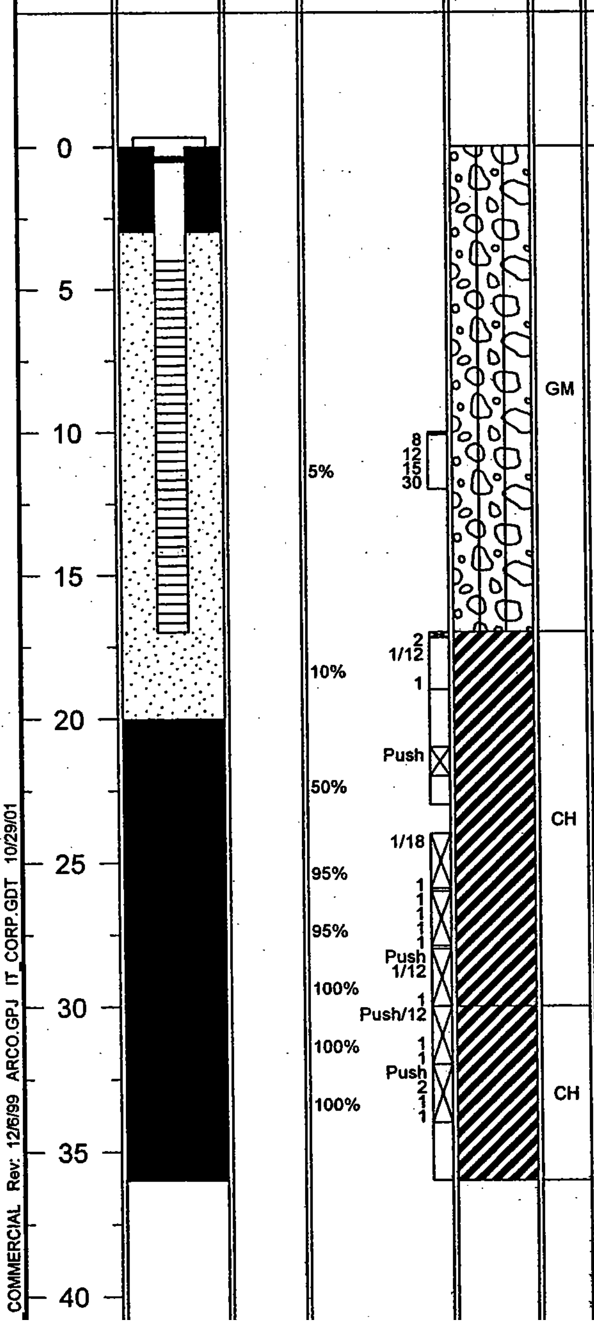
Drilling Log

Monitoring Well **MW-14B**

Project	Arco Hastings	Owner	Arco		
Location	Hastings-on-Hudson, New York	Proj. No.	823752		
Surface Elev.	NA	Total Hole Depth	36.0 ft.	North / East	
Top of Casing	NA	Water Level Initial	NA	Static NA	Diameter 8.25 in.
Screen: Dia	2 in.	Length	13 ft.	Type/Size	Sched. 40 PVC/0.020 in.
Casing: Dia	2 in.	Length	4 ft.	Type	Sched. 40 PVC
Fill Material		Rig/Core	CME		
Drill Co.	ADT, Inc.	Method	HSA		
Driller	Les	Log By	Drew Graham	Date 8/28/01	Permit # NA
Checked By	Julie Bergeron	License No.			

COMMENTS

Depth (ft.)	Well Completion	PID (ppm)	Sample ID % Recovery	Blow Count Recovery	Graphic Log	USCS Class.	Description (Color, Texture, Structure) Geologic descriptions are based on ASTM Standard D 2487-93 and the USCS.
0						GM	FILL: brown to black, gravel, brick fragments, copper wire, saturated.
17						CH	SILT: black, organic silt, leaf fragments embedded in silt, saturated, soft.
30						CH	GRAY MARINE SILT: grey silt, thin layers of fine grained silty sand, trace shells.



INTERNATIONAL TECHNOLOGY CORPORATION

Drilling Log

Monitoring Well **MW-15A**

Project	Arco Hastings	Owner	Arco
Location	Hastings-on-Hudson, New York	Proj. No.	823752
Surface Elev.	NA	Total Hole Depth	87.0 ft.
North		East	
Top of Casing	NA	Water Level Initial	NA
Static	NA	Diameter	12 in.
Screen: Dia	2 in.	Length	15 ft.
Type/Size	Sched. 40 PVC/0.020 in.		
Casing: Dia	2 in.	Length	71 ft.
Type	Sched. 40 PVC		
Fill Material		Rig/Core	Schramm
Drill Co.	ADT. Inc.	Method	Mud Rotary/Drive and Wash
Driller	Derrek	Log By	Drew Graham
Date	9/24/01	Permit #	NA
Checked By	Julie Bergeron	License No.	

COMMENTS

Depth (ft.)	PID (ppm)	Sample ID % Recovery	Blow Count Recovery	USCS Class.	Description (Color, Texture, Structure) Geologic descriptions are based on ASTM Standard D 2487-93 and the USCS.
0		15%	2, 12, 50/4	GM	FILL MATERIAL: cinders, cobbles, brick fragments, some sand and fine gravel, saturated.
		50%	5, 7, 7, 10		
5		60%	9, 9, 6, 6		
		50%	31, 20, 6, 4		
10		10%	1, 1, 1/12		
15		5%	1/12, 1/12		
20		20%	1/18, 1		
25		15%	1, 1, 1/12		
30		15%	2, 1, 1, 3		
		0%	Push/24		
		5%	Push/24		
35		80%	1/18, Push	CH	GRAY MARINE SILT: gray silt, thin layers of fine grained silty sand, trace of shell fragments, moist.
40					

Continued Next Page

INTERNATIONAL TECHNOLOGY CORPORATION

Drilling Log

Monitoring Well **MW-15A**

Project: Arco Hastings   Owner: Arco

Location: Hastings-on-Hudson, New York   Proj. No. 823752

Depth (ft.)	Sample ID / % Recovery	Blow Count / Recovery	USCS Class.	Description (Color, Texture, Structure) Geologic descriptions are based on ASTM Standard D 2487-93 and the USCS.
40				*Continued*
45	50%	Push/18, 2		
	100%	Push, 1/18		
50	100%	Push/18, 1	CH	
55	80%	Push/1, 2, 2		
	0%	1/24		
60	90%	Push, 1/24, 1		BASAL SANDS: grey alternating layers of sandy silt, and dense, medium to fine grained sand, moist to wet.
65	80%	Push/12, 1		
	60%	Push/24	SP	
	100%	Push/24		
70	100%	Push/12, 2, 1		
	100%	1, 3, 3, 7		
75	100%	7, 1, 3, 3	SP	Several thin layers of clayey silt from 74 to 76.
	30%	15, 31, 21, 21	SM	Reddish brown silty sand, fine grained.
80				
85				
90				

INTERNATIONAL TECHNOLOGY CORPORATION

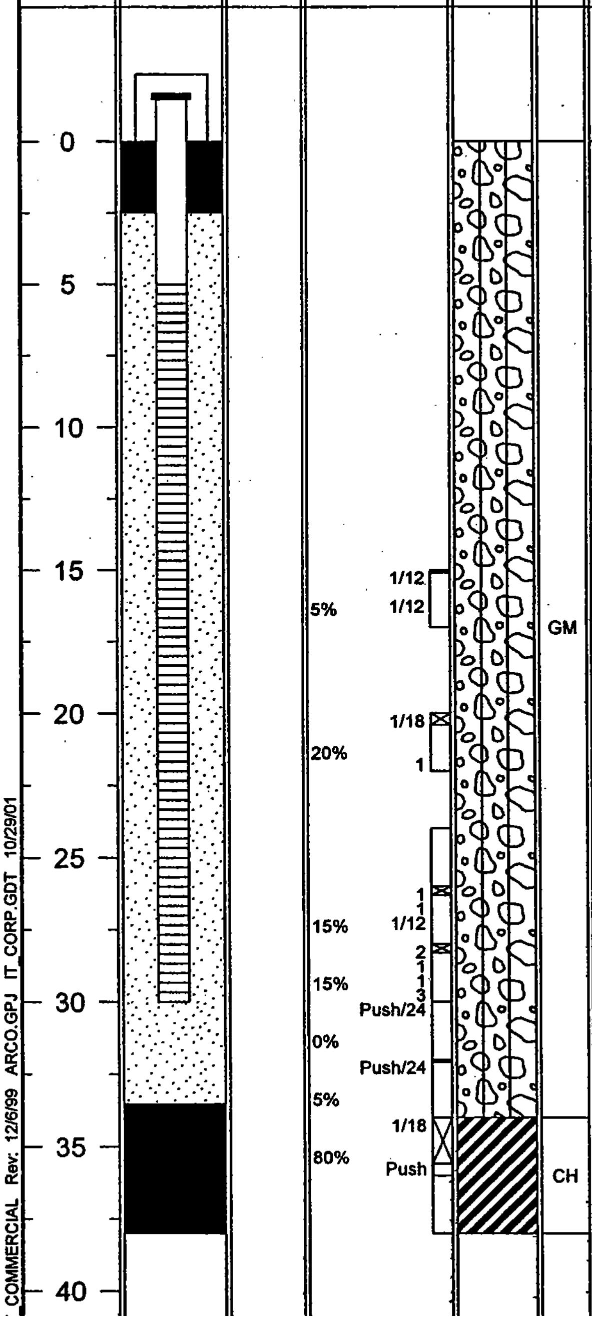
Drilling Log

Monitoring Well **MW-15B**

Project *Arco Hastings* Owner *Arco*
Location *Hastings-on-Hudson, New York* Proj. No. *823752*
Surface Elev. *NA* Total Hole Depth *38.0 ft.* North ___ East ___
Top of Casing *NA* Water Level Initial *NA* Static *NA* Diameter *8.25 in.*
Screen: Dia *2 in.* Length *25 ft.* Type/Size *Sched. 40 PVC/0.020 in.*
Casing: Dia *2 in.* Length *5 ft.* Type *Sched. 40 PVC*
Fill Material ___ Rig/Core *CME*
Drill Co. *ADT, Inc.* Method *HSA*
Driller *Les* Log By *Drew Graham* Date *8/29/01* Permit # *NA*
Checked By *Julie Bergeron* License No. ___

COMMENTS

Depth (ft.)	Well Completion	PID (ppm)	Sample ID / % Recovery	Blow Count / Recovery	Graphic Log	USCS Class.	Description (Color, Texture, Structure) Geologic descriptions are based on ASTM Standard D 2487-93 and the USCS.



0–34 ft (GM): FILL MATERIAL: cinders, cobbles, brick fragments, some sand and fine gravel, saturated.

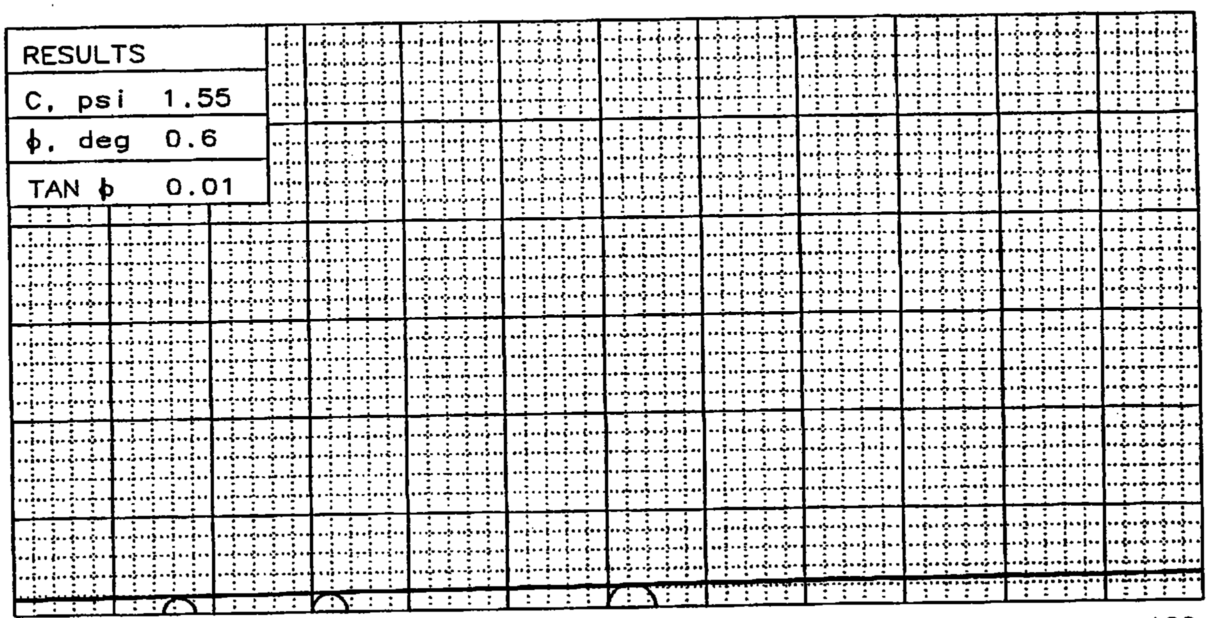
34–38 ft (CH): GRAY MARINE SILT: gray silt, thin layers of fine grained silty sand, trace of shell fragments, moist.

ATTACHMENT B

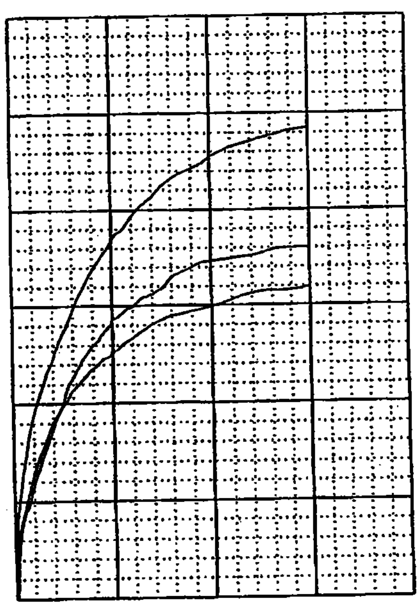
GEOTECHNICAL LABORATORY ANALYTICAL DATA

TRIAXIAL SHEAR TEST REPORTS

UNCONSOLIDATED UNDRAINED TEST



RESULTS	
C, psi	1.55
ϕ, deg	0.6
TAN ϕ	0.01



	SAMPLE NO.	1	2	3
INITIAL	WATER CONTENT, %	40.1	47.0	39.5
	DRY DENSITY, pcf	80.1	73.1	80.6
	SATURATION, %	99.6	98.5	99.6
	VOID RATIO	1.066	1.264	1.052
	DIAMETER, in	2.83	2.83	2.83
	HEIGHT, in	5.42	5.38	5.53
AT TEST	WATER CONTENT, %	40.1	47.0	39.5
	DRY DENSITY, pcf	80.1	73.1	80.6
	SATURATION, %	99.6	98.5	99.6
	VOID RATIO	1.066	1.264	1.052
	DIAMETER, in	2.83	2.83	2.83
	HEIGHT, in	5.42	5.38	5.53
	Strain rate, in/min	0.040	0.040	0.030
	BACK PRESSURE, psi	0.00	0.00	0.00
	CELL PRESSURE, psi	15.00	30.00	60.00
	FAILURE STRESS, psi	3.19	3.60	4.85
	PORE PRESSURE, psi			
	ULTIMATE STRESS, psi			
	PORE PRESSURE, psi			
	σ_1 FAILURE, psi	18.19	33.60	64.85
	σ_3 FAILURE, psi	15	30	60

TYPE OF TEST:
Unconsolidated undrained

SAMPLE TYPE:

DESCRIPTION: Clayey silt

LL= PL= PI=

SPECIFIC GRAVITY= 2.65

REMARKS:

FGI 9/18/01

CLIENT: IT Concord CA

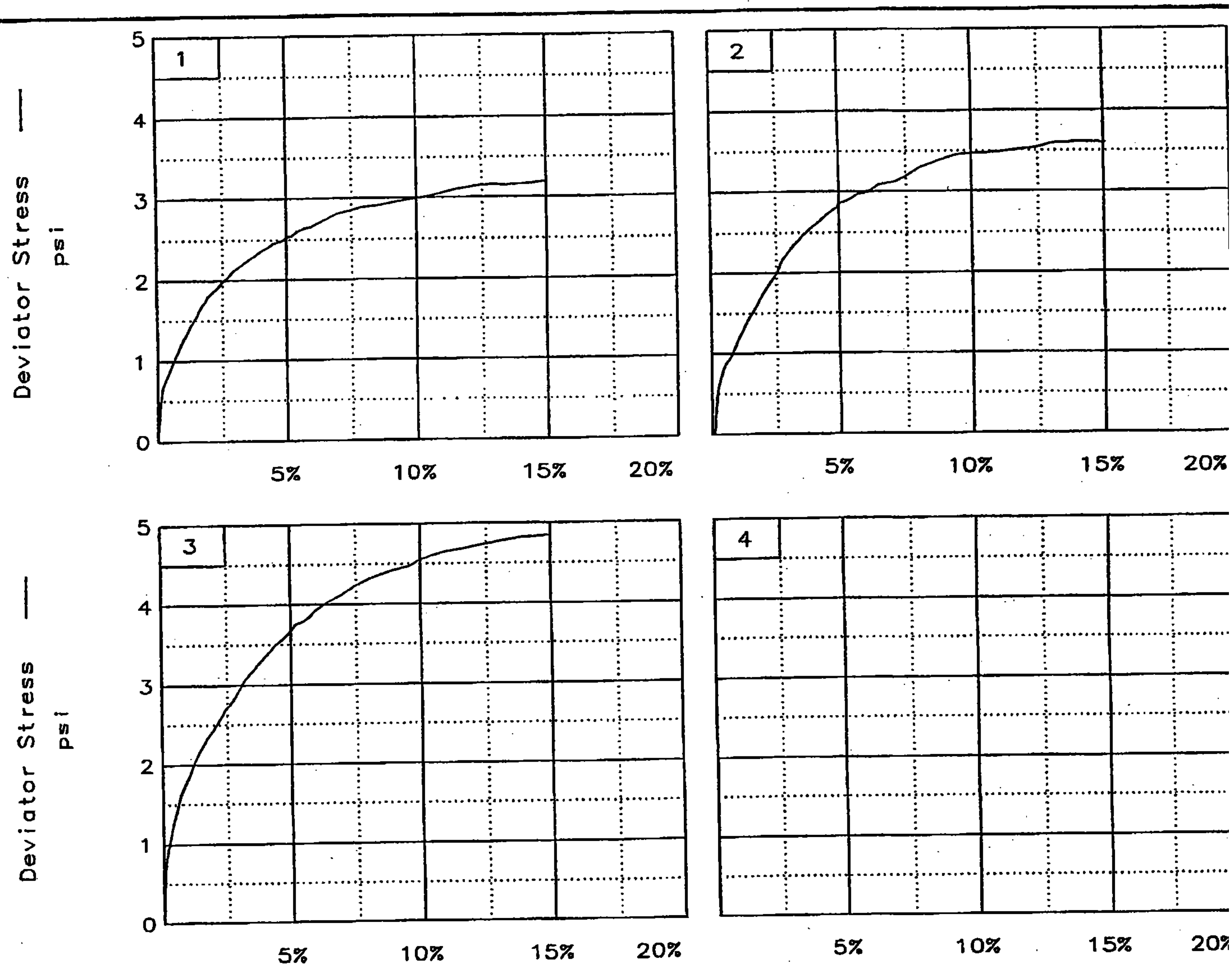
PROJECT: ARCO Hastings

SAMPLE LOCATION: Lab sample ID: ETDC-9788
Client sample ID: MW-13B (30-32)

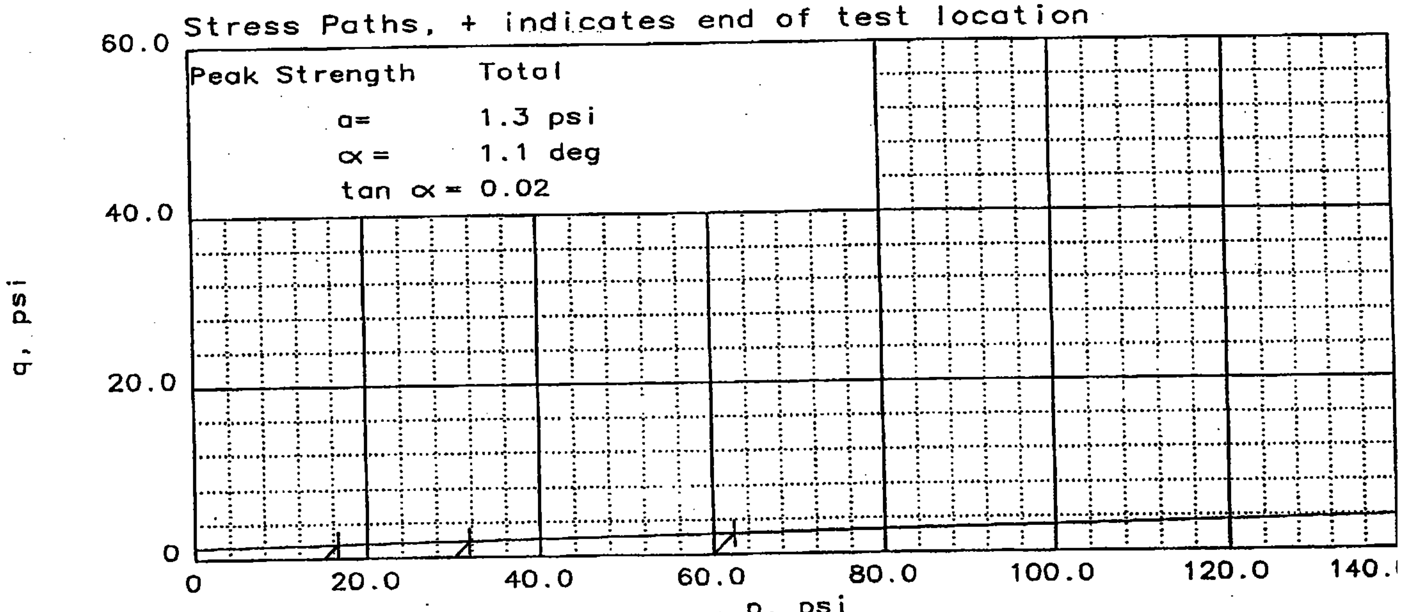
PROJ. NO.: 806938 DATE: 9/17/2001

TRIAXIAL SHEAR TEST REPORT

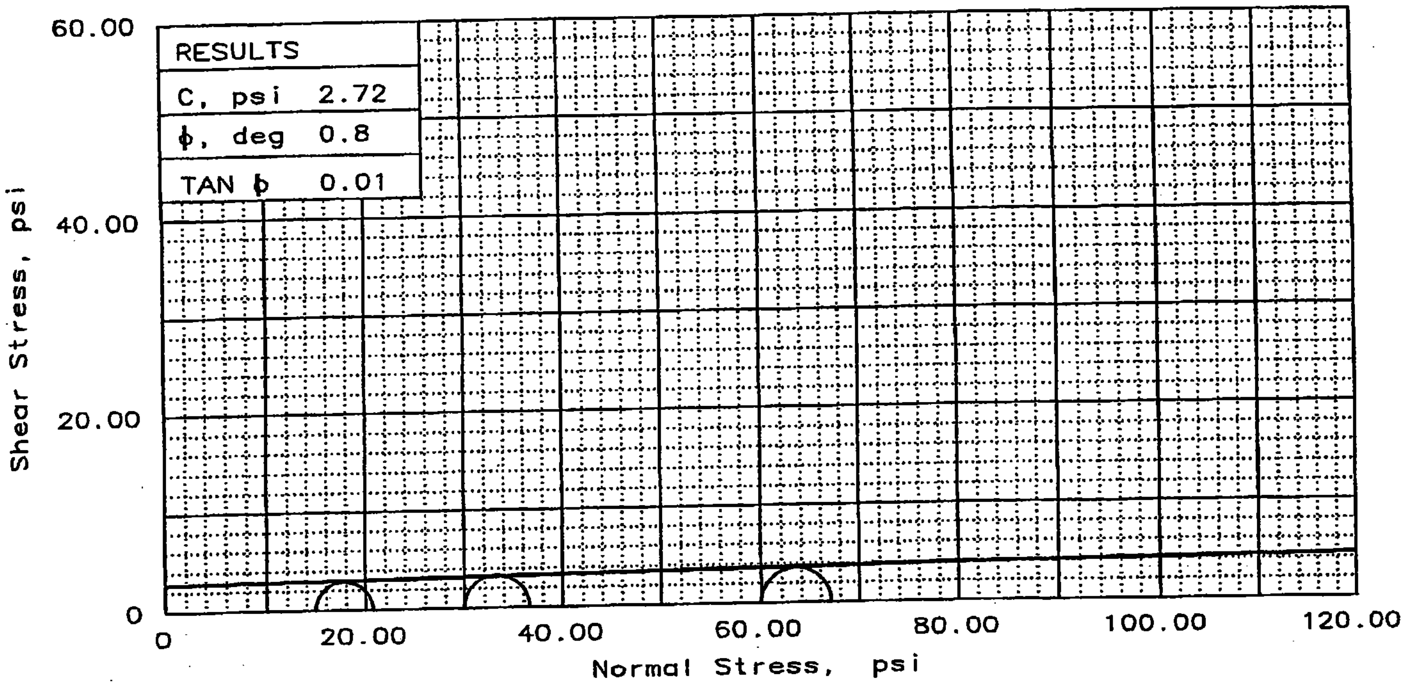
IT CORPORATION GEOTECHNICAL LABORATORY

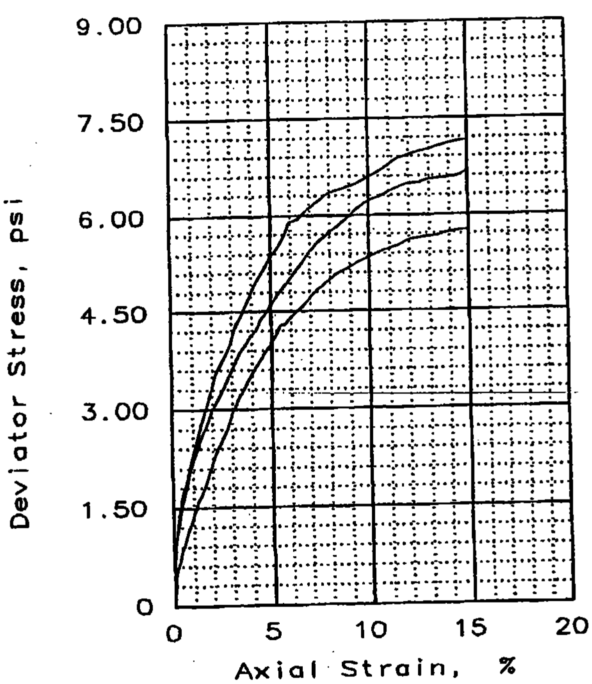


Stress Paths, + indicates end of test location



Client: IT Concord CA
Project: ARCO Hastings
Location: Lab sample ID: ETDC-9788 Client sample ID: MW-13B (30-32)





SAMPLE NO.		1	2	3
INITIAL	WATER CONTENT, %	70.9	65.5	61.6
	DRY DENSITY, pcf	56.0	58.2	61.9
	SATURATION, %	96.1	94.3	97.7
	VOID RATIO	1.955	1.841	1.671
	DIAMETER, in	2.01	2.01	1.99
	HEIGHT, in	4.01	4.01	4.04
AT TEST	WATER CONTENT, %	70.9	65.5	61.6
	DRY DENSITY, pcf	56.0	58.2	61.9
	SATURATION, %	96.1	94.3	97.7
	VOID RATIO	1.955	1.841	1.671
	DIAMETER, in	2.01	2.01	1.99
	HEIGHT, in	4.01	4.01	4.04
Strain rate, in/min		0.020	0.020	0.020
BACK PRESSURE, psi		0.00	0.00	0.00
CELL PRESSURE, psi		15.00	30.00	60.00
FAILURE STRESS, psi		5.77	6.66	7.14
PORE PRESSURE, psi				
ULTIMATE STRESS, psi				
PORE PRESSURE, psi				
σ_1 FAILURE, psi		20.77	36.66	67.14
σ_3 FAILURE, psi		15	30	60

TYPE OF TEST:
Unconsolidated undrained

SAMPLE TYPE: Undisturbed

DESCRIPTION: Clayey silt

LL= PL= PI=

SPECIFIC GRAVITY= 2.65

REMARKS:

FYI 9/18/01

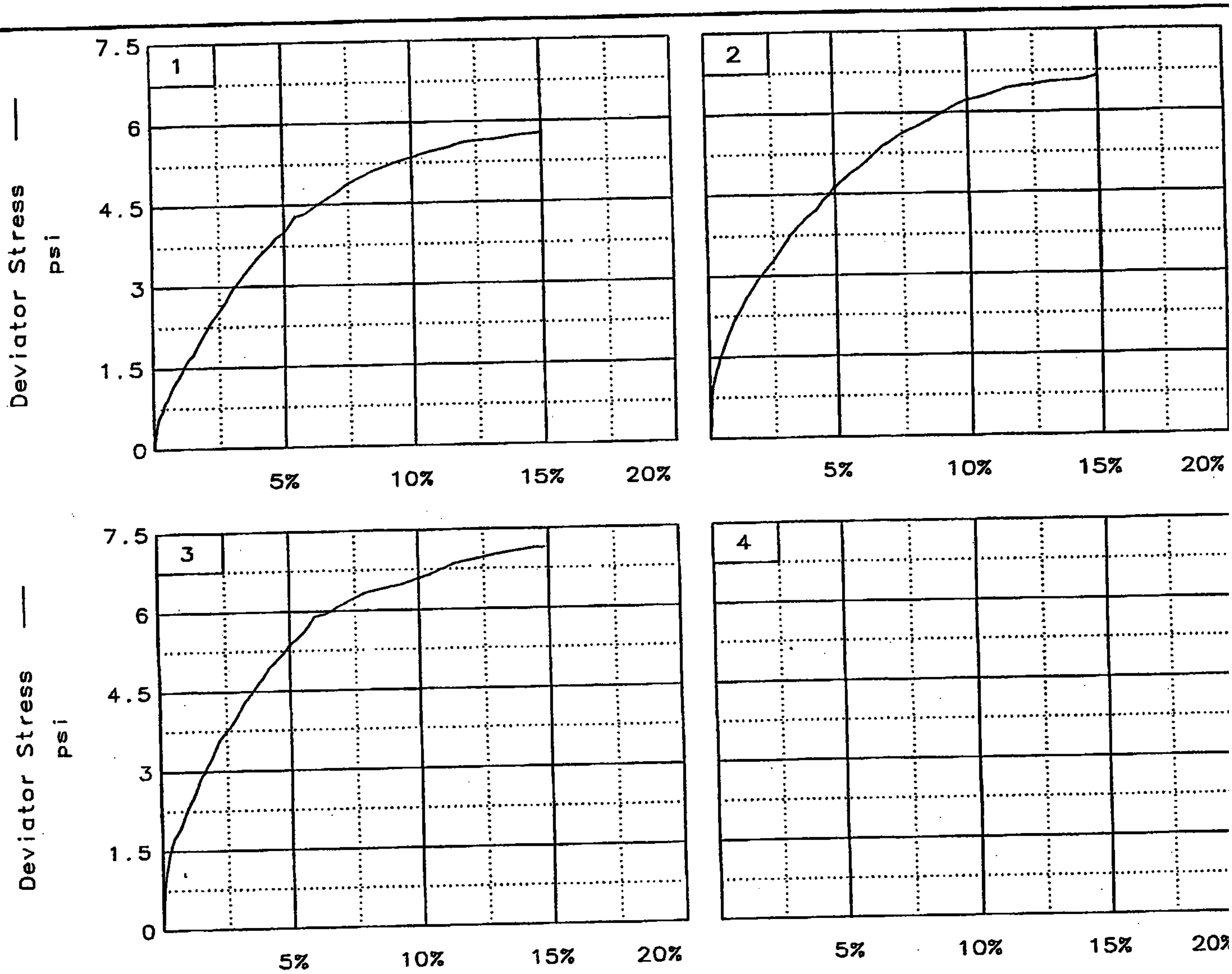
CLIENT: IT Concord CA

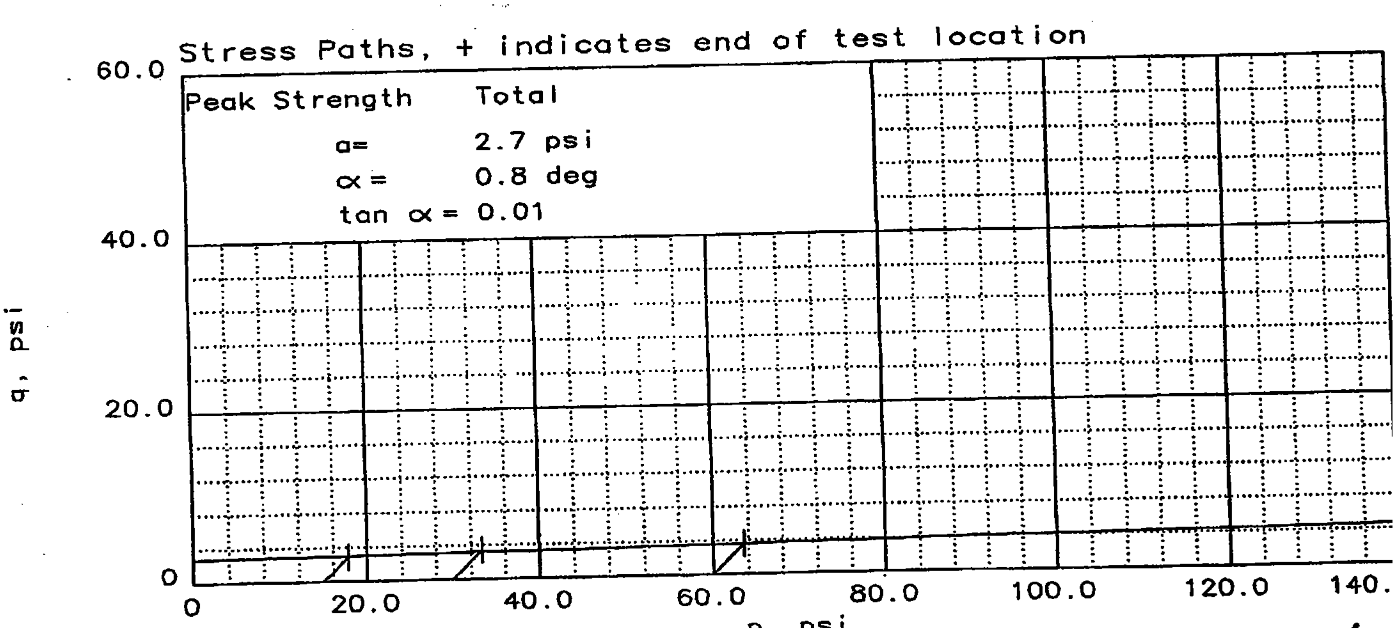
PROJECT: ARCO Hastings

SAMPLE LOCATION: Lab sample ID: ETDC-9785
Client sample ID: MW-14B (19-21)

PROJ. NO.: 806938 DATE: 9/17/2001

TRIAXIAL SHEAR TEST REPORT

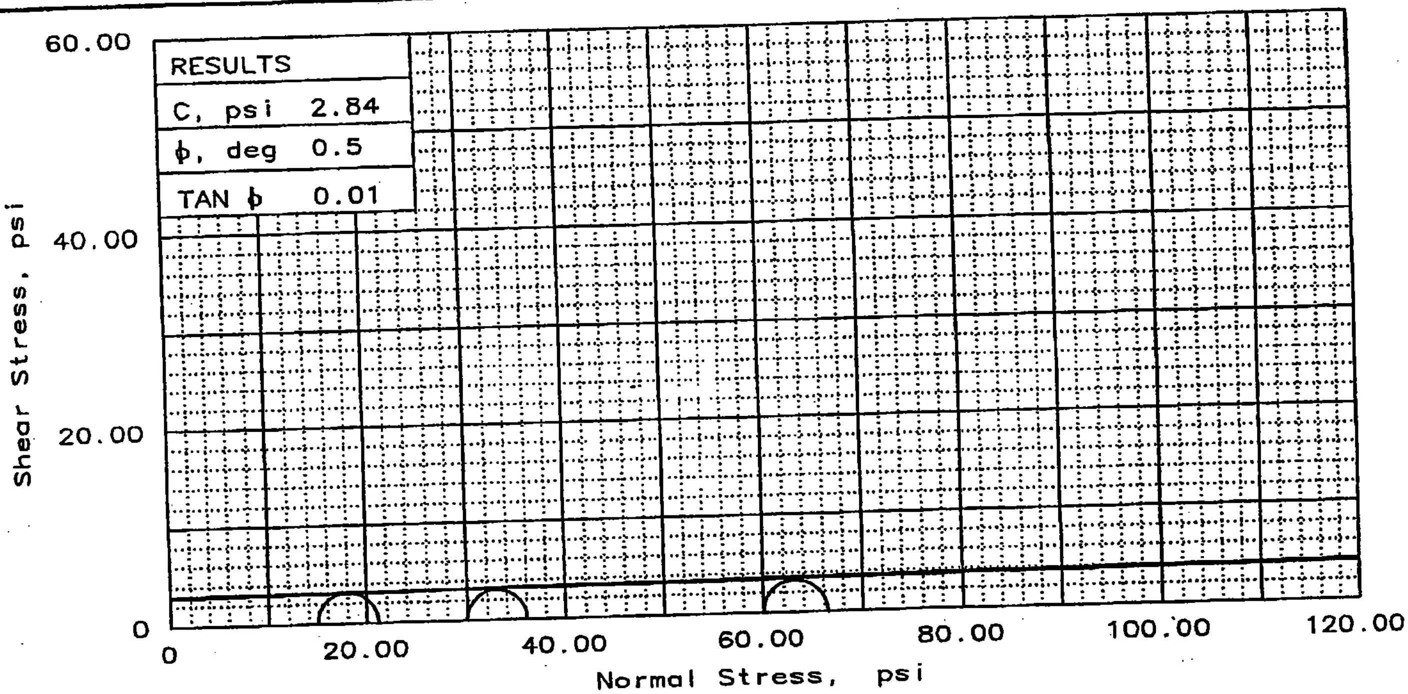


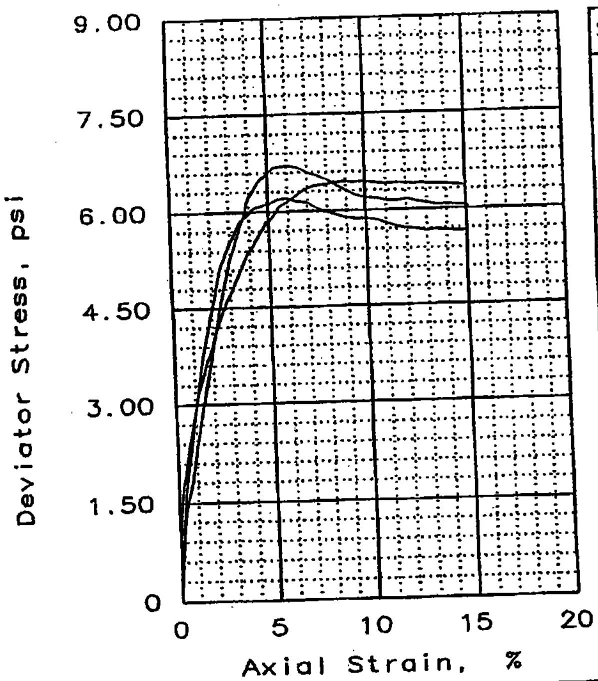


Fy1 9/18

Client: IT Concord CA
Project: ARCO Hastings
Location: Lab sample ID: ETDC-9785 Client sample ID: MW-14B (19-21)

RESULTS	
C, psi	2.84
ϕ, deg	0.5
TAN ϕ	0.01





SAMPLE NO.		1	2	3
INITIAL	WATER CONTENT, %	51.5	57.6	45.4
	DRY DENSITY, pcf	70.0	67.3	78.1
	SATURATION, %	100.0	104.8	107.5
	VOID RATIO	1.365	1.457	1.119
	DIAMETER, in	2.81	2.82	2.80
	HEIGHT, in	5.62	5.26	5.65
AT TEST	WATER CONTENT, %	51.5	57.6	45.4
	DRY DENSITY, pcf	70.0	67.3	78.1
	SATURATION, %	100.0	104.8	107.5
	VOID RATIO	1.365	1.457	1.119
	DIAMETER, in	2.81	2.82	2.80
	HEIGHT, in	5.62	5.26	5.65
Strain rate, in/min		0.040	0.040	0.030
BACK PRESSURE, psi		0.00	0.00	0.00
CELL PRESSURE, psi		15.00	30.00	60.00
FAILURE STRESS, psi		6.15	6.07	6.44
PORE PRESSURE, psi				
ULTIMATE STRESS, psi				
PORE PRESSURE, psi				
σ_1 FAILURE, psi		21.15	36.07	66.44
σ_3 FAILURE, psi		15	30	60

TYPE OF TEST:
Unconsolidated undrained
SAMPLE TYPE: Undisturbed
DESCRIPTION: Clayey silt

LL= PL= PI=
SPECIFIC GRAVITY= 2.65
REMARKS:

Fyi 9/18/01

CLIENT: IT Concord CA

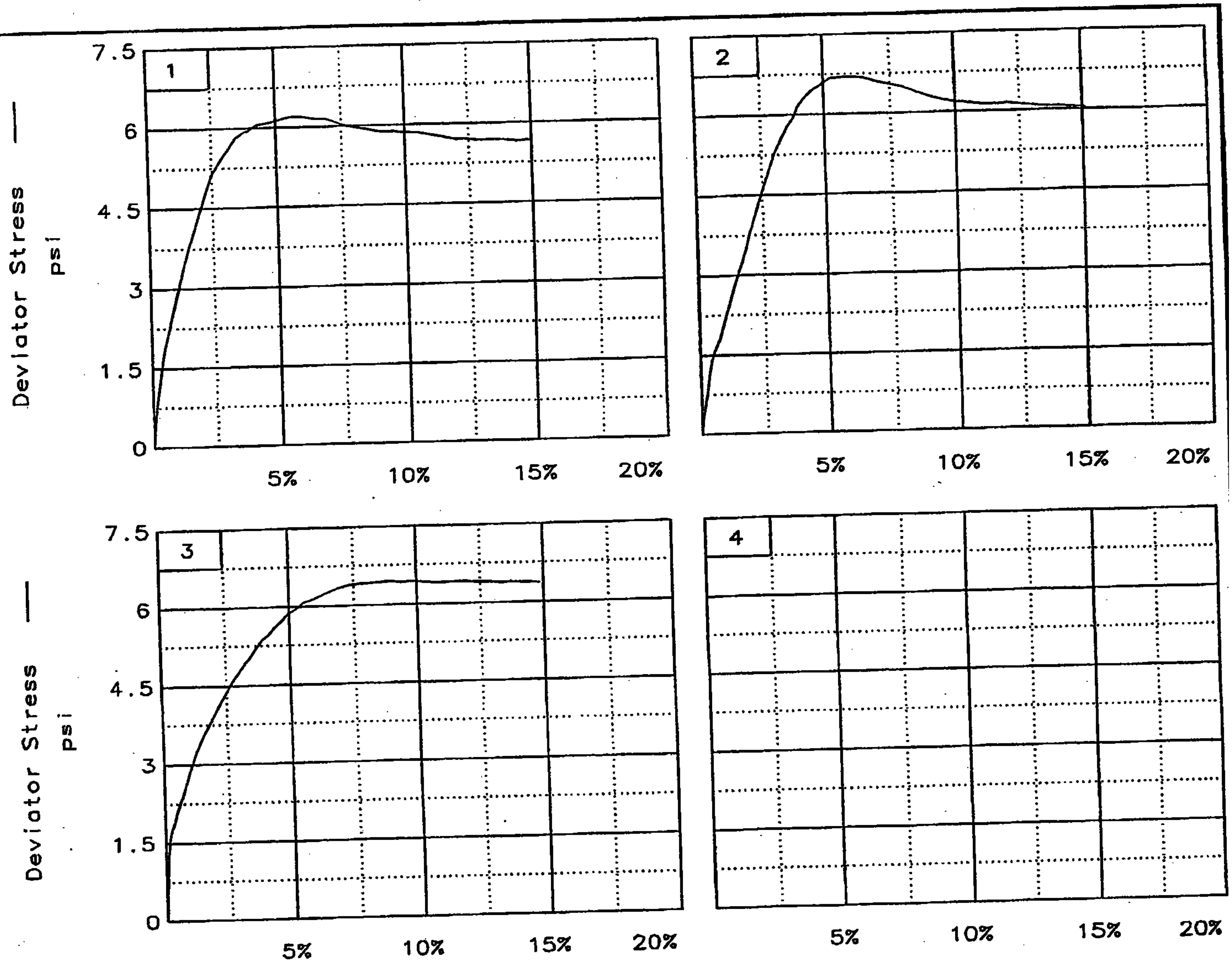
PROJECT: ARCO Hastings

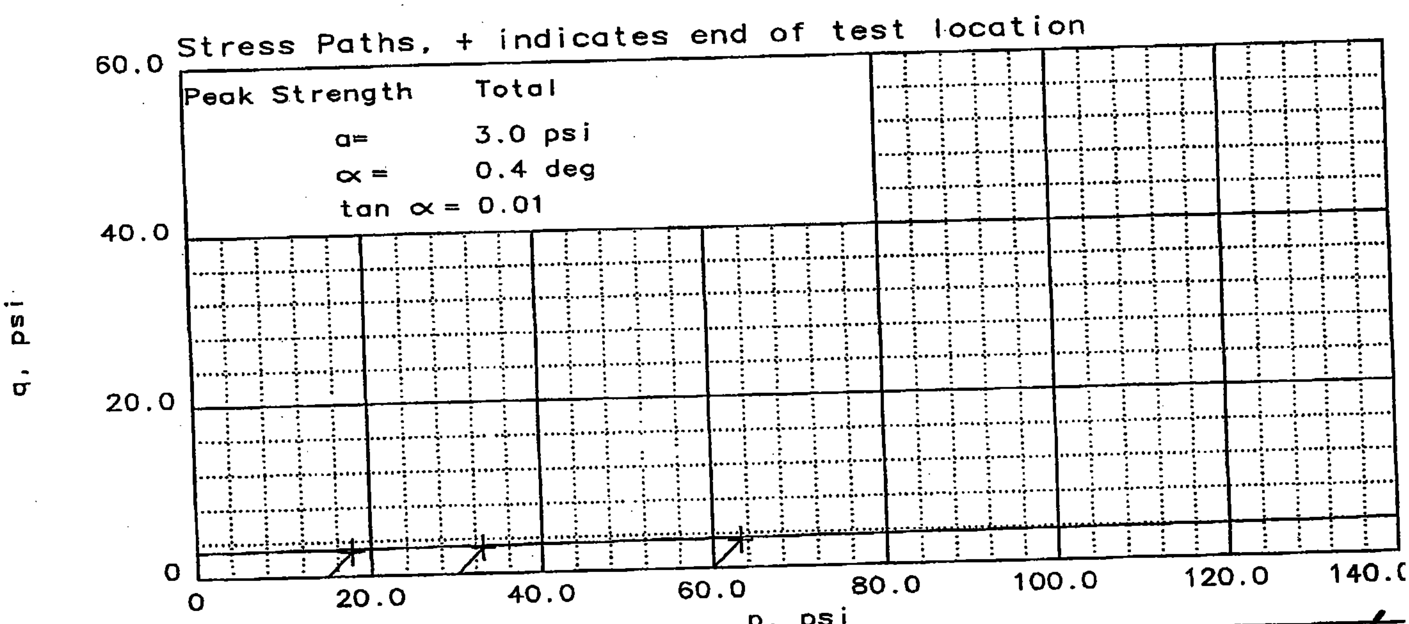
SAMPLE LOCATION: Lab sample ID: ETDC-9789
Client sample ID: MW-14B (34-36)

PROJ. NO.: 806938 DATE: 9/17/2001

TRIAXIAL SHEAR TEST REPORT

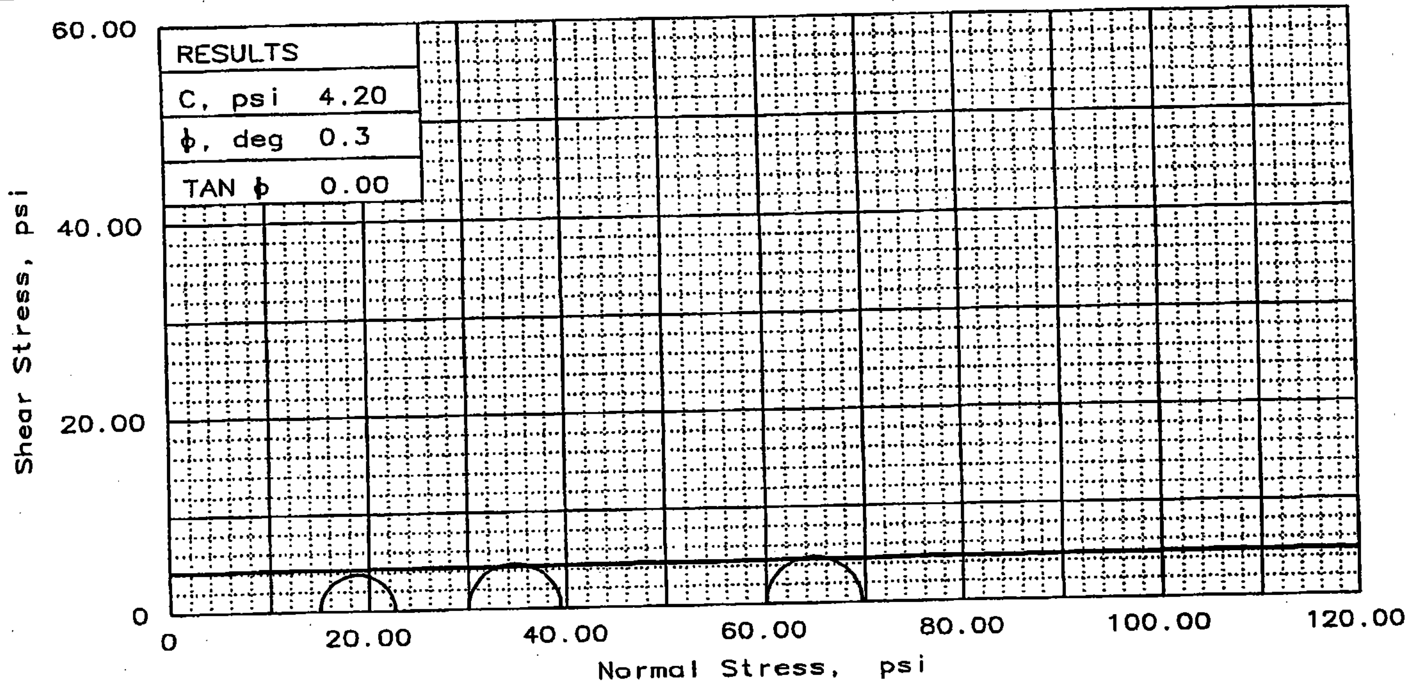
GEOTECHNICAL LABORATORY

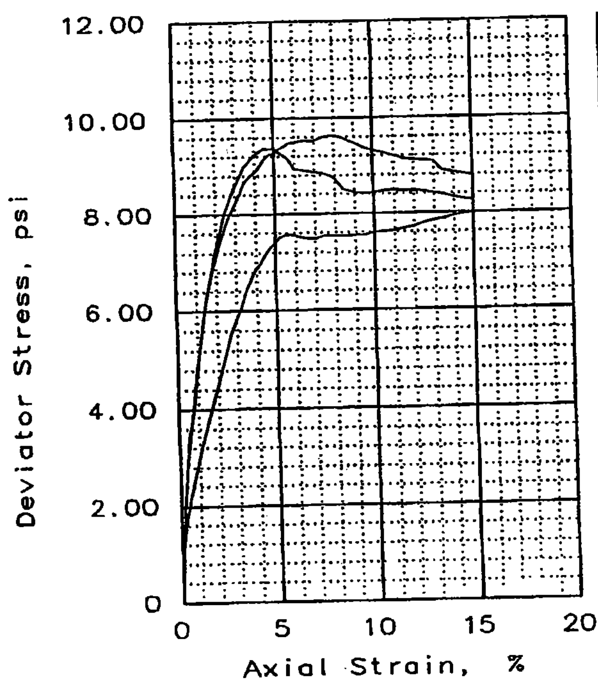




fyi 9/18

Client: IT Concord CA
Project: ARCO Hastings
Location: Lab sample ID: ETDC-9789 Client sample ID: MW-14B (34-36)





SAMPLE NO.		1	2	3
INITIAL	WATER CONTENT, %	52.5	57.3	54.6
	DRY DENSITY, pcf	68.8	67.4	68.3
	SATURATION, %	99.0	104.2	101.8
	VOID RATIO	1.406	1.456	1.422
	DIAMETER, in	2.84	2.84	2.85
	HEIGHT, in	5.17	5.60	5.60
AT TEST	WATER CONTENT, %	52.5	57.3	54.6
	DRY DENSITY, pcf	68.8	67.4	68.3
	SATURATION, %	99.0	104.2	101.8
	VOID RATIO	1.406	1.456	1.422
	DIAMETER, in	2.84	2.84	2.85
	HEIGHT, in	5.17	5.60	5.60
Strain rate, in/min		0.020	0.020	0.020
BACK PRESSURE, psi		0.00	0.00	0.00
CELL PRESSURE, psi		15.00	30.00	60.00
FAILURE STRESS, psi		7.55	9.37	9.64
PORE PRESSURE, psi				
ULTIMATE STRESS, psi				
PORE PRESSURE, psi				
σ_1 FAILURE, psi		22.55	39.37	69.64
σ_3 FAILURE, psi		15	30	60

TYPE OF TEST:
Unconsolidated undrained

SAMPLE TYPE: Undisturbed

DESCRIPTION: Clayey silt

LL= PL= PI=

SPECIFIC GRAVITY= 2.65

REMARKS:

Fyi 9/18/01

CLIENT: IT Concord CA

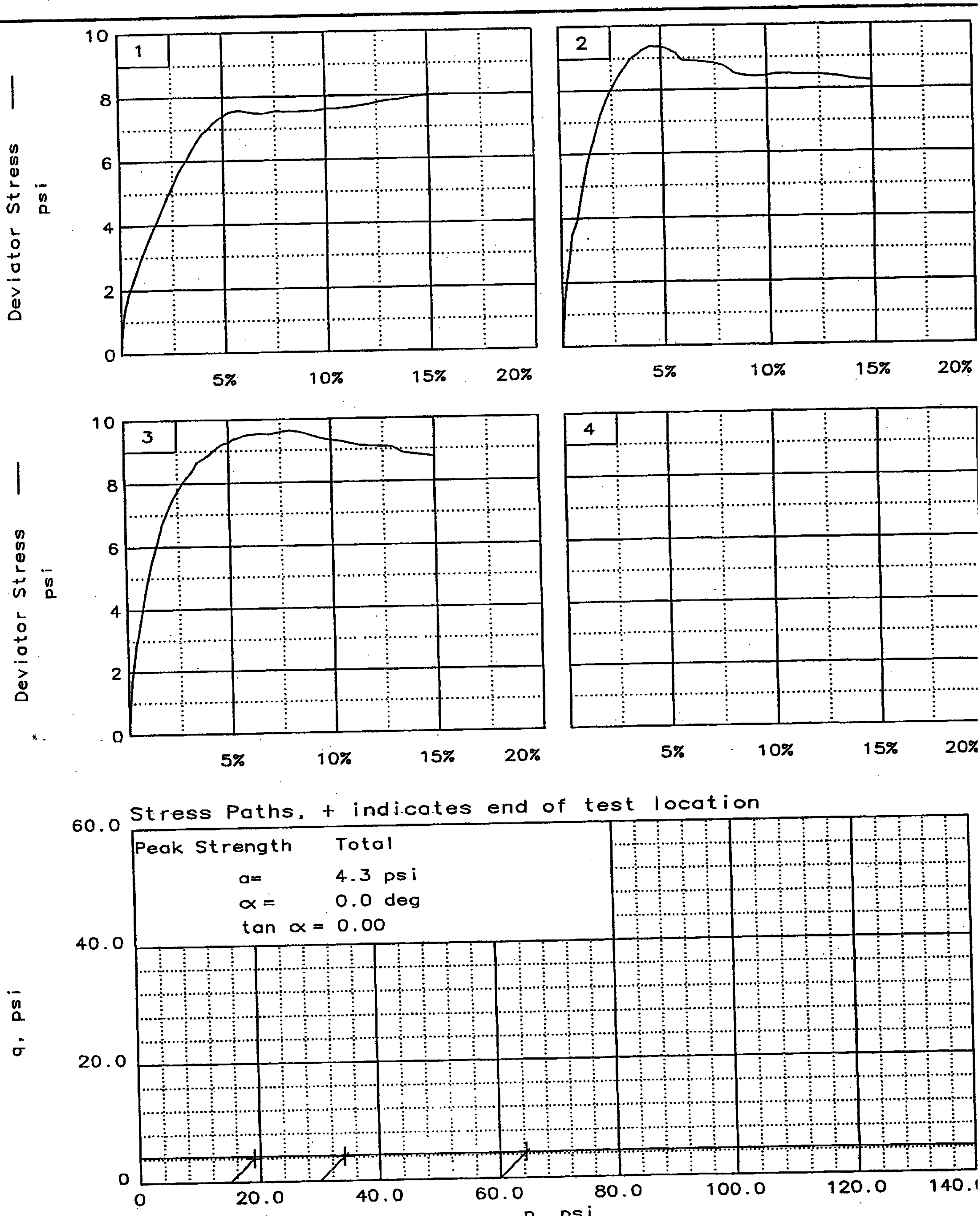
PROJECT: ARCO Hastings

SAMPLE LOCATION: Lab sample ID: ETDC-9787
Client sample ID: MW-15B (36-38)

PROJ. NO.: 806938 DATE: 9/17/2001

TRIAXIAL SHEAR TEST REPORT

CORPORATION GEOTECHNICAL LABORATORY



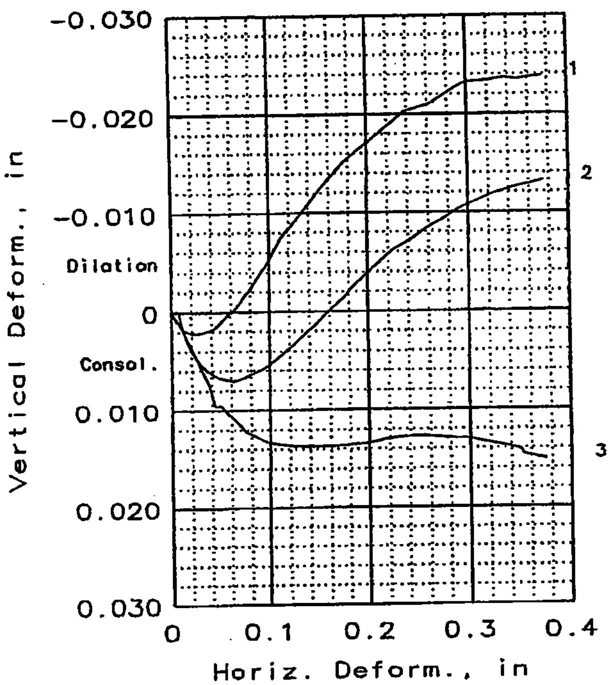
Client: IT Concord CA

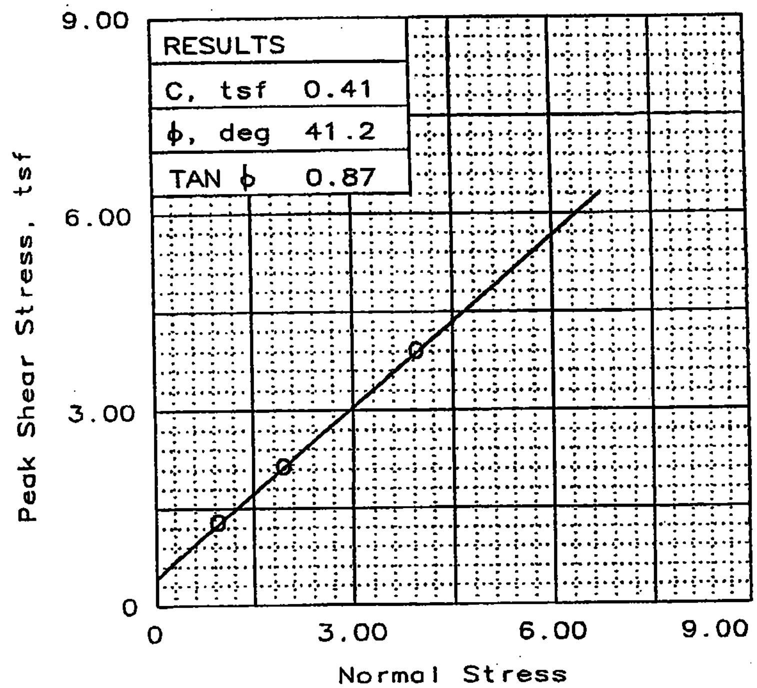
Project: ARCO Hastings

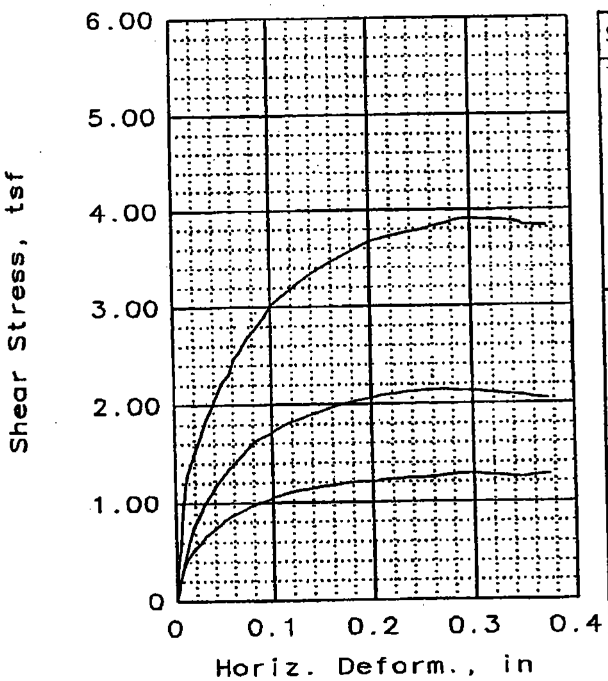
Location: Lab sample ID: ETDC-9787 Client sample ID: MW-15B (36-38)

FYI 9/18

DIRECT SHEAR TEST REPORTS







SAMPLE NO.		1	2	3
INITIAL	WATER CONTENT, %	44.9	44.9	44.9
	DRY DENSITY, pcf	65.6	65.7	65.7
	SATURATION, %	78.2	78.3	78.4
	VOID RATIO	1.522	1.520	1.518
	DIAMETER, in	2.50	2.50	2.50
	HEIGHT, in	1.00	1.00	1.00
AT TEST	WATER CONTENT, %	47.6	35.8	44.8
	DRY DENSITY, pcf	69.5	68.5	69.6
	SATURATION, %	91.4	66.9	86.1
	VOID RATIO	1.382	1.417	1.378
	DIAMETER, in	2.50	2.50	2.50
	HEIGHT, in	0.94	0.96	0.94
NORMAL STRESS, tsf		1.00	2.00	4.00
MAXIMUM SHEAR, tsf		1.29	2.14	3.91
RESIDUAL SHEAR, tsf				
Strain rate, in/min		0.013	0.014	0.013

SAMPLE DATA

SAMPLE TYPE: Remolded

DESCRIPTION: Silty sand

LL= NP PL= NP PI=

SPECIFIC GRAVITY= 2.65

REMARKS:

CLIENT: IT Concord CA

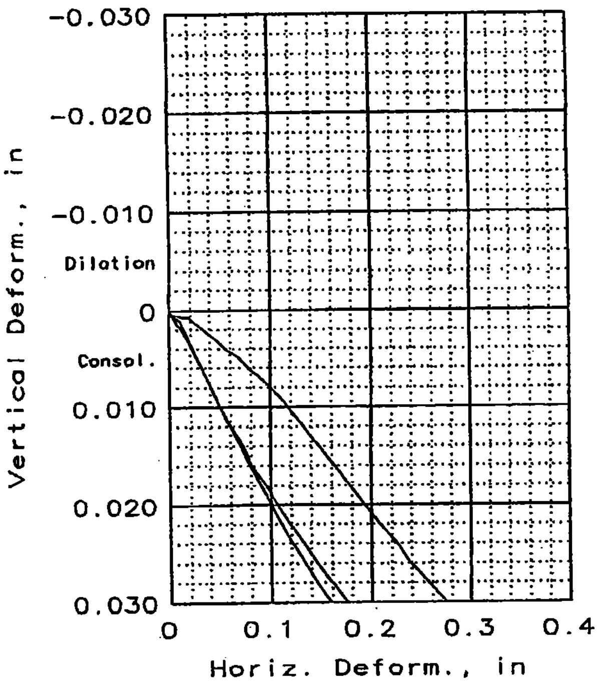
PROJECT: ARCO Hastings

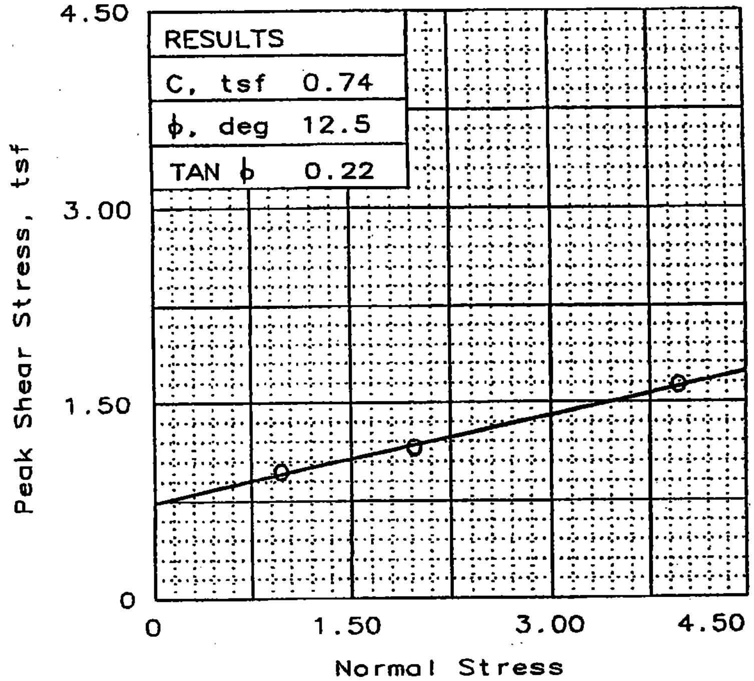
SAMPLE LOCATION: Lab sample ID: ETDC-9784
Client sample ID: MW-13B (20-22)

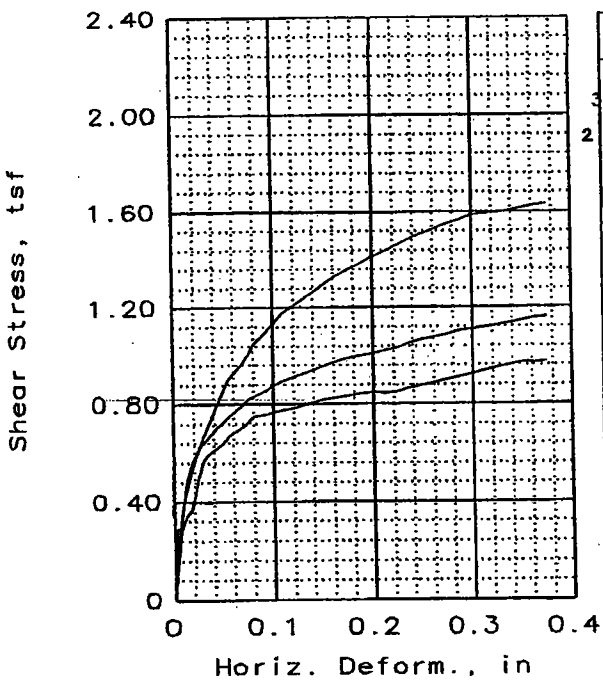
PROJ. NO.: 806938 DATE: 9/21/2001

DIRECT SHEAR TEST REPORT

IT CORPORATION GEOTECHNICAL LABORATORY







	SAMPLE NO.	1	2	3
INITIAL	WATER CONTENT, %	56.7	62.5	61.1
	DRY DENSITY, pcf	65.1	61.2	62.4
	SATURATION, %	97.5	97.3	98.0
	VOID RATIO	1.541	1.704	1.653
	DIAMETER, in	2.50	2.50	2.50
	HEIGHT, in	1.00	1.00	1.00
AT TEST	WATER CONTENT, %	54.4	51.5	46.1
	DRY DENSITY, pcf	68.5	68.6	75.7
	SATURATION, %	101.9	96.7	103.1
	VOID RATIO	1.416	1.412	1.184
	DIAMETER, in	2.50	2.50	2.50
	HEIGHT, in	0.95	0.89	0.82
	NORMAL STRESS, tsf	1.00	2.00	4.00
	MAXIMUM SHEAR, tsf	0.97	1.16	1.63
	RESIDUAL SHEAR, tsf			
	Strain rate, in/min	0.013	0.014	0.012

SAMPLE DATA

SAMPLE TYPE: Undisturbed

DESCRIPTION: Silt

LL= PL= PI=

SPECIFIC GRAVITY= 2.65

REMARKS:

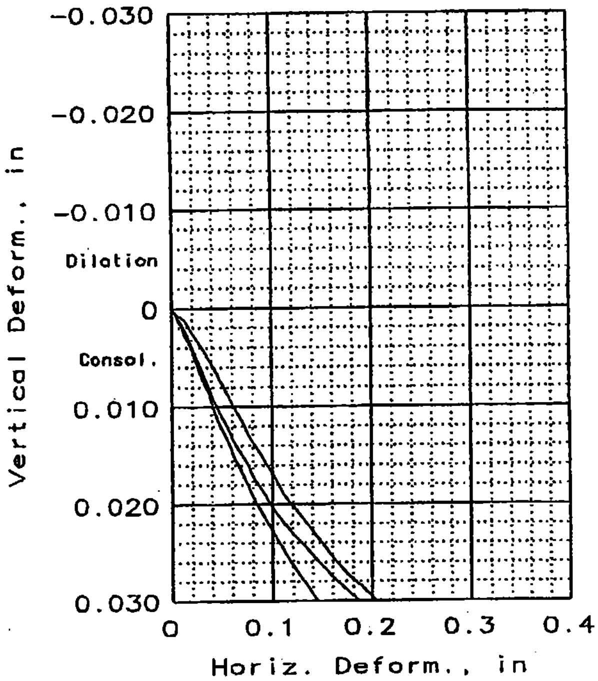
CLIENT: IT Latham NY

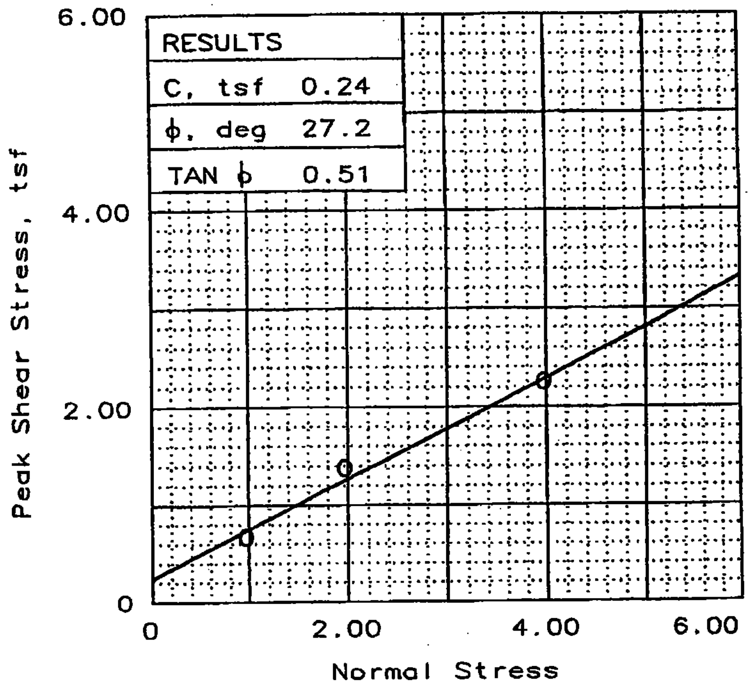
PROJECT: ARCO Hastings

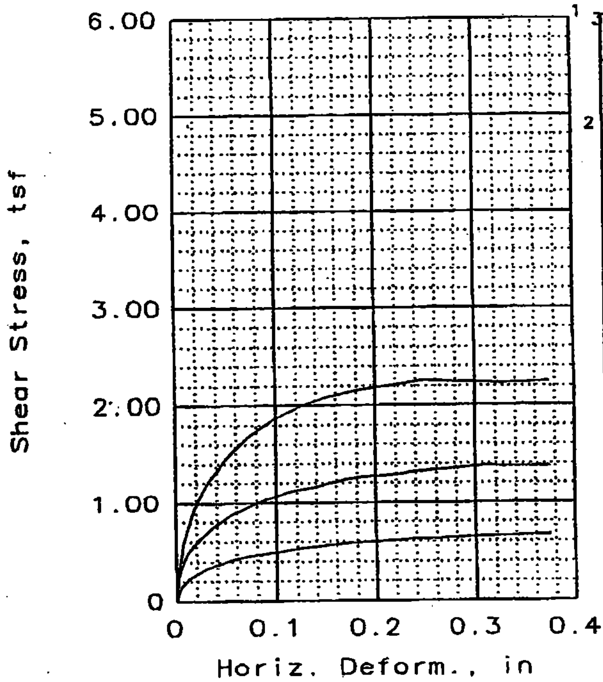
SAMPLE LOCATION: Lab sample ID: ETDC-9802
Client sample ID: MW13 (40-42)

PROJ. NO.: 806938 DATE: 10/15/2001

DIRECT SHEAR TEST REPORT







	SAMPLE NO.	1	2	3
INITIAL	WATER CONTENT, %	52.3	58.9	50.4
	DRY DENSITY, pcf	66.5	61.3	69.5
	SATURATION, %	93.2	91.9	96.8
	VOID RATIO	1.487	1.699	1.379
	DIAMETER, in	2.50	2.50	2.50
	HEIGHT, in	1.00	1.00	1.00
AT TEST	WATER CONTENT, %	54.1	56.3	38.3
	DRY DENSITY, pcf	73.5	68.1	70.9
	SATURATION, %	114.7	104.5	76.1
	VOID RATIO	1.249	1.429	1.332
	DIAMETER, in	2.50	2.50	2.50
	HEIGHT, in	0.90	0.90	0.98
	NORMAL STRESS, tsf	1.00	2.00	4.00
	MAXIMUM SHEAR, tsf	0.67	1.38	2.25
	RESIDUAL SHEAR, tsf			
	Strain rate, in/min	0.013	0.014	0.011

SAMPLE DATA

SAMPLE TYPE: Undisturbed

DESCRIPTION: Silt

LL= PL= PI=

SPECIFIC GRAVITY= 2.65

REMARKS:

CLIENT: IT Latham NY

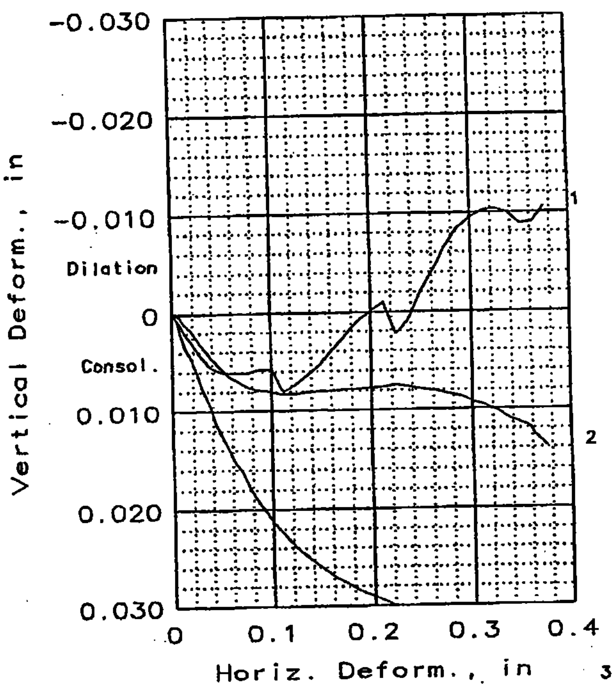
PROJECT: ARCO Hastings

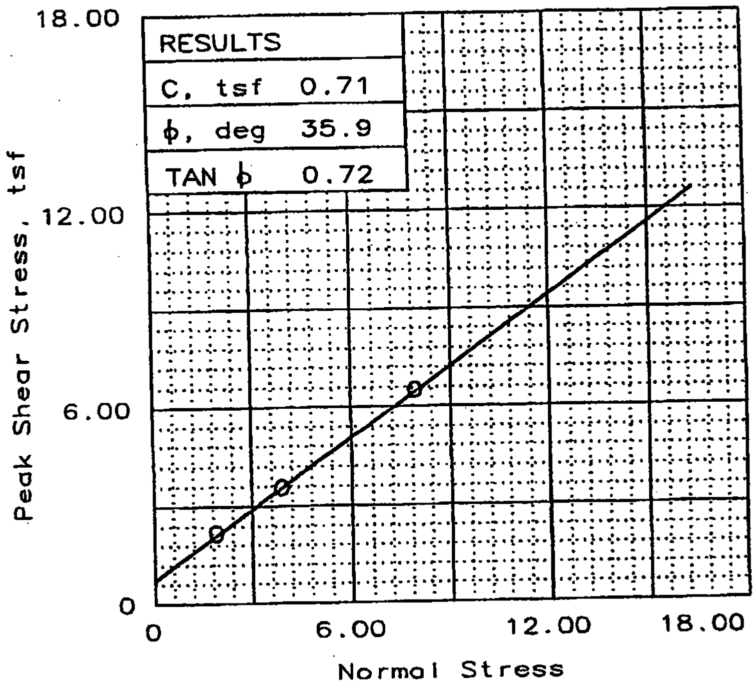
SAMPLE LOCATION: Lab sample ID: ETDC-9801
Client sample ID: MW-14A (40-42)

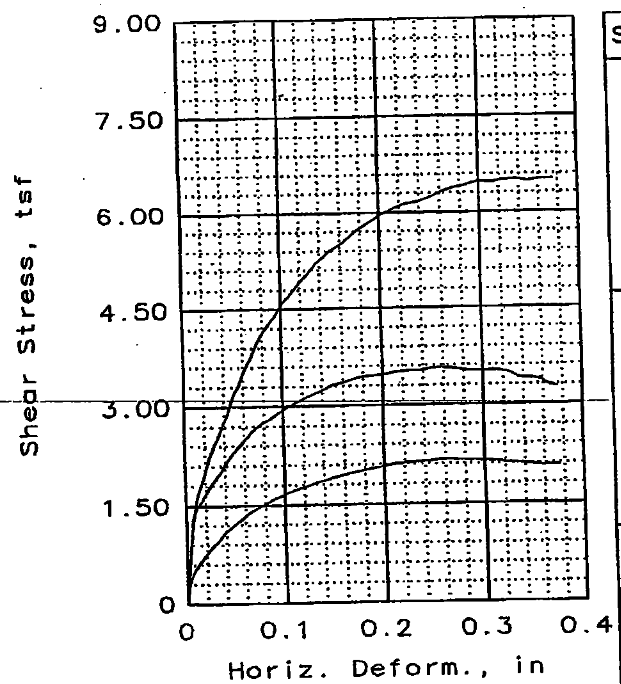
PROJ. NO.: 806938 DATE: 10/15/2001

DIRECT SHEAR TEST REPORT

IT CORPORATION GEOTECHNICAL LABORATORY







	SAMPLE NO.	1	2	3
INITIAL	WATER CONTENT, %	41.0	41.0	39.8
	DRY DENSITY, pcf	62.1	62.0	62.6
	SATURATION, %	65.3	65.1	64.3
	VOID RATIO	1.665	1.669	1.641
	DIAMETER, in	2.50	2.50	2.50
	HEIGHT, in	1.00	1.00	1.00
AT TEST	WATER CONTENT, %	45.8	42.8	39.2
	DRY DENSITY, pcf	63.0	67.0	68.5
	SATURATION, %	74.7	77.2	73.4
	VOID RATIO	1.626	1.468	1.414
	DIAMETER, in	2.50	2.50	2.50
	HEIGHT, in	0.99	0.92	0.91
	NORMAL STRESS, tsf	2.00	4.00	8.00
	MAXIMUM SHEAR, tsf	2.18	3.56	6.51
	RESIDUAL SHEAR, tsf			
	Strain rate, in/min	0.017	0.017	0.017

SAMPLE DATA

SAMPLE TYPE: Remolded

DESCRIPTION: Silty sand

LL= PL= PI=

SPECIFIC GRAVITY= 2.65

REMARKS:

CLIENT: IT Concord CA

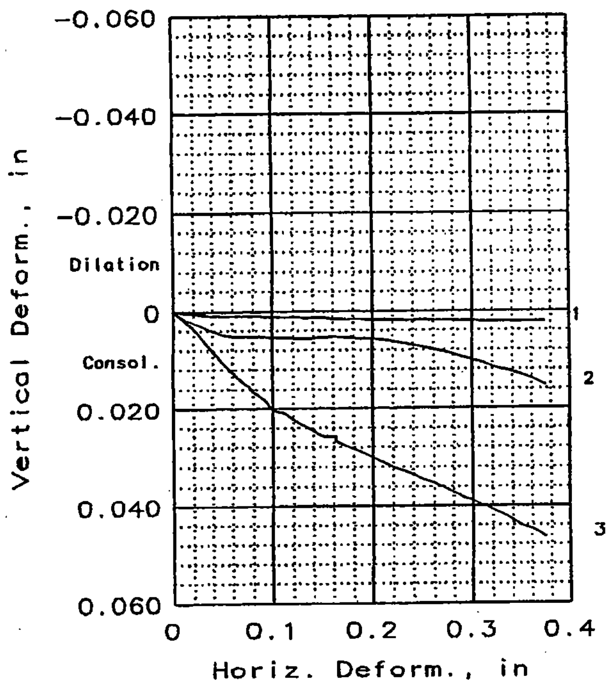
PROJECT: ARCO Hastings

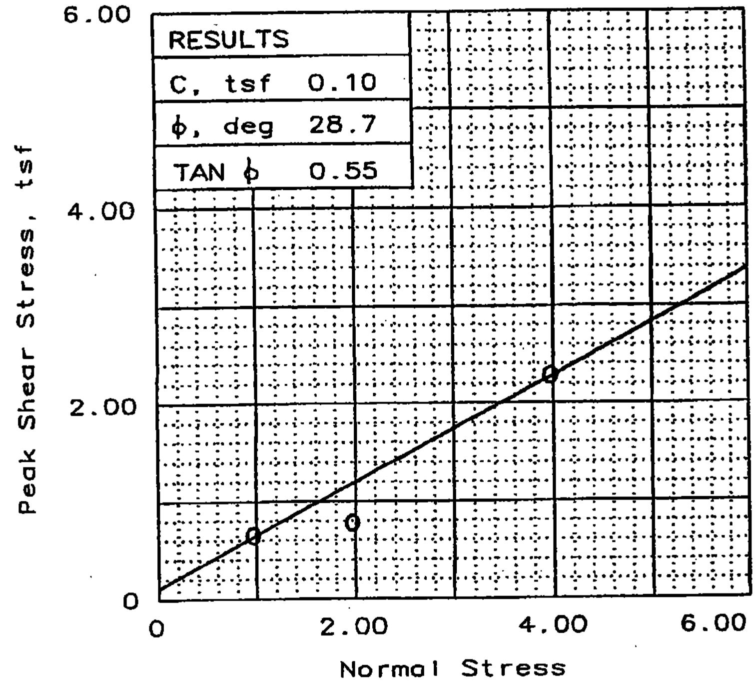
SAMPLE LOCATION: Lab sample ID: ETDC-9786
Client sample ID: MW-15B (24-26)

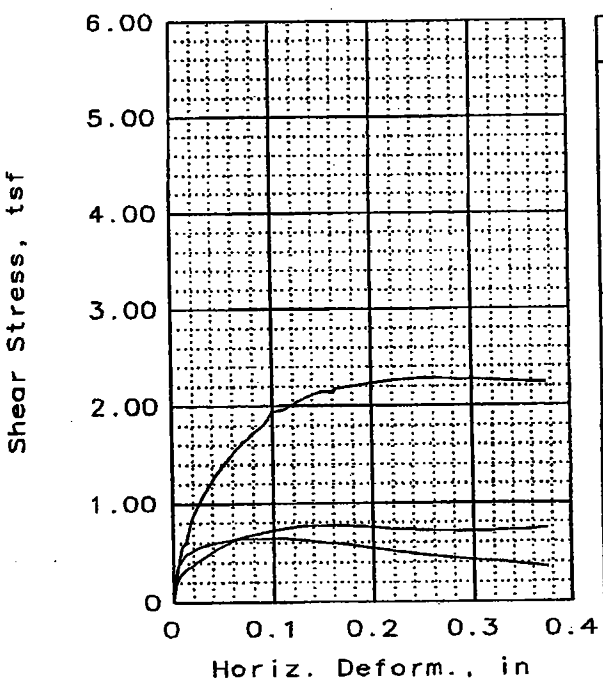
PROJ. NO.: 806938 DATE: 9/19/2001

DIRECT SHEAR TEST REPORT

LABORATORY







	SAMPLE NO.	1	2	3
INITIAL	WATER CONTENT, %	49.0	49.0	48.4
	DRY DENSITY, pcf	75.2	79.4	72.1
	SATURATION, %	108.1	119.9	99.2
	VOID RATIO	1.201	1.083	1.294
	DIAMETER, in	2.50	2.50	2.50
	HEIGHT, in	1.00	1.00	1.00
AT TEST	WATER CONTENT, %	33.6	28.2	33.2
	DRY DENSITY, pcf	87.1	85.8	93.2
	SATURATION, %	99.0	80.4	113.4
	VOID RATIO	0.898	0.929	0.775
	DIAMETER, in	2.50	2.50	2.50
	HEIGHT, in	0.86	0.93	0.77
	NORMAL STRESS, tsf	1.00	2.00	4.00
	MAXIMUM SHEAR, tsf	0.65	0.77	2.28
	RESIDUAL SHEAR, tsf			
	Strain rate, in/min	0.008	0.009	0.004

SAMPLE DATA

SAMPLE TYPE: Undisturbed

DESCRIPTION: Silt

LL= PL= PI=

SPECIFIC GRAVITY= 2.65

REMARKS: Sample contained many thin horizontal laminations.
2 tsf specimen ignored.
Spec gravity assumed.

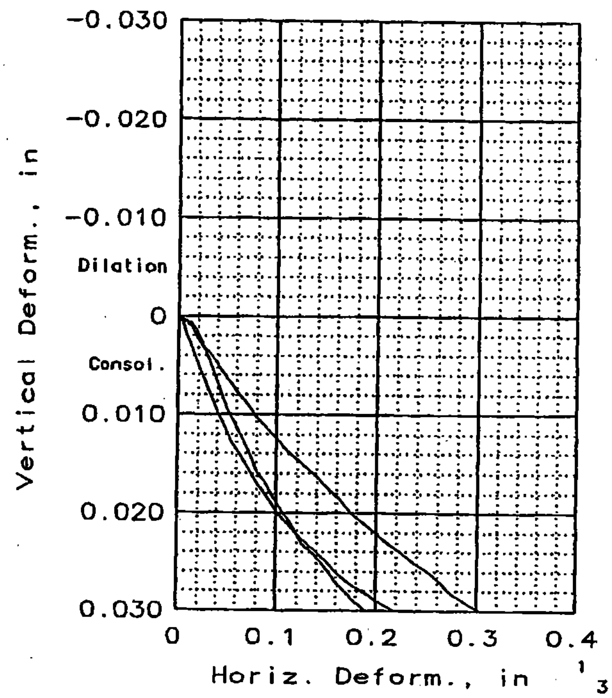
CLIENT: IT Latham NY

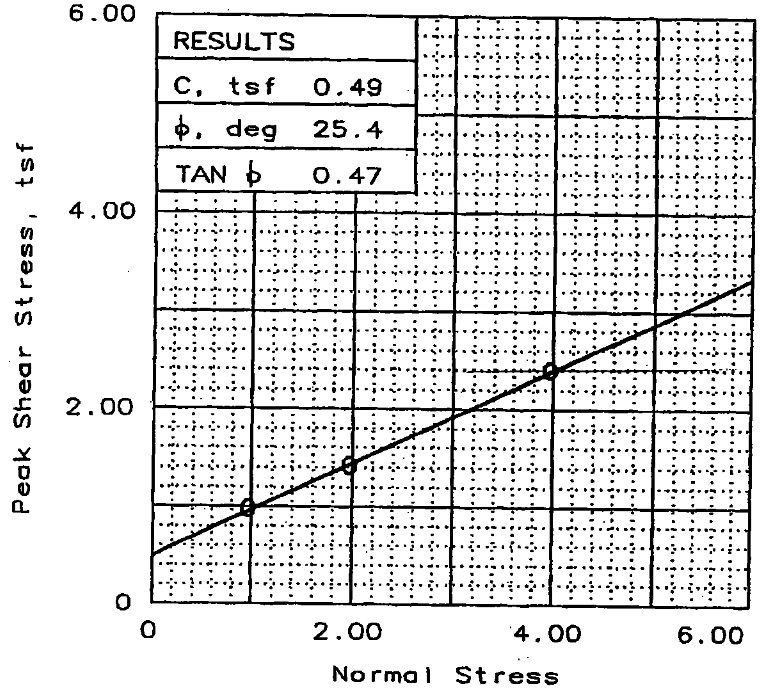
PROJECT: ARCO Hastings

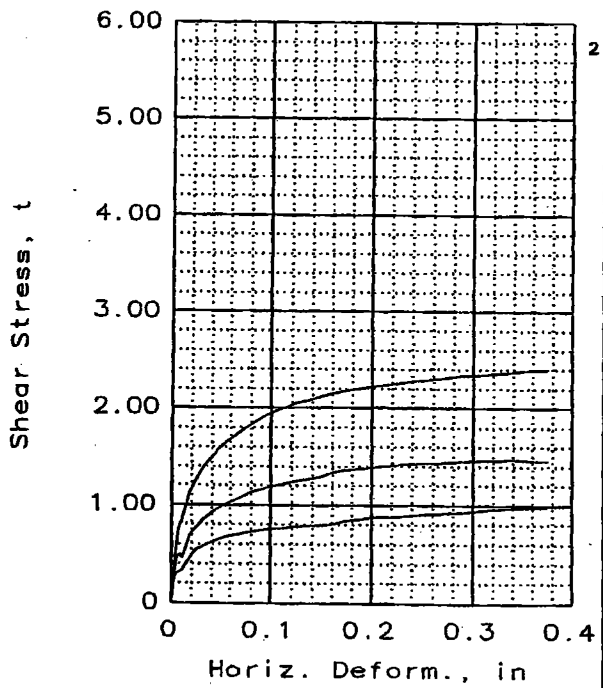
SAMPLE LOCATION: Lab sample ID: ETDC-9805
MW-15A (44-46)

PROJ. NO.: 806938 DATE: 10/8/2001

DIRECT SHEAR TEST REPORT







	SAMPLE NO.	1	2	3
INITIAL	WATER CONTENT, %	43.7	50.2	50.2
	DRY DENSITY, pcf	75.8	72.1	72.2
	SATURATION, %	97.8	102.8	102.9
	VOID RATIO	1.184	1.294	1.292
	DIAMETER, in	2.50	2.50	2.50
	HEIGHT, in	1.00	1.00	1.00
AT TEST	WATER CONTENT, %	40.3	40.4	32.0
	DRY DENSITY, pcf	83.6	87.3	88.0
	SATURATION, %	109.1	119.7	96.4
	VOID RATIO	0.980	0.895	0.880
	DIAMETER, in	2.50	2.50	2.50
	HEIGHT, in	0.91	0.83	0.82
	NORMAL STRESS, tsf	1.00	2.00	4.00
	MAXIMUM SHEAR, tsf	0.98	1.42	2.40
	RESIDUAL SHEAR, tsf			
	Strain rate, in/min	0.010	0.008	0.014

SAMPLE DATA

SAMPLE TYPE: Undisturbed

DESCRIPTION: Silt

LL= PL= PI=

SPECIFIC GRAVITY= 2.65

\RKS:

CLIENT: IT Latham NY

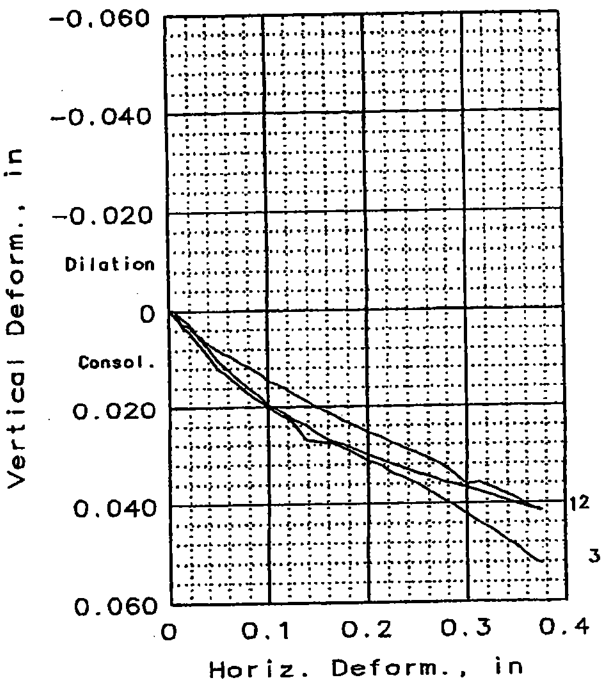
PROJECT: ARCO Hastings

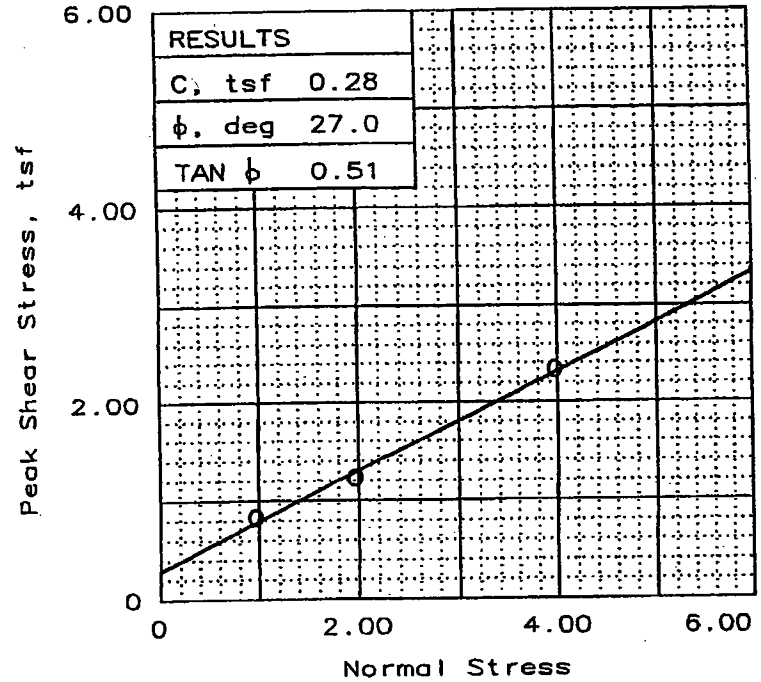
SAMPLE LOCATION: Lab sample ID: ETDC-9804
Client sample ID: MW-14A (48-50)

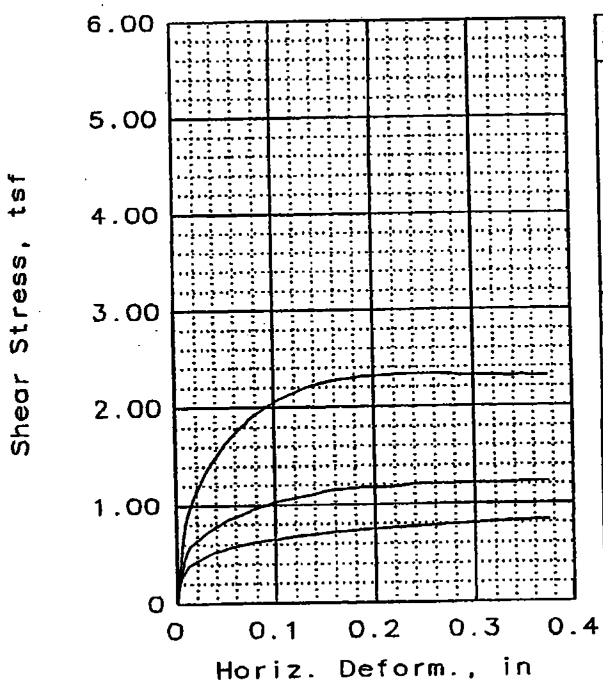
PROJ. NO.: 806938 DATE: 10/18/2001

DIRECT SHEAR TEST REPORT

IT CORPORATION GEOTECHNICAL LABORATORY







SAMPLE NO.		1	2	3
INITIAL	WATER CONTENT, %	42.9	42.9	42.9
	DRY DENSITY, pcf	77.5	77.1	74.0
	SATURATION, %	100.2	99.3	92.1
	VOID RATIO	1.135	1.146	1.235
	DIAMETER, in	2.50	2.50	2.50
	HEIGHT, in	1.00	1.00	1.00
AT TEST	WATER CONTENT, %	39.9	41.0	38.8
	DRY DENSITY, pcf	80.4	84.3	90.2
	SATURATION, %	100.0	112.7	123.4
	VOID RATIO	1.058	0.963	0.833
	DIAMETER, in	2.50	2.50	2.50
	HEIGHT, in	0.96	0.92	0.82
NORMAL STRESS, tsf		1.00	2.00	4.00
MAXIMUM SHEAR, tsf		0.83	1.23	2.34
RESIDUAL SHEAR, tsf				
Strain rate, in/min		0.016	0.016	0.016

SAMPLE DATA

SAMPLE TYPE: Undisturbed

DESCRIPTION: Silt

LL= PL= PI=

SPECIFIC GRAVITY= 2.65

REMARKS: Sample contained many horizontal thin laminations.

Spec gravity assumed.

CLIENT: IT Latham NY

PROJECT: ARCO Hastings

SAMPLE LOCATION: Lab sample ID: ETDC-9806
Client sample ID: MW-15A (54-56)

PROJ. NO.: 806938 DATE: 10/8/2001

DIRECT SHEAR TEST REPORT

SOIL DENSITY/PERCENT MOISTURE TEST REPORTS

BULK DENSITY/DRY DENSITY
EM-1110-2-1906, APPENDIX II

PROJECT NAME: ARCO Hastings

PROJECT NUMBER: 806938.40000000

ETDC SAMPLE NUMBER:	CLIENT SAMPLE NUMBER:	AVERAGE LENGTH, INCHES:	AVERAGE DIAMETER, INCHES:	WET WEIGHT, GRAMS:	MOISTURE CONTENT, %:	BULK DENSITY, PCF:	DRY DENSITY, PCF:
ETDC-9784	MW-13B (20-22)	15.79	2.880	2557	44.3	94.7	65.6
ETDC-9785	MW-14B (19-21)	4.009	2.009	319.19	72.4	95.7	55.5
ETDC-9786	MW-15B (24-26)	14.25	2.855	2094	41.0	87.5	62.0
ETDC-9787	MW-15B (36-38)	5.604	2.836	984.48	55.2	106.0	68.3
ETDC-9788	MW-13B (30-32)	5.415	2.830	1002.96	39.6	112.2	80.3
ETDC-9789	MW-14B (34-36)	5.623	2.813	972.04	56.2	106.0	67.8

Moisture content calculated by ASTM D 2216 based on sample dry weight.

Bulk density is the weight of wet sample divided by the volume of the wet sample (as-received).

Dry density is the weight of the dry sample solids divided by the volume of the original sample.

BULK DENSITY/DRY DENSITY
EM-1110-2-1906, APPENDIX II

PROJECT NAME: ARCO Hastiongs PROJECT NUMBER: 806938.40000000

ETDC SAMPLE NUMBER:	CLIENT SAMPLE NUMBER:	AVERAGE LENGTH, INCHES:	AVERAGE DIAMETER, INCHES:	WET WEIGHT, GRAMS:	MOISTURE CONTENT, %:	BULK DENSITY, PCF:	DRY DENSITY, PCF:
ETDC-9801	MW-14A (40-42)	5.6103	2.8240	966.2	50.4	104.8	69.6
ETDC-9802	MW-13 (40-42)	5.5798	2.8197	966.76	50.1	105.7	70.5
ETDC-9803	MW-134 (50-52)	5.2110	2.8123	939.5	37.7	110.6	80.3
ETDC-9804	MW-14A (48-50)	5.4315	2.8438	987.3	51.3	109.0	72.1
ETDC-9805	MW-15A (44-46)	7.4667	2.8013	1492.36	28.5	123.6	96.1
ETDC-9806	MW-15A (54-56)	5.5083	2.8230	1050.72	43.3	116.1	81.0

Moisture content calculated by ASTM D 2216 based on sample dry weight.

Bulk density is the weight of wet sample divided by the volume of the wet sample (as-received).

Dry density is the weight of the dry sample solids divided by the volume of the original sample.

MOISTURE CONTENT

PROJECT NAME
ARCO Hastings

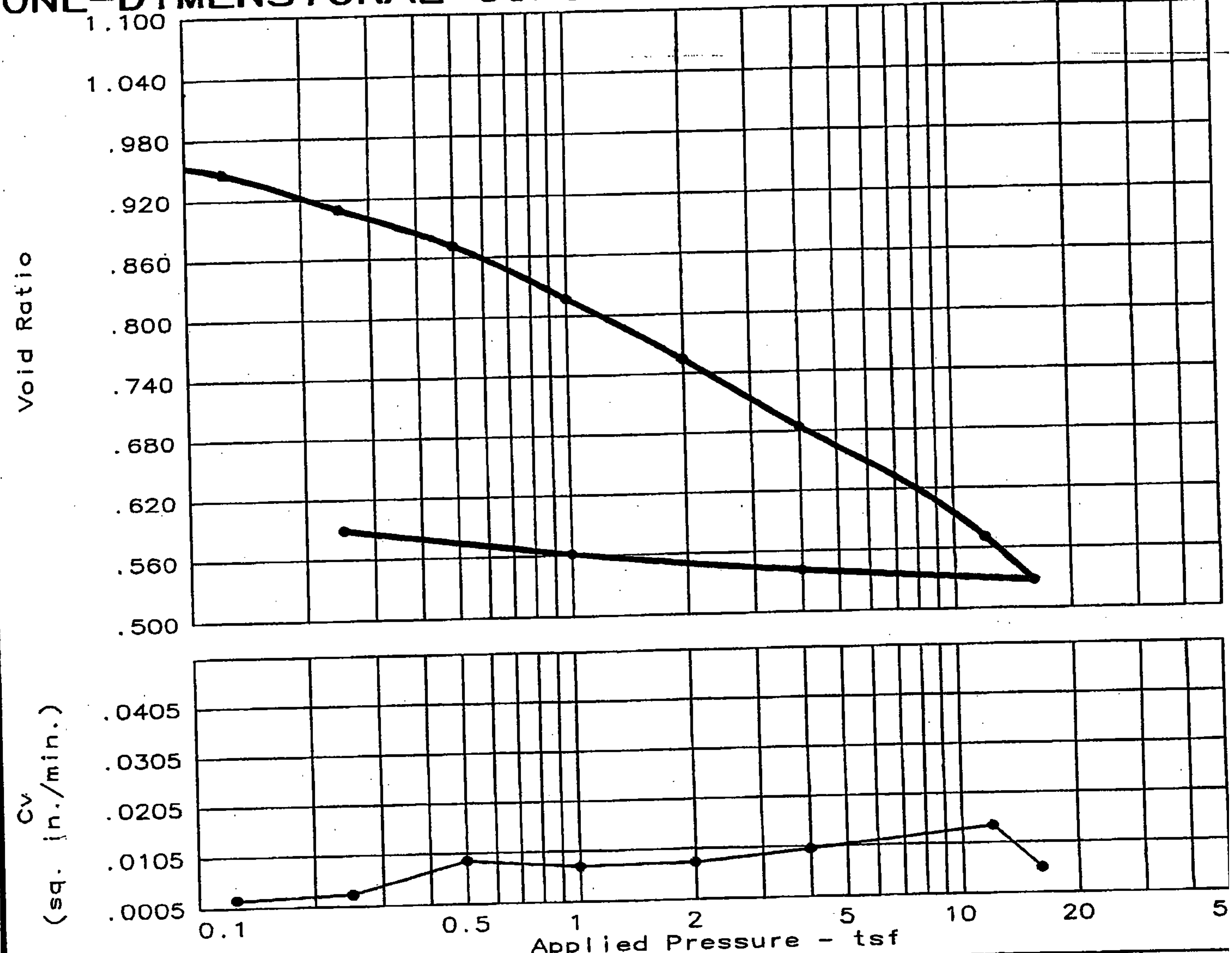
PROJECT NUMBER
806938.40000000

IT LAB SAMPLE NO.	CLIENT SAMPLE NO.	MOISTURE, % ASTM D 2216	MOISTURE , % SW846	SOLIDS, % SW846
ETDC-9791	MW-13A-58'-60'	28.6	22.2	77.8
ETDC-9792	MW-13A-75'-76'	20.7	17.1	82.9
ETDC-9793	MW13A-76'-77'	24.7	19.8	80.2
ETDC-9794	MW13A-82.9'-83'	26.7	21.1	78.9
ETDC-9795	MW-13A-86.4'-86.6	20.0	16.7	83.3
ETDC-9796	MW14A-60'-62'	23.7	19.2	80.8
ETDC-9797	MW14A-79-80	12.3	11.0	89.0
ETDC-9798	MW14A-80-81	23.7	19.1	80.9
ETDC-9799	MW-15A-70-72	24.4	19.6	80.4
ETDC-9800	MW-15A-76-80	20.4	16.9	83.1
ETDC-9801	MW-14A (40-42)	50.4	33.5	66.5
ETDC-9802	MW-13 (40-42)	50.1	33.4	66.6
ETDC-9803	MW-134 (50-52)	37.7	27.4	72.6
ETDC-9804	MW-14A (48-50)	51.3	33.9	66.1
ETDC-9805	MW-15A (44-46)	28.5	22.2	77.8
ETDC-9806	MW-15A (54-56)	44.5	30.8	69.2

ASTM D 2216 results are based on dry sample weight.
SW846 results are based on wet sample weight.
Solids content is determined by subtracting the SW846 moisture (%) from 100.

ONE-DIMENSIONAL CONSOLIDATION TEST REPORTS

ONE-DIMENSIONAL CONSOLIDATION ASTM D 2435



Natural Saturation	Natural Moisture	Dry Density	LL	PI	Sp.Gr.	Precons. press.	C_c	e_o
100.6 %	39.0	81.5	32	9	2.65	10.92	0.35	1.02

TEST RESULTS

Compression Index = 0.35

MATERIAL DESCRIPTION

Sandy lean CLAY

Class: CL

ETDC Project Name: ARCO Hastings
ETDC Project No.: 806938.4000000
ETDC Sample No.: 9788
Client Sample No.: MW-13B3032

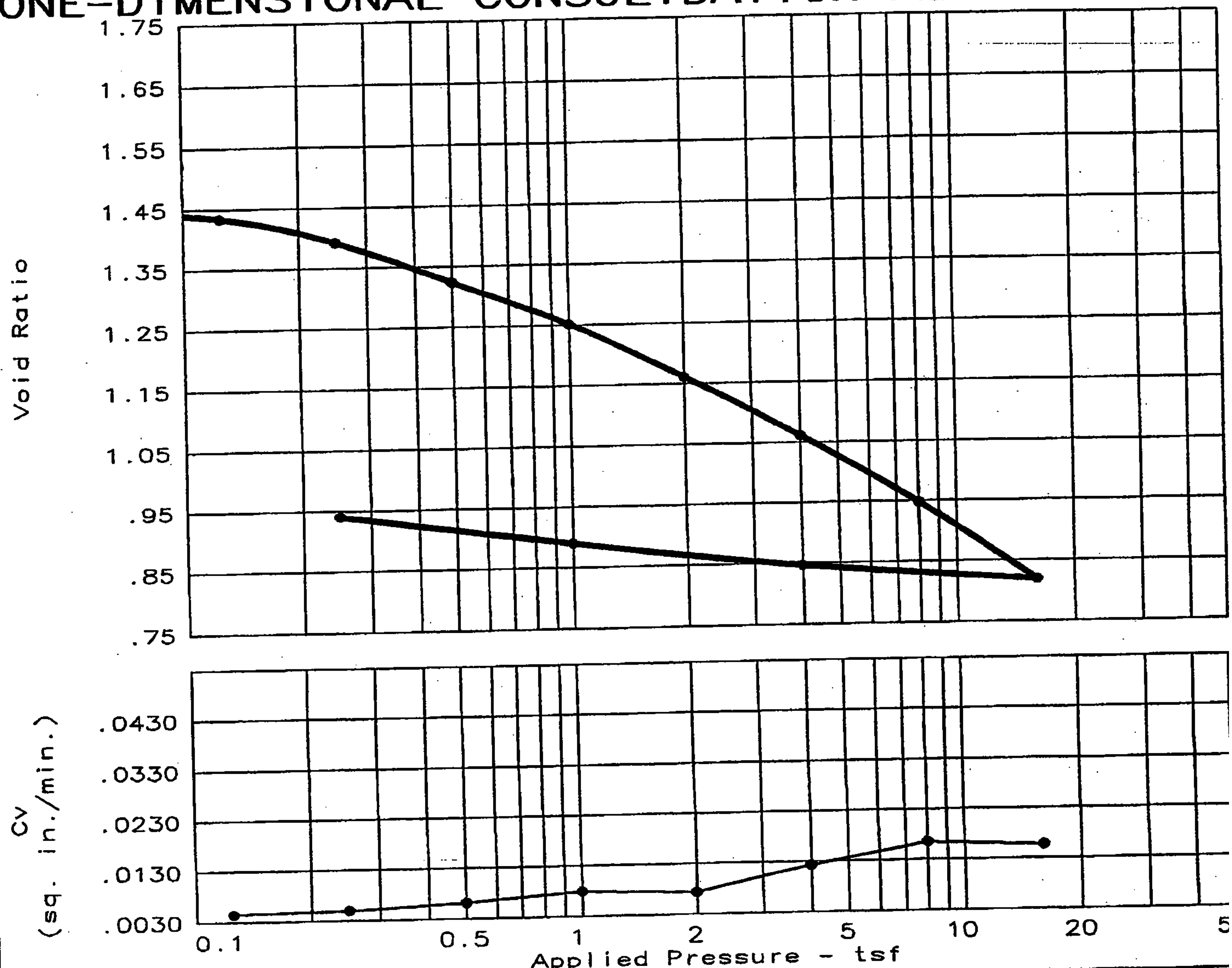
Remarks:

Testing begun 9/12/01
Testing completed 9/27/2001

Spec gravity assumed.

ONE-DIMENSIONAL CONSOLIDATION ASTM D 2435

ONE-DIMENSIONAL CONSOLIDATION ASTM D 2435



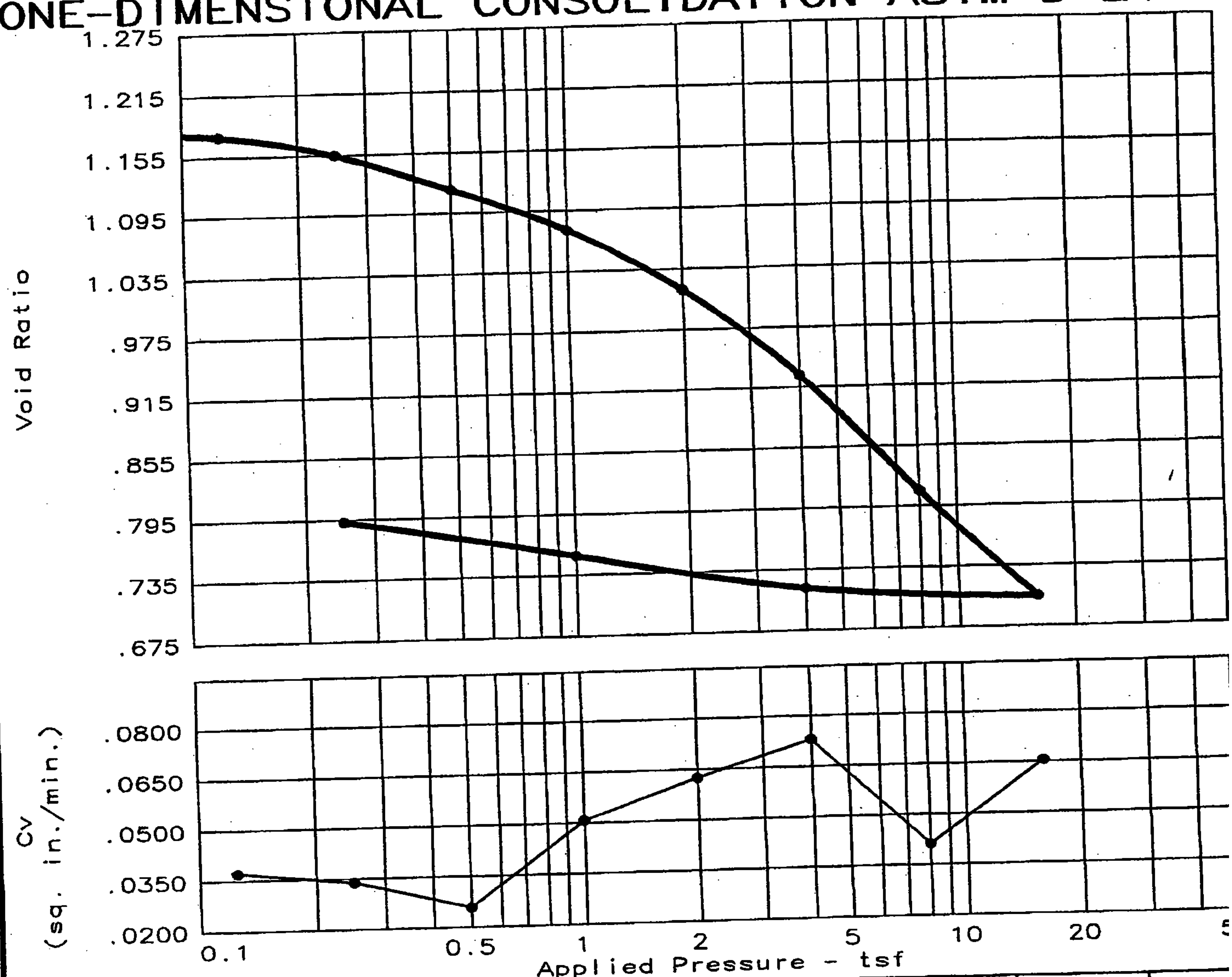
Natural Saturation	Natural Moisture	Dry Density	LL	PI	Sp.Gr.	Precons. press.	C_c	e_o
101.5 %	58.3	65.8			2.65	0.69	0.43	1.52

TEST RESULTS	MATERIAL DESCRIPTION
Compression Index = 0.43	

ETDC Project Name: ARCO Hastings
ETDC Project No.: 806938.4000000
ETDC Sample No.: 9802
Client Sample No.: MW-13 4042

Remarks:
Testing begun 9/28/01
Testing completed 10/5/2001

ONE-DIMENSIONAL CONSOLIDATION ASTM D 2435



Natural Saturation	Natural Moisture	Dry Density	LL	PI	Sp.Gr.	Precons. press.	C_c	e_o
101.8 %	46.5	75.2			2.65	3.59	0.37	1.20

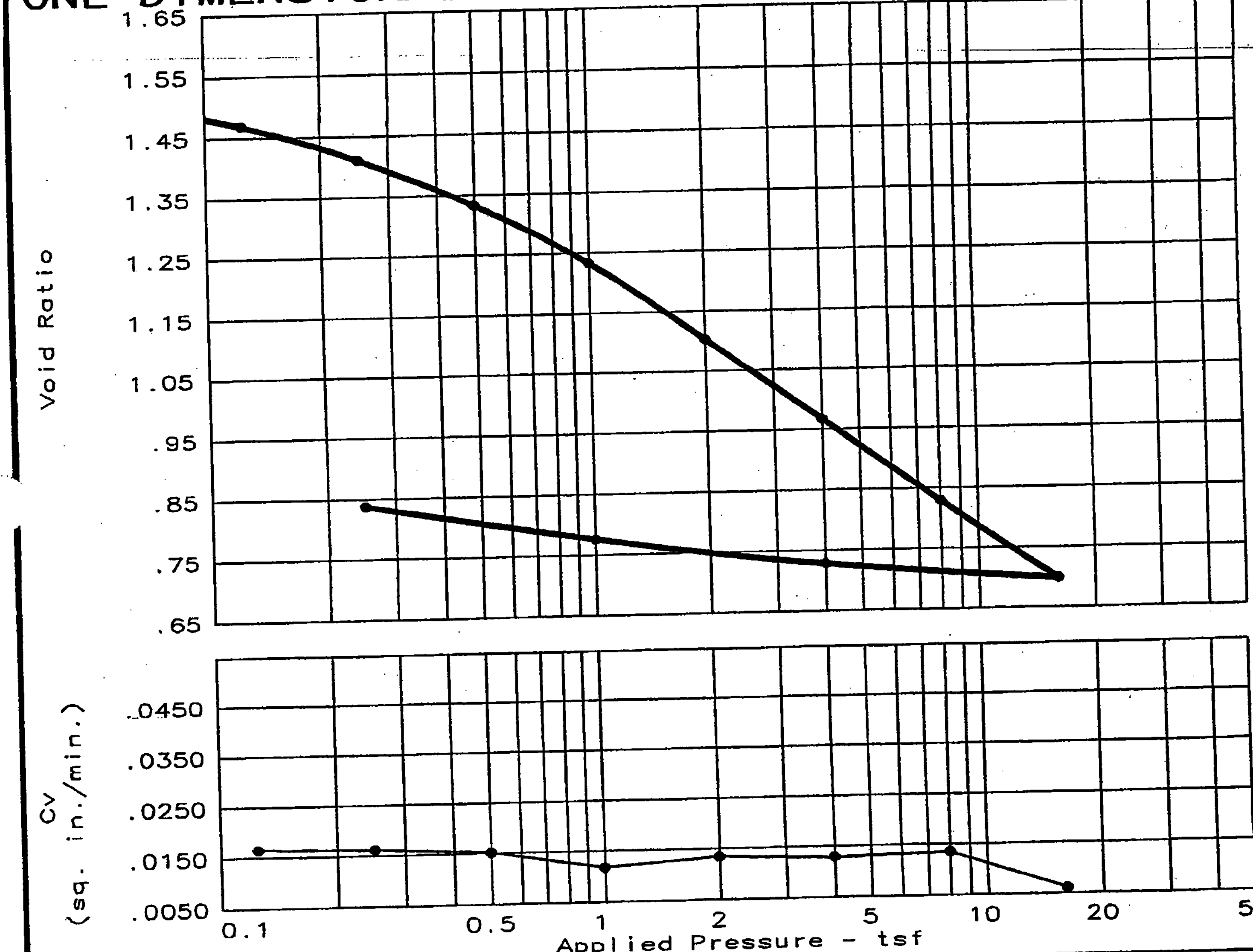
TEST RESULTS	MATERIAL DESCRIPTION
Compression Index = 0.37	

ETDC Project Name: ARCO Hastings
ETDC Project No.: 806938.4000000
ETDC Sample No.: 9803
Client Sample No.: MW-13 5052

Remarks:
Testing begun 9/28/0
Testing completed
10/5/2001
Spec. gravity assumed

ONE-DIMENSIONAL CONSOLIDATION ASTM D 2435

ONE-DIMENSIONAL CONSOLIDATION ASTM D 2435



Natural Saturation	Natural Moisture	Dry Density	LL	PI	Sp.Gr.	Precons. press.	C_c	e_o
102.4 %	60.5	644.5	36	12	2.65	0.84	0.44	1.56

TEST RESULTS

Compression Index = 0.44

ETDC Project Name: ARCO Hastings
ETDC Project No.: 806938.4000000
ETDC Sample No.: 9789
Client Sample No.: MW-14B3436

MATERIAL DESCRIPTION

Lean CLAY with sand

Class: CL

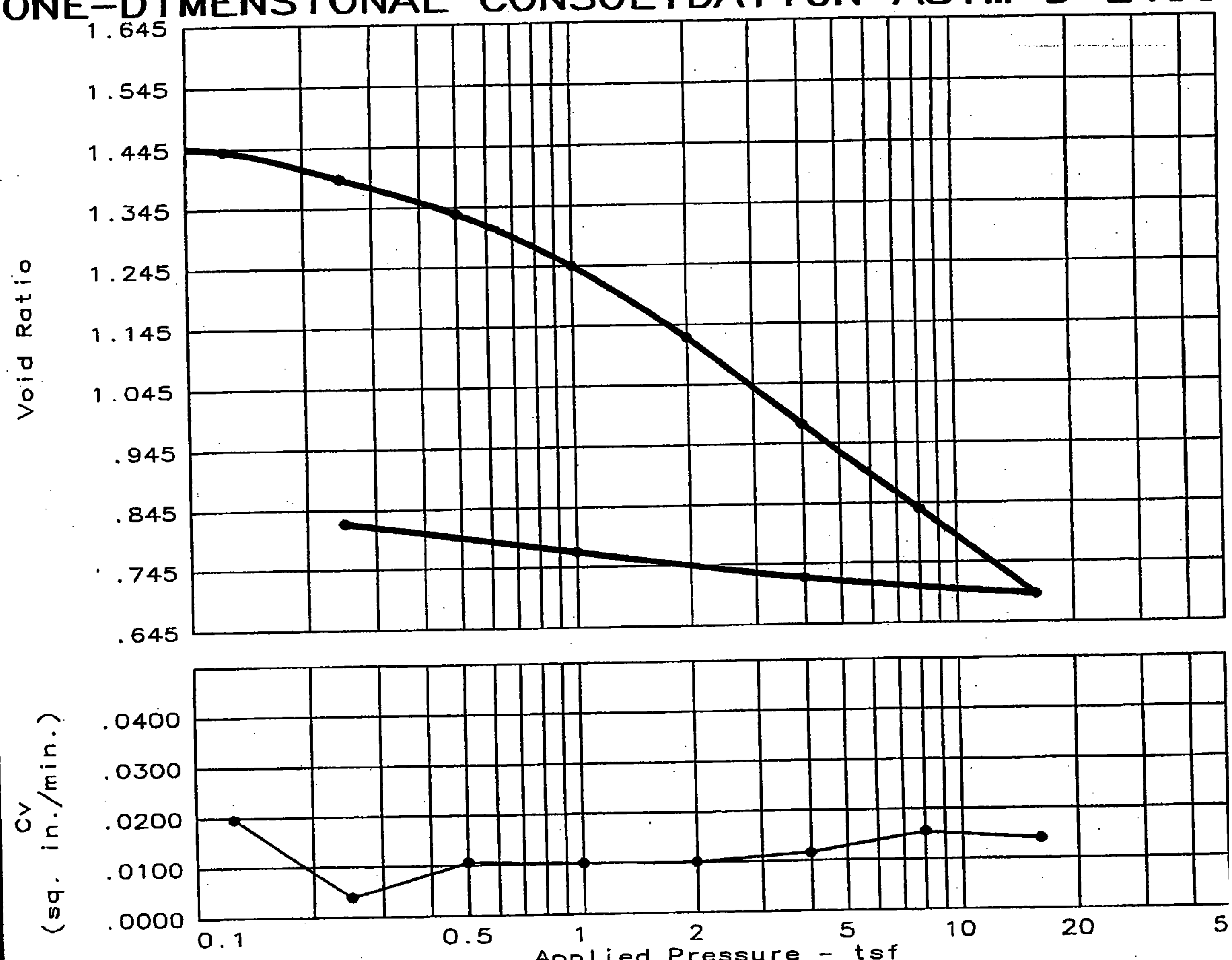
Remarks:

Testing begun 9/12/01
Testing completed 9/27/2001

Spec gravity assumed.

ONE-DIMENSIONAL CONSOLIDATION ASTM D 2435

ONE-DIMENSIONAL CONSOLIDATION ASTM D 2435



Natural Saturation	Natural Moisture	Dry Density	LL	PI	Sp.Gr.	Precons. press.	Cc	eo
106.9 %	63.3	64.7			2.65	0.46	0.48	1.56[illegible]

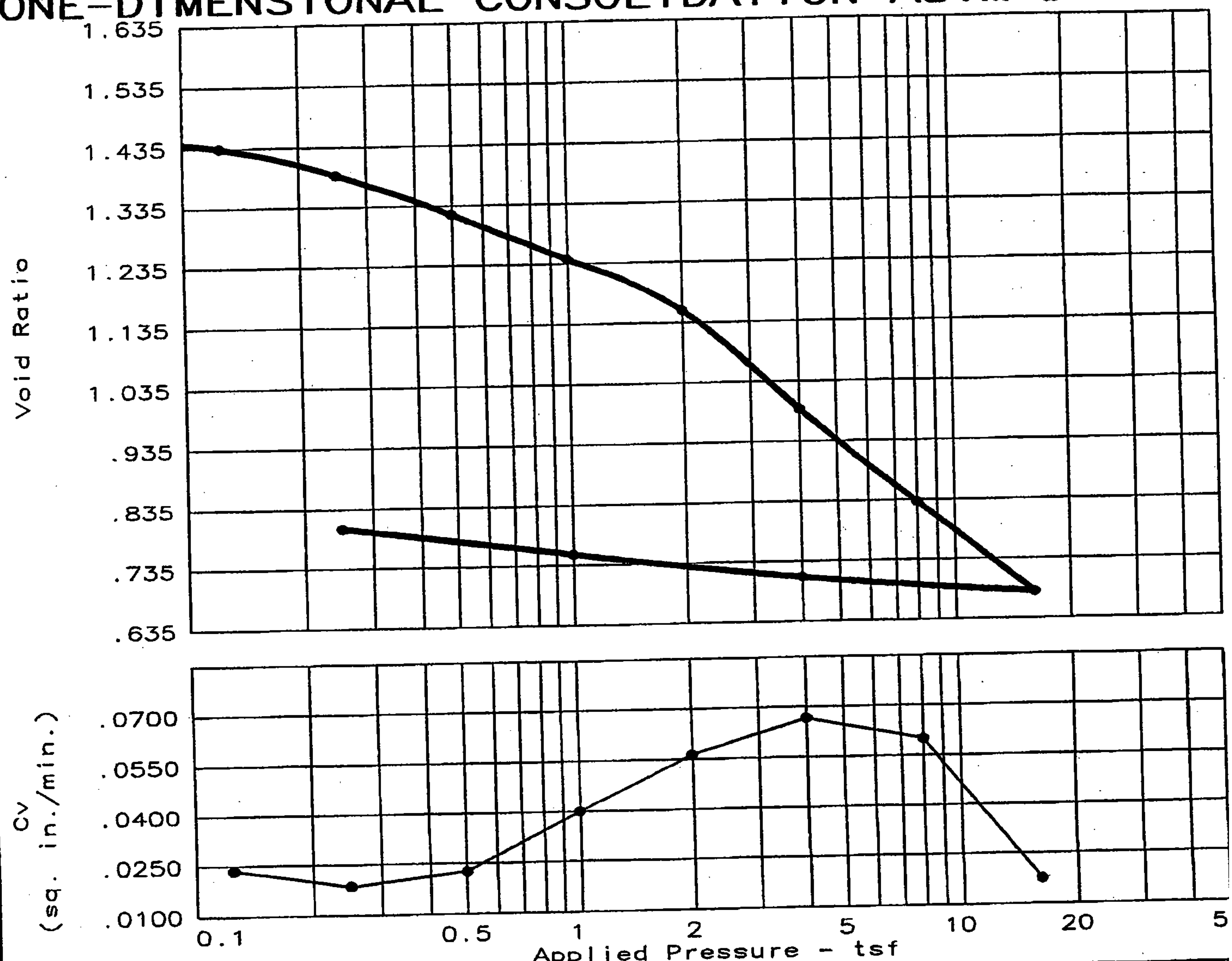
TEST RESULTS	MATERIAL DESCRIPTION
Compression Index = 0.48	

ETDC Project Name: ARCO Hastings
ETDC Project No.: 806938.4000000
ETDC Sample No.: 9801
Client Sample No.: MW-14A4042

ONE-DIMENSIONAL CONSOLIDATION ASTM D 2435

Remarks:
Testing begun 9/28/01
Testing completed
10/5/2001

ONE-DIMENSIONAL CONSOLIDATION ASTM D 2435



Natural Saturation	Natural Moisture	Dry Density	LL	PI	Sp.Gr.	Precons. press.	C_c	e_o
101.9 %	60.1	64.9			2.65	1.95	0.54	1.56

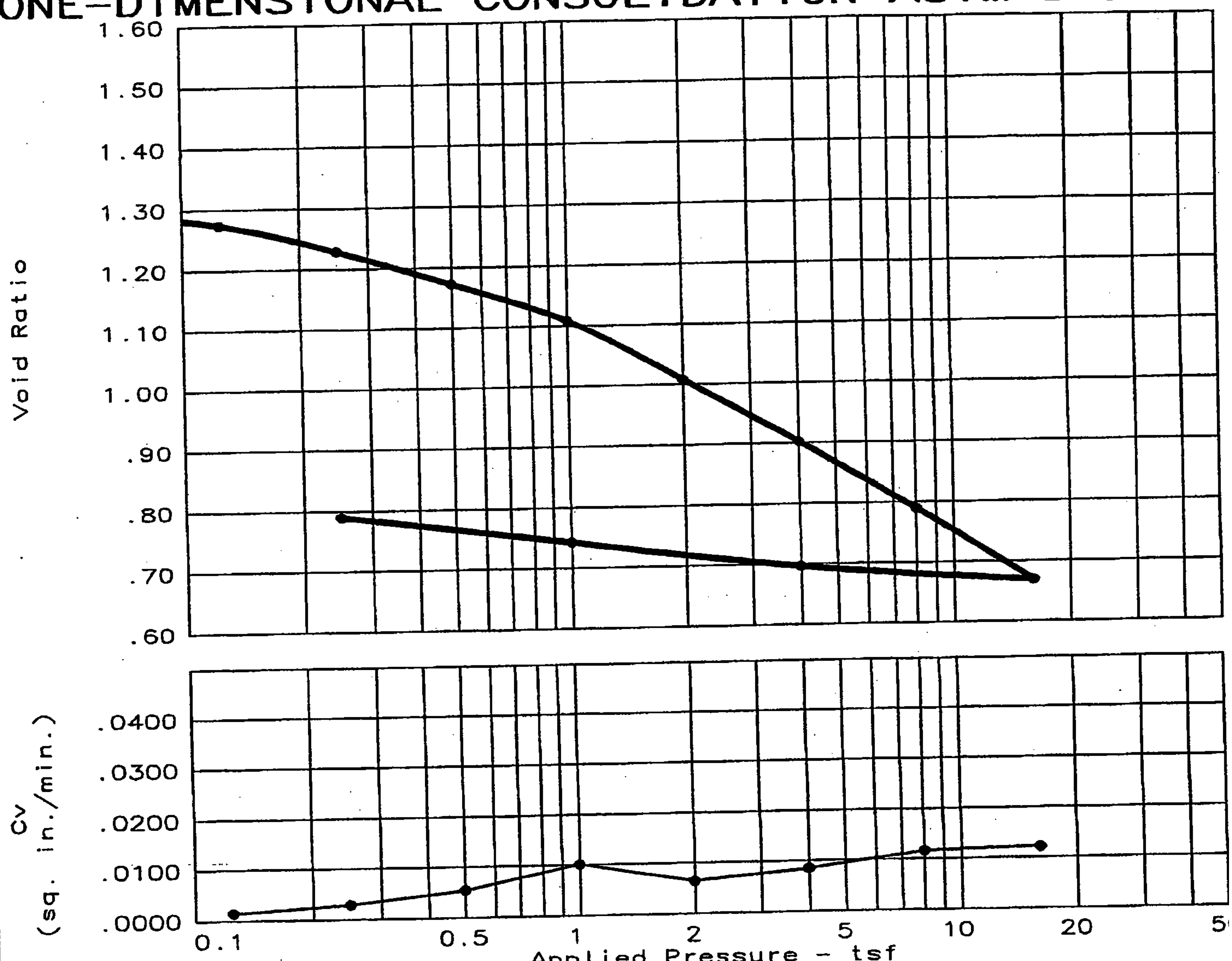
TEST RESULTS	MATERIAL DESCRIPTION
Compression Index = 0.54	

ETDC Project Name: ARCO Hastings
ETDC Project No.: 806938.4000000
ETDC Sample No.: 9804
Client Sample No.: MW14A 4850

Remarks:
Testing begun 10/1/01
Testing completed
10/5/2001

ONE-DIMENSIONAL CONSOLIDATION ASTM D 2435

ONE-DIMENSIONAL CONSOLIDATION ASTM D 2435



Natural Saturation	Natural Moisture	Dry Density	LL	PI	Sp.Gr.	Precons. press.	C_c	e_o
103.6 %	54.5	69.9			2.65	1.44	0.40	1.393

TEST RESULTS	MATERIAL DESCRIPTION
Compression Index = 0.40	

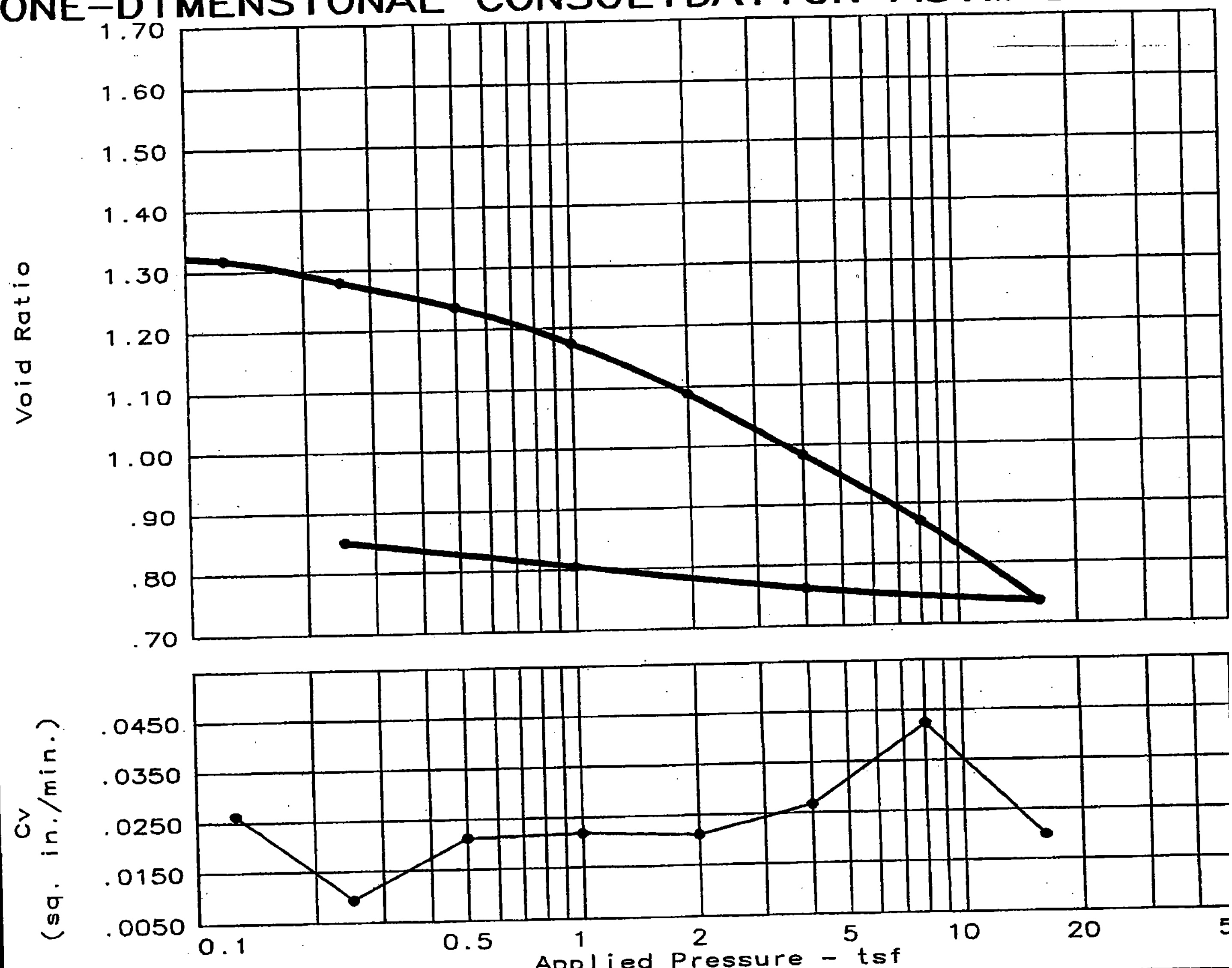
ETDC Project Name: ARCO Hastings
ETDC Project No.: 806938.4000000
ETDC Sample No.: 9805
Client Sample No.: MW15A 4446

Remarks:
Testing begun 10/1/01
Testing completed 10/5/2001

Spec gravity assumed.

ONE-DIMENSIONAL CONSOLIDATION ASTM D 2435

ONE-DIMENSIONAL CONSOLIDATION ASTM D 2435



Natural Saturation	Natural Moisture	Dry Density	LL	PI	Sp.Gr.	Precons. press.	C_c	e_o
98.2 %	51.1	69.8			2.65	0.89	0.45	1.38

TEST RESULTS	MATERIAL DESCRIPTION
Compression Index = 0.45	

ETDC Project Name: ARCO Hastings
ETDC Project No.: 806938.4000000
ETDC Sample No.: 9806
Client Sample No.: MW15A 5456

Remarks:
Testing begun 10/1/01
Testing completed 10/5/2001

ONE-DIMENSIONAL CONSOLIDATION ASTM D 2435

ATTERBURG LIMITS TEST REPORTS

ATTERBERG LIMITS
ASTM D 4318

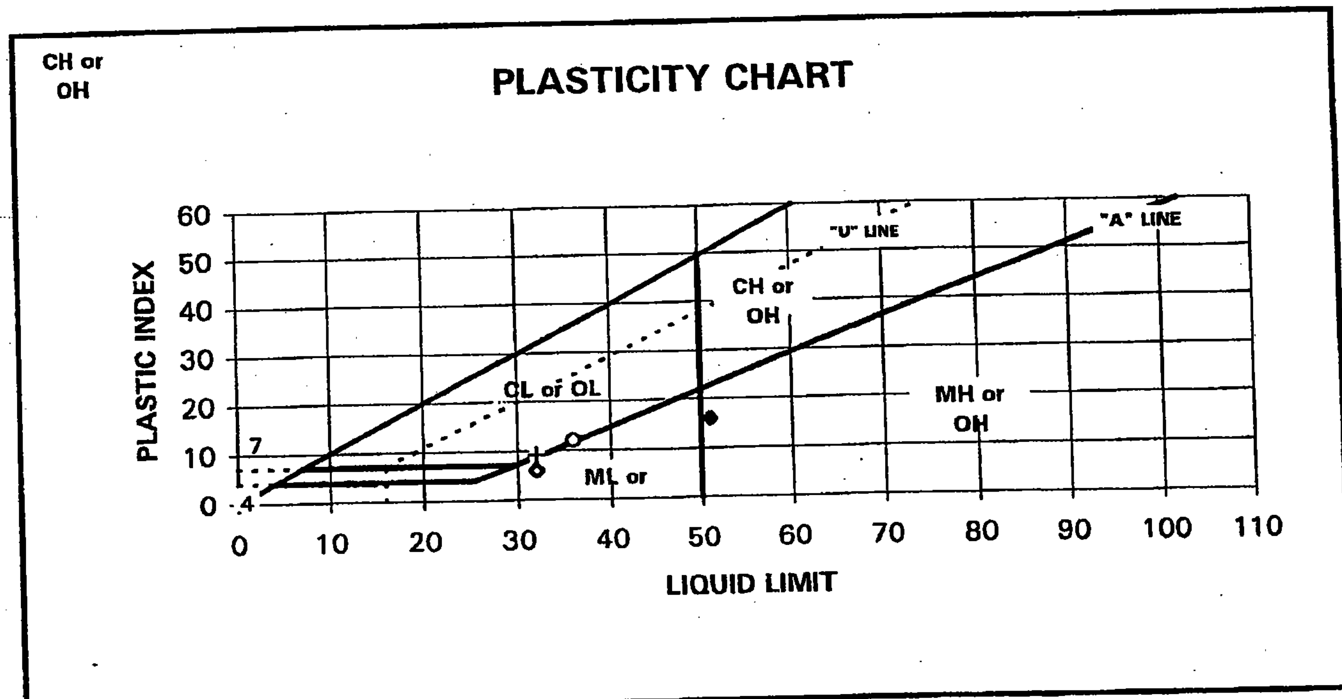
PROJECT NAME:
ARCO Hastings

PROJECT NO.
806983.40000000

ATTERBERG LIMITS RESULTS

LAB SAMPLE NO.		FIELD SAMPLE NO.	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	USCS SYMBOL
ETDC-9784	●	MW-13B (20-22)	NP	NP	NP	NP
ETDC-9785	◆	MW-14B (19-21)	51	35	16	MH
ETDC-9786	□	MW-15B (24-26	NP	NP	NP	NP
ETDC-9787	◇	MW-15B (36-38)	32	26	6	ML
ETDC-9788	+	MW-13B (30-32)	32	23	9	CL
ETDC-9789	○	MW-14B (34-36)	36	24	12	CL
	■					
	x					
	▲					
	★					

*NP=Nonplastic



ATTERBERG LIMITS
ASTM D 4318

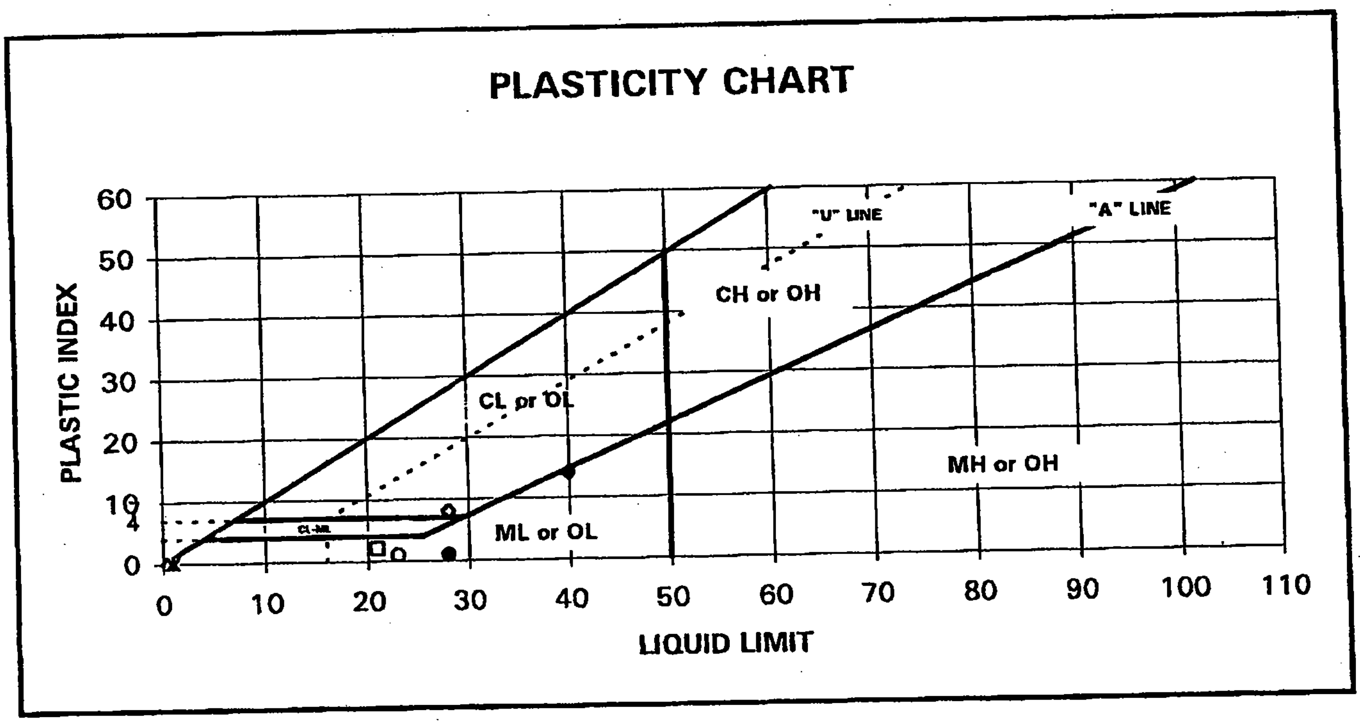
PROJECT NAME:
ARCO Hastings

PROJECT NO.
806938.40000000

ATTERBERG LIMITS RESULTS

LAB SAMPLE NO.		FIELD SAMPLE NO.	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	USCS SYMBOL
ETDC-9801	●	MW-14A (40-42)	28	27	1	ML
ETDC-9802	◆	MW-13 (40-42)	40	26	14	ML
ETDC-9803	□	MW13 (50-52)	21	19	2	ML
ETDC-9804	◇	MW-14A (48-50)	28	20	8	CL
ETDC-9805	+	MW-15A (44-46)	NP	NP	NP	NP
ETDC-9806	○	MW-15A (54-56)	23	22	1	ML
	■					
	x					
	▲					
	★					

*NP=Nonplastic



ATTERBERG LIMITS
ASTM D 4318

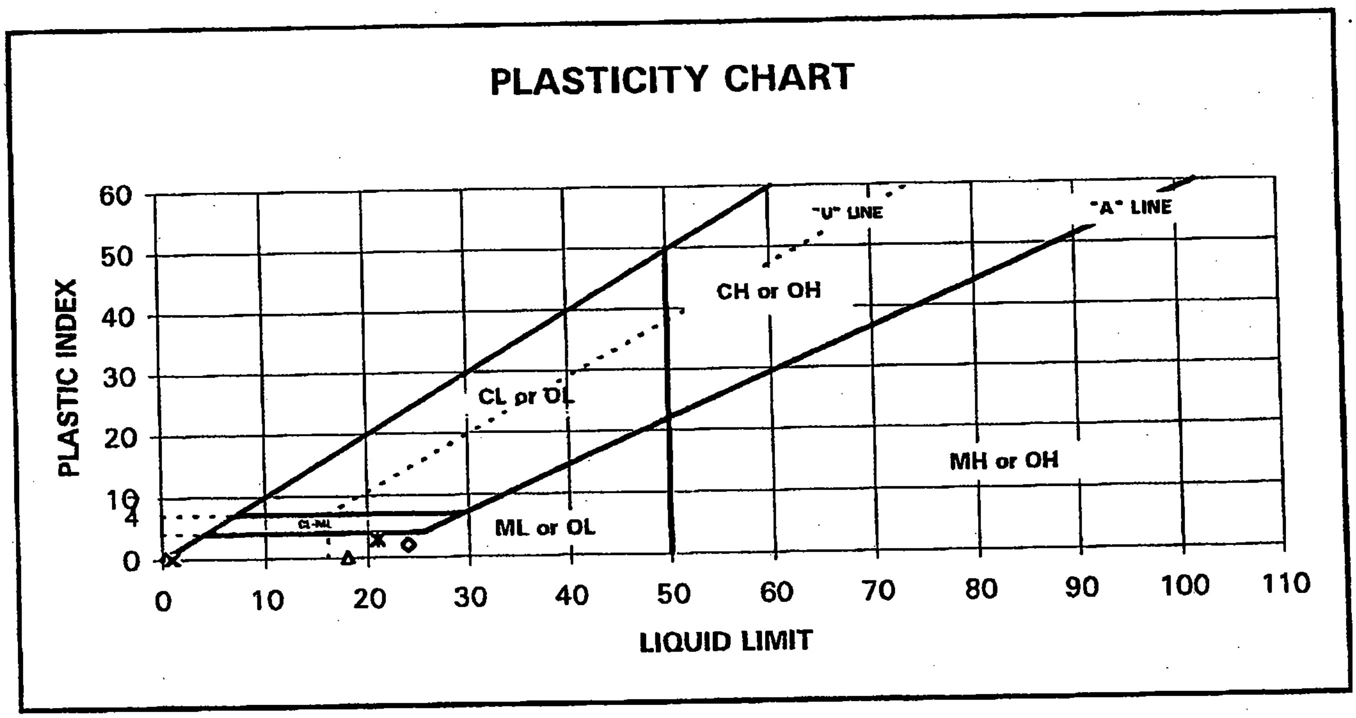
PROJECT NAME: ARCO Hastings

PROJECT NO. 806938.40000000

ATTERBERG LIMITS RESULTS

LAB SAMPLE NO.		FIELD SAMPLE NO.	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	USCS SYMBOL
ETDC-9791	●	MW-13A-58'-60'	NP	NP	NP	NP
ETDC-9792	◆	MW-13A-75'-76'	NP	NP	NP	NP
ETDC-9793	□	MW13A-76'-77'	23	24	-1	NP
ETDC-9794	◇	MW13A-82.9'-83'	24	22	2	ML
ETDC-9795	+	W-13A-86.4'-86.6	NP	NP	NP	NP
ETDC-9796	○	MW14A-60'-62'	NP	NP	NP	NP
ETDC-9797	■	MW14A-79-80	NP	NP	NP	NP
ETDC-9798	x	MW14A-80-81	NP	NP	NP	NP
ETDC-9799	▲	MW-15A-70-72	18	NP	NP	NP
ETDC-9800	★	MW-15A-76-80	21	18	3	ML

*NP=Nonplastic



PARTICLE SIZE ANALYSIS TEST REPORTS

PARTICLE-SIZE ANALYSIS
ASTM D 422

Project Name ARCO Hastings

Project No. 806938.40000000

Client Sample No. MW-13B (20-22)

IT Lab Sample No. ETDC-9784

Specific Gravity = 2.65
assumed for calculations

Moisture Content = 44.3%
based on dry sample weight

SIEVE ANALYSIS

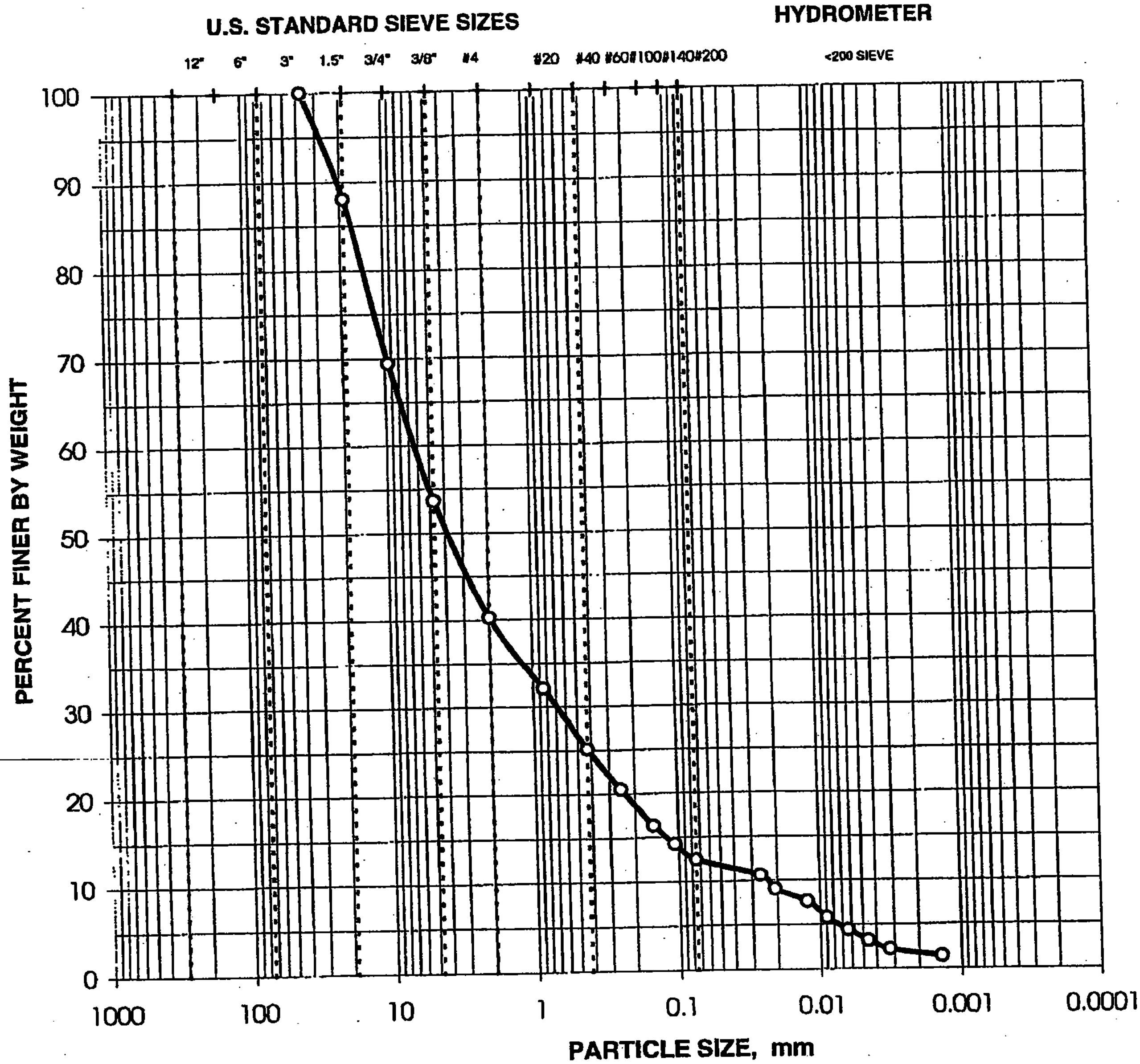
COARSE	Sieve No.	Diameter mm	Percent Finer
	3"	75.000	100.0%
	1.5"	37.500	100.0%
	0.75"	19.000	88.0%
	0.375"	9.500	69.4%
	#4	4.750	53.7%
	#10	2.000	40.3%

FINE	Sieve No.	Diameter mm	Percent Finer
	#20	0.850	32.1%
	#40	0.425	25.1%
	#60	0.250	20.5%
	#100	0.149	16.3%
	#140	0.106	14.2%
	#200	0.075	12.4%

HYDROMETER ANALYSIS

HYDROMETER	Diameter mm	Percent Finer
	0.02599	10.6%
	0.02071	9.0%
	0.01226	7.6%
	0.00891	5.8%
	0.00636	4.4%
	0.00458	3.2%
	0.00322	2.2%
	0.00137	1.4%

ARCO Hastings



CLIENT SAMPLE NO.: MW-13B (20-22)

IT LAB SAMPLE NO.: ETDC-9784

BOULDERS	COBBLES	GRAVEL		SAND			SILT 2 - 75 microns CLAY <2 microns
		COARSE	FINE	COARSE	MEDIUM	FINE	

PARTICLE-SIZE ANALYSIS
ASTM D 422

Project Name ARCO Hastings

Project No. 806938.40000000

Client Sample No. MW-13B (30-32)

IT Lab Sample No. ETDC-9788

Specific Gravity = 2.65
assumed for calculations

Moisture Content = 39.6%
based on dry sample weight

SIEVE ANALYSIS

COARSE

Sieve No.	Diameter mm	Percent Finer
3"	75.000	100.0%
1.5"	37.500	100.0%
0.75"	19.000	100.0%
0.375"	9.500	97.0%
#4	4.750	96.1%
#10	2.000	95.3%

FINE

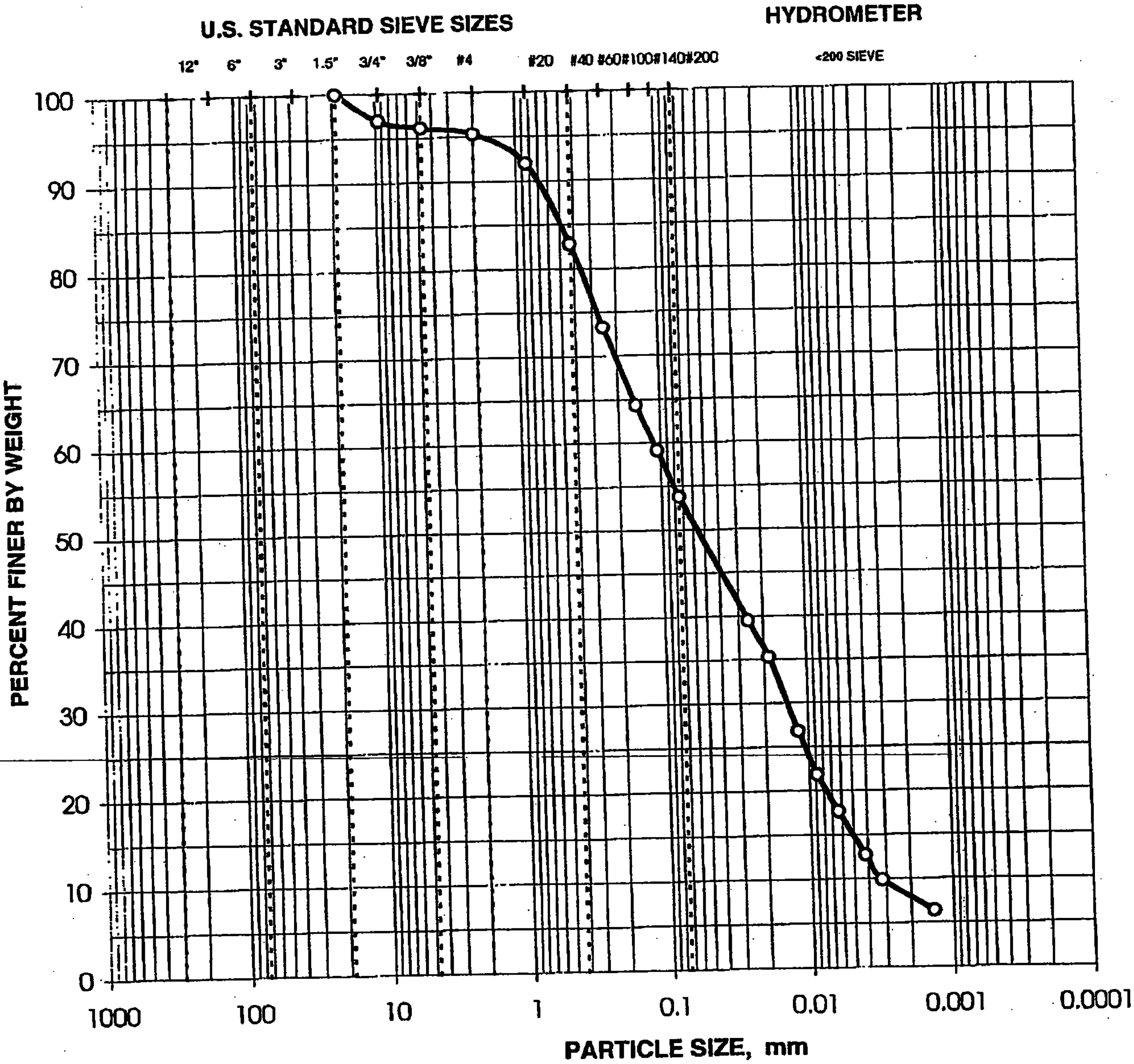
Sieve No.	Diameter mm	Percent Finer
#20	0.850	91.9%
#40	0.425	82.8%
#60	0.250	73.2%
#100	0.149	64.3%
#140	0.106	59.1%
#200	0.075	53.8%

HYDROMETER ANALYSIS

HYDROMETER

Diameter mm	Percent Finer
0.02558	39.5%
0.01850	35.3%
0.01182	26.8%
0.00884	21.9%
0.00635	17.6%
0.00417	12.7%
0.00320	9.9%
0.00136	6.3%

ARCO Hastings



CLIENT SAMPLE NO.: MW-13B (30-32)

IT LAB SAMPLE NO.: ETDC-9788

BOULDERS	COBBLES	GRAVEL		SAND			
		COARSE	FINE	COARSE	MEDIUM	FINE	SILT 2 - 75 microns CLAY <2 microns

PARTICLE-SIZE ANALYSIS
ASTM D 422

Project Name ARCO Hastings

Project No. 806938.40000000

Client Sample No. MW-13 (40-42)

IT Lab Sample No. ETDC-9802

Specific Gravity : 2.65
assumed for calculations

Moisture Content = 50.1%
based on dry sample weight

SIEVE ANALYSIS

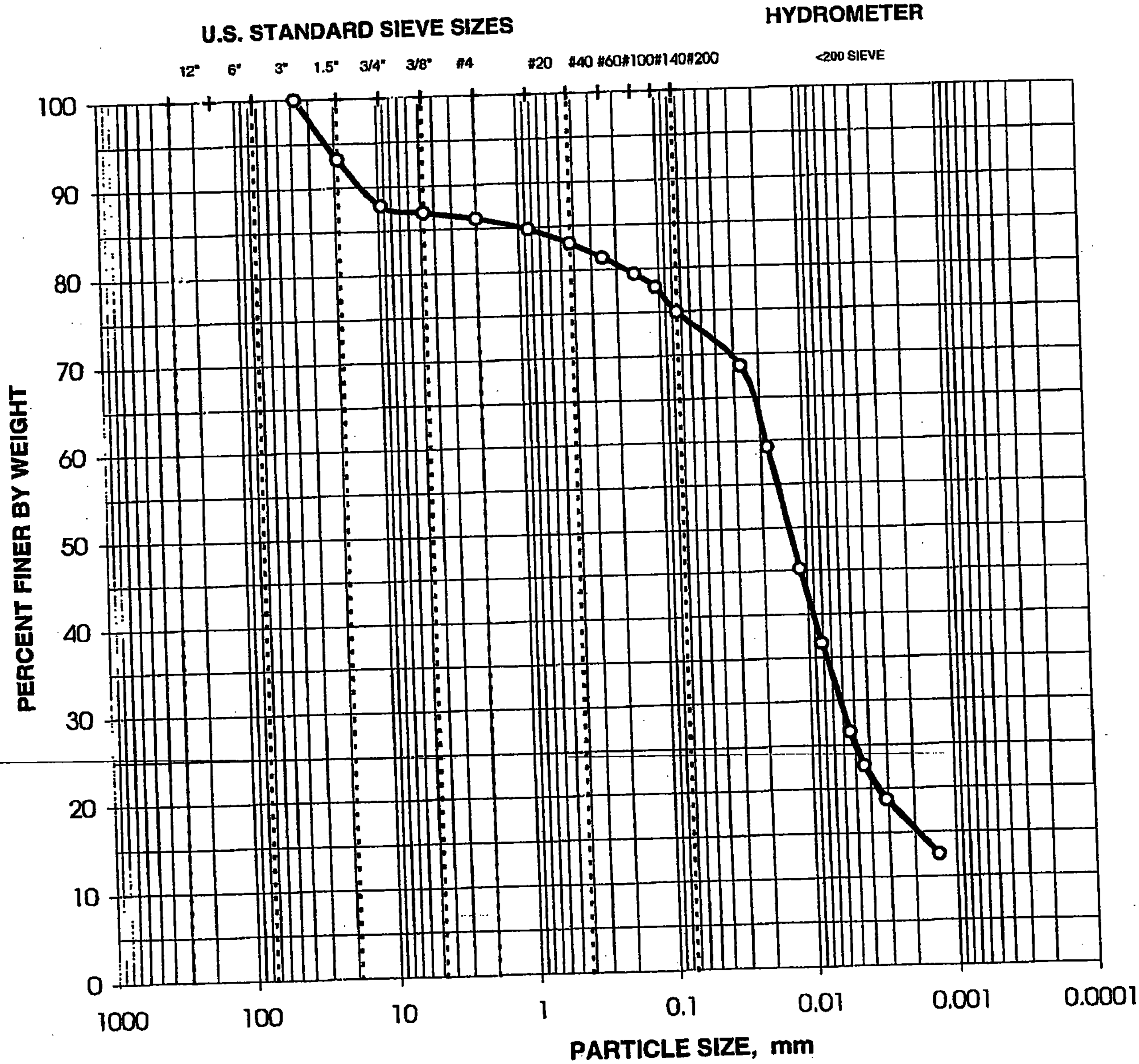
COARSE	Sieve No.	Diameter mm	Percent Finer
	3"	75.000	100.0%
	1.5"	37.500	100.0%
	0.75"	19.000	93.2%
	0.375"	9.500	87.8%
	#4	4.750	86.9%
	#10	2.000	86.1%

FINE	Sieve No.	Diameter mm	Percent Finer
	#20	0.850	84.8%
	#40	0.425	83.0%
	#60	0.250	81.4%
	#100	0.149	79.4%
	#140	0.106	77.8%
	#200	0.075	75.0%

HYDROMETER ANALYSIS

HYDROMETER	Diameter mm	Percent Finer
	0.02681	68.6%
	0.01797	59.3%
	0.01120	45.2%
	0.00814	36.7%
	0.00540	26.5%
	0.00438	22.6%
	0.00311	18.7%
	0.00135	12.5%

ARCO Hastings



CLIENT SAMPLE NO.: MW-13 (40-42)

IT LAB SAMPLE NO.: ETDC-9802

BOULDERS	COBBLES	GRAVEL		SAND			
		COARSE	FINE	COARSE	MEDIUM	FINE	SILT 2 - 75 microns CLAY <2 microns

PARTICLE-SIZE ANALYSIS
ASTM D 422

Project Name ARCO Hastings

Project No. 806938.40000000

Client Sample No. MW-13A-58'-60'

IT Lab Sample No. ETDC-9791

Specific Gravity : 2.65
assumed for calculations

Moisture Content = 28.6%
based on dry sample weight

SIEVE ANALYSIS

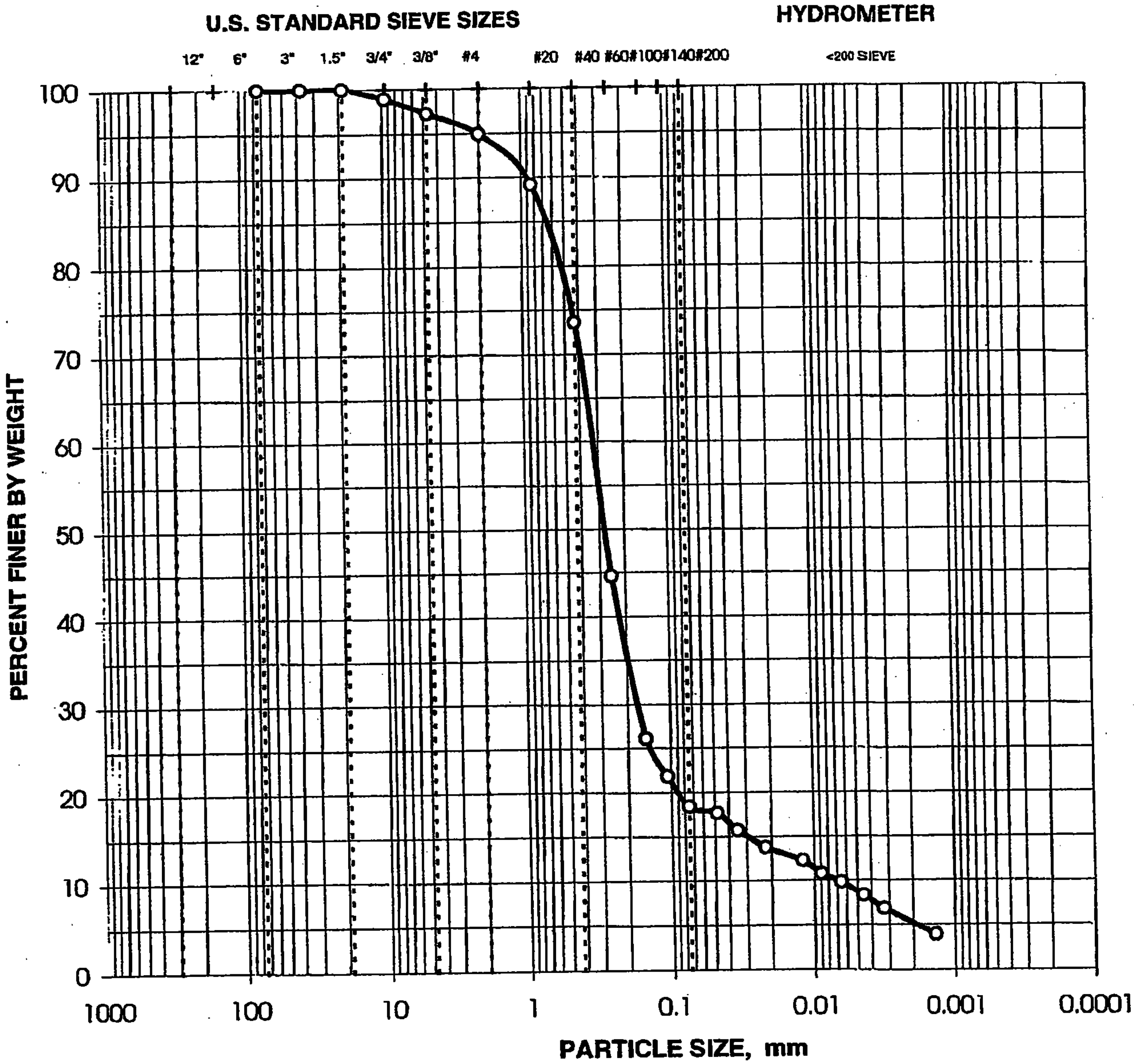
COARSE	Sieve No.	Diameter mm	Percent Finer
	3"	75.000	100.0%
	1.5"	37.500	100.0%
	0.75"	19.000	100.0%
	0.375"	9.500	98.9%
	#4	4.750	97.2%
	#10	2.000	94.9%

FINE	Sieve No.	Diameter mm	Percent Finer
	#20	0.850	89.2%
	#40	0.425	73.6%
	#60	0.250	44.6%
	#100	0.149	26.1%
	#140	0.106	21.8%
	#200	0.075	18.4%

HYDROMETER ANALYSIS

HYDROMETER	Diameter mm	Percent Finer
	0.04807	17.6%
	0.03440	15.7%
	0.02201	13.7%
	0.01205	12.2%
	0.00887	10.8%
	0.00652	9.8%
	0.00453	8.3%
	0.00325	6.9%
	0.00138	3.9%

ARCO Hastings



CLIENT SAMPLE NO.: MW-13A-58'-60'

IT LAB SAMPLE NO.: ETDC-9791

BOULDERS	COBBLES	GRAVEL		SAND			SILT 2 - 75 microns CLAY <2 microns
		COARSE	FINE	COARSE	MEDIUM	FINE	

PARTICLE-SIZE ANALYSIS
ASTM D 422

Project Name ARCO Hastings

Project No. 806938.40000000

Client Sample No. MW-13A-75'-76'

IT Lab Sample No. ETDC-9792

Specific Gravity : 2.65
assumed for calculations

Moisture Content = 20.7%
based on dry sample weight

SIEVE ANALYSIS

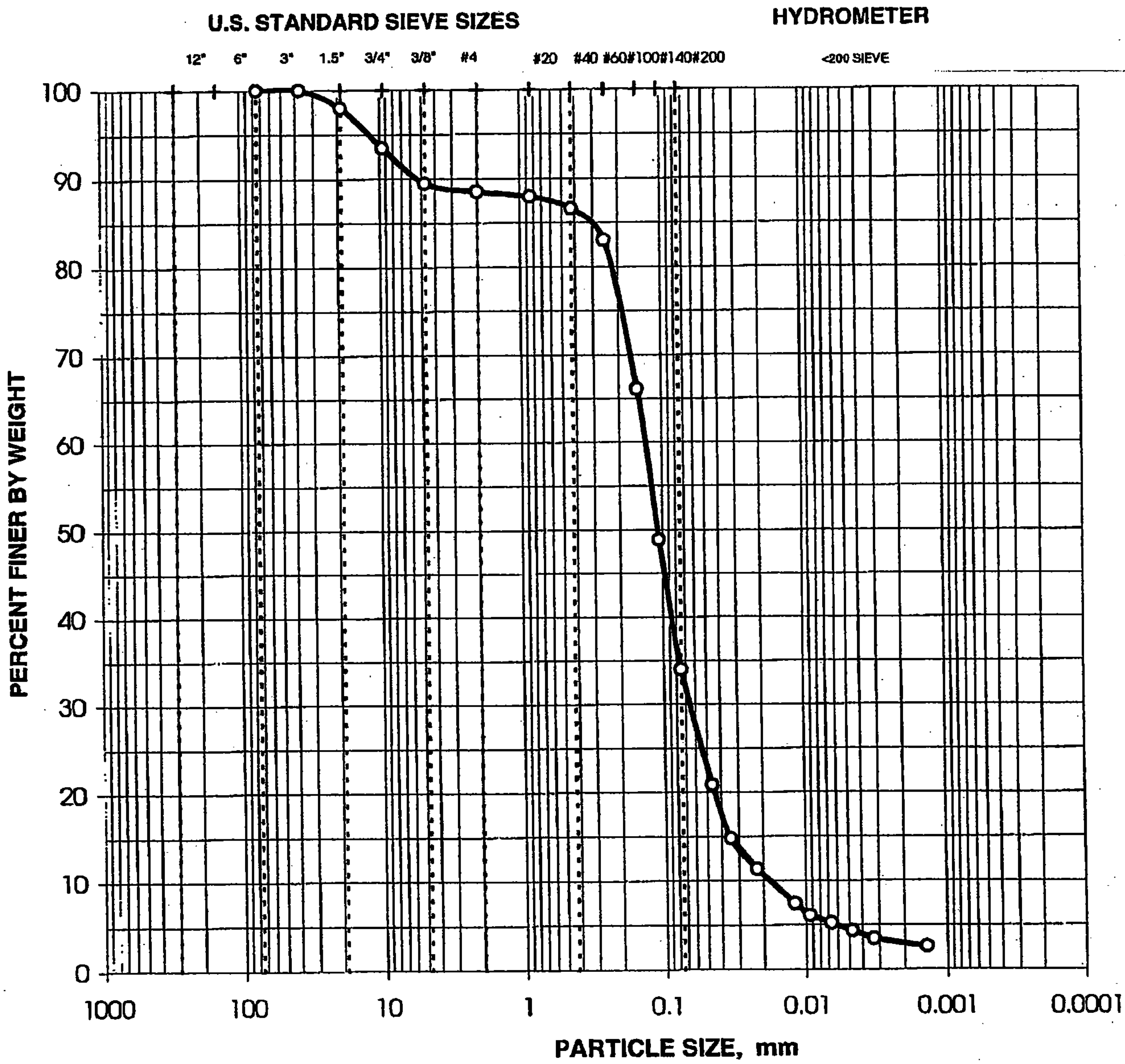
COARSE	Sieve No.	Diameter mm	Percent Finer
	3"	75.000	100.0%
	1.5"	37.500	100.0%
	0.75"	19.000	98.0%
	0.375"	9.500	93.5%
	#4	4.750	89.5%
	#10	2.000	88.6%

FINE	Sieve No.	Diameter mm	Percent Finer
	#20	0.850	88.0%
	#40	0.425	86.6%
	#60	0.250	83.0%
	#100	0.149	66.1%
	#140	0.106	48.9%
	#200	0.075	34.0%

HYDROMETER ANALYSIS

HYDROMETER	Diameter mm	Percent Finer
	0.06104	28.2%
	0.04609	20.8%
	0.03413	14.8%
	0.02218	11.3%
	0.01200	7.4%
	0.00939	6.1%
	0.00666	5.2%
	0.00474	4.3%
	0.00331	3.5%
	0.00138	2.6%

ARCO Hastings



CLIENT SAMPLE NO.: MW-13A-75'-76'

IT LAB SAMPLE NO.: ETDC-9792

BOULDERS	COBBLES	GRAVEL		SAND			
		COARSE	FINE	COARSE	MEDIUM	FINE	SILT 2 - 75 microns CLAY <2 microns

PARTICLE-SIZE ANALYSIS
ASTM D 422

Project Name ARCO Hastings

Project No. 806938.40000000

Client Sample No. MW-13A-76'-77'

IT Lab Sample No. ETDC-9793

Specific Gravity : 2.65
assumed for calculations

Moisture Content = 5.9%
based on dry sample weight

SIEVE ANALYSIS

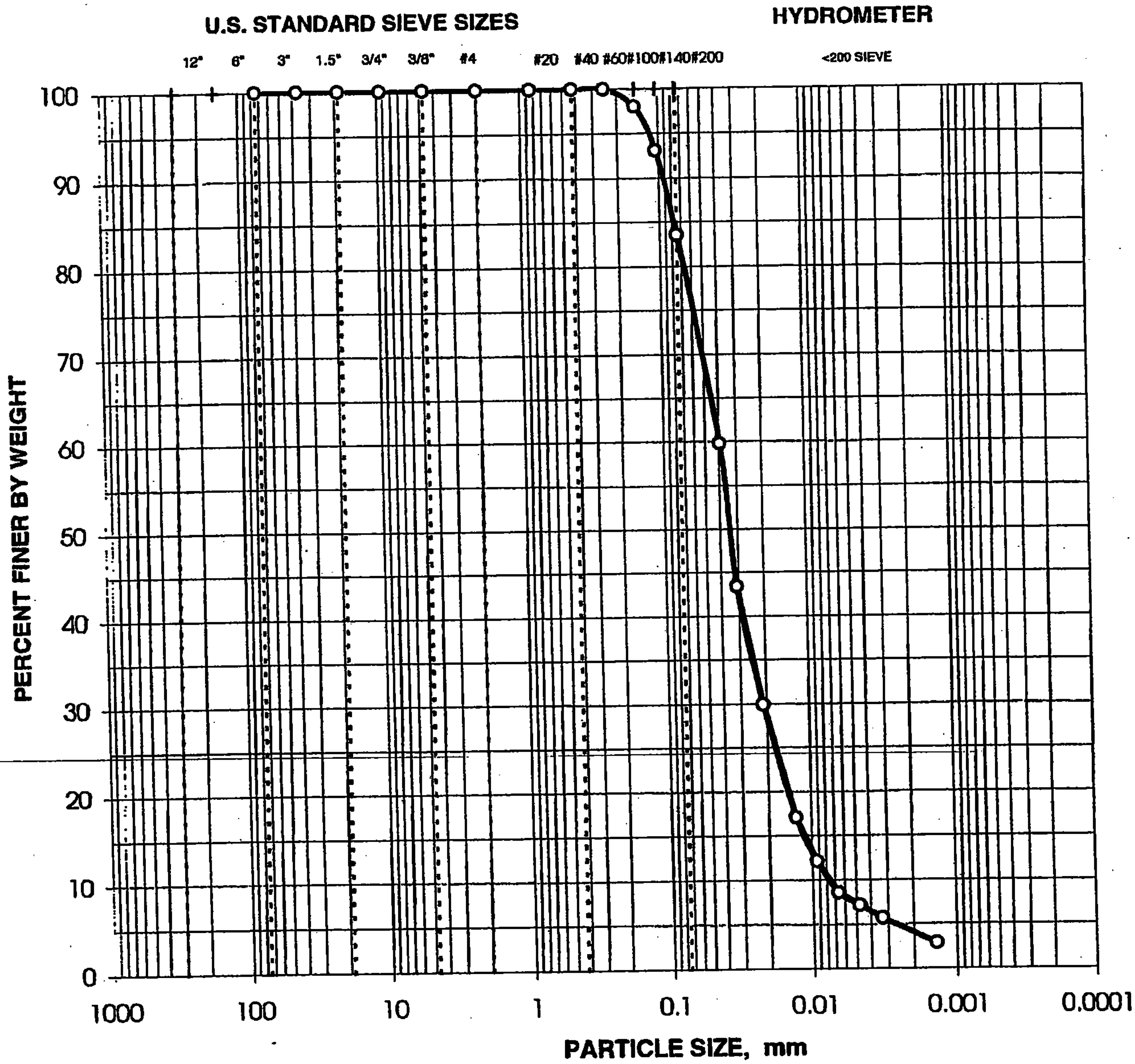
	Sieve No.	Diameter mm	Percent Finer
COARSE	3"	75.000	100.0%
	1.5"	37.500	100.0%
	0.75"	19.000	100.0%
	0.375"	9.500	100.0%
	#4	4.750	100.0%
	#10	2.000	100.0%

	Sieve No.	Diameter mm	Percent Finer
FINE	#20	0.850	100.0%
	#40	0.425	100.0%
	#60	0.250	100.0%
	#100	0.149	98.0%
	#140	0.106	93.1%
	#200	0.075	83.6%

HYDROMETER ANALYSIS

	Diameter mm	Percent Finer
HYDROMETER		
	0.03956	59.8%
	0.03098	43.4%
	0.02106	29.9%
	0.01285	17.1%
	0.00929	12.1%
	0.00666	8.5%
	0.00474	7.1%
	0.00331	5.7%
	0.00139	2.8%

ARCO Hastings



CLIENT SAMPLE NO.: MW-13A-76'-77'

IT LAB SAMPLE NO.: ETDC-9793

BOULDERS	COBBLES	GRAVEL		SAND			
		COARSE	FINE	COARSE	MEDIUM	FINE	SILT 2 - 75 microns CLAY <2 microns

PARTICLE-SIZE ANALYSIS
ASTM D 422

Project Name ARCO Hastings

Project No. 806938.40000000

Client Sample No. MW-13A-82.9'-83'

IT Lab Sample No. ETDC-9794

Specific Gravity : 2.65
assumed for calculations

Moisture Content = 26.7%
based on dry sample weight

SIEVE ANALYSIS

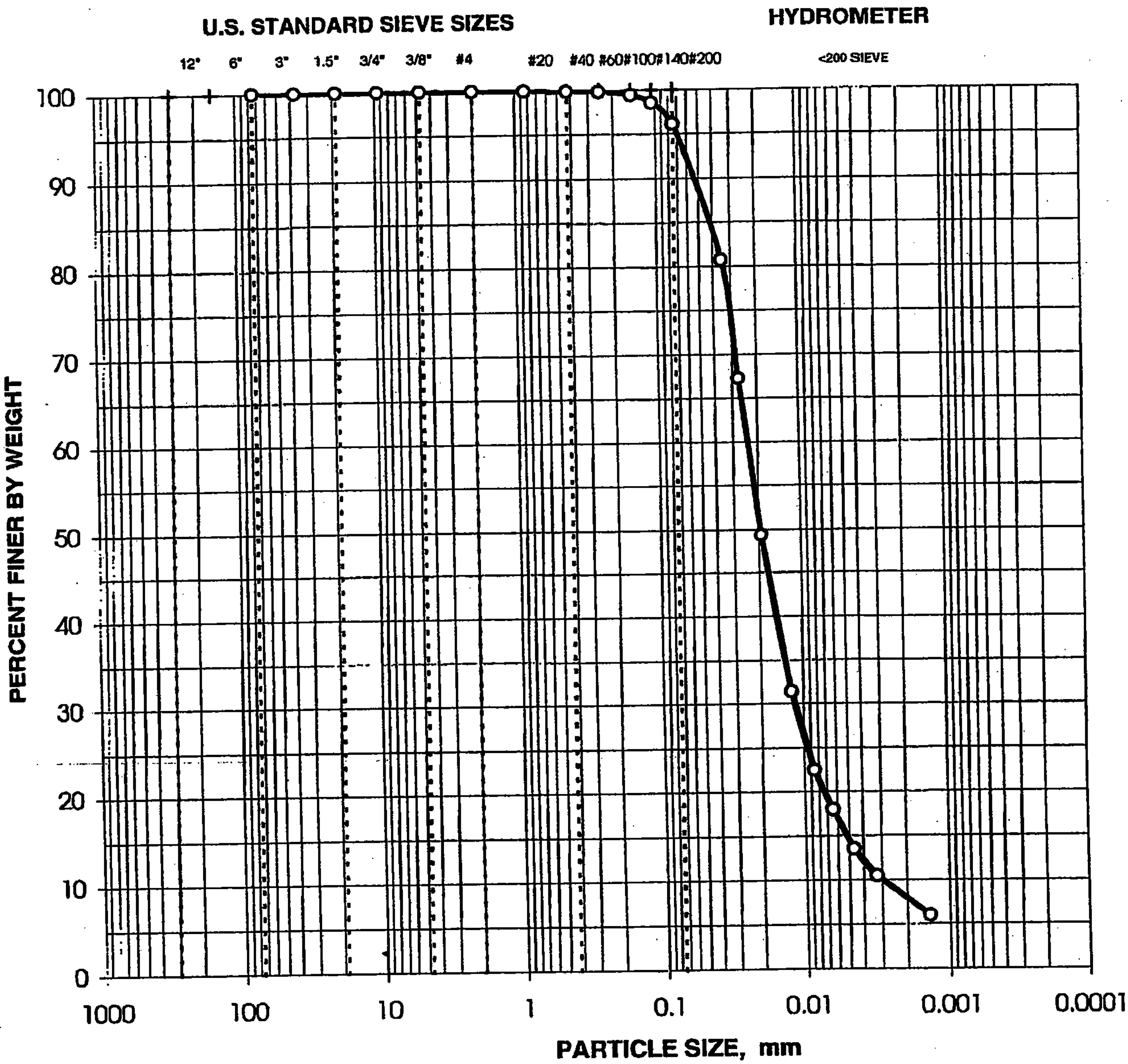
COARSE	Sieve No.	Diameter mm	Percent Finer
	3"	75.000	100.0%
	1.5"	37.500	100.0%
	0.75"	19.000	100.0%
	0.375"	9.500	100.0%
	#4	4.750	100.0%
	#10	2.000	100.0%

FINE	Sieve No.	Diameter mm	Percent Finer
	#20	0.850	99.9%
	#40	0.425	99.9%
	#60	0.250	99.8%
	#100	0.149	99.4%
	#140	0.106	98.5%
	#200	0.075	96.1%

HYDROMETER ANALYSIS

HYDROMETER	Diameter mm	Percent Finer
	0.03480	80.7%
	0.02713	67.3%
	0.01921	49.3%
	0.01216	31.4%
	0.00853	22.4%
	0.00643	17.9%
	0.00463	13.5%
	0.00325	10.5%
	0.00138	6.0%

ARCO Hastings



CLIENT SAMPLE NO.: MW-13A-82.9'-83'

IT LAB SAMPLE NO.: ETDC-9794

BOULDERS	COBBLES	GRAVEL		SAND			SILT 2 - 75 microns CLAY <2 microns
		COARSE	FINE	COARSE	MEDIUM	FINE	

PARTICLE-SIZE ANALYSIS
ASTM D 422

Project Name ARCO Hastings

Client Sample No. MW-13A-86.4'-86.6'

Project No. 806938.40000000

IT Lab Sample No. ETDC-9795

Specific Gravity : 2.65
assumed for calculations

Moisture Content = 20.0%
based on dry sample weight

SIEVE ANALYSIS

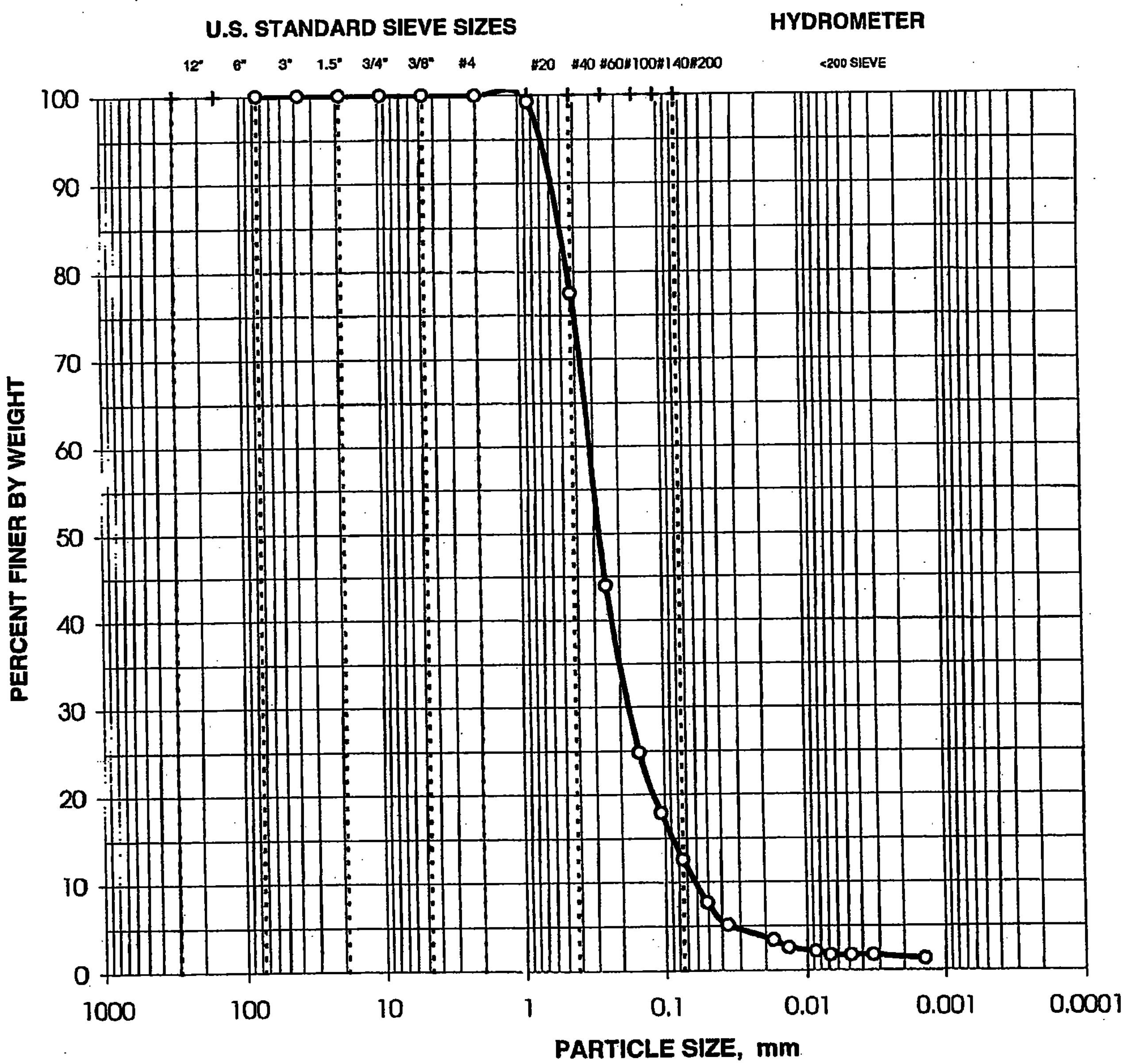
COARSE	Sieve No.	Diameter mm	Percent Finer
	3"	75.000	100.0%
	1.5"	37.500	100.0%
	0.75"	19.000	100.0%
	0.375"	9.500	100.0%
	#4	4.750	100.0%
	#10	2.000	99.9%

FINE	Sieve No.	Diameter mm	Percent Finer
	#20	0.850	99.2%
	#40	0.425	77.5%
	#60	0.250	44.0%
	#100	0.149	24.8%
	#140	0.106	17.9%
	#200	0.075	12.6%

HYDROMETER ANALYSIS

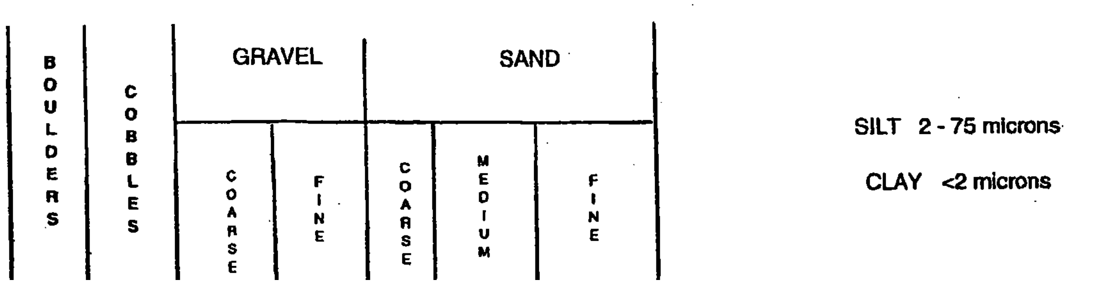
HYDROMETER	Diameter mm	Percent Finer
	0.05071	7.7%
	0.03650	5.1%
	0.01744	3.4%
	0.01356	2.6%
	0.00866	2.1%
	0.00683	1.7%
	0.00483	1.7%
	0.00334	1.7%
	0.00140	1.3%

ARCO Hastings



CLIENT SAMPLE NO.: MW-13A-86.4'-

IT LAB SAMPLE NO.: ETDC-9795



PARTICLE-SIZE ANALYSIS
ASTM D 422

Project Name ARCO Hastings

Project No. 806938.40000000

Client Sample No. MW-13 (50-52)

IT Lab Sample No. ETDC-9803

Specific Gravity = 2.65
assumed for calculations

Moisture Content = 37.7%
based on dry sample weight

SIEVE ANALYSIS

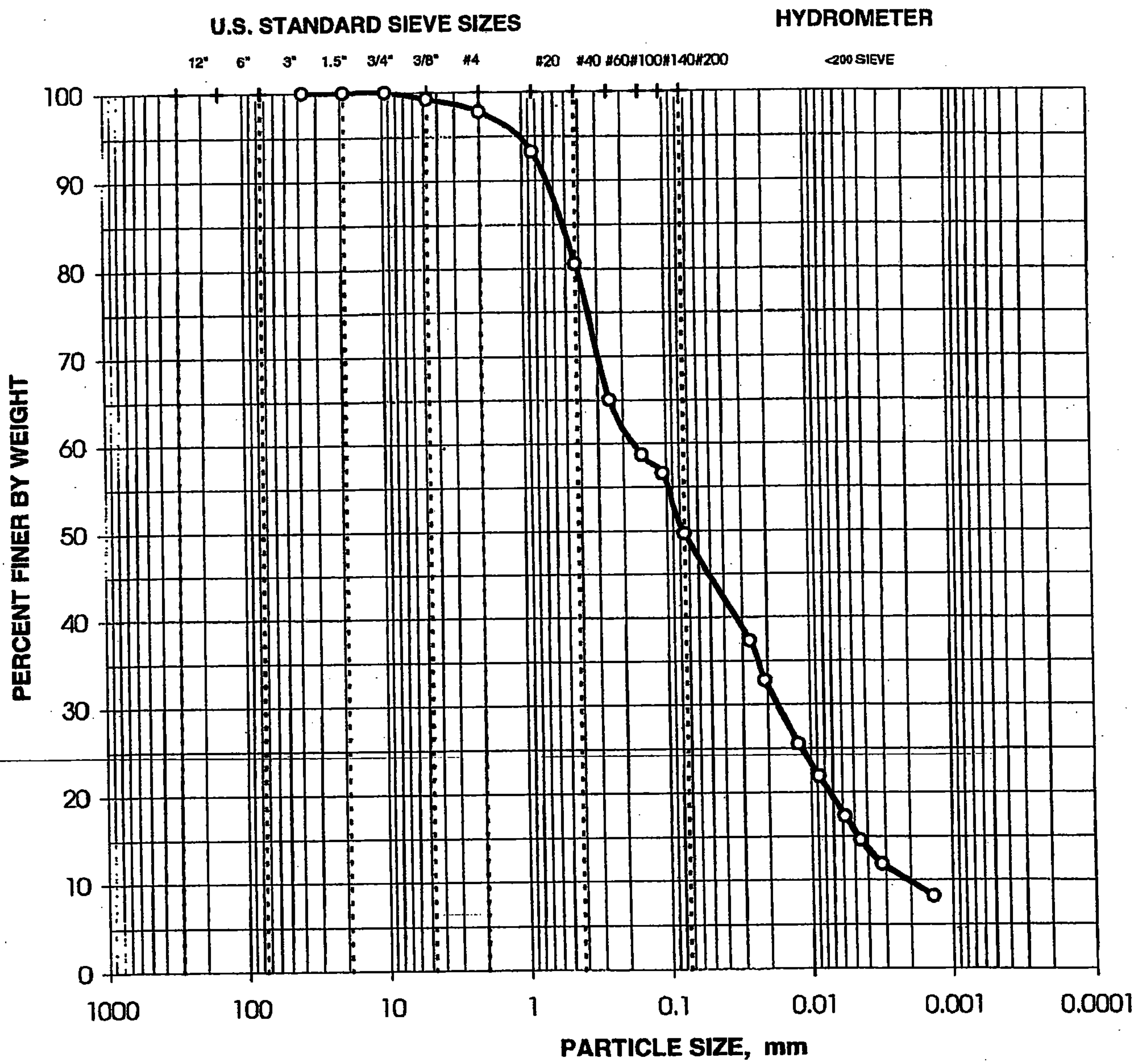
COARSE	Sieve No.	Diameter mm	Percent Finer
	3"	75.000	100.0%
	1.5"	37.500	100.0%
	0.75"	19.000	100.0%
	0.375"	9.500	100.0%
	#4	4.750	99.2%
	#10	2.000	97.8%

FINE	Sieve No.	Diameter mm	Percent Finer
	#20	0.850	93.3%
	#40	0.425	80.5%
	#60	0.250	65.1%
	#100	0.149	58.7%
	#140	0.106	56.6%
	#200	0.075	49.7%

HYDROMETER ANALYSIS

HYDROMETER	Diameter mm	Percent Finer
	0.02658	37.3%
	0.02098	32.7%
	0.01226	25.5%
	0.00877	21.8%
	0.00582	17.3%
	0.00455	14.6%
	0.00320	11.8%
	0.00137	8.2%

ARCO Hastings



CLIENT SAMPLE NO.: MW-13 (50-52)

IT LAB SAMPLE NO.: ETDC-9803

BOULDERS	COBBLES	GRAVEL		SAND			
		COARSE	FINE	COARSE	MEDIUM	FINE	SILT 2 - 75 microns CLAY <2 microns

PARTICLE-SIZE ANALYSIS
ASTM D 422

Project Name ARCO Hastings

Project No. 806938.40000000

Client Sample No. MW-14B (19-21)

IT Lab Sample No. ETDC-9785

Specific Gravity : 2.65
assumed for calculations

Moisture Content = 72.4%
based on dry sample weight

SIEVE ANALYSIS

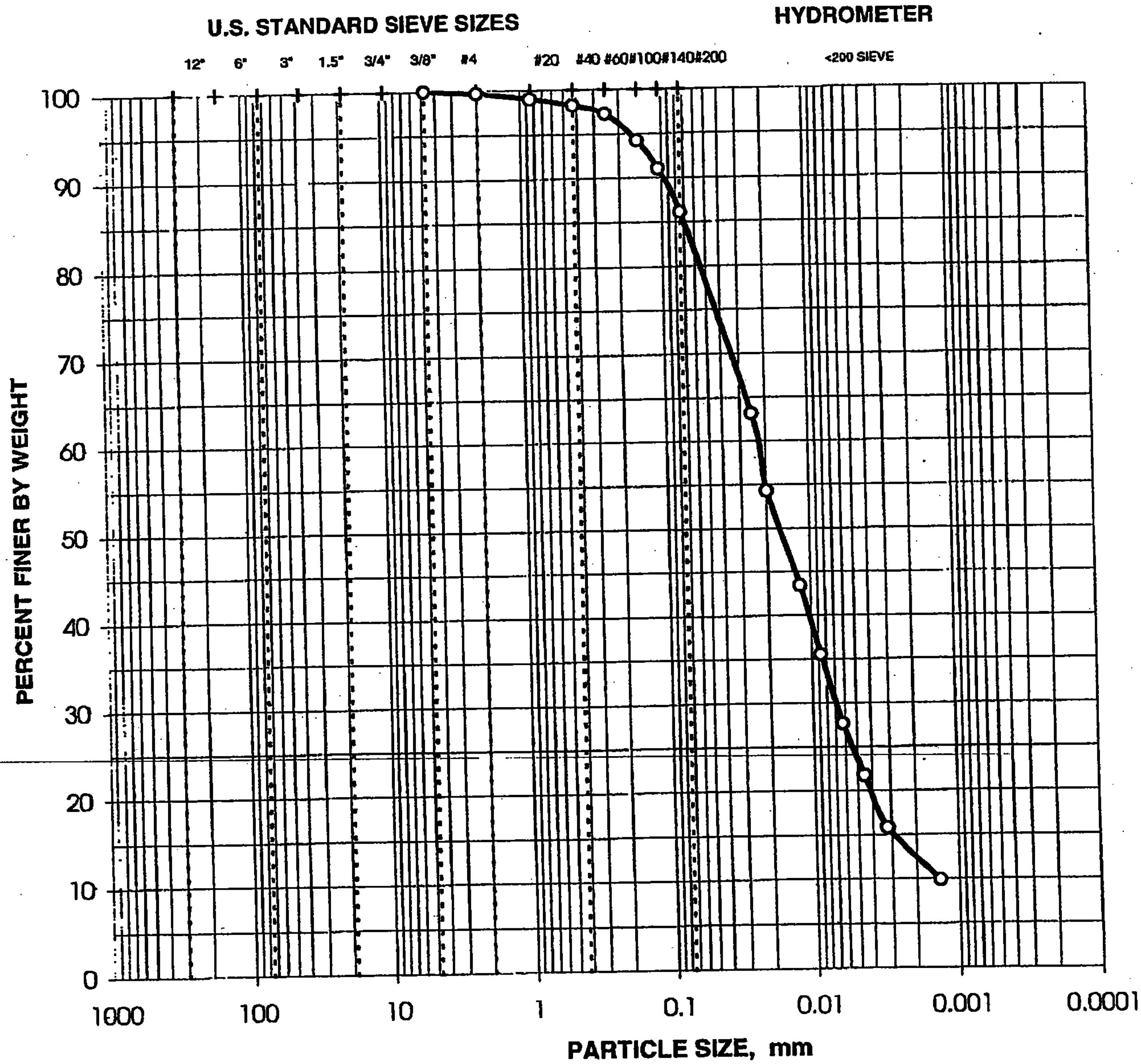
	Sieve No.	Diameter mm	Percent Finer
COARSE	3"	75.000	100.0%
	1.5"	37.500	100.0%
	0.75"	19.000	100.0%
	0.375"	9.500	100.0%
	#4	4.750	100.0%
	#10	2.000	99.7%

	Sieve No.	Diameter mm	Percent Finer
FINE	#20	0.850	99.0%
	#40	0.425	98.3%
	#60	0.250	97.3%
	#100	0.149	94.2%
	#140	0.106	91.0%
	#200	0.075	86.1%

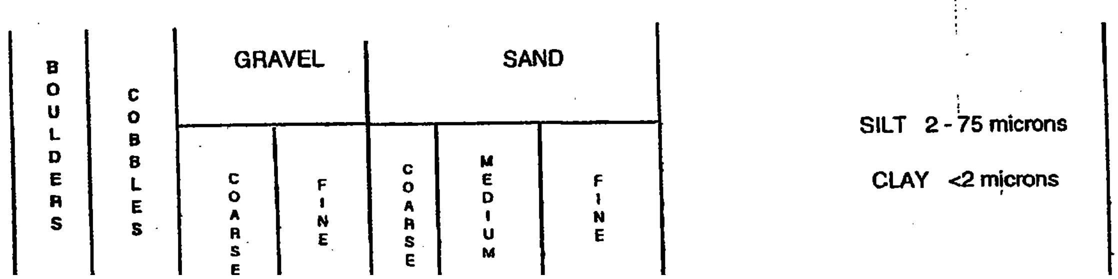
HYDROMETER ANALYSIS

	Diameter mm	Percent Finer
HYDROMETER		
	0.02486	63.2%
	0.01999	54.3%
	0.01201	43.4%
	0.00870	35.5%
	0.00625	27.6%
	0.00450	21.7%
	0.00317	15.8%
	0.00136	9.9%

ARCO Hastings



CLIENT SAMPLE NO.: MW-14B (19-21) **IT LAB SAMPLE NO.:** ETDC-9785



PARTICLE-SIZE ANALYSIS
ASTM D 422

Project Name ARCO Hastings

Project No. 806938.40000000

Client Sample No. MW-14B (34-36)

IT Lab Sample No. ETDC-9789

Specific Gravity : 2.65
assumed for calculations

Moisture Content = 56.2%
based on dry sample weight

SIEVE ANALYSIS

COARSE

Sieve No.	Diameter mm	Percent Finer
3"	75.000	100.0%
1.5"	37.500	100.0%
0.75"	19.000	100.0%
0.375"	9.500	99.1%
#4	4.750	98.6%
#10	2.000	97.9%

FINE

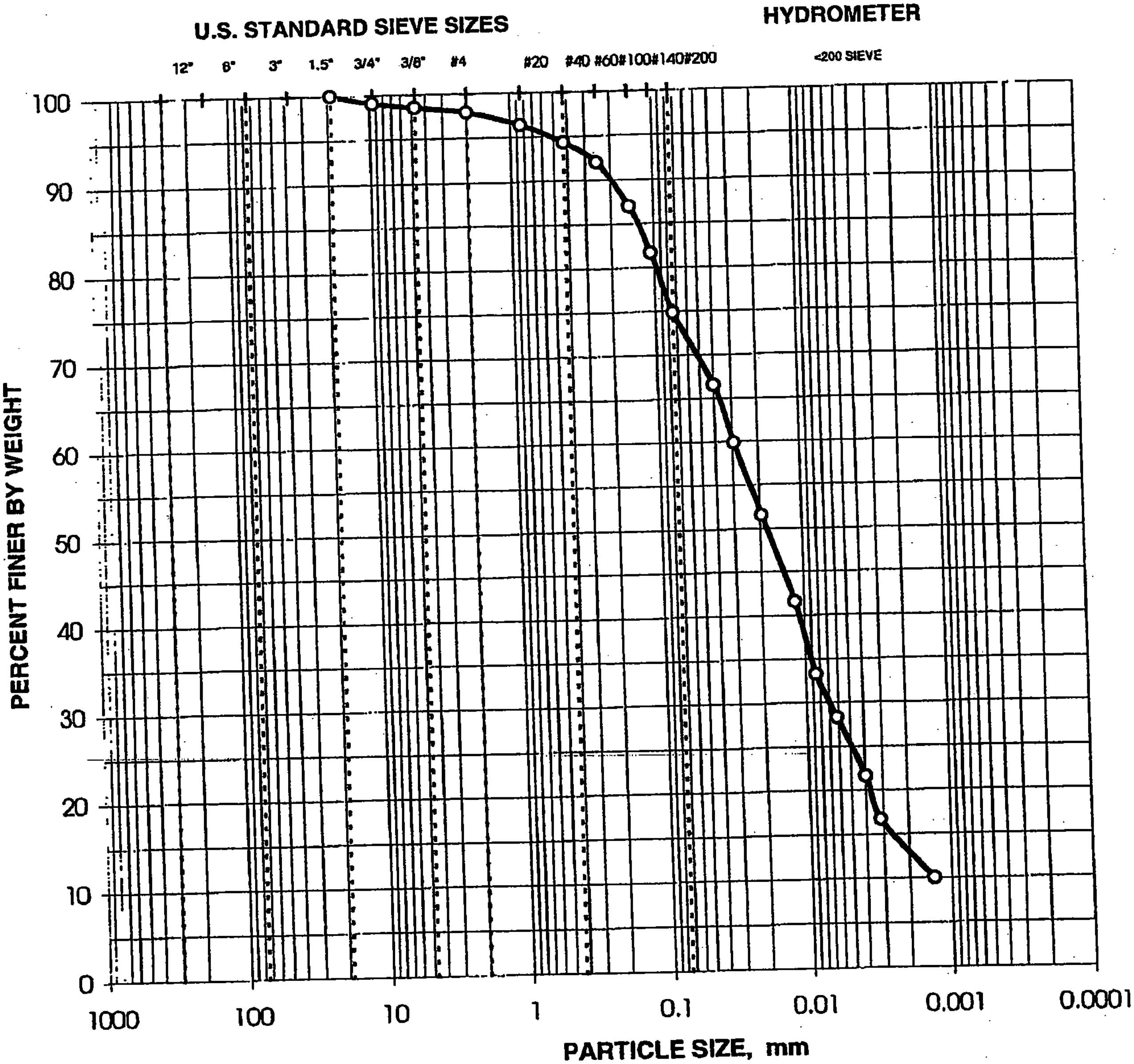
Sieve No.	Diameter mm	Percent Finer
#20	0.850	96.3%
#40	0.425	94.3%
#60	0.250	92.0%
#100	0.149	87.0%
#140	0.106	81.7%
#200	0.075	74.9%

HYDROMETER ANALYSIS

HYDROMETER

Diameter mm	Percent Finer
0.04010	66.5%
0.02938	59.9%
0.01935	51.6%
0.01170	41.6%
0.00856	33.3%
0.00618	28.3%
0.00397	21.6%
0.00316	16.6%
0.00135	10.0%

ARCO Hastings



CLIENT SAMPLE NO.: MW-14B (34-36) IT LAB SAMPLE NO.: ETDC-9789

BOULDERS	COBBLES	GRAVEL		SAND			
		COARSE	FINE	COARSE	MEDIUM	FINE	SILT 2 - 75 microns CLAY <2 microns

PARTICLE-SIZE ANALYSIS
ASTM D 422

Project Name ARCO Hastings

Project No. 806938.40000000

Client Sample No. MW-14A (40-42)

IT Lab Sample No. ETDC-9801

Specific Gravity : 2.65
assumed for calculations

Moisture Content = 50.4%
based on dry sample weight

SIEVE ANALYSIS

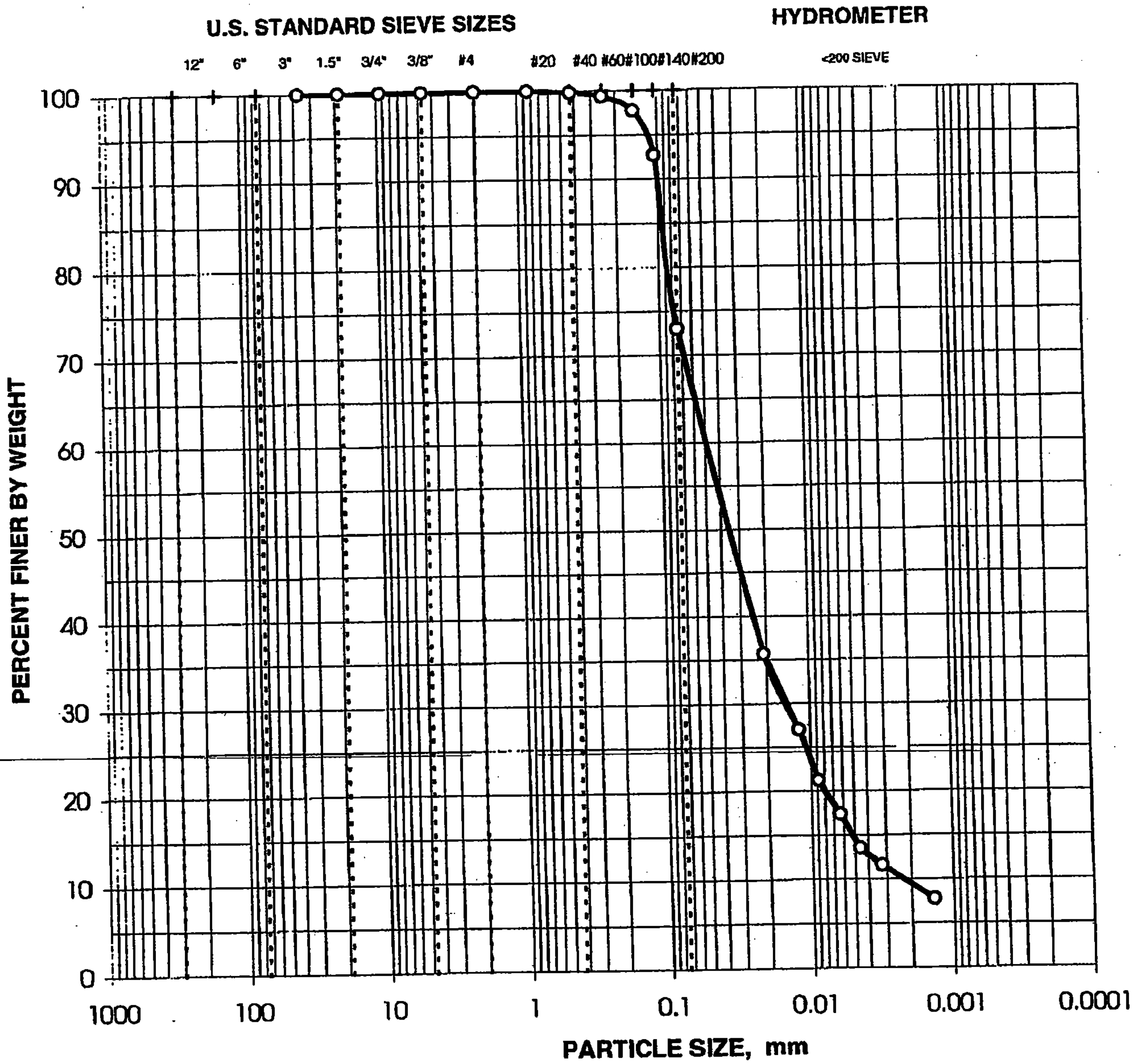
	Sieve No.	Diameter mm	Percent Finer
COARSE	3"	75.000	100.0%
	1.5"	37.500	100.0%
	0.75"	19.000	100.0%
	0.375"	9.500	100.0%
	#4	4.750	100.0%
	#10	2.000	100.0%

	Sieve No.	Diameter mm	Percent Finer
FINE	#20	0.850	100.0%
	#40	0.425	99.8%
	#60	0.250	99.4%
	#100	0.149	97.7%
	#140	0.106	92.7%
	#200	0.075	73.0%

HYDROMETER ANALYSIS

	Diameter mm	Percent Finer
HYDROMETER		
	0.02089	35.7%
	0.01201	27.0%
	0.00883	21.2%
	0.00632	17.4%
	0.00458	13.5%
	0.00322	11.6%
	0.00138	7.7%

ARCO Hastings



CLIENT SAMPLE NO.: MW-14A (40-42) IT LAB SAMPLE NO.: ETDC-9801

BOULDERS	COBBLES	GRAVEL		SAND			
		COARSE	FINE	COARSE	MEDIUM	FINE	SILT 2 - 75 microns CLAY <2 microns

PARTICLE-SIZE ANALYSIS
ASTM D 422

Project Name ARCO Hastings

Project No. 806938.40000000

Client Sample No. MW14A-60'-62'

IT Lab Sample No. ETDC-9796

Specific Gravity : 2.65
assumed for calculations

Moisture Content = 23.7%
based on dry sample weight

SIEVE ANALYSIS

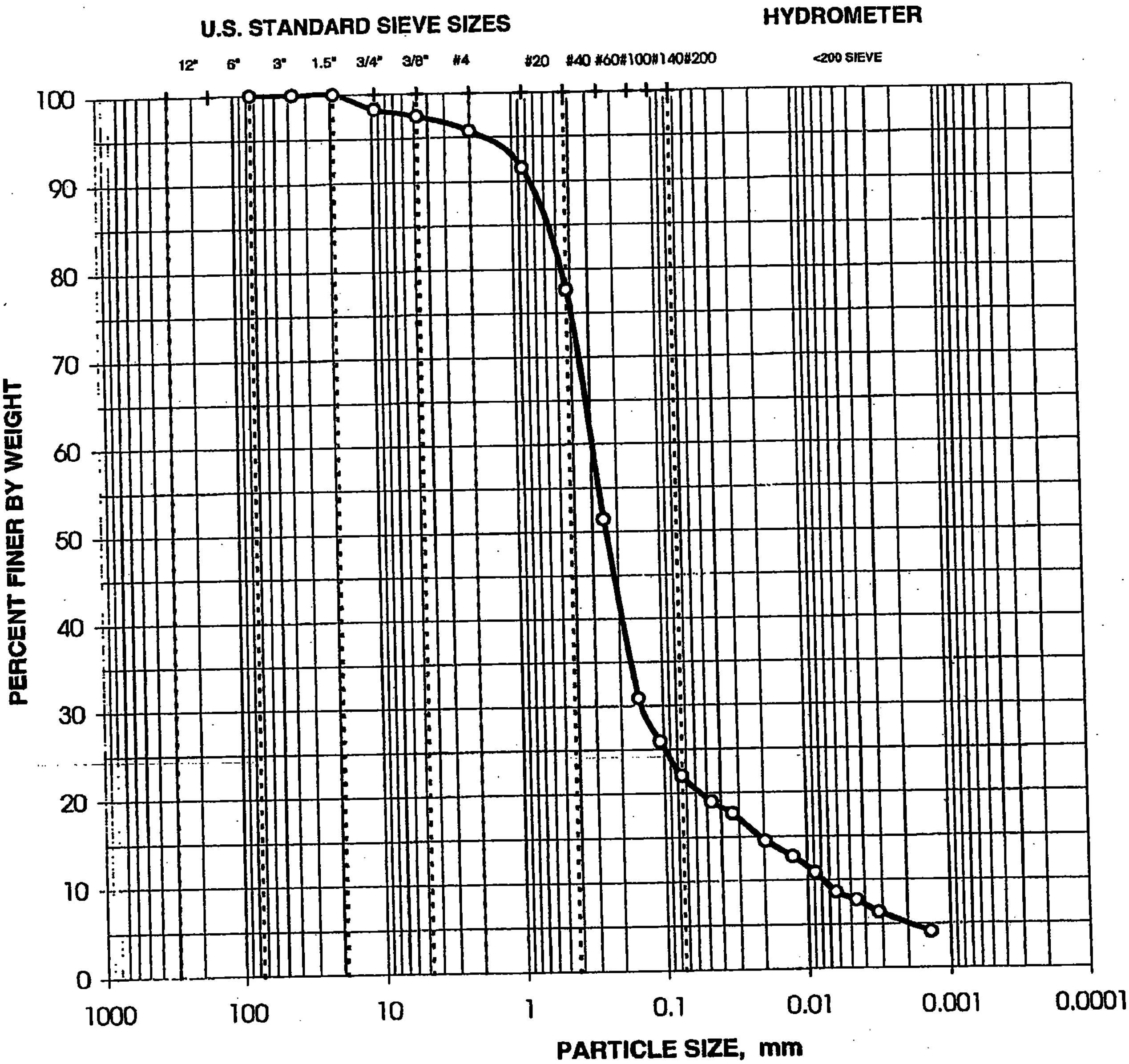
COARSE	Sieve No.	Diameter mm	Percent Finer
	3"	75.000	100.0%
	1.5"	37.500	100.0%
	0.75"	19.000	100.0%
	0.375"	9.500	98.3%
	#4	4.750	97.4%
	#10	2.000	95.7%

FINE	Sieve No.	Diameter mm	Percent Finer
	#20	0.850	91.5%
	#40	0.425	77.6%
	#60	0.250	51.4%
	#100	0.149	30.9%
	#140	0.106	25.9%
	#200	0.075	22.0%

HYDROMETER ANALYSIS

HYDROMETER	Diameter mm	Percent Finer
	0.04650	19.0%
	0.03316	17.7%
	0.01961	14.5%
	0.01255	12.7%
	0.00883	10.9%
	0.00630	8.6%
	0.00453	7.7%
	0.00317	6.3%
	0.00137	4.1%

ARCO Hastings



CLIENT SAMPLE NO.: MW14A-60'-62'

IT LAB SAMPLE NO.: ETDC-9796

BOULDERS	COBBLES	GRAVEL		SAND			
		COARSE	FINE	COARSE	MEDIUM	FINE	SILT 2 - 75 microns CLAY <2 microns

PARTICLE-SIZE ANALYSIS
ASTM D 422

Project Name ARCO Hastings

Project No. 806938.40000000

Client Sample No. MW14A-79'-80'

IT Lab Sample No. ETDC-9797

Specific Gravity : 2.65
assumed for calculations

Moisture Content = 12.3%
based on dry sample weight

SIEVE ANALYSIS

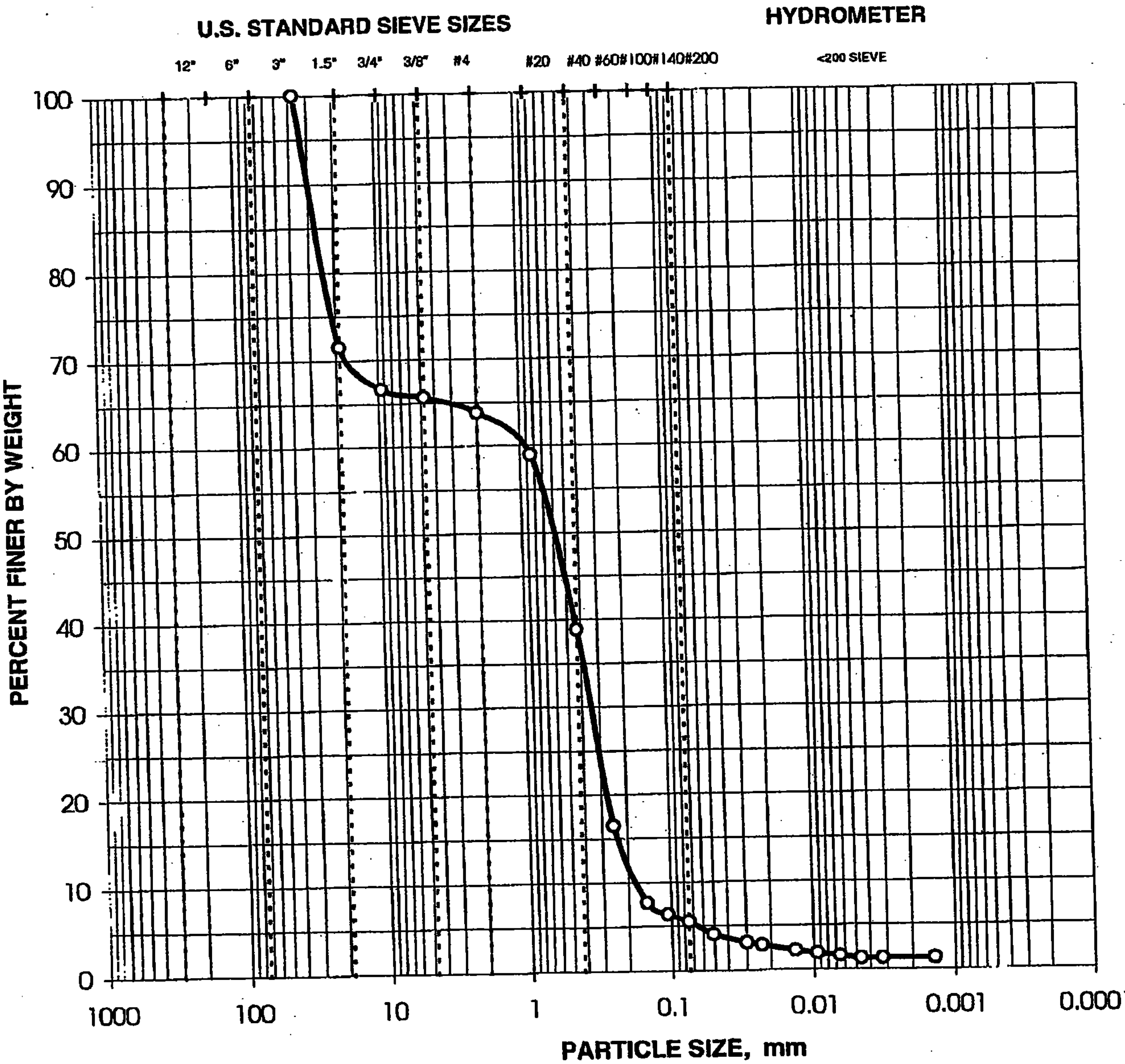
COARSE	Sieve No.	Diameter mm	Percent Finer
	3"	75.000	100.0%
	1.5"	37.500	100.0%
	0.75"	19.000	71.5%
	0.375"	9.500	66.7%
	#4	4.750	65.7%
	#10	2.000	63.9%

FINE	Sieve No.	Diameter mm	Percent Finer
	#20	0.850	59.0%
	#40	0.425	38.9%
	#60	0.250	16.4%
	#100	0.149	7.7%
	#140	0.106	6.4%
	#200	0.075	5.5%

HYDROMETER ANALYSIS

HYDROMETER	Diameter mm	Percent Finer
	0.05062	4.1%
	0.02964	3.1%
	0.02303	2.8%
	0.01337	2.2%
	0.00947	1.9%
	0.00656	1.6%
	0.00466	1.3%
	0.00326	1.3%
	0.00139	1.3%

ARCO Hastings



CLIENT SAMPLE NO.: MW14A-79'-80'

IT LAB SAMPLE NO.: ETDC-9797

BOULDERS	COBBLES	GRAVEL		SAND			
		COARSE	FINE	COARSE	MEDIUM	FINE	SILT 2 - 75 microns CLAY <2 microns

PARTICLE-SIZE ANALYSIS
ASTM D 422

Project Name ARCO Hastings

Project No. 806938.40000000

Client Sample No. MW14A-80'-81'

IT Lab Sample No. ETDC-9798

Specific Gravity : 2.65
assumed for calculations

Moisture Content = 23.7%
based on dry sample weight

SIEVE ANALYSIS

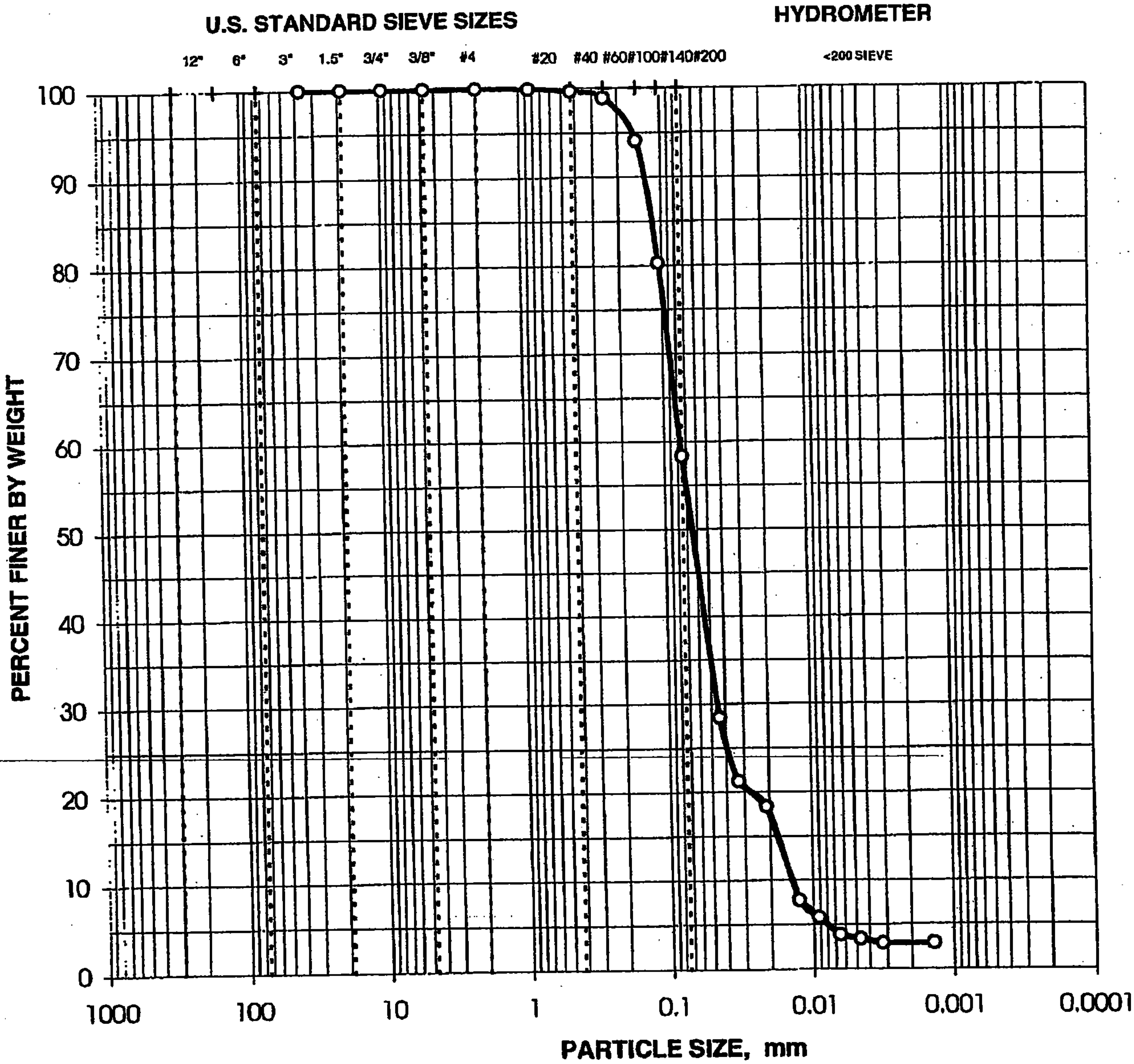
COARSE	Sieve No.	Diameter mm	Percent Finer
	3"	75.000	100.0%
	1.5"	37.500	100.0%
	0.75"	19.000	100.0%
	0.375"	9.500	100.0%
	#4	4.750	100.0%
	#10	2.000	100.0%

FINE	Sieve No.	Diameter mm	Percent Finer
	#20	0.850	99.9%
	#40	0.425	99.7%
	#60	0.250	98.9%
	#100	0.149	94.1%
	#140	0.106	80.3%
	#200	0.075	58.3%

HYDROMETER ANALYSIS

HYDROMETER	Diameter mm	Percent Finer
	0.05392	42.9%
	0.04368	28.5%
	0.03260	21.2%
	0.02106	18.3%
	0.01261	7.7%
	0.00920	5.8%
	0.00652	3.9%
	0.00467	3.4%
	0.00324	2.9%
	0.00138	2.9%

ARCO Hastings



CLIENT SAMPLE NO.: MW14A-80'-81'

IT LAB SAMPLE NO.: ETDC-9798

BOULDERS	COBBLES	GRAVEL		SAND			
		COARSE	FINE	COARSE	MEDIUM	FINE	SILT 2 - 75 microns CLAY <2 microns

PARTICLE-SIZE ANALYSIS
ASTM D 422

Project Name ARCO Hastings

Project No. 806938.40000000

Client Sample No. MW-15B (24-26)

IT Lab Sample No. ETDC-9786

Specific Gravity : 2.65
assumed for calculations

Moisture Content = 41.0%
based on dry sample weight

SIEVE ANALYSIS

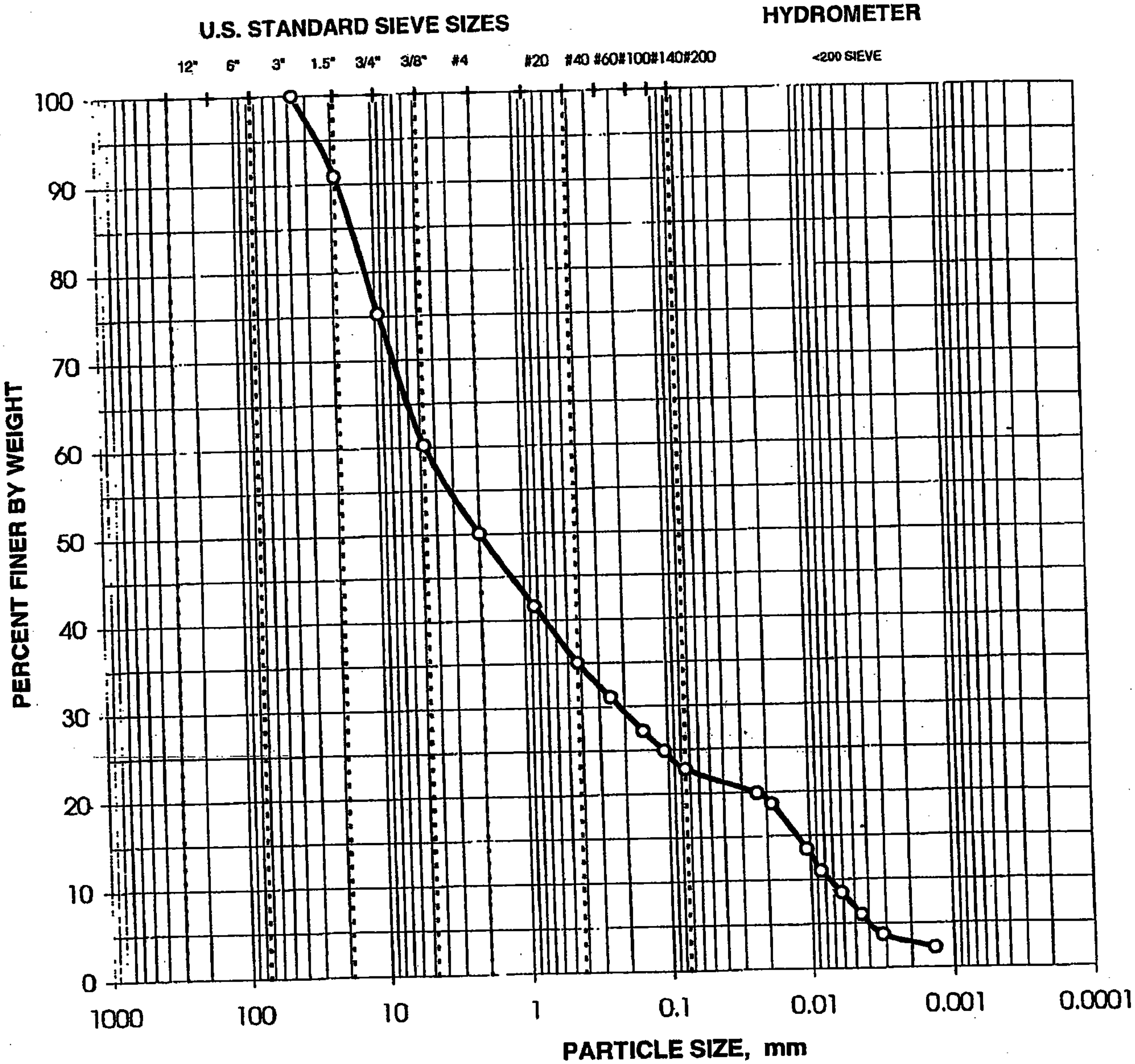
COARSE	Sieve No.	Diameter mm	Percent Finer
	3"	75.000	100.0%
	1.5"	37.500	100.0%
	0.75"	19.000	90.9%
	0.375"	9.500	75.3%
	#4	4.750	60.2%
	#10	2.000	50.0%

FINE	Sieve No.	Diameter mm	Percent Finer
	#20	0.850	41.6%
	#40	0.425	35.1%
	#60	0.250	31.0%
	#100	0.149	27.2%
	#140	0.106	24.9%
	#200	0.075	22.8%

HYDROMETER ANALYSIS

HYDROMETER	Diameter mm	Percent Finer
	0.02322	19.9%
	0.01838	18.7%
	0.01059	13.4%
	0.00849	11.0%
	0.00613	8.5%
	0.00447	6.0%
	0.00316	3.7%
	0.00136	2.2%

ARCO Hastings



CLIENT SAMPLE NO.: MW-15B (24-26)

IT LAB SAMPLE NO.: ETDC-9786

BOULDERS	COBBLES	GRAVEL		SAND			SILT 2 - 75 microns CLAY <2 microns
		COARSE	FINE	COARSE	MEDIUM	FINE	

PARTICLE-SIZE ANALYSIS
ASTM D 422

Project Name ARCO Hastings

Project No. 806938.40000000

Client Sample No. MW-15B (36-38)

IT Lab Sample No. ETDC-9787

Specific Gravity : 2.65
assumed for calculations

Moisture Content = 55.2%
based on dry sample weight

SIEVE ANALYSIS

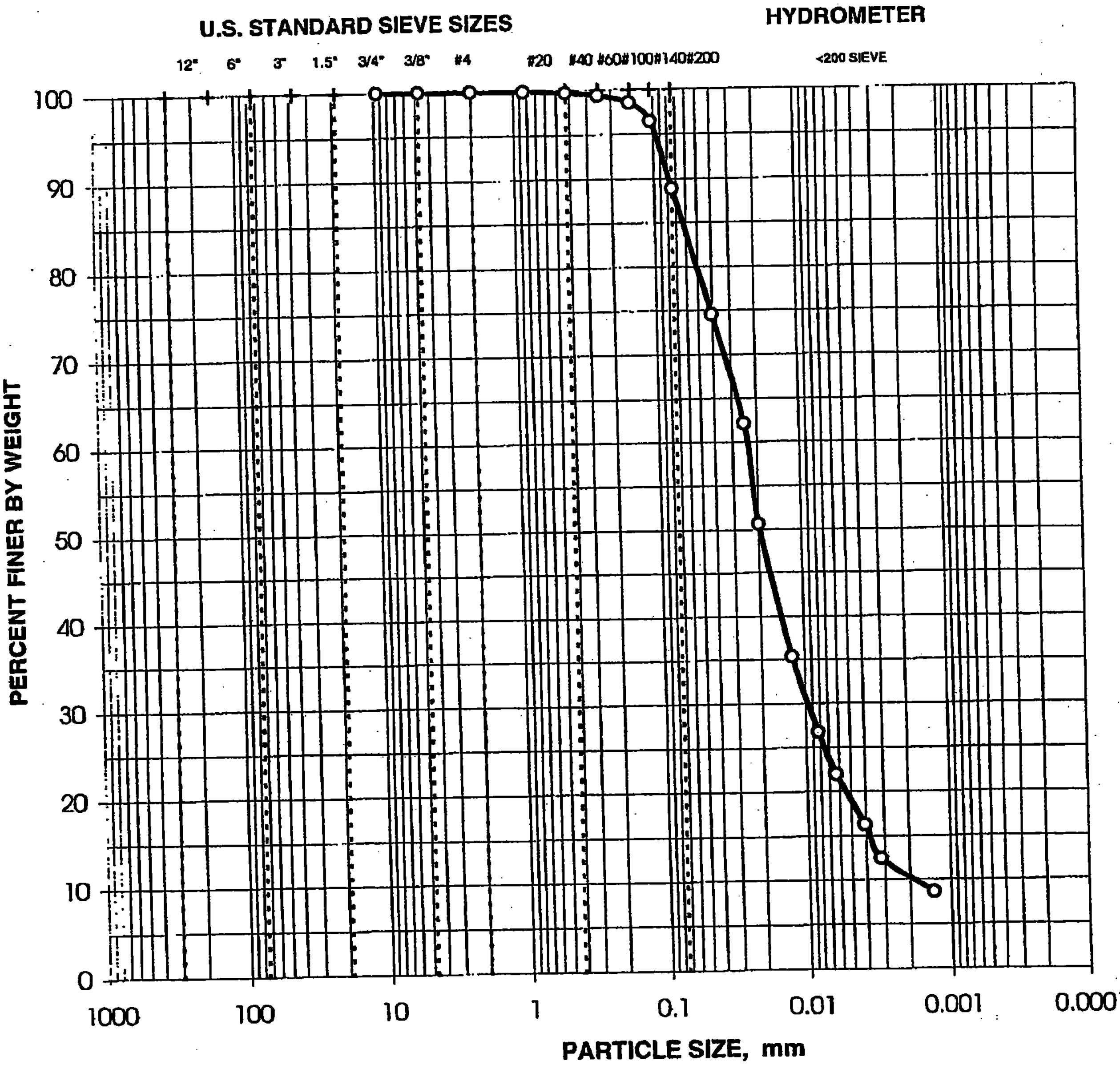
COARSE	Sieve No.	Diameter mm	Percent Finer
	3"	75.000	100.0%
	1.5"	37.500	100.0%
	0.75"	19.000	100.0%
	0.375"	9.500	100.0%
	#4	4.750	100.0%
	#10	2.000	100.0%

FINE	Sieve No.	Diameter mm	Percent Finer
	#20	0.850	99.9%
	#40	0.425	99.7%
	#60	0.250	99.4%
	#100	0.149	98.5%
	#140	0.106	96.4%
	#200	0.075	88.9%

HYDROMETER ANALYSIS

HYDROMETER	Diameter mm	Percent Finer
	0.04044	74.6%
	0.02473	62.1%
	0.02008	50.7%
	0.01226	35.4%
	0.00825	26.8%
	0.00632	22.0%
	0.00407	16.2%
	0.00319	12.4%
	0.00134	8.6%

ARCO Hastings



CLIENT SAMPLE NO.: MW-15B (36-38)

IT LAB SAMPLE NO.: ETDC-9787

BOULDERS	COBBLES	GRAVEL		SAND			
		COARSE	FINE	COARSE	MEDIUM	FINE	SILT 2 - 75 microns CLAY <2 microns

PARTICLE-SIZE ANALYSIS
ASTM D 422

Project Name ARCO Hastings

Project No. 806938.40000000

Client Sample No. MW-15A-70-72

IT Lab Sample No. ETDC-9799

Specific Gravity : 2.65
assumed for calculations

Moisture Content = 24.4%
based on dry sample weight

SIEVE ANALYSIS

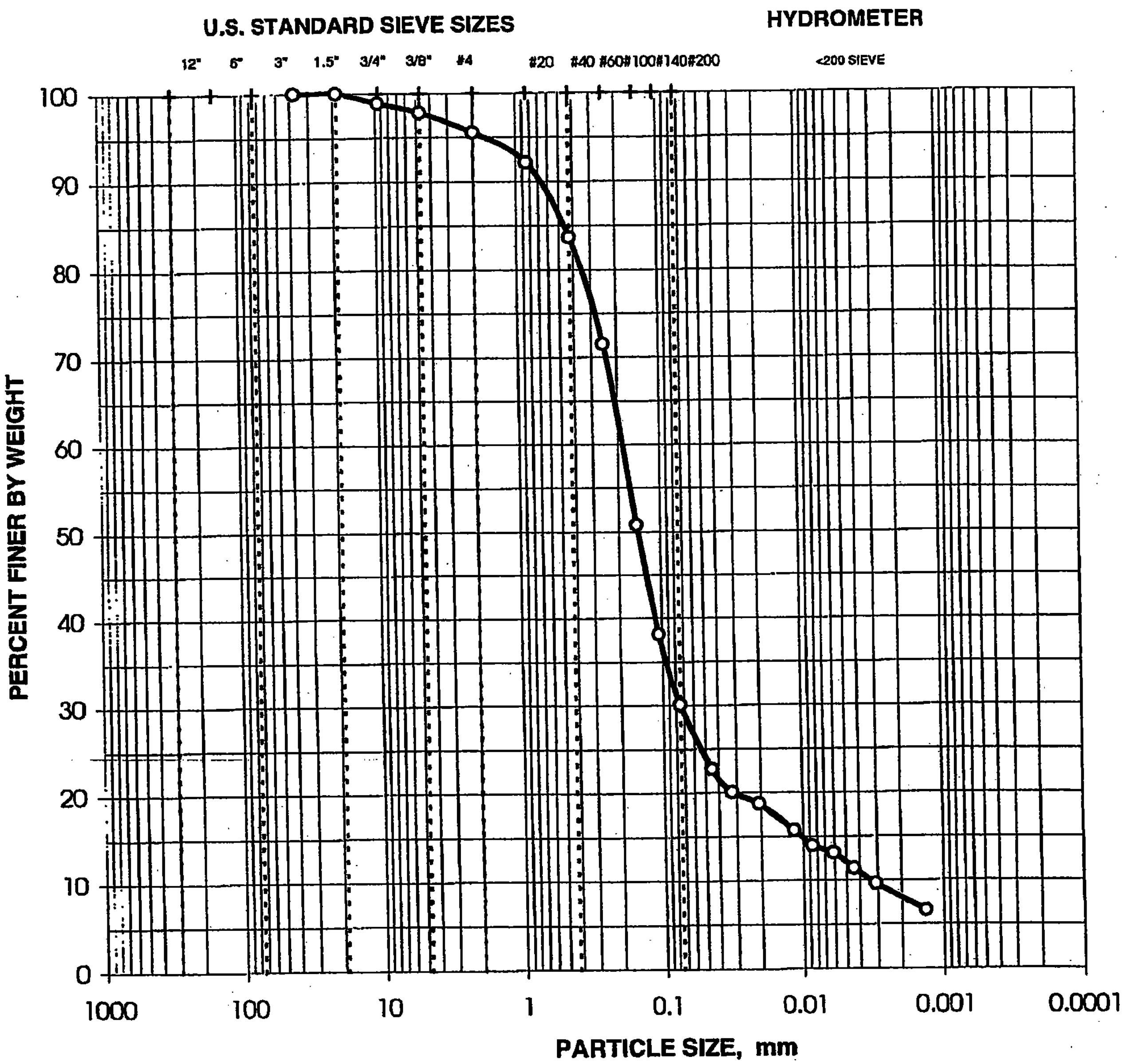
	Sieve No.	Diameter mm	Percent Finer
COARSE	3"	75.000	100.0%
	1.5"	37.500	100.0%
	0.75"	19.000	100.0%
	0.375"	9.500	98.9%
	#4	4.750	97.8%
	#10	2.000	95.5%

	Sieve No.	Diameter mm	Percent Finer
FINE	#20	0.850	92.1%
	#40	0.425	83.7%
	#60	0.250	71.5%
	#100	0.149	50.8%
	#140	0.106	38.1%
	#200	0.075	30.1%

HYDROMETER ANALYSIS

	Diameter mm	Percent Finer
HYDROMETER		
	0.04491	22.7%
	0.03232	20.1%
	0.02071	18.8%
	0.01151	15.7%
	0.00863	14.0%
	0.00611	13.1%
	0.00442	11.4%
	0.00310	9.6%
	0.00135	6.5%

ARCO Hastings



CLIENT SAMPLE NO.: MW-15A-70-72

IT LAB SAMPLE NO.: ETDC-9799

BOULDERS	COBBLES	GRAVEL		SAND			
		COARSE	FINE	COARSE	MEDIUM	FINE	SILT 2 - 75 microns CLAY <2 microns

PARTICLE-SIZE ANALYSIS
ASTM D 422

Project Name ARCO Hastings

Client Sample No. MW-15A-76-80

Project No. 806938.40000000

IT Lab Sample No. ETDC-9800

Specific Gravity = 2.65
assumed for calculations

Moisture Content = 20.4%
based on dry sample weight

SIEVE ANALYSIS

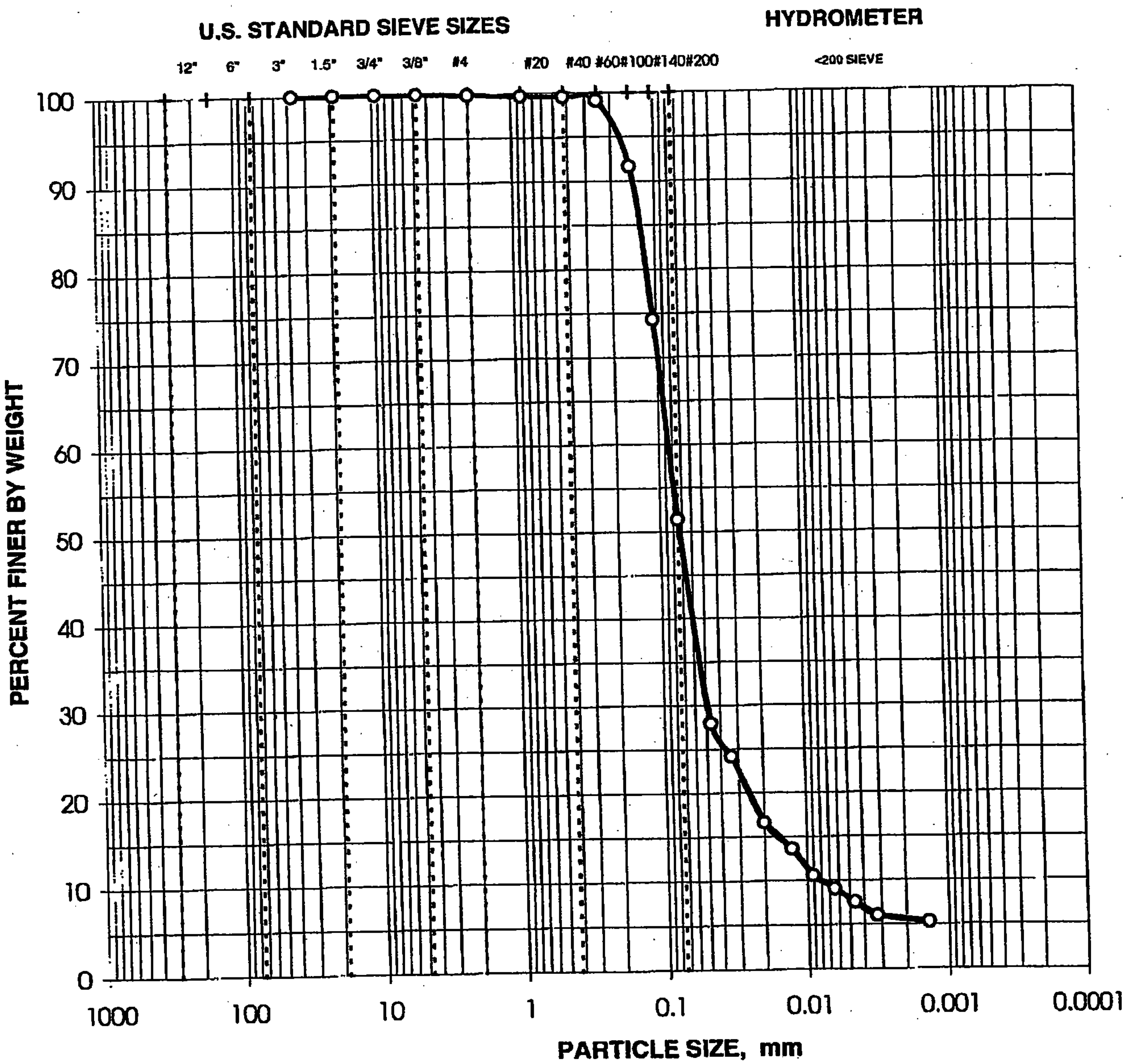
COARSE Sieve No.	Diameter mm	Percent Finer
3"	75.000	100.0%
1.5"	37.500	100.0%
0.75"	19.000	100.0%
0.375"	9.500	100.0%
#4	4.750	100.0%
#10	2.000	99.8%

FINE Sieve No.	Diameter mm	Percent Finer
#20	0.850	99.7%
#40	0.425	99.5%
#60	0.250	99.1%
#100	0.149	91.6%
#140	0.106	74.3%
#200	0.075	51.4%

HYDROMETER ANALYSIS

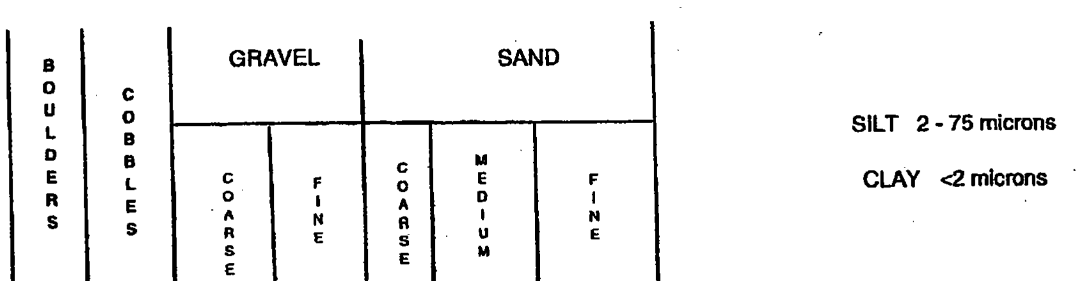
HYDROMETER Diameter mm	Percent Finer
0.04672	27.9%
0.03357	24.1%
0.01998	16.6%
0.01278	13.6%
0.00916	10.6%
0.00643	9.1%
0.00463	7.5%
0.00323	6.0%
0.00138	5.3%

ARCO Hastings



CLIENT SAMPLE NO.: MW-15A-76-80

IT LAB SAMPLE NO.: ETDC-9800



UNIFIED SOIL CLASSIFICATION SYSTEM RESULTS

UNITED SOIL CLASSIFICATION SYSTEM
ASTM D 2487

PROJECT NAME: ARCO Hastings

PROJECT NO: 806938.40000000

	IT LAB SAMPLE NUMBER	CLIENT SAMPLE NUMBER	GROUP SYMBOL:	CLASSIFICATION-GROUP NAME:
SAMPLE 1:	ETDC-9784	MW-13B (20-22)	GM	Silty GRAVEL with sand
SAMPLE 2:	ETDC-9785	MW-14B (19-21)	MH	Elastic SILT
SAMPLE 3:	ETDC-9786	MW-15B (24-26)	GM	Silty GRAVEL with sand
SAMPLE 4:	ETDC-9787	MW-15B (36-38)	ML	SILT
SAMPLE 5:	ETDC-9788	MW-13B (30-32)	CL	Sandy lean CLAY
SAMPLE 6:	ETDC-9789	MW-14B (34-36)	CL	Lean CLAY with sand
SAMPLE 7:				
SAMPLE 8:				
SAMPLE 9:				
SAMPLE 10:				

****

UNITED SOIL CLASSIFICATION SYSTEM
ASTM D 2487

PROJECT NAME: ARCO Hastings

PROJECT NO: 806938.40000000

	IT LAB SAMPLE NUMBER	CLIENT SAMPLE NUMBER	GROUP SYMBOL:	CLASSIFICATION-GROUP NAME:
SAMPLE 1:	ETDC-9801	MW-14A (40-42)	ML	SILT with sand
SAMPLE 2:	ETDC-9802	MW-13 (40-42)	CL	Lean CLAY with gravel
SAMPLE 3:	ETDC-9803	MW-13 (50-52)	SM	Silty SAND
SAMPLE 4:	ETDC-9804	MW-14A (48-50)	CL	Sandy lean CLAY
SAMPLE 5:	ETDC-9805	MW-15A (44-46)	SM	Silty SAND
SAMPLE 6:	ETDC-9806	MW-15A (54-56)	ML	SILT with sand
SAMPLE 7:				
SAMPLE 8:				
SAMPLE 9:				
SAMPLE 10:				

****

UNITED SOIL CLASSIFICATION SYSTEM
ASTM D 2487

PROJECT NAME: ARCO Hastings

PROJECT NO: 806938.40000000

	IT LAB SAMPLE NUMBER	CLIENT SAMPLE NUMBER	GROUP SYMBOL:	CLASSIFICATION-GROUP NAME:
SAMPLE 1:	ETDC-9791	MW-13A-58'-60'	SM	Silty SAND
SAMPLE 2:	ETDC-9792	MW-13A-75'-76'	SM	Silty SAND
SAMPLE 3:	ETDC-9793	MW13A-76'-77'	ML	Sandy SILT
SAMPLE 4:	ETDC-9794	MW13A-82.9'-83'	ML	SILT
SAMPLE 5:	ETDC-9795	MW-13A-86.4'-86.6'	SM	Silty SAND
SAMPLE 6:	ETDC-9796	MW14A-60'-62'	SM	Silty SAND
SAMPLE 7:	ETDC-9797	MW14A-79-80	SP-SM	Poorly graded SAND with silt and gravel
SAMPLE 8:	ETDC-9798	MW14A-80-81	ML	Sandy SILT
SAMPLE 9:	ETDC-9799	MW-15A-70-72	SP	Poorly graded SAND
SAMPLE 10:	ETDC-9800	MW-15A-76-80	ML	Sandy SILT

****

ATTACHMENT C

EXCAVATION DESIGN CALCULATIONS

ATTACHMENT C

EXCAVATION DESIGN CALCULATIONS

TABLE OF CONTENTS

Shaw E & I, Inc.

By EJR Date June 27, 2002 Subject AERL Full Excavation OU-1 Sheet No. 1 of 2
Chkd By WTC Date June 28, 2002 Proj. No. 806938

Objective

The purpose of these calculations is to determine the maximum possible dry and wet excavation depth, the effect of a four-foot grout layer at the bottom of the excavation and the requirements of sheet pile penetration.

References

- Peer Review Summary Report, November 30, 2001
- "SPW911 version 2.0" Sheet Pile Design Software developed by Pile Buck, Inc
- Soil Boring Logs for MW13, MW14, and MW15 (Included in Peer Review Summary Report)
- Geotechnical testing results on soil samples from MW13, MW14, and MW15 (Included in Peer Review Summary Report)

Case Descriptions and Conclusions

The sheet pile in each case for each monitoring well location is an Arbed AZ48 with a section modulus of 89.3 in^3/ft and a working stress of 25 ksi. The sequence of excavation is as stated on the SPW911 output for each case at each boring location.

Scenario 1 is for the shallow excavation to the existing groundwater table, approximately 0 to 3 feet below existing grade. Shoring or steel sheet pile is not necessary, and no calculation is conduct for this case.
Conclusion: shallow excavation to the existing groundwater table is practical and feasible to a depth up to 3 feet.

Scenario 2 (Case a) for each of the locations near borings MW13, MW14, and MW15 determined the cantilever length of the sheet pile with a maximum dry excavation before a deflection of 1.0" was reached.
Conclusion: Cases aMW13, aMW14, aMW15 have sheet pile lengths of 38.65, 34.73, and 36.11 feet, respectively and maximum excavation depths of 4.1, 4.7, and 4.3 respectively.

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Scenario 3 (Case b) for each of the locations near borings MW13, MW14, and MW15 determined the maximum dry excavation with walers installed at the lowest possible locations. **Conclusion: Cases bMW13, bMW14, and bMW15 have maximum excavation depths of 6.3, 8.6, and 8.7 feet, respectively.**

Scenario 4 (Case c) Blanked and not used.

Scenario 5 (Case d) for each of the locations near borings MW13, MW14, and MW15 determined the length of the sheet pile in a dry excavation of 15 feet, with four feet of grout at depths between 15 feet and 19 feet and walers installed the lowest possible locations (case b). **Conclusion: Cases dMW13, dMW14, and dMW15 have sheet pile lengths of 15.45, 15.42, and 15.37 feet respectively. For design purposes, provide a 19 feet sheet pile penetration to the bottom of grout for grout containment.**

Sheetpile Waler Structural Design

A preliminary Sheetpile Waler structural capacity calculation was conducted to determine the supporting capacity as required.
Conclusion: A steel waler and strut system could be designed and used to support the required lateral loads of up to 7,000 lbs per ft of waler at each level.

SUMMARY OF SHEET PILE CASES

Case	Scenario	Shear Strength	Water Level		Excavation		Sheetpile Length, ft.	Waler			Grout location
			Existing	Excavation	Excavation Condition	Depth, ft.		No.	Location	Loads, lb/ft	
aMW13	2	based on SPT and strength test data, and Boring MW-13	0	4.1	dry	4.1	38.65	0	NA	NA	NA
bMW13	3		0	6.3	dry	6.3	24.79	2	3.60	1,289.5	NA
									5.30	3,042.3	
dMW13	5		0	15.0	dry	15.0	15.45 (19.0)*	2	3.60	1,284.1	15 to 19
									5.30	3,734.7	
aMW14	2	based on SPT and strength test data, and Boring MW-14	0	4.7	dry	4.7	34.73	0	NA	NA	NA
bMW14	3		0	8.6	dry	8.6	25.17	2	4.20	2,075.0	NA
									7.80	4,471.7	
dMW14	5		0	15.0	dry	15.0	15.42 (19.0)*	2	4.20	2,062.2	15 to 19
									7.80	4,328.2	
aMW15	2	based on SPT and strength test data, and Boring MW-15	0	4.3	dry	4.3	36.11	0	NA	NA	NA
bMW15	3		0	8.7	dry	8.7	32.74	2	3.80	1,831.4	NA
									7.30	5,801.0	
dMW15	5		0	15.0	dry	15.0	15.37 (19.0)*	2	3.80	1,822.0	15 to 19
									7.30	4,039.8	

Purpose

Select representative geotechnical design parameters for each layer, in order to simplify the design calculation for the sheet pile design.

Given

Laboratory Test Results (See MW13, MW14, and MW15)

Methodology

For design purposes, the geotechnical design parameters will be selected from all the test data for MW13, MW14, and MW15 using the COE recommended lowest 1/3 data point (33 percentile).

References

(1) "Foundation Design," by W.C. Teng (Page 12).
(2) Boring Logs for MW13, MW14, and MW15.
(3) Geotechnical Testing Results for MW13, MW14, and MW15.

Fill

Two remolded soil samples were tested in the IT-Geotechnical Laboratory in Oak Ridge, TN. The results are summarized as follows:

Boring	Depth	γ_T (pcf)	γ_d (pcf)	w%	Direct Shear	
					c (psi)	ϕ (deg.)
MW13	20'-22'	94.7	65.6	44.3	0.41	41.2
MW14	24'-26'	87.5	62	41	0.71	35.9

The standard penetration test (SPT) blow count from MW14 and MW15: 27 and 14, 15, 26, and 27 blow/ft. The 33 percentile is approximately 15. Based on Reference 1:

$$\phi = 27 + 0.3N = 27 + (0.3)(15) = 31.5°$$

The ϕ determined from the remolded sample of 35.9° is higher than in-situ N, ϕ=31.5°.
Repeat for lower fill.
N < 1, assumed $\phi = 25°$
$\gamma_T = 91$ pcf, $\gamma_{sub} = 91-62.4=28.6$ pcf

Depth	c (psi)	ϕ
0'-10'	0	31°
>10'	0	25°

Marine Gray Silt

A total of 3 UU and 5 direct shear strength tests were performed for the marine gray silt layer. Since the sheet pile design is for short-term conditions, UU test results will be used.

Boring	Depth (ft)	U.U. c (psi)	U.U. ϕ	USCS
MW13	30'-32'	1.55	0.6	CL
MW14	34'-36'	2.84	0.5	CL
MW15	36'-38'	4.2	0.3	ML

Using COE 33 percentile, c = 1.55 psi and $\phi = 0°$ were selected for design.

Use $\gamma_T = 110$ pcf
$\gamma_{sub} = 50$ pcf (assumed)
c = 1.55 psi = 223 psf
$\phi = 0°$

Basal Sand

The SPT blow counts for gray basal sand and reddish basal sand as shown on the Boring Logs for MW13, MW14, and MW15 indicate:

Gray Basal Sand MW13	Gray Basal Sand MW14	Gray Basal Sand MW15	Reddish Basal Sand MW13	Reddish Basal Sand MW14	Reddish Basal Sand MW15
4	4	1	12	>50	>50
4	<1	1	37		
4	10	6	>50		
	<1	4			
	<1				

For gray basal sand
Avg. N = 3.4 $\phi = 27 + 0.3N = 28°$

For reddish basal sand
Avg. N = 50 $\phi = 36 + (N-30)/4 = 41°$
Be conservative use $\phi = 35°$

Assume: Total Unit Weight = $\gamma_T = 110$ pcf
Submerged Unit Weight = $\gamma_{sub} = 62$ pcf

Transition Between Fill and Marine Silt at MW14

Based on test data:

γ_T = 96 pcf
γ_{sub} = 33 pcf (Assumed)
c = 2.72 psi = 390 psf
$\phi = 0°$

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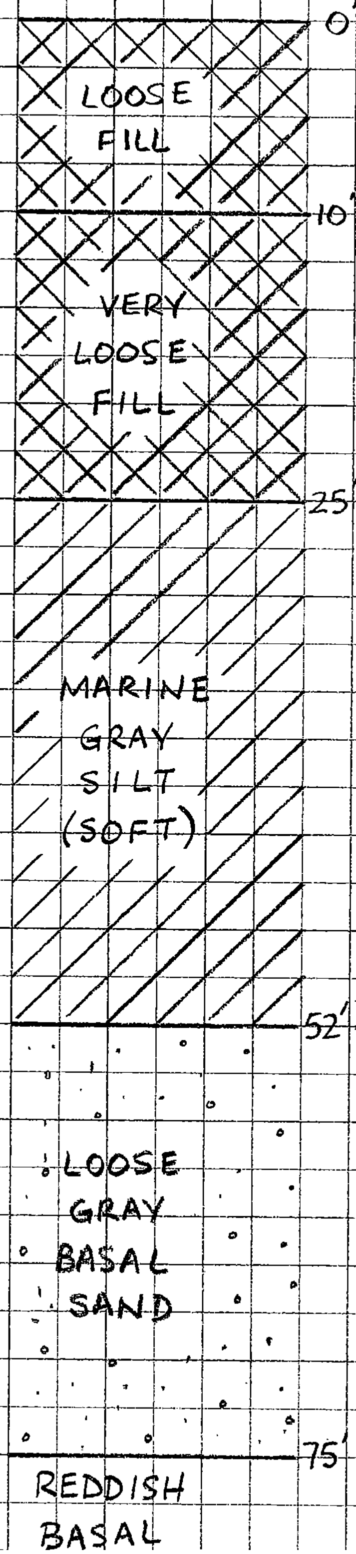
By WTC Date 11/20/01 Subject SOIL PROFILE / DESIGN PARAMETERS Sheet No. 1 of 1

Chkd. By EJR Date 7/2/02 AERL HASTING-ON-HARBOR, NY Proj. No. 806938

.25 in. X .

SOIL PROFILE AND DESIGN PARAMETERS FOR BORING MW13



0'–10' LOOSE FILL

γ_T = 91 PCF γ_{SUB} = 28.6 PCF

C = 0 ϕ = 31°

(BASED ON SPT N = 15)

10'–25' VERY LOOSE FILL

γ_T = 91 PCF γ_{SUB} = 28.6 PCF

C = 0 ϕ = 25°

(BASED ON SPT N < 1)

25'–52' MARINE GRAY SILT (SOFT)

γ_T = 110 PCF γ_{SUB} = 50 PCF (ASSUMED)

C = 1.55 PSI = 223 PSF

ϕ = 0

52'–75' LOOSE GRAY BASAL SAND

γ_T = 110 PCF γ_{SUB} = 62 PCF (ASSUMED)

C = 0 ϕ = 28°

(BASED ON SPT N_{AVG} = 3.4)

75' REDDISH BASAL

γ_T = 110 PCF γ_{SUB} = 62 PCF (ASSUMED)

C = 0 ϕ = 35°

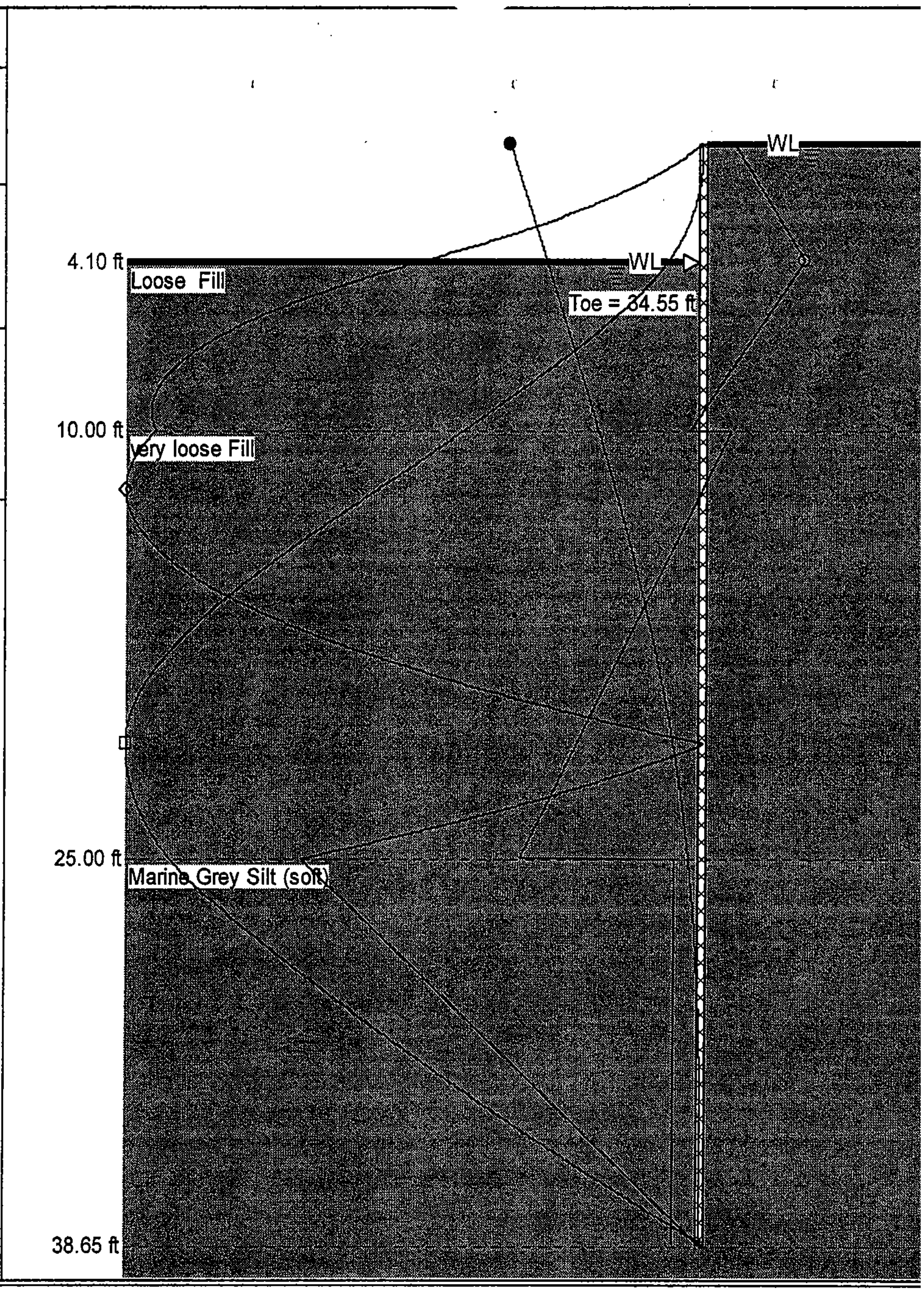
Client: AERL Hasting
Site: Hasting-on-Hudson, NY

Title: Boring MW-13, Cantilever
Ref: Case aMW13
Page: 1
Date: 6.27.02

Sheet: Arbed AZ48
Pressure: Coulomb; Full hydrostatic pressure in cohesive soils.
FOS: 1.0
Toe: Cantilever

	Maximum	d (ft)
○	421.2 psf	4.10
□	31869.1 ftlb/ft	21.00
◇	2340.4 lb/ft	12.05
●	0.9 in	0.00

dry excavation to 4.10' (cantilever)



Harbor-At-Hastings Site at MW13

Client:	AERL Hasting
Site:	Hasting-on-Hudson, NY
Title:	Boring MW-13, Cantilever
Ref:	Case aMW13
Page:	2
Date:	6.27.02
Sheet:	Arbed AZ48
Pressure:	Coulomb; Full hydrostatic pressure in cohesive soils.
FOS:	1.0
Toe:	Cantilever

dry excavation to 4.10' (cantilever)

Input Data

Depth Of Excavation = 4.10 ft   Depth Of Active Water = 0.00 ft

Surcharge = 400.0 psf   Depth Of Passive Water = 4.10 ft   M…

Soil Profile

Depth (ft)	Soil Name	γ (pcf)	γ' (pcf)	C (psf)	C_a (psf)	φ (°)	δ (°)
0.00	Loose Fill	91.00	28.60	0.0	0.0	31.0	0.C
10.00	very loose Fill	91.00	28.60	0.0	0.0	25.0	0.C
25.00	Marine Grey Silt (soft)	110.00	50.00	223.0	0.0	0.0	0.C
52.00	Loose Basal Sand, some silt	110.00	62.00	0.0	0.0	28.0	0.C
75.00	Reddish Basal Sand	110.00	62.00	0.0	0.0	35.0	0.C

Solution

Sheet

Sheet Name	I (in⁴/ft)	E (psi)	Z (in³/ft)	f (psi)	Maximum Ben… Moment (ftlb/…
Arbed AZ48	847.10	3.04E+07	89.30	25000.0	1858…

Maxima

	Maximum	Depth
Bending Moment	31869.1 ftlb/ft	21.00 ft
Deflection	0.9 in	0.00 ft
Pressure	421.2 psf	4.10 ft
Shear Force	2340.4 lb/ft	12.05 ft

Harbor-At-Hastings Site at MW13

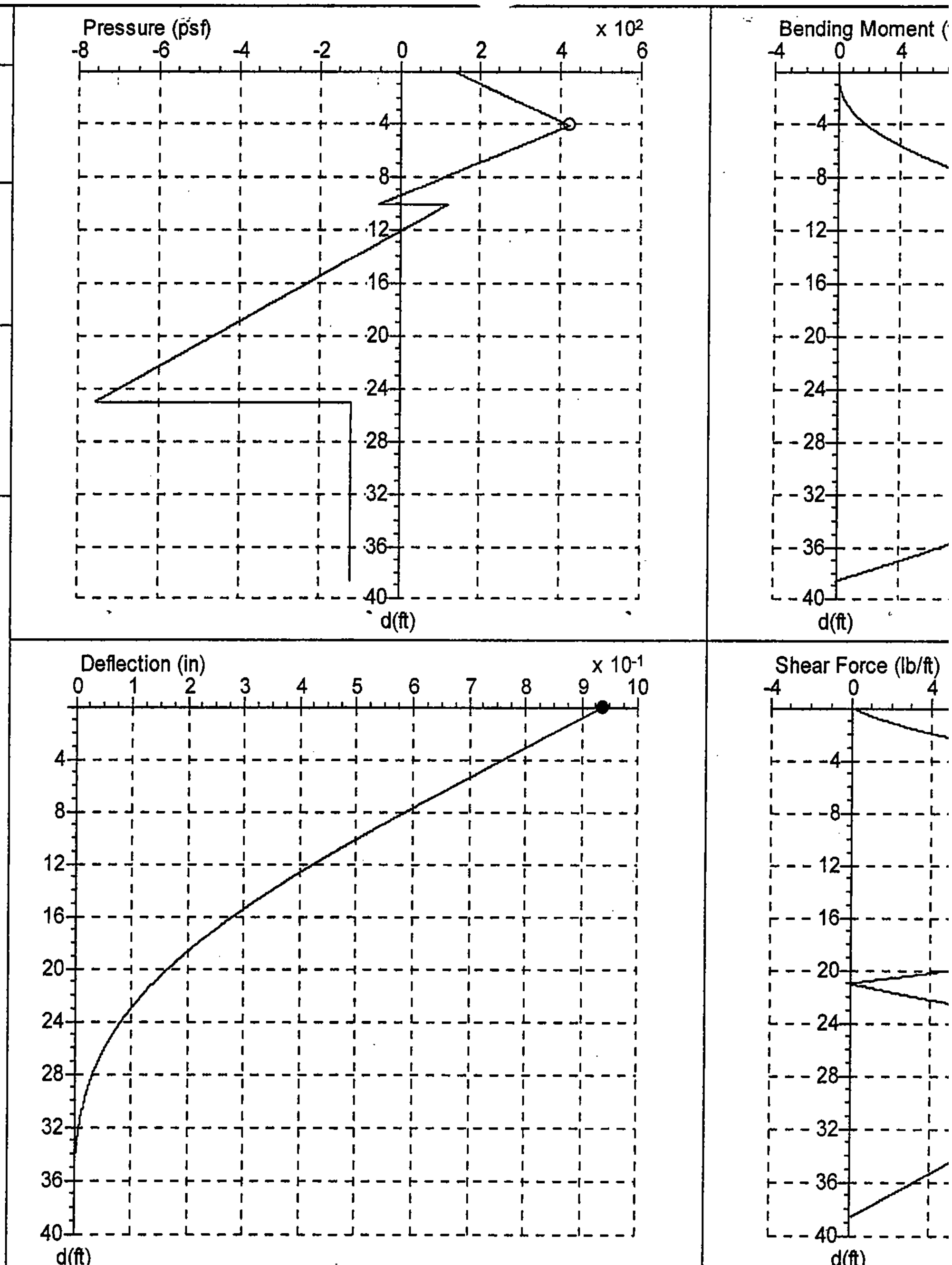
Client: AERL Hasting
Site: Hasting-on-Hudson, NY

Title: Boring MW-13, Cantilever
Ref: Case aMW13
Page: 3
Date: 6.27.02

Sheet: Arbed AZ48
Pressure: Coulomb; Full hydrostatic pressure in cohesive soils.
FOS: 1.0
Toe: Cantilever

	Maximum	d (ft)
○	421.2 psf	4.10
□	31869.1 ftlb/ft	21.00
◇	2340.4 lb/ft	12.05
●	0.9 in	0.00

dry excavation to 4.10' (cantilever)



Harbor-At-Hastings Site at MW13

Client: AERL Hasting
Site: Hasting-on-Hudson, NY

Title: Boring MW-13, Cantilever
Ref: Case aMW13
Page: 4
Date: 6.27.02

Sheet: Arbed AZ48
Pressure: Coulomb; Full hydrostatic pressure in cohesive soils.
FOS: 1.0
Toe: Cantilever

dry excavation to 4.10' (cantilever)

depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)
0.00	128.0	0.1	0.9	8.2
0.34	153.3	9.3	0.9	54.3
0.68	178.7	37.8	0.9	113.5
1.03	201.7	83.1	0.9	175.1
1.37	227.1	157.2	0.9	251.5
1.71	252.4	259.8	0.9	336.9
2.05	275.4	380.4	0.8	422.2
2.39	300.8	546.3	0.8	524.7
2.74	323.8	729.7	0.8	625.7
3.08	349.1	970.4	0.8	745.3
3.42	374.5	1254.9	0.8	873.9
3.76	397.5	1554.2	0.8	998.6
4.10	421.2	1931.2	0.8	1144.3
4.45	391.0	2360.0	0.7	1287.4
4.79	365.2	2792.5	0.7	1408.8
5.13	336.9	3311.9	0.7	1532.7
5.47	311.1	3820.9	0.7	1636.7
5.81	282.7	4417.9	0.7	1741.4
6.16	254.3	5050.4	0.7	1836.1
6.50	228.5	5653.2	0.7	1913.4
6.84	200.2	6343.6	0.6	1988.9
7.18	171.8	7059.1	0.6	2054.3
7.52	146.0	7728.3	0.6	2105.1
7.87	117.6	8481.9	0.6	2151.3
8.21	91.8	9179.9	0.6	2184.7
8.55	63.5	9958.6	0.6	2211.7
8.89	35.1	10745.2	0.5	2228.7
9.24	9.3	11464.2	0.5	2235.4
9.58	-19.1	12256.2	0.5	2233.2
9.92	-44.9	12974.1	0.5	2222.5
10.26	105.8	13763.5	0.5	2246.7
10.60	85.0	14565.2	0.5	2280.2
10.95	66.1	15303.2	0.5	2304.2
11.29	45.3	16123.0	0.5	2323.6
11.63	24.5	16948.4	0.4	2335.7
11.97	5.7	17701.5	0.4	2340.2
12.31	-15.1	18530.5	0.4	2338.2
12.66	-34.0	19282.6	0.4	2330.0

depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)
13.00	-54.8	20105.7	0.4	2314.0
13.34	-75.5	20922.0	0.4	2290.5
13.68	-94.4	21656.0	0.4	2262.9
14.02	-115.2	22451.9	0.3	2225.4
14.37	-136.0	23233.3	0.3	2180.6
14.71	-154.9	23929.0	0.3	2133.4
15.05	-175.6	24675.6	0.3	2074.6
15.39	-194.5	25335.3	0.3	2014.6
15.73	-215.3	26037.6	0.3	1941.7
16.08	-236.1	26712.8	0.3	1861.4
16.42	-254.9	27301.1	0.3	1782.0
16.76	-275.7	27917.5	0.3	1687.7
17.10	-294.6	28447.9	0.2	1595.6
17.44	-315.4	28996.0	0.2	1487.2
17.79	-336.1	29504.4	0.2	1371.4
18.13	-355.0	29930.2	0.2	1259.8
18.47	-375.8	30355.8	0.2	1130.0
18.81	-396.6	30734.3	0.2	992.8
19.15	-415.5	31035.3	0.2	861.8
19.50	-436.2	31316.5	0.2	710.6
19.84	-455.1	31524.6	0.2	566.7
20.18	-475.9	31699.0	0.2	401.5
20.52	-496.7	31813.7	0.2	228.8
20.86	-515.5	31863.9	0.1	65.5
21.21	-536.3	31863.4	0.1	56.3
21.55	-557.1	31825.4	0.1	165.3
21.89	-576.0	31762.4	0.1	270.8
22.23	-596.8	31655.4	0.1	393.9
22.57	-615.6	31530.5	0.1	512.1
22.92	-636.4	31351.0	0.1	649.2
23.26	-657.2	31131.4	0.1	793.7
23.60	-676.1	30905.5	0.1	931.4
23.94	-696.8	30608.0	0.1	1089.9
24.29	-715.7	30267.4	0.1	1240.4
24.63	-736.5	29882.9	0.1	1412.9
24.97	-757.3	29453.3	0.1	1592.8
25.31	-119.0	29039.7	0.1	1595.6
25.65	-119.0	28523.0	0.1	1553.4

Harbor-At-Hastings Site at MW13

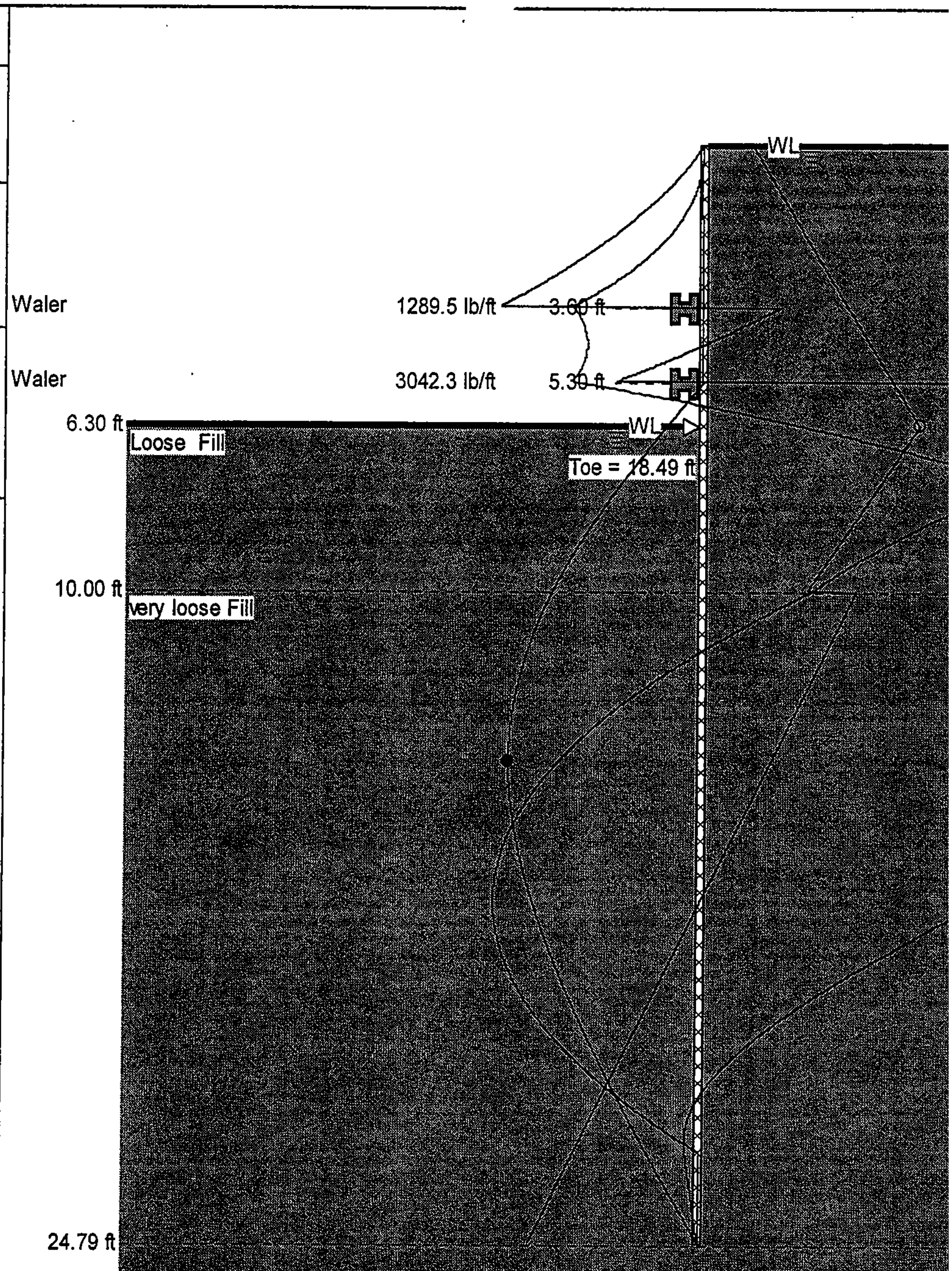
Client: AERL Hasting
Site: Hasting-on-Hudson, NY

Title: Boring MW-13, Cantilever
Ref: Case bMW13
Page: 1
Date: 6.27.02

Sheet: Arbed AZ48
Pressure: Coulomb; Full hydrostatic pressure in cohesive soils.
FOS: 2.0
Toe: Free Earth Support

	Maximum	d (ft)
○	578.6 psf	6.30
□	6556.3 ftlb/ft	11.57
◇	2638.0 lb/ft	5.30
●	0.0 in	13.90

1) dry excavation to 4.10' (cantilever)
2) install waler at 3.60'
3) dry excavation to 5.80'
4) install waler at 5.30'
5) dry excavation to 6.30' - inadequate space to install additional waler



Harbor-At-Hastings Site at MW13

Client:	AERL Hasting
Site:	Hasting-on-Hudson, NY
Title:	Boring MW-13, Cantilever
Ref:	Case bMW13
Page:	2
Date:	6.27.02
Sheet:	Arbed AZ48
Pressure:	Coulomb; Full hydrostatic pressure in cohesive soils.
FOS:	2.0
Toe:	Free Earth Support

1) dry excavation to 4.10' (cantilever)
2) install waler at 3.60'
3) dry excavation to 5.80'
4) install waler at 5.30'
5) dry excavation to 6.30' - inadequate space to install additional waler

Input Data

Depth Of Excavation = 6.30 ft   Depth Of Active Water = 0.00 ft

Surcharge = 400.0 psf   Depth Of Passive Water = 6.30 ft   M

Soil Profile

Depth (ft)	Soil Name	γ (pcf)	γ' (pcf)	C (psf)	C_a (psf)	ϕ (°)	δ (°
0.00	Loose Fill	91.00	28.60	0.0	0.0	31.0	0.C
10.00	very loose Fill	91.00	28.60	0.0	0.0	25.0	0.C
25.00	Marine Grey Silt (soft)	110.00	50.00	223.0	0.0	0.0	0.C
52.00	Loose Basal Sand, some silt	110.00	62.00	0.0	0.0	28.0	0.C
75.00	Reddish Basal Sand	110.00	62.00	0.0	0.0	35.0	0.C

Solution

Sheet

Sheet Name	I (in⁴/ft)	E (psi)	Z (in³/ft)	f (psi)	Maximum Ben Moment (ft-lb
Arbed AZ48	847.10	3.04E+07	89.30	25000.0	1858

Load Model: Area Distribution

Supports

Depth (ft)	Type	Linear Load (lb/ft)
3.60	Waler	1289.5
5.30	Waler	3042.3

Maxima

Bending Mo
Deflection
Pressure
Shear Forc

Harbor-At-Hastings Site at MW13

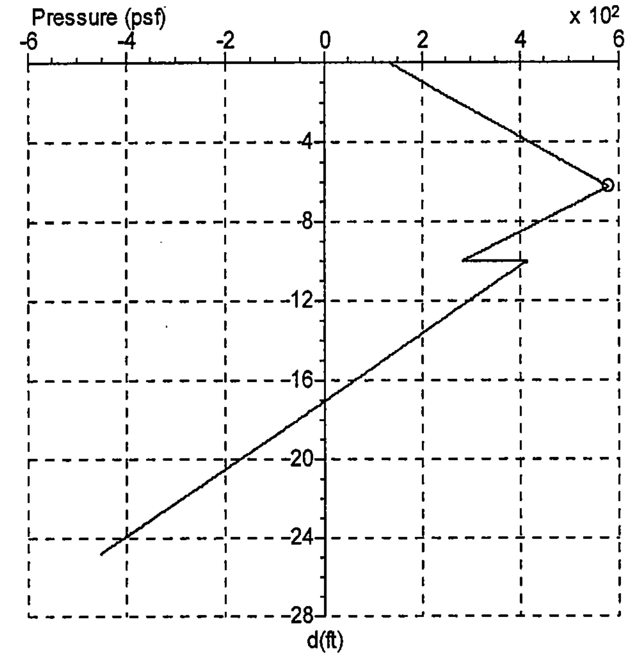
Client: AERL Hasting
Site: Hasting-on-Hudson, NY

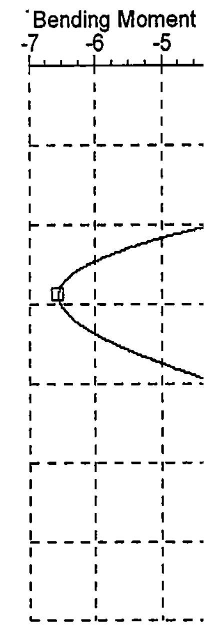
Title: Boring MW-13, Cantilever
Ref: Case bMW13
Page: 3
Date: 6.27.02

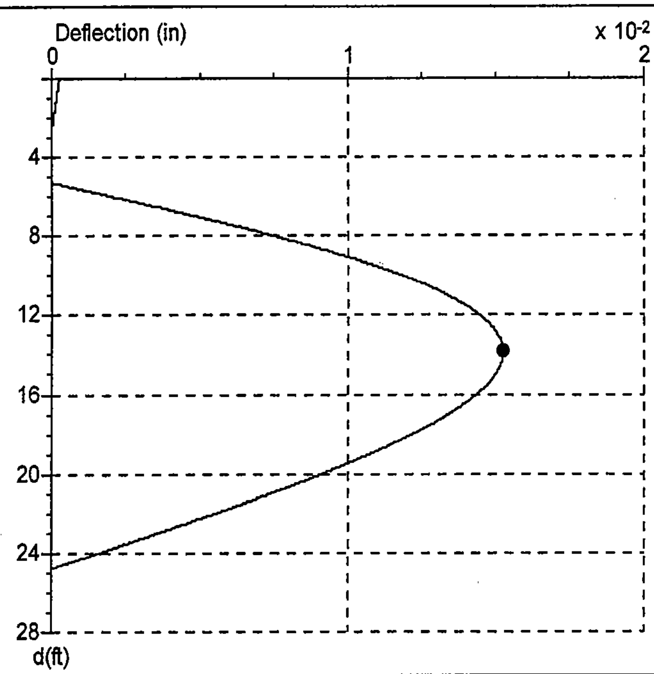
Sheet: Arbed AZ48
Pressure: Coulomb; Full hydrostatic pressure in cohesive soils.
FOS: 2.0
Toe: Free Earth Support

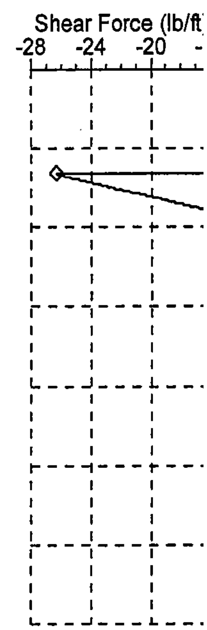
	Maximum	d (ft)
○	578.6 psf	6.30
□	6556.3 ftlb/ft	11.57
◇	2638.0 lb/ft	5.30
●	0.0 in	13.90

1) dry excavation to 4.10' (cantilever)
2) install waler at 3.60'
3) dry excavation to 5.80'
4) install waler at 5.30'
5) dry excavation to 6.30' - inadequate space to install additional waler









Harbor-At-Hastings Site at MW13

Client: AERL Hasting
Site: Hasting-on-Hudson, NY

Title: Boring MW-13, Cantilever
Ref: Case bMW13
Page: 4
Date: 6.27.02

Sheet: Arbed AZ48
Pressure: Coulomb; Full hydrostatic pressure in cohesive soils.
FOS: 2.0
Toe: Free Earth Support

1) dry excavation to 4.10' (cantilever)
2) install waler at 3.60'
3) dry excavation to 5.80'
4) install waler at 5.30'
5) dry excavation to 6.30' - inadequate space to install additional waler

depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)
0.00	128.0	0.2	0.0	5.3
0.22	144.3	4.7	0.0	33.7
0.44	160.5	17.2	0.0	68.5
0.66	175.3	36.2	0.0	103.3
0.88	191.5	66.3	0.0	145.2
1.10	207.8	106.9	0.0	190.7
1.32	222.5	153.7	0.0	235.3
1.54	238.8	216.8	0.0	287.9
1.75	253.6	285.5	0.0	338.9
1.97	269.8	374.2	0.0	398.5
2.19	286.1	477.8	0.0	461.8
2.41	300.8	585.5	0.0	522.6
2.63	317.1	719.6	0.0	593.0
2.85	333.3	871.1	0.0	667.0
3.07	348.1	1024.6	0.0	737.6
3.29	364.4	1211.6	0.0	818.7
3.51	379.1	1398.8	0.0	895.6
3.73	395.4	1428.2	0.0	-305.7
3.95	411.6	1366.9	0.0	-213.9
4.17	426.4	1330.7	0.0	-127.2
4.39	442.7	1313.1	0.0	-28.3
4.61	458.9	1319.7	0.0	74.3
4.83	473.7	1347.3	0.0	170.8
5.05	489.9	1402.4	0.0	280.4
5.26	504.7	1475.7	0.0	383.3
5.48	521.0	906.6	0.0	-2542.3
5.70	537.2	297.2	0.0	-2421.9
5.92	552.0	-231.3	0.0	-2309.3
6.14	568.2	-784.0	0.0	-2181.8
6.36	575.3	-1259.5	0.0	-2063.1
6.58	555.4	-1753.0	0.0	-1935.0
6.80	537.2	-2216.4	0.0	-1811.1
7.02	520.7	-2612.4	0.0	-1702.0
7.24	502.5	-3021.1	0.0	-1585.9
7.46	484.3	-3402.5	0.0	-1474.0
7.68	467.8	-3726.5	0.0	-1375.9
7.90	449.6	-4058.7	0.0	-1271.8
8.12	433.0	-4339.5	0.0	-1180.9

depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)
8.34	414.8	-4626.1	0.0	-1084.7
8.55	396.6	-4890.2	0.0	-992.7
8.77	380.1	-5111.6	0.0	-912.7
8.99	361.9	-5335.6	0.0	-828.6
9.21	343.7	-5540.0	0.0	-748.6
9.43	327.2	-5709.6	0.0	-679.5
9.65	309.0	-5879.4	0.0	-607.4
9.87	292.4	-6019.2	0.0	-545.5
10.09	408.0	-6157.3	0.0	-470.2
10.31	394.6	-6274.5	0.0	-379.2
10.53	382.5	-6362.5	0.0	-299.1
10.75	369.2	-6439.5	0.0	-213.8
10.97	357.1	-6492.1	0.0	-138.9
11.19	343.8	-6531.6	0.0	-59.4
11.41	330.5	-6552.4	0.0	17.0
11.63	318.3	-6555.8	0.0	83.9
11.85	305.0	-6543.1	0.0	154.6
12.06	291.7	-6513.8	0.0	222.3
12.28	279.6	-6473.5	0.0	281.1
12.50	266.3	-6414.8	0.0	343.0
12.72	254.2	-6348.8	0.0	396.6
12.94	240.8	-6263.2	0.0	452.7
13.16	227.5	-6164.5	0.0	505.8
13.38	215.4	-6064.1	0.0	551.4
13.60	202.1	-5942.6	0.0	598.7
13.82	188.8	-5810.2	0.0	643.0
14.04	176.6	-5680.9	0.0	680.6
14.26	163.3	-5529.6	0.0	719.1
14.48	151.2	-5384.4	0.0	751.4
14.70	137.9	-5216.9	0.0	784.1
14.92	124.6	-5042.0	0.0	813.8
15.14	112.5	-4877.1	0.0	838.2
15.36	99.1	-4690.1	0.0	862.1
15.57	87.0	-4515.3	0.0	881.2
15.79	73.7	-4318.7	0.0	899.3
16.01	60.4	-4118.1	0.0	914.4
16.23	48.3	-3933.0	0.0	925.5
16.45	35.0	-3726.9	0.0	934.8

Harbor-At-Hastings Site at MW13

Client: AERL Hasting
Site: Hasting-on-Hudson, NY

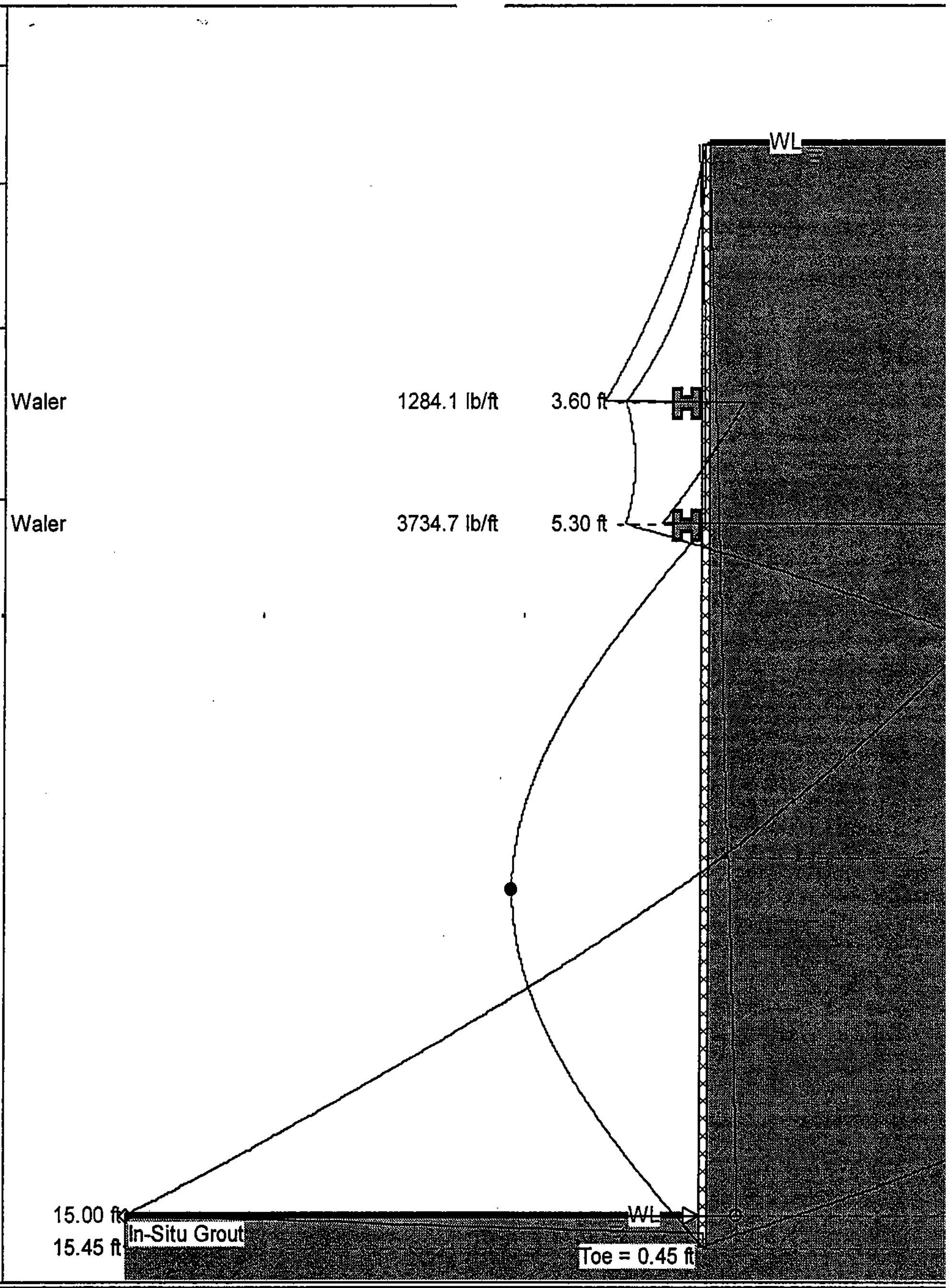
Title: Boring MW-13, two walers
Ref: CasedMW13
Page: 1
Date: 6.27.02

Sheet: Arbed AZ48
Pressure: Coulomb; Full hydrostatic pressure in cohesive soils.
FOS: 2.0
Toe: Free Earth Support

	Maximum	d (ft)
○	1275.4 psf	15.00
□	10131.2 ftlb/ft	10.17
◇	5296.6 lb/ft	15.00
●	0.0 in	10.46

15' excavation with grout from 15.00 to 19.00, walers at 3.6 and 5.3

1) dry excavation to 4.10' cantilever
2) install waler at 3.60'
3) dry excavation to 5.80'
4) install waler at 5.30'
5) dry excavation to 15.00'



Harbor-At-Hastings Site at MW13

Client: AERL Hasting
Site: Hasting-on-Hudson, NY

Title: Boring MW-13, two walers
Ref: CasedMW13
Page: 2
Date: 6.27.02

Sheet: Arbed AZ48
Pressure: Coulomb; Full hydrostatic pressure in cohesive soils.
FOS: 2.0
Toe: Free Earth Support

15' excavation with grout from 15.00 to 19.00, walers at 3.6 and 5.3

1) dry excavation to 4.10' cantilever
2) install waler at 3.60'
3) dry excavation to 5.80'
4) install waler at 5.30'
5) dry excavation to 15.00'

Input Data

Depth Of Excavation = 15.00 ft   Depth Of Active Water = 0.00 ft
Surcharge = 400.0 psf   Depth Of Passive Water = 15.00 ft   N

Soil Profile

Depth (ft)	Soil Name	γ (pcf)	γ' (pcf)	C (psf)	C_a (psf)	ϕ (°)	δ (°)
0.00	Loose Fill	91.00	28.60	0.0	0.0	31.0	0.(
10.00	very loose fill	91.00	28.60	0.0	0.0	25.0	0.(
15.00	In-Situ Grout	125.00	63.00	10800.0	1800.0	0.0	0.(
19.00	very loose fill	91.00	28.60	0.0	0.0	25.0	0.(
25.00	Marine Grey Silt (soft)	110.00	50.00	223.0	0.0	0.0	0.(
52.00	Loose Basal Sand, some silt	110.00	62.00	0.0	0.0	28.0	0.(
75.00	Reddish Basal Sand	110.00	62.00	0.0	0.0	35.0	0.(

Solution

Sheet

Sheet Name	I (in⁴/ft)	E (psi)	Z (in³/ft)	f (psi)	Maximum Ben Moment (ftlb
Arbed AZ48	847.10	3.04E+07	89.30	25000.0	1858

Load Model: Area Distribution

Supports

Depth (ft)	Type	Linear Load (lb/ft)
3.60	Waler	1284.1
5.30	Waler	3734.7

Maxima

Bending Mo
Deflection
Pressure
Shear Forc

Harbor-At-Hastings Site at MW13

Client: AERL Hasting
Site: Hasting-on-Hudson, NY

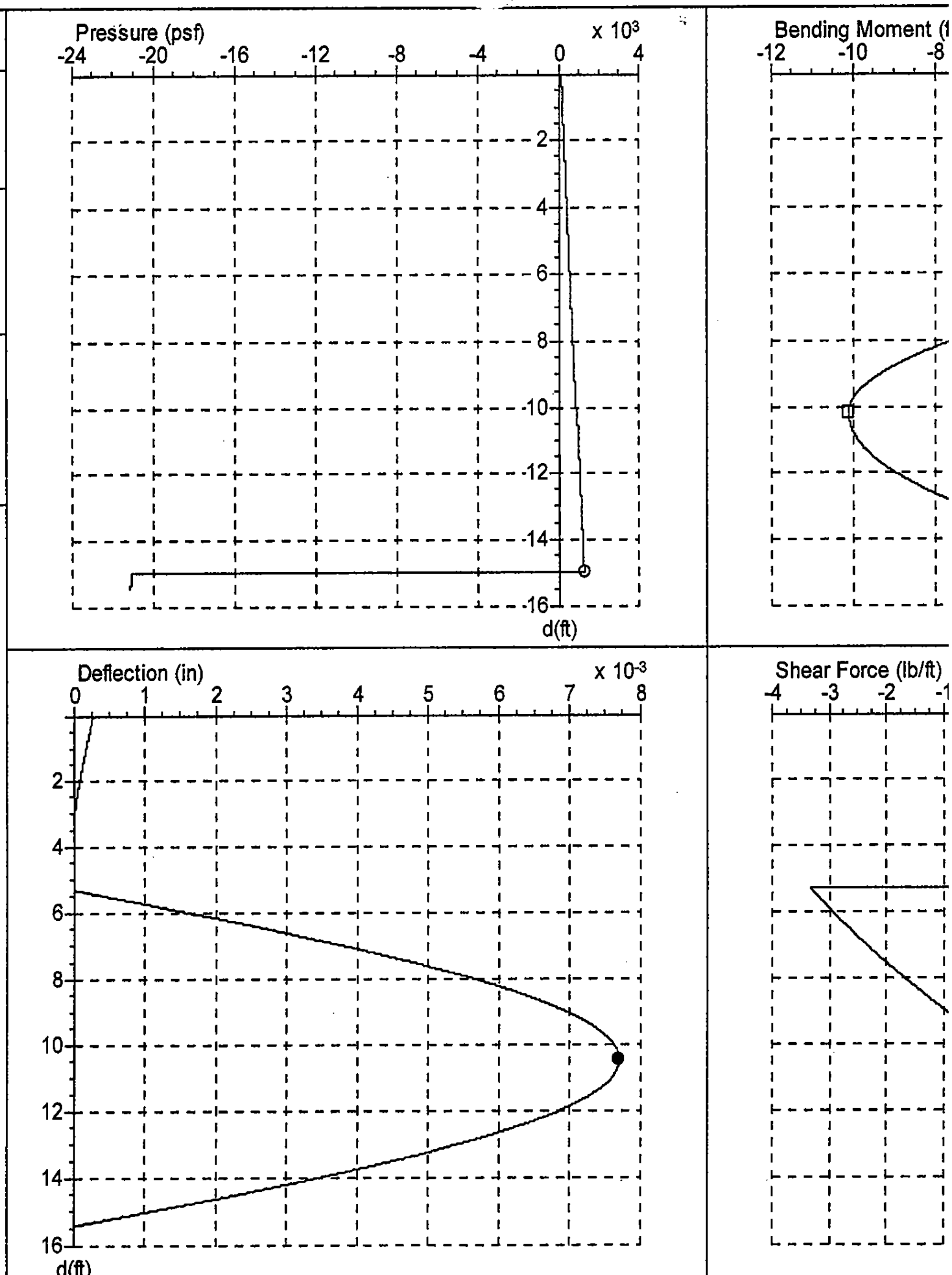
Title: Boring MW-13, two walers
Ref: CasedMW13
Page: 3
Date: 6.27.02

Sheet: Arbed AZ48
Pressure: Coulomb; Full hydrostatic pressure in cohesive soils.
FOS: 2.0
Toe: Free Earth Support

	Maximum	d (ft)
○	1275.4 psf	15.00
□	10131.2 ftlb/ft	10.17
◇	5296.6 lb/ft	15.00
●	0.0 in	10.46

15' excavation with grout from 15.00 to 19.00, walers at 3.6 and 5.3

1) dry excavation to 4.10' cantilever
2) install waler at 3.60'
3) dry excavation to 5.80'
4) install waler at 5.30'
5) dry excavation to 15.00'



Harbor-At-Hastings Site at MW13

Client: AERL Hasting
Site: Hasting-on-Hudson, NY

Title: Boring MW-13, two walers
Ref: CasedMW13
Page: 4
Date: 6.27.02

Sheet: Arbed AZ48
Pressure: Coulomb; Full hydrostatic pressure in cohesive soils.
FOS: 2.0
Toe: Free Earth Support

15' excavation with grout from 15.00 to 19.00, walers at 3.6 and 5.3

1) dry excavation to 4.10' cantilever
2) install waler at 3.60'
3) dry excavation to 5.80'
4) install waler at 5.30'
5) dry excavation to 15.00'

depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)
0.00	128.0	0.1	0.0	3.3
0.14	138.1	1.7	0.0	20.5
0.27	148.3	6.2	0.0	40.9
0.41	157.5	12.8	0.0	60.6
0.55	167.6	23.2	0.0	83.7
0.68	177.7	36.9	0.0	108.2
0.82	186.9	52.5	0.0	131.8
0.96	197.1	73.2	0.0	159.0
1.09	206.3	95.6	0.0	185.1
1.23	216.4	124.1	0.0	215.1
1.37	226.5	156.9	0.0	246.5
1.50	235.7	190.8	0.0	276.3
1.64	245.9	232.5	0.0	310.5
1.78	256.0	279.2	0.0	346.1
1.91	265.2	326.2	0.0	379.7
2.05	275.3	382.9	0.0	418.0
2.19	284.5	439.3	0.0	454.1
2.32	294.7	506.7	0.0	495.2
2.46	304.8	580.2	0.0	537.7
2.60	314.0	652.2	0.0	577.6
2.73	324.1	737.5	0.0	622.9
2.87	334.3	829.3	0.0	669.6
3.01	343.5	918.6	0.0	713.3
3.14	353.6	1023.4	0.0	762.7
3.28	362.8	1124.9	0.0	808.9
3.42	373.0	1243.5	0.0	861.1
3.56	383.1	1369.6	0.0	914.7
3.69	392.3	1358.6	0.0	-319.4
3.83	402.4	1317.7	0.0	-263.1
3.97	411.6	1287.5	0.0	-210.6
4.10	421.8	1262.2	0.0	-151.5
4.24	431.9	1245.4	0.0	-91.0
4.38	441.1	1237.7	0.0	-34.7
4.51	451.2	1237.6	0.0	28.5
4.65	461.4	1246.7	0.0	93.2
4.79	470.6	1262.9	0.0	153.3
4.92	480.7	1289.8	0.0	220.7
5.06	489.9	1322.6	0.0	283.2
5.20	500.0	1368.2	0.0	353.4
5.33	510.2	1208.6	0.0	-3309.7
5.47	519.4	671.2	0.0	-3243.3
5.61	529.5	49.6	0.0	-3169.0
5.74	539.6	-510.9	0.0	-3093.2
5.88	548.8	-1013.3	0.0	-3023.1
6.02	559.0	-1548.7	0.0	-2944.6
6.15	568.2	-2027.6	0.0	-2872.0
6.29	578.3	-2578.7	0.0	-2790.7
6.43	588.4	-3072.9	0.0	-2708.0
6.56	597.6	-3513.2	0.0	-2631.6
6.70	607.8	-3979.7	0.0	-2546.2
6.84	617.0	-4394.4	0.0	-2467.3
6.97	627.1	-4868.1	0.0	-2379.1
7.11	637.2	-5289.4	0.0	-2289.5
7.25	646.4	-5661.9	0.0	-2206.8
7.38	656.6	-6053.1	0.0	-2114.5
7.52	666.7	-6428.2	0.0	-2020.7
7.66	675.9	-6787.0	0.0	-1934.2
7.79	686.0	-7129.1	0.0	-1837.7
7.93	695.3	-7427.9	0.0	-1748.7
8.07	705.4	-7737.5	0.0	-1649.4
8.20	715.5	-8029.6	0.0	-1548.8
8.34	724.7	-8304.1	0.0	-1456.0
8.48	734.9	-8560.7	0.0	-1352.5
8.61	745.0	-8799.1	0.0	-1247.7
8.75	754.2	-9001.5	0.0	-1151.1
8.89	764.3	-9204.3	0.0	-1043.5
9.02	773.5	-9373.6	0.0	-944.4
9.16	783.7	-9552.8	0.0	-834.1
9.30	793.8	-9698.0	0.0	-722.3
9.43	803.0	-9813.7	0.0	-619.5
9.57	813.1	-9920.8	0.0	-505.0
9.71	822.3	-10000.0	0.0	-399.6
9.84	832.5	-10069.9	0.0	-282.4
9.98	842.6	-10111.2	0.0	-163.7
10.12	913.9	-10129.3	0.0	-47.4
10.26	924.3	-10129.1	0.0	82.9

Harbor-At-Hastings Site at MW13

IT CORPORATION
A Member of The IT Group

By WTC Date 11/20/01 Subject SOIL PROFILE/DESIGN PARAMETERS Sheet No. 1 of 1

Chkd. By EJR Date 7/2/02 AERL HASTING-ON-HUDSON, NY Proj. No. 806938

.25 in. X .

SOIL PROFILE AND DESIGN PARAMETERS FOR BORING MW14

0' – 10'	LOOSE FILL	γ_T = 91 PCF, γ_{SUB} = 28.6 PCF; c = 0, ϕ = 31°; (BASED ON SPT N = 15)
10' – 17'	VERY LOOSE FILL	γ_T = 91 PCF, γ_{SUB} = 28.6 PCF; c = 0, ϕ = 25°; (BASED ON SPT N < 1)
17' – 30'	TRANSITION (FILL TO MARINE SILT) "CL"	γ_T = 96 PCF, γ_{SUB} = 33 PCF (ASSUMED); c = 2.72 PSI = 390 PSF; ϕ = 0
30' – 56'	MARINE GRAY SILT (SOFT)	~~γ_T = 110 PCF, γ_{SUB} = 50 PCF (ASSUMED); c = 1.55 PSI = 223 PSF; ϕ = 0~~
56' – 80'	LOOSE GRAY BASAL SAND	~~γ = 110 PCF, γ_{SUB} = 62 PCF (ASSUMED); c = 0, ϕ = 28°; (BASED ON SPT N_{AVG} = 3.4)~~
80' –	REDDISH [illegible]	γ = 110 PCF, γ [illegible] = 62 PCF (ASSUMED)

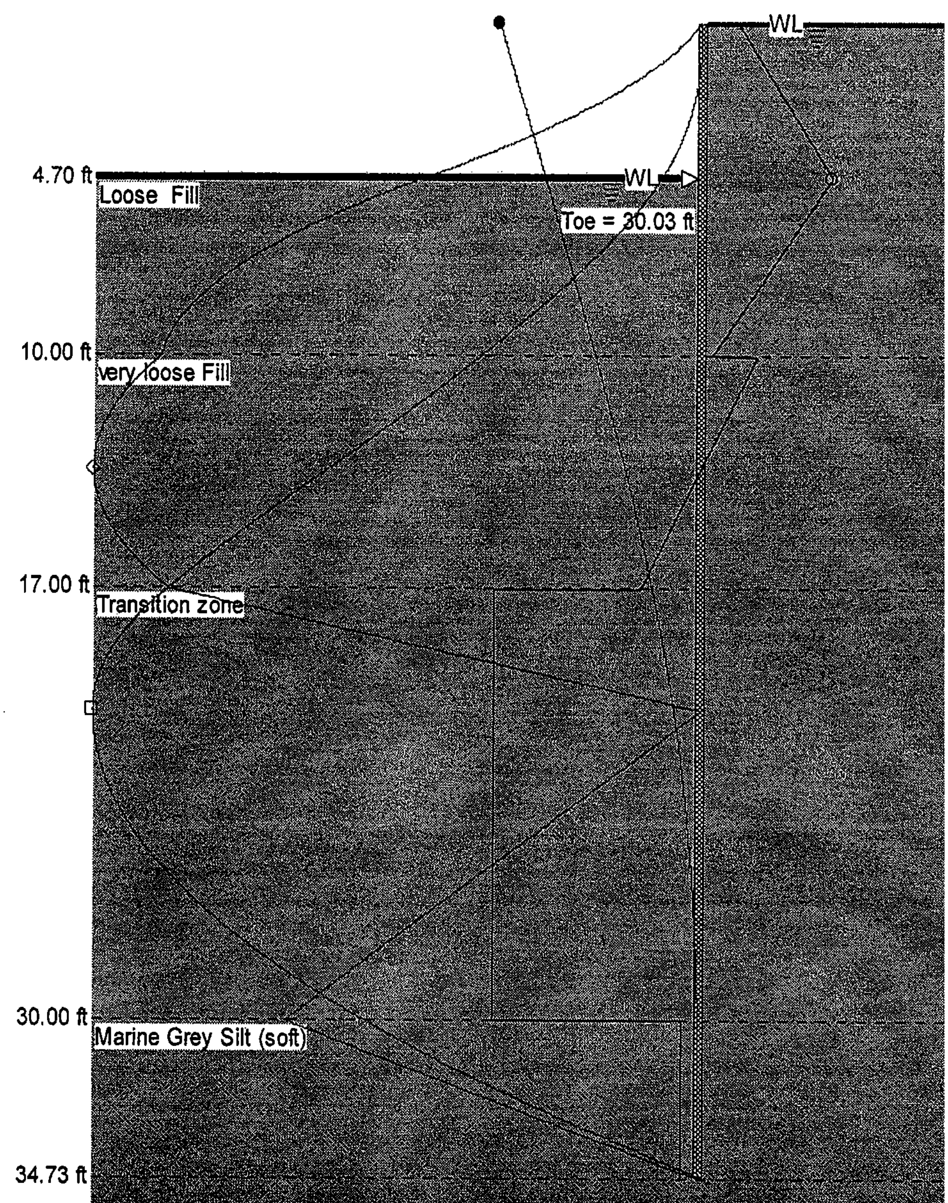
Client: AERL Hasting
Site: Hasting-on-Hudson, NY

Title: Boring MW-14, Cantilever
Ref: Case aMW14
Page: 1
Date: 6.27.02

Sheet: Arbed AZ48
Pressure: Coulomb; Full hydrostatic pressure in cohesive soils.
FOS: 1.0
Toe: Cantilever

	Maximum	d (ft)
○	464.1 psf	4.70
□	40264.3 ftlb/ft	20.70
◇	3070.2 lb/ft	13.43
●	1.0 in	0.00

dry excavation to 4.70 (cantilever)



Harbor-At-Hastings Site at MW14

Hasting-on Hu

Client:	AERL Hasting
Site:	Hasting-on-Hudson, NY
Title:	Boring MW-14, Cantilever
Ref:	Case aMW14
Page:	2
Date:	6.27.02
Sheet:	Arbed AZ48
Pressure:	Coulomb; Full hydrostatic pressure in cohesive soils.
FOS:	1.0
Toe:	Cantilever

dry excavation to 4.70 (cantilever)

Input Data

Depth Of Excavation = 4.70 ft
Surcharge = 400.0 psf
Depth Of Active Water = 0.00 ft
Depth Of Passive Water = 4.70 ft

Mi

Soil Profile

Depth (ft)	Soil Name	γ (pcf)	γ' (pcf)	C (psf)	C_a (psf)	φ (°)	δ (°)
0.00	Loose Fill	91.00	28.60	0.0	0.0	31.0	0.0
10.00	very loose Fill	91.00	28.60	0.0	0.0	25.0	0.0
17.00	Transition zone	96.00	33.00	390.0	0.0	0.0	0.0
30.00	Marine Grey Silt (soft)	110.00	50.00	223.0	0.0	0.0	0.0
56.00	Loose Basal Sand, some silt	110.00	62.00	0.0	0.0	28.0	0.0
80.00	Reddish Basal Sand	110.00	62.00	0.0	0.0	35.0	0.0

Solution

Sheet

Sheet Name	I (in⁴/ft)	E (psi)	Z (in³/ft)	F (psi)	Maximum Bendi Moment (ftlb/ft
Arbed AZ48	847.10	3.04E+07	89.30	25000.0	185820

Maxima

	Maximum	Depth
Bending Moment	40264.3 ftlb/ft	20.70 ft
Deflection	1.0 in	0.00 ft
Pressure	464.1 psf	4.70 ft
Shear Force	3070.2 lb/ft	13.43 ft

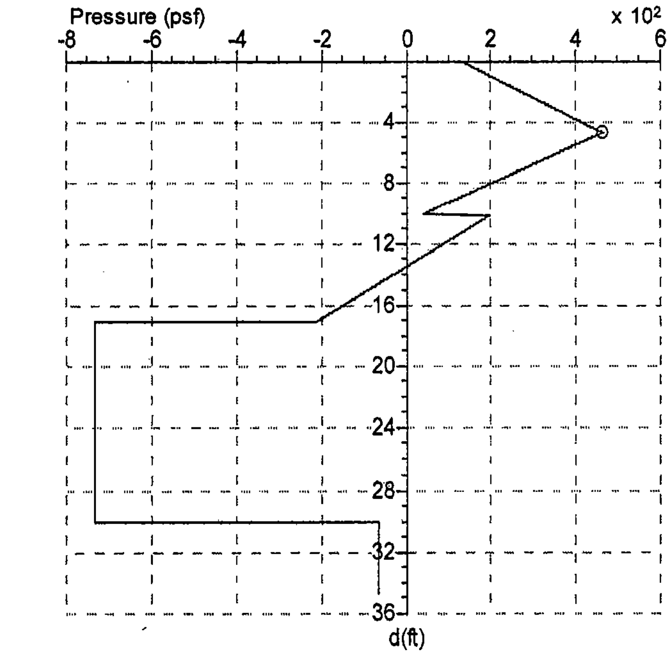
Client: AERL Hasting
Site: Hasting-on-Hudson, NY

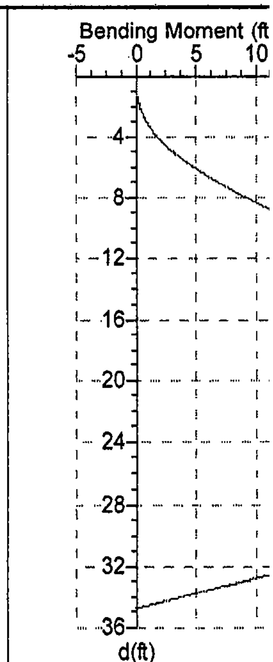
Title: Boring MW-14, Cantilever
Ref: Case aMW14
Page: 3
Date: 6.27.02

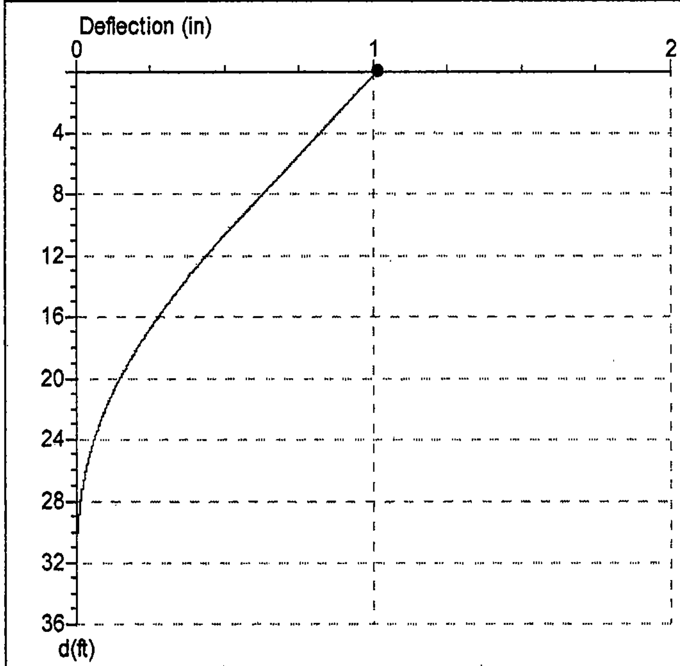
Sheet: Arbed AZ48
Pressure: Coulomb; Full hydrostatic pressure in cohesive soils.
FOS: 1.0
Toe: Cantilever

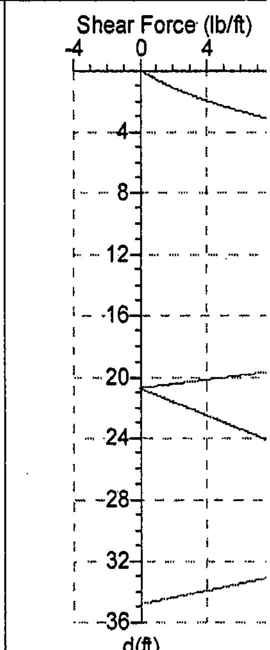
	Maximum	d (ft)
○	464.1 psf	4.70
□	40264.3 ftlb/ft	20.70
◇	3070.2 lb/ft	13.43
●	1.0 in	0.00

dry excavation to 4.70 (cantilever)









Harbor-At-Hastings Site at MW14

Hasting-on Hud

Client: AERL Hasting
Site: Hasting-on-Hudson, NY

Title: Boring MW-14, Cantilever
Ref: Case aMW14
Page: 4
Date: 6.27.02

Sheet: Arbed AZ48
Pressure: Coulomb; Full hydrostatic pressure in cohesive soils.
FOS: 1.0
Toe: Cantilever

dry excavation to 4.70 (cantilever)

depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)
0.00	128.0	0.1	1.0	7.4
0.31	150.8	7.4	1.0	48.4
0.61	173.5	30.2	1.0	100.3
0.92	194.2	66.0	1.0	153.8
1.23	217.0	124.3	1.0	219.6
1.54	239.8	204.7	0.9	292.7
1.84	260.5	298.7	0.9	365.4
2.15	283.3	427.4	0.9	452.3
2.46	304.0	569.3	0.9	537.6
2.77	326.7	754.9	0.9	638.3
3.07	349.5	973.5	0.9	746.3
3.38	370.2	1203.0	0.9	850.7
3.69	393.0	1491.3	0.8	972.6
4.00	415.7	1819.5	0.8	1101.6
4.30	436.5	2154.3	0.8	1225.3
4.61	459.2	2564.9	0.8	1368.2
4.92	446.5	2978.3	0.8	1500.3
5.23	421.0	3476.1	0.8	1638.1
5.53	395.5	4016.6	0.7	1767.7
5.84	372.3	4542.9	0.7	1878.4
6.15	346.8	5157.7	0.7	1992.6
6.46	321.3	5807.7	0.7	2098.5
6.76	298.1	6426.9	0.7	2187.9
7.07	272.6	7136.8	0.7	2278.4
7.38	249.5	7806.3	0.7	2353.6
7.68	224.0	8566.7	0.6	2428.6
7.99	198.5	9349.9	0.6	2495.4
8.30	175.3	10079.3	0.6	2549.2
8.61	149.8	10898.6	0.6	2600.6
8.91	126.6	11656.7	0.6	2640.2
9.22	101.1	12502.8	0.6	2676.1
9.53	75.6	13359.1	0.6	2703.9
9.84	52.4	14144.3	0.5	2722.1
10.14	192.1	15014.3	0.5	2758.2
10.45	173.5	15901.1	0.5	2816.1
10.76	156.5	16722.5	0.5	2863.6
11.07	137.8	17641.2	0.5	2910.2
11.37	120.9	18488.5	0.5	2947.4

depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)
11.68	102.2	19432.2	0.5	2982.6
11.99	83.5	20386.3	0.4	3011.9
12.30	66.6	21261.0	0.4	3033.4
12.60	47.9	22229.6	0.4	3051.3
12.91	29.2	23203.0	0.4	3063.3
13.22	12.2	24090.5	0.4	3069.1
13.52	-6.4	25068.0	0.4	3069.7
13.83	-23.4	25956.0	0.4	3065.2
14.14	-42.1	26930.6	0.3	3054.5
14.45	-60.7	27900.9	0.3	3037.9
14.75	-77.7	28777.6	0.3	3017.6
15.06	-96.4	29734.5	0.3	2989.6
15.37	-113.3	30595.9	0.3	2959.0
15.68	-132.0	31532.5	0.3	2919.7
15.98	-150.7	32455.8	0.3	2874.4
16.29	-167.6	33281.8	0.3	2828.1
16.60	-186.3	34174.3	0.3	2771.5
16.91	-205.0	35047.8	0.2	2708.9
17.21	-732.4	35814.8	0.2	2542.5
17.52	-732.4	36590.5	0.2	2309.2
17.83	-732.4	37231.3	0.2	2097.2
18.14	-732.4	37865.3	0.2	1864.0
18.44	-732.4	38425.1	0.2	1630.8
18.75	-732.4	38869.5	0.2	1418.8
19.06	-732.4	39287.5	0.2	1185.6
19.37	-732.4	39631.3	0.2	952.4
19.67	-732.4	39879.3	0.2	740.4
19.98	-732.4	40081.3	0.1	507.2
20.29	-732.4	40200.5	0.1	295.2
20.59	-732.4	40260.8	0.1	62.0
20.90	-732.4	40254.8	0.1	45.5
21.21	-732.4	40215.8	0.1	110.5
21.52	-732.4	40121.5	0.1	182.1
21.82	-732.4	40013.8	0.1	247.1
22.13	-732.4	39853.9	0.1	318.6
22.44	-732.4	39627.1	0.1	390.1
22.75	-732.4	39416.3	0.1	455.1
23.05	-732.4	39101.1	0.1	526.7

Harbor-At-Hastings Site at MW14

Hasting-on Huds

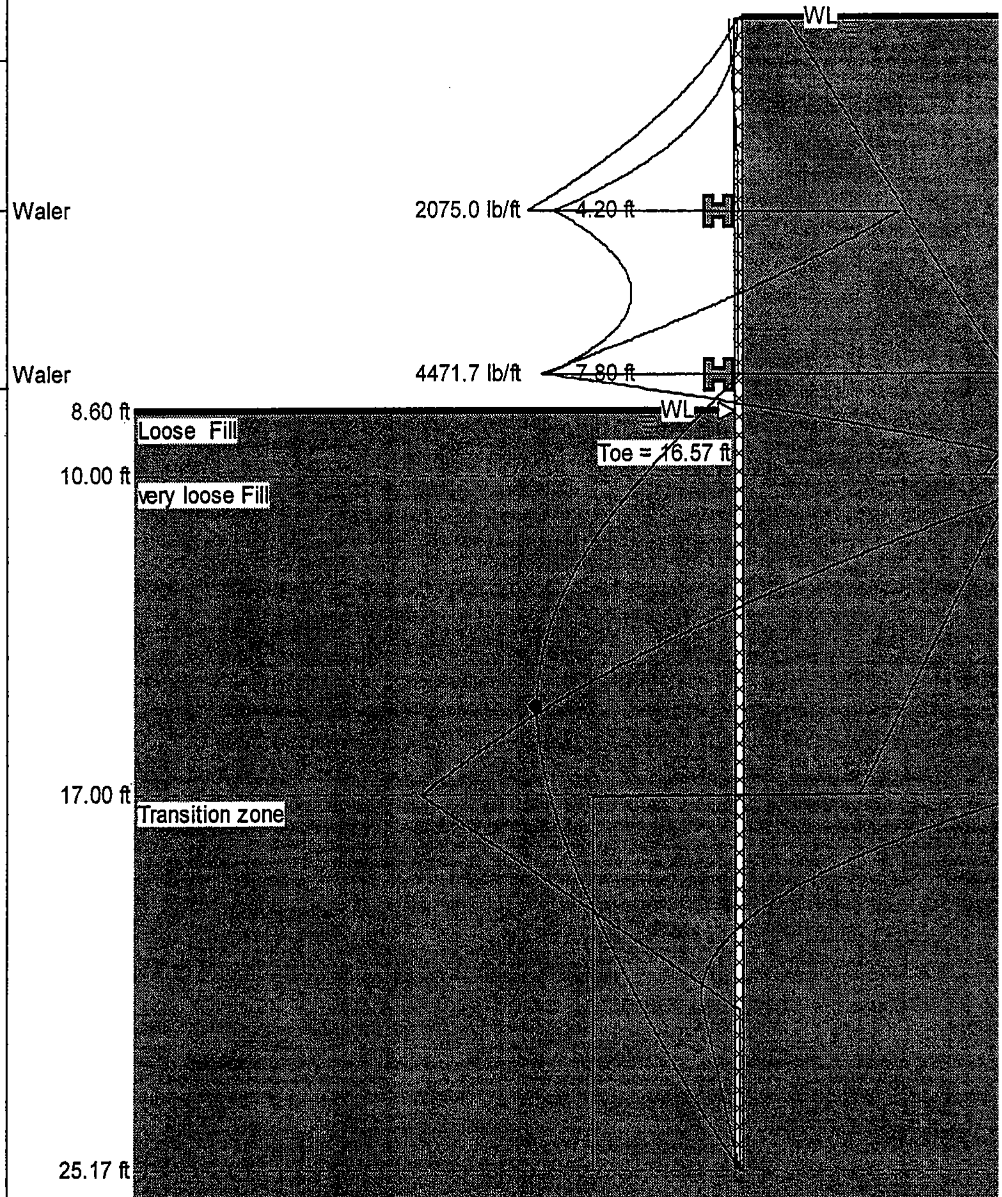
Client: AERL Hasting
Site: Hasting-on-Hudson, NY

Title: Boring MW-14, Cantilever
Ref: Case bMW14
Page: 1
Date: 6.27.02

Sheet: Arbed AZ48
Pressure: Coulomb; Full hydrostatic pressure in cohesive soils.
FOS: 2.0
Toe: Free Earth Support

	Maximum	d (ft)
○	743.1 psf	8.60
□	7166.7 ftlb/ft	13.09
◇	3363.0 lb/ft	7.80
●	0.0 in	15.08

1. dry excavation to 4.70' (cantilever)
2. install waler at 4.20'
3. dry excavation to 8.30'
4. install waler at 7.80'
5. dry excavation to 8.60' - inadequate space to install additional waler



Harbor-At-Hastings Site at MW14

Client: AERL Hasting
Site: Hasting-on-Hudson, NY

Title: Boring MW-14, Cantilever
Ref: Case bMW14
Page: 2
Date: 6.27.02

Sheet: Arbed AZ48
Pressure: Coulomb; Full hydrostatic pressure in cohesive soils.
FOS: 2.0
Toe: Free Earth Support

1. dry excavation to 4.70' (cantilever)
2. install waler at 4.20'
3. dry excavation to 8.30'
4. install waler at 7.80'
5. dry excavation to 8.60' - inadequate space to install additional waler

Input Data

Depth Of Excavation = 8.60 ft   Depth Of Active Water = 0.00 ft
Surcharge = 400.0 psf   Depth Of Passive Water = 8.60 ft   M

Soil Profile

Depth (ft)	Soil Name	γ (pcf)	γ' (pcf)	C (psf)	C_a (psf)	φ (°)	δ (°)
0.00	Loose Fill	91.00	28.60	0.0	0.0	31.0	0.0
10.00	very loose Fill	91.00	28.60	0.0	0.0	25.0	0.0
17.00	Transition zone	96.00	33.00	390.0	0.0	0.0	0.0
30.00	Marine Grey Silt (soft)	110.00	50.00	223.0	0.0	0.0	0.0
56.00	Loose Basal Sand, some silt	110.00	62.00	0.0	0.0	28.0	0.0
80.00	Reddish Basal Sand	110.00	62.00	0.0	0.0	35.0	0.0

Solution

Sheet

Sheet Name	I (in^4/ft)	E (psi)	Z (in^3/ft)	f (psi)	Maximum Bend Moment (ft-lb/
Arbed AZ48	847.10	3.04E+07	89.30	25000.0	18582

Load Model: Area Distribution

Supports

Depth (ft)	Type	Linear Load (lb/ft)
4.20	Waler	2075.0
7.80	Waler	4471.7

Maxima

Bending Moi
Deflection
Pressure
Shear Force

Harbor-At-Hastings Site at MW14

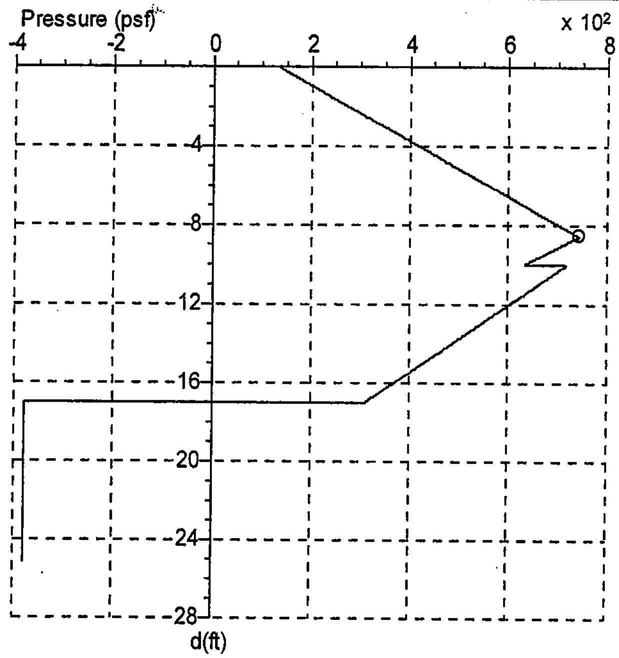
Client: A[illegible] Hasting
Site: Hasting-on-Hudson, NY

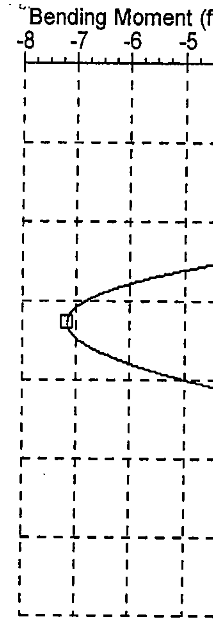
Title: Boring MW-14, Cantilever
Ref: Case bMW14
Page: 3
Date: 6.27.02

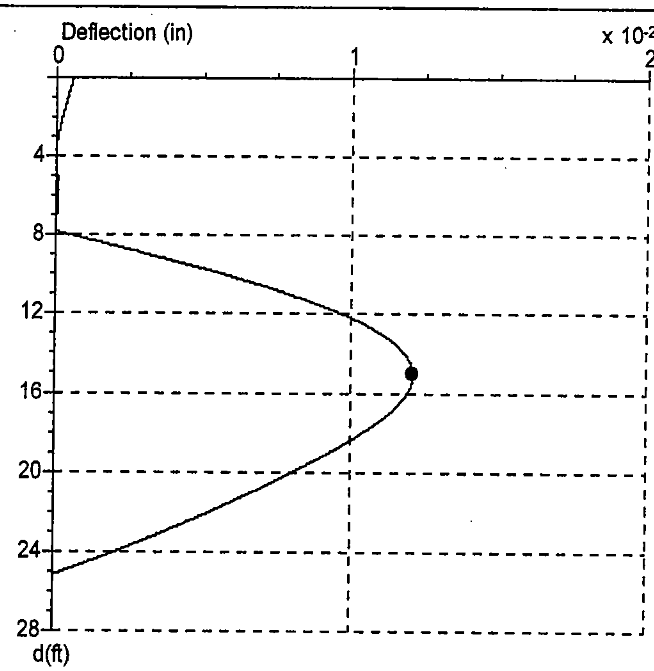
Sheet: Arbed AZ48
Pressure: Coulomb; Full hydrostatic pressure in cohesive soils.
FOS: 2.0
Toe: Free Earth Support

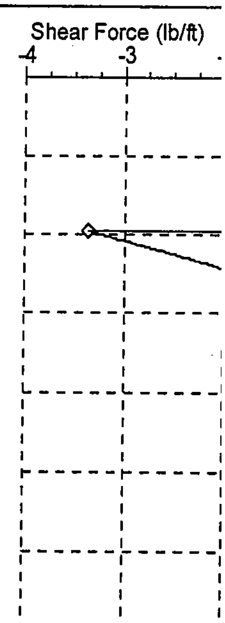
	Maximum	d (ft)
○	743.1 psf	8.60
□	7166.7 ftlb/ft	13.09
◇	3363.0 lb/ft	7.80
●	0.0 in	15.08

1. dry excavation to 4.70' (cantilever)
2. install waler at 4.20'
3. dry excavation to 8.30'
4. install waler at 7.80'
5. dry excavation to 8.60' - inadequate space to install additional waler









Harbor-At-Hastings Site at MW14

Client: AERL Hasting
Site: Hasting-on-Hudson, NY

Title: Boring MW-14, Cantilever
Ref: Case bMW14
Page: 4
Date: 6.27.02

Sheet: Arbed AZ48
Pressure: Coulomb; Full hydrostatic pressure in cohesive soils.
FOS: 2.0
Toe: Free Earth Support

1. dry excavation to 4.70' (cantilever)
2. install waler at 4.20'
3. dry excavation to 8.30'
4. install waler at 7.80'
5. dry excavation to 8.60' - inadequate space to install additional waler

depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)
0.00	128.0	0.2	0.0	5.4
0.22	144.5	4.9	0.0	34.3
0.45	161.0	18.0	0.0	69.7
0.67	176.0	37.9	0.0	105.2
0.89	192.5	69.5	0.0	147.8
1.11	209.0	112.1	0.0	194.3
1.34	224.0	161.2	0.0	239.9
1.56	240.5	227.5	0.0	293.6
1.78	255.5	299.7	0.0	345.8
2.00	272.0	393.1	0.0	406.8
2.23	288.5	502.0	0.0	471.6
2.45	303.5	615.3	0.0	533.9
2.67	320.0	756.5	0.0	606.0
2.90	336.5	916.0	0.0	681.9
3.12	351.5	1077.7	0.0	754.2
3.34	368.0	1274.7	0.0	837.3
3.56	383.0	1472.0	0.0	916.2
3.79	399.5	1709.9	0.0	1006.7
4.01	416.0	1970.7	0.0	1100.9
4.23	431.0	2135.3	0.0	-885.1
4.45	447.5	1930.7	0.0	-783.6
4.68	464.0	1751.6	0.0	-678.3
4.90	479.0	1611.7	0.0	-579.3
5.12	495.5	1484.0	0.0	-466.7
5.35	510.5	1392.4	0.0	-361.0
5.57	527.0	1319.4	0.0	-241.2
5.79	543.5	1276.5	0.0	-117.6
6.01	558.5	1264.4	0.0	-1.8
6.24	575.0	1281.4	0.0	129.1
6.46	590.0	1325.4	0.0	251.4
6.68	606.5	1405.8	0.0	389.6
6.90	623.0	1520.9	0.0	531.6
7.13	638.0	1656.3	0.0	663.9
7.35	654.5	1839.9	0.0	813.2
7.57	671.0	2060.9	0.0	966.2
7.80	686.0	2194.7	0.0	-3363.0
8.02	702.5	1358.9	0.0	-3202.6
8.24	717.5	634.0	0.0	-3053.6
8.46	734.0	-124.3	0.0	-2886.0
8.69	734.8	-840.8	0.0	-2715.5
8.91	718.0	-1456.0	0.0	-2563.3
9.13	699.5	-2093.9	0.0	-2400.0
9.35	681.0	-2692.1	0.0	-2241.0
9.58	664.2	-3202.4	0.0	-2100.1
9.80	645.8	-3727.7	0.0	-1949.2
10.02	717.7	-4173.5	0.0	-1813.8
10.24	704.1	-4626.5	0.0	-1650.0
10.47	690.6	-5039.6	0.0	-1489.2
10.69	678.3	-5381.1	0.0	-1345.8
10.91	664.8	-5720.1	0.0	-1191.0
11.14	652.5	-5995.4	0.0	-1053.0
11.36	639.0	-6263.0	0.0	-904.2
11.58	625.4	-6494.2	0.0	-758.5
11.80	613.1	-6673.7	0.0	-628.7
12.03	599.6	-6837.9	0.0	-489.0
12.25	586.1	-6968.0	0.0	-352.4
12.47	573.8	-7057.5	0.0	-230.9
12.69	560.3	-7124.8	0.0	-100.2
12.92	548.0	-7158.4	0.0	15.9
13.14	534.4	-7165.7	0.0	140.6
13.36	520.9	-7142.7	0.0	262.2
13.59	508.6	-7096.1	0.0	370.0
13.81	495.1	-7017.3	0.0	485.6
14.03	481.6	-6910.5	0.0	598.2
14.25	469.3	-6789.6	0.0	697.7
14.48	455.7	-6631.3	0.0	804.3
14.70	443.5	-6464.9	0.0	898.4
14.92	429.9	-6257.9	0.0	999.0
15.14	416.4	-6026.5	0.0	1096.5
15.37	404.1	-5795.6	0.0	1182.4
15.59	390.6	-5519.8	0.0	1274.0
15.81	378.3	-5249.9	0.0	1354.5
16.04	364.8	-4932.5	0.0	1440.0
16.26	351.2	-4594.4	0.0	1522.5
16.48	338.9	-4269.8	0.0	1594.7
16.70	325.4	-3894.4	0.0	1671.2

Harbor-At-Hastings Site at MW14

Client: AERL Hasting
Site: Hasting-on-Hudson, NY

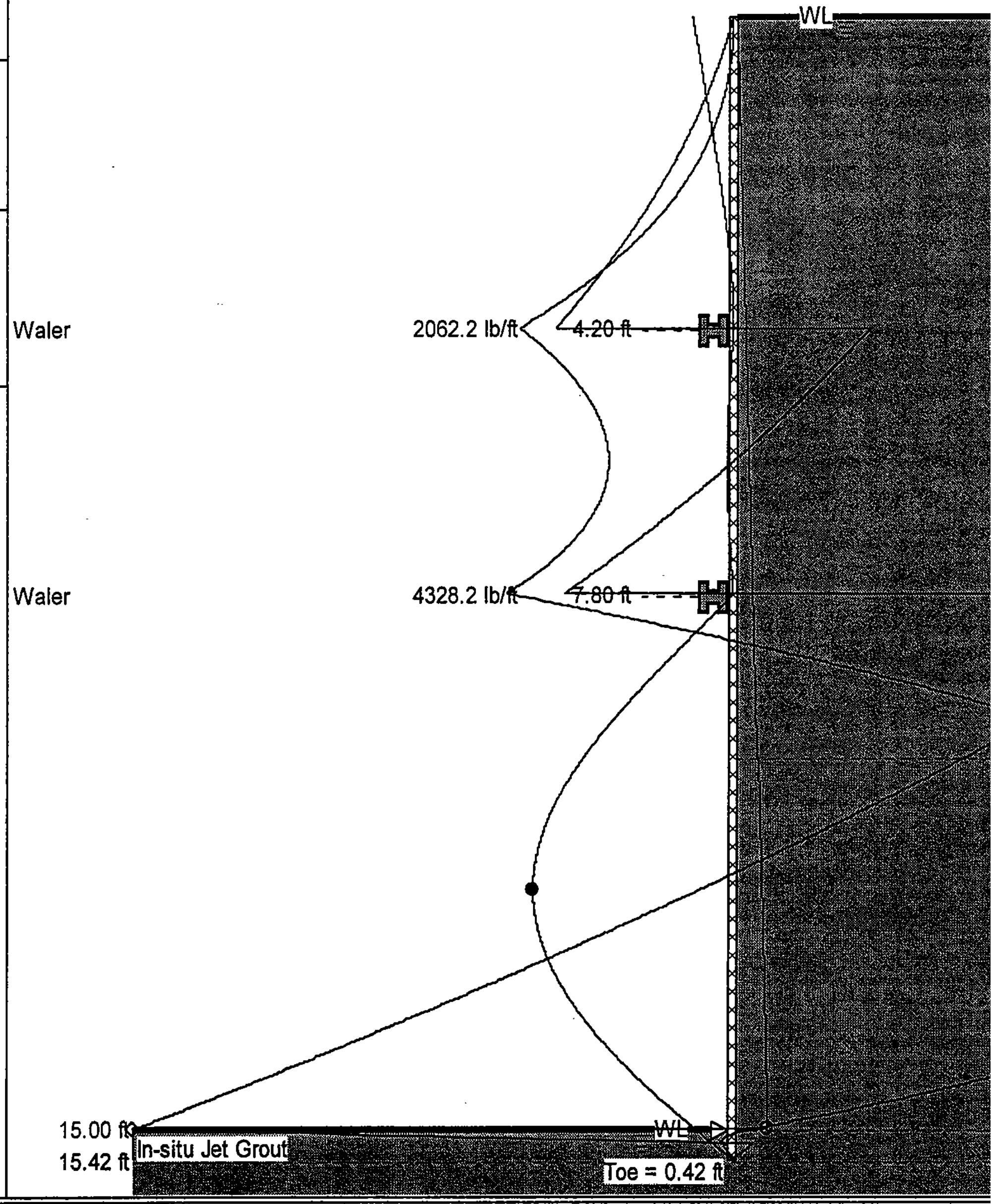
Title: Boring MW-14, two walers
Ref: CasedMW14
Page: 1
Date: 6.27.02

Sheet: Arbed AZ48
Pressure: Coulomb; Full hydrostatic pressure in cohesive soils.
FOS: 2.1
Toe: Fixed Earth Support

	Maximum	d (ft)
○	1275.4 psf	15.00
□	4299.0 ftlb/ft	11.89
◇	3941.1 lb/ft	15.01
●	0.0 in	11.80

15' excavation with 4' of grout (grout from 15.00 to 19.00)

1) dry excavation to 4.70' (cantilever)
2) install waler at 4.20'
3) dry excavation to 8.30'
4) install waler at 7.80'
5) dry excavation to 15.00'



Harbor-At-Hastings Site at MW14

Client: AERL Hasting
Site: Hasting-on-Hudson, NY

Title: Boring MW-14, two walers
Ref: CasedMW14
Page: 2
Date: 6.27.02

Sheet: Arbed AZ48
Pressure: Coulomb; Full hydrostatic pressure in cohesive soils.
FOS: 2.1
Toe: Fixed Earth Support

15' excavation with 4' of grout (grout from 15.00 to 19.00)

1) dry excavation to 4.70' (cantilever)
2) install waler at 4.20'
3) dry excavation to 8.30'
4) install waler at 7.80'
5) dry excavation to 15.00'

Input Data

Depth Of Excavation = 15.00 ft   Depth Of Active Water = 0.00 ft
Surcharge = 400.0 psf   Depth Of Passive Water = 15.00 ft   Mi

Soil Profile

Depth (ft)	Soil Name	γ (pcf)	γ' (pcf)	C (psf)	C_a (psf)	ϕ (°)	δ (°)
0.00	Loose Fill	91.00	28.60	0.0	0.0	31.0	0.0
10.00	very loose Fill	91.00	28.60	0.0	0.0	25.0	0.0
15.00	In-situ Jet Grout	125.00	63.00	10800.0	1800.0	0.0	0.0
19.00	Transition zone	96.00	33.00	390.0	0.0	0.0	0.0
30.00	Marine Gray Silt (soft)	110.00	50.00	223.0	0.0	0.0	0.0
56.00	Loose Basal Sand, some silt	110.00	62.00	0.0	0.0	28.0	0.0
80.00	Reddish Basal Sand	110.00	62.00	0.0	0.0	35.0	0.0

Solution

Sheet

Sheet Name	I (in^4/ft)	E (psi)	Z (in^3/ft)	f (psi)	Maximum Bend Moment (ftlb/f
Arbed AZ48	847.10	3.04E+07	89.30	25000.0	18582

Load Model: Area Distribution

Supports

Depth (ft)	Type	Linear Load (lb/ft)
4.20	Waler	2062.2
7.80	Waler	4328.2

Maxima

Bending Mor
Deflection
Pressure
Shear Force

Harbor-At-Hastings Site at MW14

Client: AERL Hasting
Site: Hasting-on-Hudson, NY

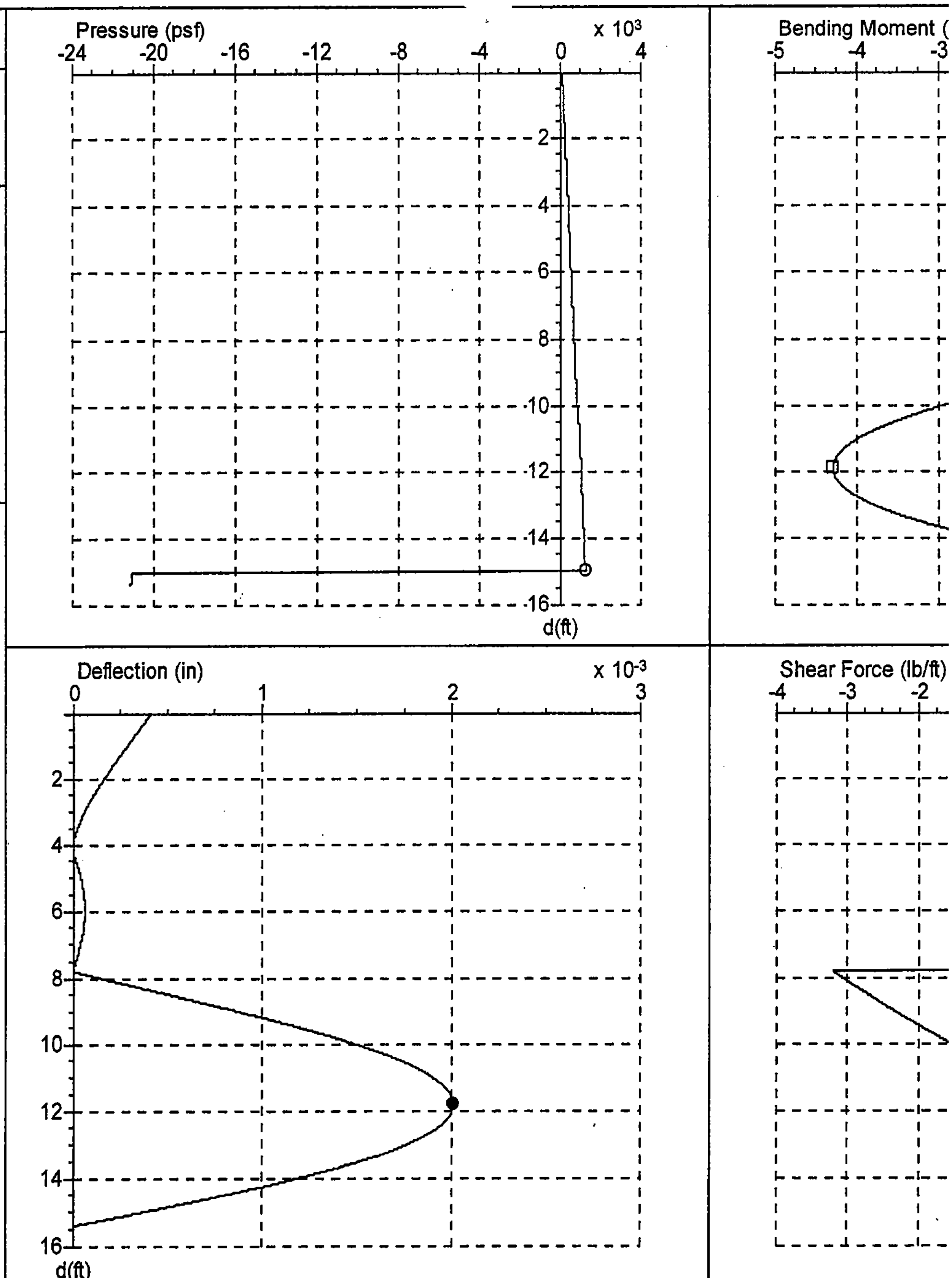
Title: Boring MW-14, two walers
Ref: CasedMW14
Page: 3
Date: 6.27.02

Sheet: Arbed AZ48
Pressure: Coulomb; Full hydrostatic pressure in cohesive soils.
FOS: 2.1
Toe: Fixed Earth Support

	Maximum	d (ft)
○	1275.4 psf	15.00
□	4299.0 ftlb/ft	11.89
◇	3941.1 lb/ft	15.01
●	0.0 in	11.80

15' excavation with 4' of grout (grout from 15.00 to 19.00)

1) dry excavation to 4.70' (cantilever)
2) install waler at 4.20'
3) dry excavation to 8.30'
4) install waler at 7.80'
5) dry excavation to 15.00'



Harbor-At-Hastings Site at MW14

Client: AERL Hasting
Site: Hasting-on-Hudson, NY

Title: Boring MW-14, two walers
Ref: CasedMW14
Page: 4
Date: 6.27.02

Sheet: Arbed AZ48
Pressure: Coulomb; Full hydrostatic pressure in cohesive soils.
FOS: 2.1
Toe: Fixed Earth Support

15' excavation with 4' of grout (grout from 15.00 to 19.00)

1) dry excavation to 4.70' (cantilever)
2) install waler at 4.20'
3) dry excavation to 8.30'
4) install waler at 7.80'
5) dry excavation to 15.00'

depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)	depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)
0.00	128.0	0.0	0.0	3.3	5.19	499.4	1026.9	0.0	-429.3
0.14	138.1	1.3	0.0	20.5	5.32	509.5	984.9	0.0	-357.9
0.27	148.2	4.7	0.0	40.8	5.46	518.7	953.5	0.0	-291.8
0.41	157.4	9.7	0.0	60.5	5.60	528.8	926.6	0.0	-217.7
0.55	167.5	17.5	0.0	83.6	5.73	538.9	907.6	0.0	-142.1
0.68	177.6	27.9	0.0	108.0	5.87	548.1	897.5	0.0	-72.2
0.82	186.8	39.7	0.0	131.5	6.01	558.2	894.3	0.0	6.1
0.96	196.9	55.4	0.0	158.7	6.14	567.4	898.8	0.0	78.5
1.09	206.1	72.3	0.0	184.7	6.28	577.5	911.9	0.0	159.5
1.23	216.2	93.8	0.0	214.6	6.42	587.6	933.8	0.0	241.9
1.36	226.4	118.7	0.0	245.9	6.55	596.8	961.5	0.0	318.1
1.50	235.6	144.3	0.0	275.7	6.69	606.9	1000.6	0.0	403.2
1.64	245.7	175.9	0.0	309.8	6.82	616.1	1044.2	0.0	481.9
1.77	255.8	211.2	0.0	345.3	6.96	626.2	1101.1	0.0	569.8
1.91	265.0	246.7	0.0	378.8	7.10	636.4	1167.5	0.0	659.1
2.05	275.1	289.6	0.0	417.1	7.23	645.5	1236.2	0.0	741.5
2.18	284.3	332.2	0.0	453.1	7.37	655.7	1321.2	0.0	833.6
2.32	294.4	383.2	0.0	494.0	7.51	665.8	1416.1	0.0	927.1
2.46	304.5	438.7	0.0	536.4	7.64	675.0	1511.2	0.0	1013.3
2.59	313.7	493.2	0.0	576.2	7.78	685.1	1625.6	0.0	1109.5
2.73	323.8	557.7	0.0	621.4	7.92	694.3	1287.3	0.0	-3130.0
2.87	333.9	627.1	0.0	667.9	8.05	704.4	922.3	0.0	-3031.1
3.00	343.1	694.6	0.0	711.5	8.19	714.5	567.9	0.0	-2930.7
3.14	353.2	773.9	0.0	760.8	8.33	723.7	255.2	0.0	-2838.2
3.28	362.4	850.6	0.0	806.8	8.46	733.8	-78.2	0.0	-2735.1
3.41	372.5	940.2	0.0	858.8	8.60	743.9	-400.5	0.0	-2630.6
3.55	382.6	1035.5	0.0	912.3	8.74	753.1	-683.7	0.0	-2534.3
3.69	391.8	1127.2	0.0	962.1	8.87	763.2	-984.3	0.0	-2427.1
3.82	401.9	1233.8	0.0	1018.3	9.01	772.4	-1247.5	0.0	-2328.3
3.96	411.1	1336.0	0.0	1070.6	9.15	782.5	-1525.9	0.0	-2218.3
4.09	421.2	1454.4	0.0	1129.5	9.28	792.6	-1792.3	0.0	-2106.9
4.23	431.4	1498.6	0.0	-872.4	9.42	801.8	-2024.0	0.0	-2004.4
4.37	440.6	1416.5	0.0	-816.3	9.55	811.9	-2267.3	0.0	-1890.3
4.50	450.7	1332.5	0.0	-753.2	9.69	821.1	-2477.8	0.0	-1785.2
4.64	460.8	1255.4	0.0	-688.7	9.83	831.2	-2697.4	0.0	-1668.4
4.78	470.0	1191.4	0.0	-628.9	9.96	841.4	-2904.4	0.0	-1550.1
4.91	480.1	1127.8	0.0	-561.6	10.10	912.6	-3081.2	0.0	-1434.9
5.05	489.3	1076.4	0.0	-499.3	10.24	923.0	-3262.5	0.0	-1305.1

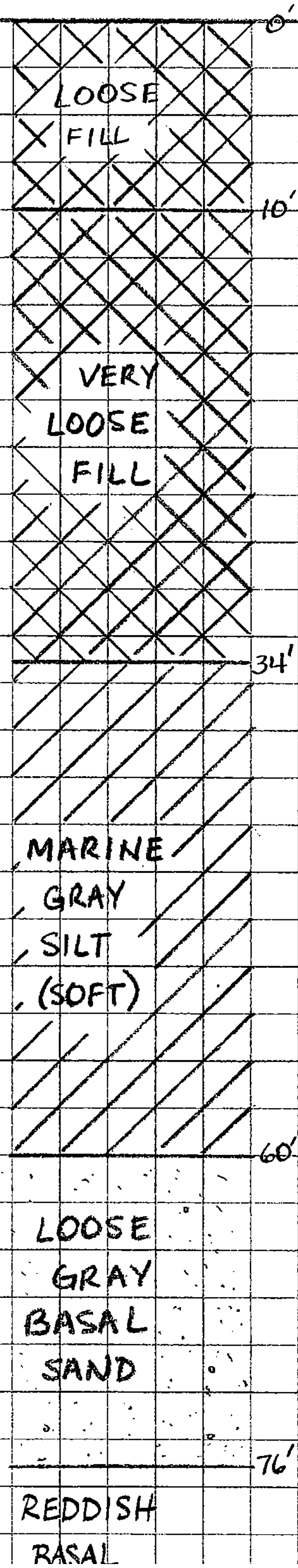
Harbor-At-Hastings Site at MW14

By WTC Date 11-20-01 Subject SOIL PROFILE / DESIGN PARAMETERS Sheet No. 1 of 1

Chkd. By EJR Date 7-2-02 AERL HASTING-ON-HUDSON, NY Proj. No. 806938

.25 in. X .25 in.

SOIL PROFILE AND DESIGN PARAMETERS FOR BORING MW15



0'–10' Loose fill

$\gamma_T = 91$ PCF $\gamma_{SUB} = 28.6$ PCF
C = 0 $\phi = 31°$
(BASED ON SPT N = 15)

10'–34' Very loose fill

$\gamma = 91$ PCF $\gamma_{SUB} = 28.6$ PCF
C = 0 $\phi = 25°$
(BASED ON SPT N < 1)

34'–60' Marine gray silt (soft)

$\gamma_T = 110$ PCF $\gamma_{SUB} = 50$ PCF (ASSUMED)
C = 1.55 PSI = 223 PSF
$\phi = 0$

60'–76' Loose gray basal sand

$\gamma_T = 110$ PCF $\gamma_{SUB} = 62$ PCF (ASSUMED)
C = 0 $\phi = 28°$
(BASED ON SPT $N_{AVG} = 3.4$)

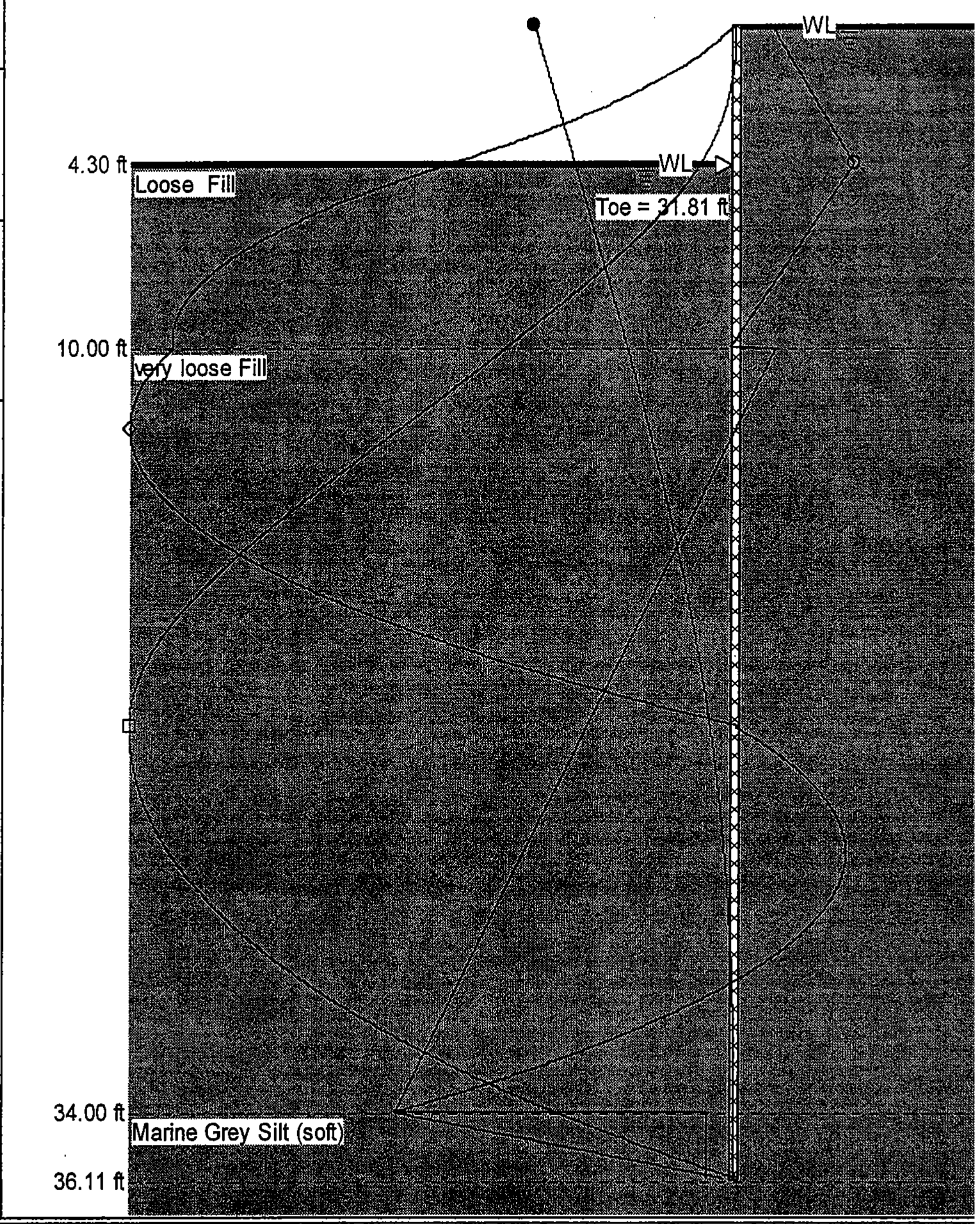
76' – Reddish basal

$\gamma_T = 110$ PCF $\gamma_{SUB} = 62$ PCF (ASSUMED)

Client:	AERL Hasting
Site:	Hasting-on-Hudson, NY
Title:	Boring MW-15, Cantilever
Ref:	Case aMW15
Page:	1
Date:	6.27.02
Sheet:	Arbed AZ48
Pressure:	Coulomb; Full hydrostatic pressure in cohesive soils.
FOS:	1.0
Toe:	Cantilever

	Maximum	d (ft)
○	435.5 psf	4.30
□	36129.3 ftlb/ft	21.91
◇	2576.8 lb/ft	12.52
●	1.0 in	0.00

dry excavation to 4.30 (cantilever)



Harbor-At-Hastings Site at MW15

Client: AERL Hasting
Site: Hasting-on-Hudson, NY

Title: Boring MW-15, Cantilever
Ref: Case aMW15
Page: 2
Date: 6.27.02

Sheet: Arbed AZ48
Pressure: Coulomb; Full hydrostatic pressure in cohesive soils.
FOS: 1.0
Toe: Cantilever

dry excavation to 4.30 (cantilever)

Input Data

Depth Of Excavation = 4.30 ft
Surcharge = 400.0 psf
Depth Of Active Water = 0.00 ft
Depth Of Passive Water = 4.30 ft

M

Soil Profile

Depth (ft)	Soil Name	γ (pcf)	γ' (pcf)	C (psf)	C_a (psf)	ϕ (°)	δ (°)
0.00	Loose Fill	91.00	28.60	0.0	0.0	31.0	0.0
10.00	very loose Fill	91.00	28.60	0.0	0.0	25.0	0.0
34.00	Marine Grey Silt (soft)	110.00	50.00	223.0	0.0	0.0	0.0
60.00	Loose Basal Sand, some silt	110.00	62.00	0.0	0.0	28.0	0.0
76.00	Reddish Basal Sand	110.00	62.00	0.0	0.0	35.0	0.0

Solution

Sheet

Sheet Name	I (in^4/ft)	E (psi)	Z (in^3/ft)	f (psi)	Maximum Bend Moment (ftlb/f
Arbed AZ48	847.10	3.04E+07	89.30	25000.0	18582

Maxima

	Maximum	Depth
Bending Moment	36129.3 ftlb/ft	21.91 ft
Deflection	1.0 in	0.00 ft
Pressure	435.5 psf	4.30 ft
Shear Force	2576.8 lb/ft	12.52 ft

Harbor-At-Hastings Site at MW15

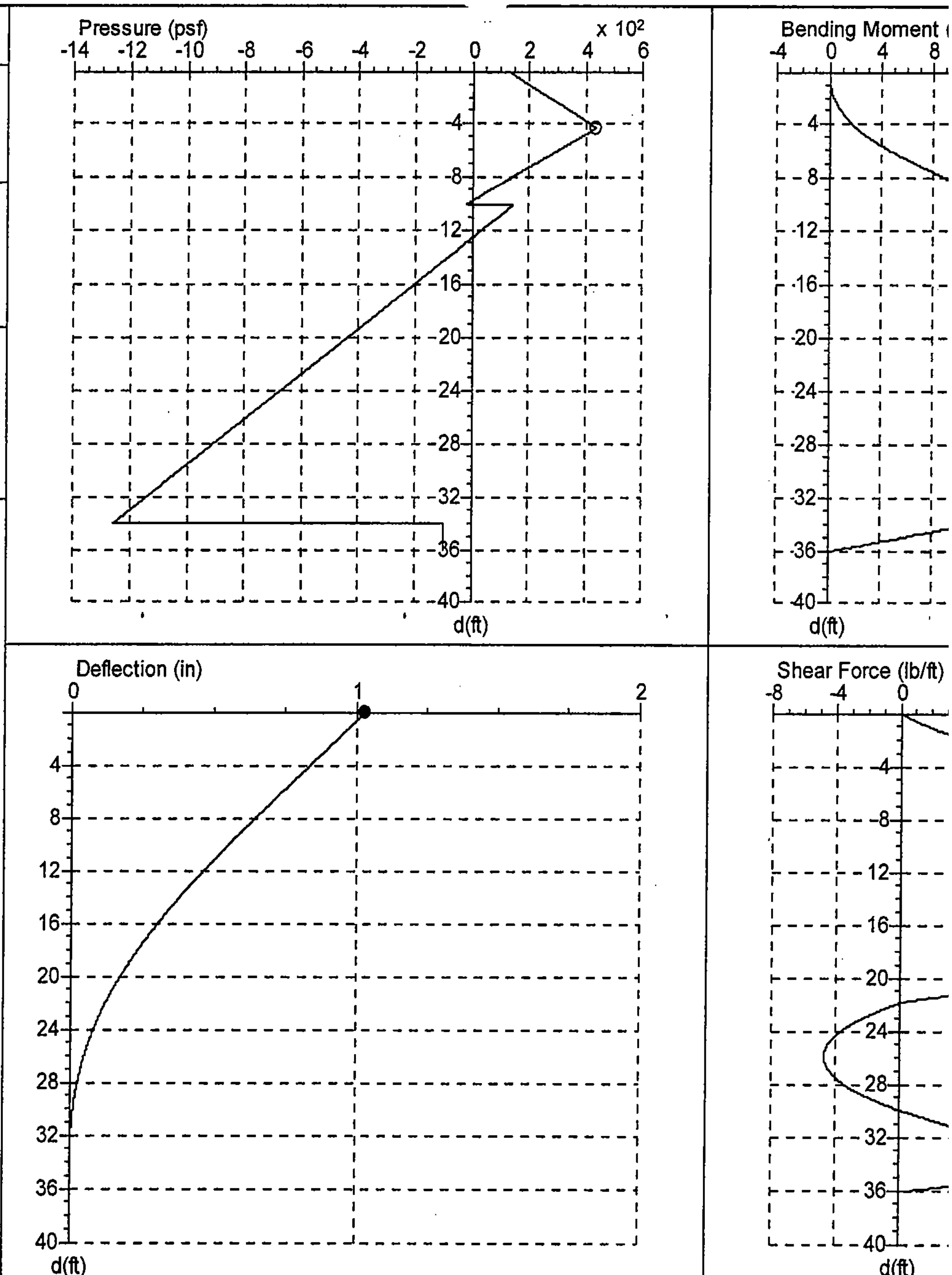
Client: AERL Hasting
Site: Hasting-on-Hudson, NY

Title: Boring MW-15, Cantilever
Ref: Case aMW15
Page: 3
Date: 6.27.02

Sheet: Arbed AZ48
Pressure: Coulomb; Full hydrostatic pressure in cohesive soils.
FOS: 1.0
Toe: Cantilever

	Maximum	d (ft)
○	435.5 psf	4.30
□	36129.3 ftlb/ft	21.91
◇	2576.8 lb/ft	12.52
●	1.0 in	0.00

dry excavation to 4.30 (cantilever)



Harbor-At-Hastings Site at MW15

Client: AERL Hasting
Site: Hasting-on-Hudson, NY

Title: Boring MW-15, Cantilever
Ref: Case aMW15
Page: 4
Date: 6.27.02

Sheet: Arbed AZ48
Pressure: Coulomb; Full hydrostatic pressure in cohesive soils.
FOS: 1.0
Toe: Cantilever

dry excavation to 4.30 (cantilever)

depth (ft)	P (psf)	M (ft-lb/ft)	D (in)	F (lb/ft)
0.00	128.0	0.1	1.0	7.7
0.32	151.7	8.1	1.0	50.4
0.64	175.4	32.7	1.0	104.9
0.96	196.9	71.8	1.0	161.3
1.28	220.6	135.4	1.0	230.7
1.60	244.2	223.2	1.0	308.0
1.92	265.8	326.2	0.9	385.1
2.24	289.4	467.3	0.9	477.3
2.56	311.0	623.1	0.9	568.0
2.88	334.6	827.0	0.9	675.2
3.20	358.3	1067.6	0.9	790.2
3.52	379.8	1320.4	0.9	901.6
3.84	403.5	1638.2	0.8	1031.7
4.15	427.2	2000.3	0.8	1169.5
4.47	420.8	2369.8	0.8	1298.7
4.79	394.3	2820.3	0.8	1433.2
5.11	370.2	3267.3	0.8	1547.9
5.43	343.7	3797.7	0.8	1665.6
5.75	317.1	4365.7	0.8	1774.6
6.07	293.0	4912.4	0.7	1866.1
6.39	266.5	5544.2	0.7	1958.3
6.71	240.0	6205.3	0.7	2041.7
7.03	215.9	6829.2	0.7	2110.0
7.35	189.4	7538.0	0.7	2176.7
7.67	165.3	8200.5	0.7	2229.7
7.99	138.8	8946.3	0.6	2279.6
8.31	112.3	9707.5	0.6	2320.8
8.63	88.2	10410.1	0.6	2350.6
8.95	61.7	11192.2	0.6	2375.0
9.27	37.6	11909.1	0.6	2389.6
9.59	11.1	12701.6	0.6	2397.2
9.91	-15.4	13495.3	0.6	2396.1
10.23	134.8	14218.7	0.5	2423.9
10.55	115.4	15027.5	0.5	2465.0
10.87	96.0	15848.9	0.5	2499.7
11.19	78.3	16604.8	0.5	2525.7
11.51	58.9	17444.5	0.5	2548.1
11.83	41.3	18213.5	0.5	2562.9
12.14	21.8	19063.6	0.5	2573.0
12.46	2.4	19916.2	0.4	2576.8
12.78	-15.2	20691.5	0.4	2574.6
13.10	-34.6	21542.7	0.4	2566.0
13.42	-54.0	22390.1	0.4	2551.1
13.74	-71.7	23155.4	0.4	2531.9
14.06	-91.1	23989.7	0.4	2504.7
14.38	-108.7	24739.5	0.4	2474.3
14.70	-128.1	25552.9	0.4	2434.8
15.02	-147.5	26352.2	0.3	2388.9
15.34	-165.2	27064.9	0.3	2341.6
15.66	-184.6	27831.5	0.3	2283.4
15.98	-202.2	28510.9	0.3	2224.9
16.30	-221.7	29237.1	0.3	2154.4
16.62	-241.1	29938.9	0.3	2077.6
16.94	-258.7	30554.1	0.3	2002.1
17.26	-278.1	31203.7	0.3	1912.9
17.58	-297.5	31822.8	0.3	1817.4
17.90	-315.2	32357.3	0.2	1724.9
18.22	-334.6	32912.3	0.2	1617.1
18.54	-352.2	33385.1	0.2	1513.5
18.86	-371.6	33868.2	0.2	1393.3
19.18	-391.1	34310.6	0.2	1266.8
19.50	-408.7	34675.7	0.2	1146.2
19.82	-428.1	35034.4	0.2	1007.4
20.13	-447.5	35346.3	0.2	862.2
20.45	-465.2	35587.3	0.2	724.6
20.77	-484.6	35803.6	0.2	567.1
21.09	-502.2	35954.3	0.1	418.3
21.41	-521.6	36067.4	0.1	248.6
21.73	-541.0	36123.3	0.1	72.4
22.05	-558.7	36126.9	0.1	-27.9
22.37	-578.1	36098.3	0.1	-100.2
22.69	-595.7	36046.2	0.1	-160.3
23.01	-615.1	35955.1	0.1	-220.4
23.33	-634.6	35847.0	0.1	-274.0
23.65	-652.2	35712.0	0.1	-317.1
23.97	-671.6	35523.9	0.1	-358.4

Harbor-At-Hastings Site at MW15

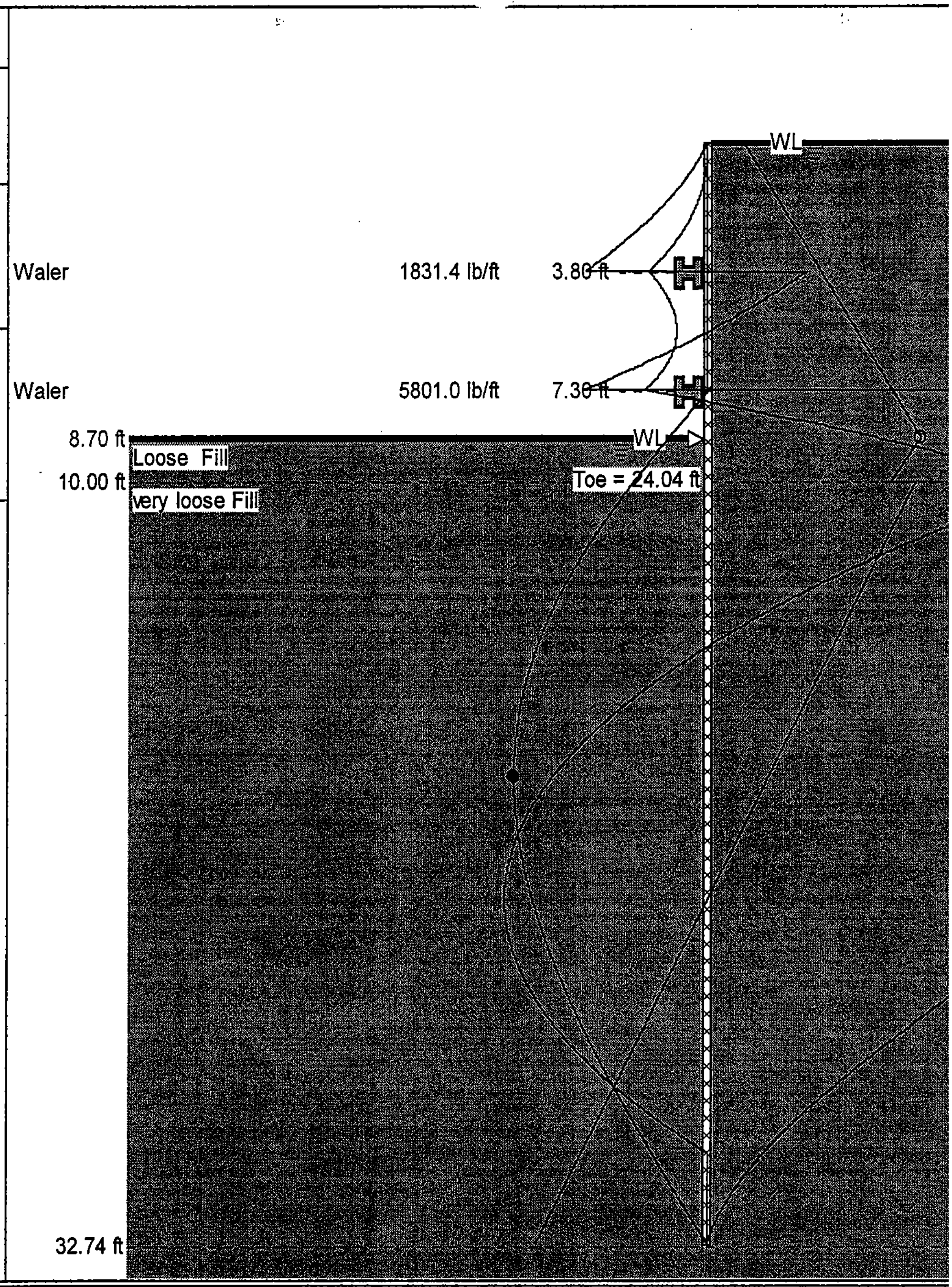
Client: AERL Hasting
Site: Hasting-on-Hudson, NY

Title: Boring MW-15
Ref: Case bMW15
Page: 1
Date: 6.27.02

Sheet: Arbed AZ48
Pressure: Coulomb; Full hydrostatic pressure in cohesive soils.
FOS: 2.0
Toe: Free Earth Support

	Maximum	d (ft)
○	750.2 psf	8.70
□	16199.2 ftlb/ft	14.93
◇	4773.4 lb/ft	7.30
●	0.1 in	18.80

1) dry excavation to 4.30' (cantilever)
2) install waler at 3.80'
3) dry excavation to 7.80'
4) install waler at 7.30'
5) dry excavation to 8.70' - inadequate space to install additional waler



Harbor-At-Hastings Site at MW15

Client: AERL Hasting
Site: Hasting-on-Hudson, NY

Title: Boring MW-15
Ref: Case bMW15
Page: 2
Date: 6.27.02

Sheet: Arbed AZ48
Pressure: Coulomb; Full hydrostatic pressure in cohesive soils.
FOS: 2.0
Toe: Free Earth Support

1) dry excavation to 4.30' (cantilever)
2) install waler at 3.80'
3) dry excavation to 7.80'
4) install waler at 7.30'
5) dry excavation to 8.70' - inadequate space to install additional waler

Input Data

Depth Of Excavation = 8.70 ft
Surcharge = 400.0 psf
Depth Of Active Water = 0.00 ft
Depth Of Passive Water = 8.70 ft

M

Soil Profile

Depth (ft)	Soil Name	γ (pcf)	γ' (pcf)	C (psf)	C_a (psf)	ϕ (°)	δ (°)
0.00	Loose Fill	91.00	28.60	0.0	0.0	31.0	0.0
10.00	very loose Fill	91.00	28.60	0.0	0.0	25.0	0.0
34.00	Marine Grey Silt (soft)	110.00	50.00	223.0	0.0	0.0	0.0
60.00	Loose Basal Sand, some silt	110.00	62.00	0.0	0.0	28.0	0.0
76.00	Reddish Basal Sand	110.00	62.00	0.0	0.0	35.0	0.0

Solution

Sheet

Sheet Name	I (in⁴/ft)	E (psi)	Z (in³/ft)	f (psi)	Maximum Bend Moment (ftlb/
Arbed AZ48	847.10	3.04E+07	89.30	25000.0	18582

Load Model: Area Distribution

Supports

Depth (ft)	Type	Linear Load (lb/ft)
3.80	Waler	1831.4
7.30	Waler	5801.0

Maxima

Bending Mo
Deflection
Pressure
Shear Force

Harbor-At-Hastings Site at MW15

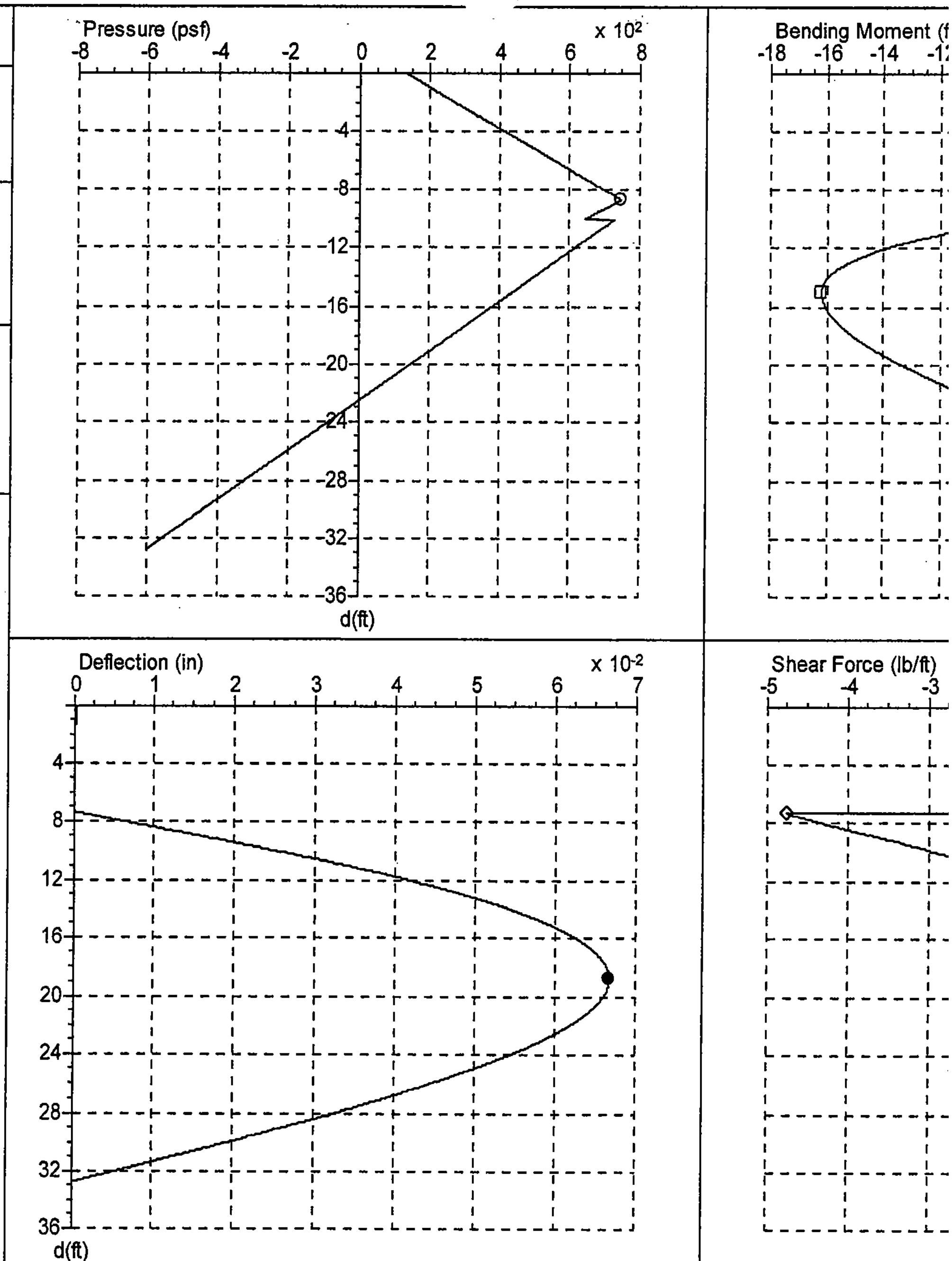
Client: AERL Hasting
Site: Hasting-on-Hudson, NY

Title: Boring MW-15
Ref: Case bMW15
Page: 3
Date: 6.27.02

Sheet: Arbed AZ48
Pressure: Coulomb; Full hydrostatic pressure in cohesive soils.
FOS: 2.0
Toe: Free Earth Support

	Maximum	d (ft)
○	750.2 psf	8.70
□	16199.2 ftlb/ft	14.93
◇	4773.4 lb/ft	7.30
●	0.1 in	18.80

1) dry excavation to 4.30' (cantilever)
2) install waler at 3.80'
3) dry excavation to 7.80'
4) install waler at 7.30'
5) dry excavation to 8.70' - inadequate space to install additional waler



Harbor-At-Hastings Site at MW15

Client: AERL Hasting
Site: Hasting-on-Hudson, NY

Title: Boring MW-15
Ref: Case bMW15
Page: 4
Date: 6.27.02

Sheet: Arbed AZ48
Pressure: Coulomb; Full hydrostatic pressure in cohesive soils.
FOS: 2.0
Toe: Free Earth Support

1) dry excavation to 4.30' (cantilever)
2) install waler at 3.80'
3) dry excavation to 7.80'
4) install waler at 7.30'
5) dry excavation to 8.70' - inadequate space to install additional waler

depth (ft)	P (psf)	M (ft-lb/ft)	D (in)	F (lb/ft)
0.00	128.0	0.3	0.0	7.0
0.29	149.5	8.1	0.0	45.4
0.58	170.9	30.2	0.0	93.8
0.87	190.5	64.1	0.0	143.3
1.16	211.9	118.6	0.0	204.0
1.45	233.4	193.0	0.0	271.1
1.74	252.9	279.6	0.0	337.7
2.03	274.4	397.5	0.0	417.2
2.32	293.9	526.9	0.0	495.0
2.61	315.4	695.6	0.0	586.7
2.90	336.8	893.8	0.0	684.8
3.19	356.3	1101.2	0.0	779.7
3.48	377.8	1361.3	0.0	890.2
3.77	399.3	1656.7	0.0	1007.1
4.06	418.8	1441.7	0.0	-712.5
4.35	440.3	1242.6	0.0	-583.3
4.64	459.8	1097.3	0.0	-460.2
4.93	481.2	978.5	0.0	-318.7
5.22	502.7	904.6	0.0	-170.7
5.51	522.2	878.1	0.0	-30.6
5.80	543.7	895.5	0.0	129.6
6.09	565.2	963.7	0.0	296.3
6.38	584.7	1071.4	0.0	453.5
6.66	606.1	1241.9	0.0	632.5
6.95	625.6	1446.0	0.0	800.8
7.24	647.1	1726.3	0.0	992.1
7.53	668.6	416.5	0.0	-4611.2
7.82	688.1	-871.1	0.0	-4425.8
8.11	709.6	-2226.2	0.0	-4215.8
8.40	729.1	-3515.1	0.0	-4019.2
8.69	750.2	-4735.9	0.0	-3796.9
8.98	725.8	-5887.7	0.0	-3575.7
9.27	704.0	-6876.4	0.0	-3380.9
9.56	679.9	-7902.1	0.0	-3173.5
9.85	655.9	-8949.4	0.0	-2973.4
10.14	723.6	-9765.2	0.0	-2785.6
10.43	706.0	-10599.0	0.0	-2571.3
10.72	690.0	-11300.4	0.0	-2381.0
11.01	672.4	-12011.2	0.0	-2176.8
11.30	654.8	-12659.9	0.0	-1977.9
11.59	638.8	-13248.2	0.0	-1801.6
11.88	621.2	-13777.6	0.0	-1612.8
12.17	603.6	-14249.9	0.0	-1429.2
12.46	587.6	-14631.0	0.0	-1267.0
12.75	570.0	-14998.7	0.0	-1093.5
13.04	554.0	-15287.4	0.0	-940.4
13.33	536.4	-15578.4	0.1	-777.0
13.62	518.8	-15793.8	0.1	-618.8
13.91	502.8	-15948.3	0.1	-479.7
14.20	485.2	-16074.4	0.1	-331.7
14.49	469.2	-16150.5	0.1	-201.7
14.78	451.6	-16193.3	0.1	-63.7
15.07	434.0	-16196.4	0.1	68.9
15.36	418.0	-16175.1	0.1	184.9
15.65	400.4	-16126.8	0.1	307.5
15.94	382.8	-16063.0	0.1	424.8
16.23	366.8	-15980.0	0.1	526.9
16.52	349.2	-15864.7	0.1	634.1
16.81	333.2	-15759.5	0.1	726.9
17.10	315.6	-15604.9	0.1	824.1
17.39	298.0	-15429.5	0.1	915.9
17.68	282.0	-15279.3	0.1	994.8
17.97	264.4	-15069.0	0.1	1076.6
18.26	246.8	-14840.4	0.1	1153.0
18.55	230.8	-14650.5	0.1	1218.0
18.84	213.2	-14391.5	0.1	1284.4
19.13	197.2	-14148.0	0.1	1340.1
19.41	179.6	-13892.5	0.1	1396.5
19.70	162.0	-13591.6	0.1	1447.5
19.99	146.0	-13312.9	0.1	1489.3
20.28	128.4	-13024.3	0.1	1530.2
20.57	112.4	-12726.4	0.1	1562.9
20.86	94.8	-12380.9	0.1	1593.7
21.15	77.2	-12065.3	0.1	1619.3
21.44	61.2	-11742.4	0.1	1637.9
21.73	43.6	-11371.1	0.1	1653.4

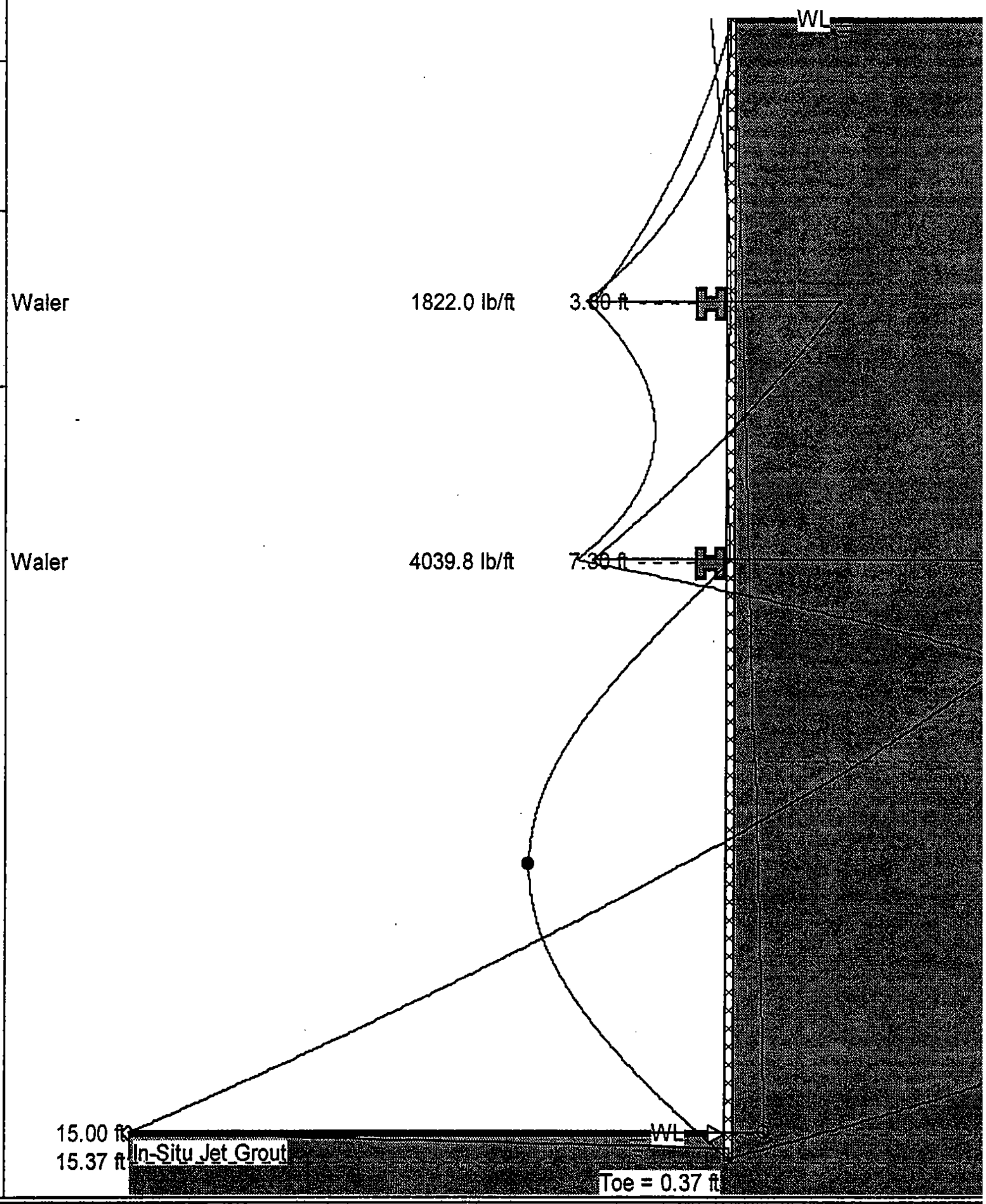
Harbor-At-Hastings Site at MW15

Client:	AERL Hasting
Site:	Hasting-on-Hudson, NY
Title:	Boring MW-15, two walers
Ref:	CasedMW15
Page:	1
Date:	6.27.02
Sheet:	Arbed AZ48
Pressure:	Coulomb; Full hydrostatic pressure in cohesive soils.
FOS:	2.0
Toe:	Free Earth Support

	Maximum	d (ft)
○	1275.4 psf	15.00
□	6633.0 ftlb/ft	11.06
◇	4454.2 lb/ft	15.00
●	0.0 in	11.41

15' excavation with 4' of grout (grout from 15.00 to 19.00)

1) dry excavation to 4.30' (cantilever)
2) install waler at 3.80'
3) dry excavation to 7.80'
4) install waler at 7.30'
5) dry excavation to 15.00'



Harbor-At-Hastings Site at MW15

Client: AERL Hasting
Site: Hasting-on-Hudson, NY

Title: Boring MW-15, two walers
Ref: CasedMW15
Page: 2
Date: 6.27.02

Sheet: Arbed AZ48
Pressure: Coulomb; Full hydrostatic pressure in cohesive soils.
FOS: 2.0
Toe: Free Earth Support

15' excavation with 4' of grout (grout from 15.00 to 19.00)

1) dry excavation to 4.30' (cantilever)
2) install waler at 3.80'
3) dry excavation to 7.80'
4) install waler at 7.30'
5) dry excavation to 15.00'

Input Data

Depth Of Excavation = 15.00 ft
Surcharge = 400.0 psf
Depth Of Active Water = 0.00 ft
Depth Of Passive Water = 15.00 ft
M

Soil Profile

Depth (ft)	Soil Name	γ (pcf)	γ' (pcf)	C (psf)	C_a (psf)	φ (°)	δ (°
0.00	Loose Fill	91.00	28.60	0.0	0.0	31.0	0.(
10.00	very loose Fill	91.00	28.60	0.0	0.0	25.0	0.(
15.00	In-Situ Jet Grout	125.00	63.00	10800.0	1800.0	0.0	0.(
19.00	very loose fill	91.00	28.60	0.0	0.0	25.0	0.(
34.00	Marine Grey Silt (soft)	110.00	50.00	223.0	0.0	0.0	0.(
60.00	Loose Basal Sand, some silt	110.00	62.00	0.0	0.0	28.0	0.(
76.00	Reddish Basal Sand	110.00	62.00	0.0	0.0	35.0	0.(

Solution

Sheet

Sheet Name	I (in^4/ft)	E (psi)	Z (in^3/ft)	f (psi)	Maximum Ben Moment (ftlb
Arbed AZ48	847.10	3.04E+07	89.30	25000.0	1858

Load Model: Area Distribution

Supports

Depth (ft)	Type	Linear Load (lb/ft)
3.80	Waler	1822.0
7.30	Waler	4039.8

Maxima

Bending M
Deflection
Pressure
Shear Forc

Harbor-At-Hastings Site at MW15

Client: AERL Hasting
Site: Hasting-on-Hudson, NY

Title: Boring MW-15, two walers
Ref: CasedMW15
Page: 3
Date: 6.27.02

Sheet: Arbed AZ48
Pressure: Coulomb; Full hydrostatic pressure in cohesive soils.
FOS: 2.0
Toe: Free Earth Support

	Maximum	d (ft)
○	1275.4 psf	15.00
□	6633.0 ftlb/ft	11.06
◇	4454.2 lb/ft	15.00
●	0.0 in	11.41

15' excavation with 4' of grout (grout from 15.00 to 19.00)

1) dry excavation to 4.30' (cantilever)
2) install waler at 3.80'
3) dry excavation to 7.80'
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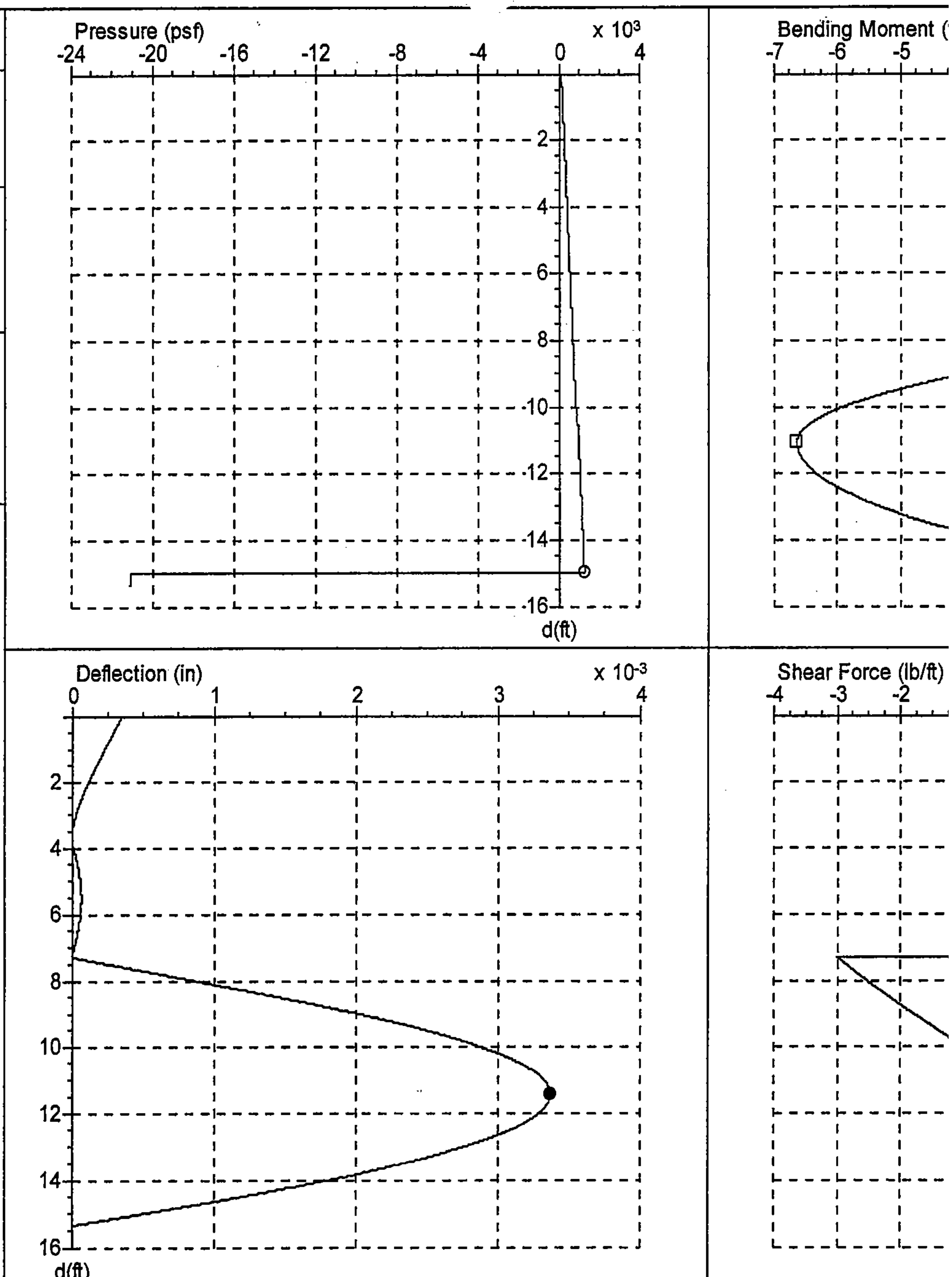
5) dry excavation to 15.00'



Harbor-At-Hastings Site at MW15

Client: AERL Hasting
Site: Hasting-on-Hudson, NY

Title: Boring MW-15, two walers
Ref: CasedMW15
Page: 4
Date: 6.27.02

Sheet: Arbed AZ48
Pressure: Coulomb; Full hydrostatic pressure in cohesive soils.
FOS: 2.0
Toe: Free Earth Support

15' excavation with 4' of grout (grout from 15.00 to 19.00)

1) dry excavation to 4.30' (cantilever)
2) install waler at 3.80'
3) dry excavation to 7.80'
4) install waler at 7.30'
5) dry excavation to 15.00'

depth (ft)	P (psf)	M (ft.lb/ft)	D (in)	F (lb/ft)
0.00	128.0	0.1	0.0	3.3
0.14	138.1	1.7	0.0	20.4
0.27	148.2	6.1	0.0	40.7
0.41	157.3	12.7	0.0	60.3
0.54	167.4	22.9	0.0	83.2
0.68	177.5	36.5	0.0	107.6
0.82	186.6	51.9	0.0	131.0
0.95	196.7	72.4	0.0	158.1
1.09	205.9	94.5	0.0	183.9
1.22	216.0	122.7	0.0	213.7
1.36	226.0	155.2	0.0	244.9
1.50	235.2	188.6	0.0	274.5
1.63	245.3	229.9	0.0	308.4
1.77	255.4	276.1	0.0	343.7
1.90	264.5	322.4	0.0	377.1
2.04	274.6	378.5	0.0	415.1
2.18	283.8	434.2	0.0	451.0
2.31	293.8	500.8	0.0	491.7
2.45	303.9	573.3	0.0	533.9
2.58	313.1	644.5	0.0	573.5
2.72	323.1	728.8	0.0	618.4
2.86	333.2	819.4	0.0	664.7
2.99	342.4	907.6	0.0	708.0
3.13	352.5	1011.2	0.0	757.0
3.26	361.6	1111.3	0.0	802.8
3.40	371.7	1228.4	0.0	854.6
3.54	381.8	1352.9	0.0	907.7
3.67	390.9	1472.7	0.0	957.3
3.81	401.0	1565.2	0.0	-808.9
3.95	410.2	1465.2	0.0	-756.9
4.08	420.3	1363.0	0.0	-698.3
4.22	430.3	1269.2	0.0	-638.3
4.35	439.5	1191.4	0.0	-582.5
4.49	449.6	1114.1	0.0	-519.8
4.63	459.7	1045.7	0.0	-455.7
4.76	468.8	991.5	0.0	-396.2
4.90	478.9	940.8	0.0	-329.3
5.03	488.1	903.0	0.0	-267.4
5.17	498.1	870.7	0.0	-197.8
5.31	508.2	848.2	0.0	-126.8
5.44	517.4	836.6	0.0	-61.1
5.58	527.5	833.6	0.0	12.6
5.71	537.5	841.2	0.0	87.7
5.85	546.7	857.3	0.0	157.2
5.99	556.8	885.4	0.0	235.0
6.12	565.9	920.6	0.0	307.0
6.26	576.0	970.0	0.0	387.5
6.39	586.1	1030.9	0.0	469.4
6.53	595.3	1096.3	0.0	545.2
6.67	605.3	1179.6	0.0	629.8
6.80	614.5	1265.8	0.0	708.0
6.94	624.6	1372.3	0.0	795.4
7.07	634.7	1491.2	0.0	884.2
7.21	643.8	1610.2	0.0	966.1
7.35	653.9	1465.2	0.0	-2982.2
7.48	664.0	886.2	0.0	-2889.3
7.62	673.1	410.8	0.0	-2803.6
7.76	683.2	-133.8	0.0	-2708.0
7.89	692.4	-579.7	0.0	-2619.8
8.03	702.5	-1088.7	0.0	-2521.5
8.16	712.5	-1578.0	0.0	-2421.7
8.30	721.7	-1976.4	0.0	-2329.8
8.43	731.8	-2428.5	0.0	-2227.3
8.57	741.8	-2827.5	0.0	-2123.4
8.71	751.0	-3208.6	0.0	-2027.7
8.84	761.1	-3571.6	0.0	-1921.1
8.98	770.2	-3916.3	0.0	-1823.0
9.11	780.3	-4242.2	0.0	-1713.7
9.25	790.4	-4574.1	0.0	-1603.0
9.39	799.6	-4837.3	0.0	-1501.1
9.52	809.6	-5127.3	0.0	-1387.6
9.66	818.8	-5374.5	0.0	-1283.3
9.79	828.9	-5601.0	0.0	-1167.1
9.93	839.0	-5821.9	0.0	-1049.5
10.07	910.0	-5988.6	0.0	-937.5
10.20	920.5	-6161.6	0.0	-808.4

Harbor-At-Hastings Site at MW15

PURPOSE: THE PURPOSE OF THE FOLLOWING CALCULATIONS IS TO DESIGN THE WALERS FOR THE SUBJECT PROJECT (ALTERNATIVE 1)

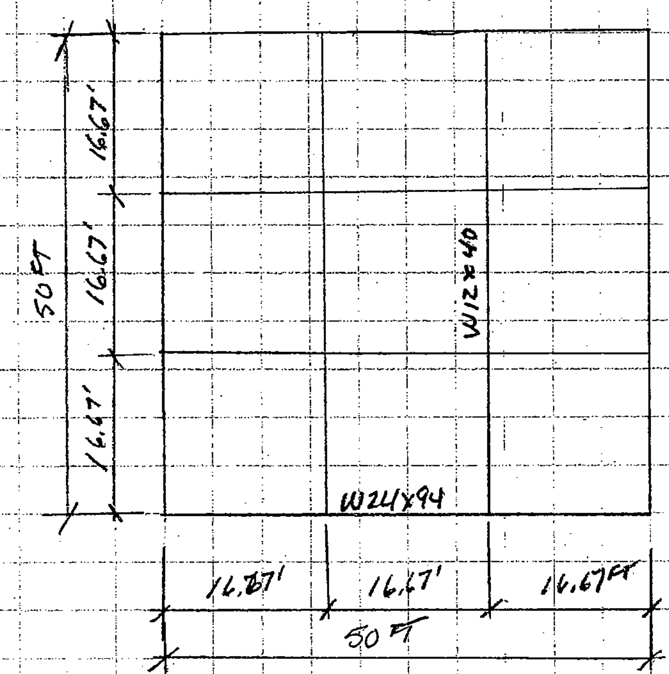
GIVEN:

1. SHEETPILE SUMMARY BY WTC 10/29/01

2. AREA MEASURES 50' x 50'

SOLUTION:

FROM SHEET PILE SUMMARY $w = 7000$ LB/FT



IT CORPORATION
Member of The IT Group

By PJI Date 10/30/01 Subject ADRL HARBOR-AT-HASTINGS SITE Sheet No. 2 of 5
Chkd. By NTC Date 10/30/01 WALER DESIGN-ALT 1 Proj. No. 806938
.25 in. X .25 i

WALER DESIGN ~

$$M = \frac{1}{10} w \ell^2 = \frac{1}{10} (7^{K/FT})(16.67^{FT})^2 = 194 \text{ K-FT}$$

$$P = 7^{K/FT} \times \frac{16.67^{FT}}{2} = 58.35^K$$

TRY W21x73

$A = 21.5 \text{ in}^2$ $r_x = 8.64 \text{ IN}$

$r_T = 2.13 \text{ in}$ $r_y = 1.81 \text{ in}$

$S_x = 151 \text{ in}^3$

DETERMINE F_b ~

$$\frac{\ell}{r_T} = \frac{16.67^{FT} \times 12^{IN/FT}}{2.13 \text{ in}} = 94$$

$$\sqrt{\frac{102 \times 10^3 C_b}{F_y}} = \sqrt{\frac{102 \times 10^3 (1.0)}{36}} = 53 < 94 < \sqrt{\frac{510 \times 10^3 C_b}{F_y}} = \sqrt{\frac{510 \times 10^3 (1.0)}{36}} = 119$$

$$\therefore F_b = \left[\frac{2}{3} - \frac{F_y (\ell/r_T)^2}{1530 \times 10^3 C_b}\right] F_y = \left[\frac{2}{3} - \frac{36(94)^2}{1530 \times 10^3 (1.0)}\right] 36 = 16.52 \text{ KSI}$$

$$f_b = \frac{194 \text{ K-FT} \times 12^{IN/FT}}{151 \text{ in}^3} = 15.42 \text{ KSI}$$

$$\frac{\ell}{r_y} = \frac{16.67^{FT} \times 12^{IN/FT}}{1.81} = 110.5 \qquad F_a = 11.67 \text{ KSI}$$ SEE SHEET NO. 5 OF 5

$$\frac{f_b}{F_b} + \frac{f_a}{F_a} = \frac{15.42 \text{ KSI}}{16.52 \text{ KSI}} + \frac{58.35^K / 21.5 \text{ IN}^2}{11.67 \text{ KSI}} = 1.17 > 1 \therefore NG$$

TRY W24x94

$A = 27.7 in^2$ $r_x = 9.87 in$
$r_T = 2.33 in$ $r_y = 1.98 in$
$S_x = 222 in^3$

$$\frac{l}{r_T} = \frac{16.67^{FT} \times 12^{IN}/FT}{2.33} = 86 \qquad 53 < 86 < 119$$

$$\therefore F_b = \left[\frac{2}{3} - \frac{36(86)^2}{1530 \times 10^3 (1.0)}\right](36) = 17.75 \text{ KSI}$$

$$f_b = \frac{194 \text{ K-FT} \times 12^{IN}/FT}{222 \text{ in}^3} = 10.49 \text{ KSI}$$

$$\frac{P}{A} = \frac{58.35^K}{27.7 \text{ in}^2} = 2.11 \text{ KSI}$$

$$\frac{l}{r_y} = \frac{16.67^{FT} \times 12^{IN}/FT}{1.98 \text{ in}} = 101 \quad \therefore F_a = 12.85 \text{ KSI}$$ SEE SHEET NO 5 OF 5

$$\frac{f_b}{F_b} + \frac{f_a}{F_a} = \frac{10.49 \text{ KSI}}{17.75 \text{ KSI}} + \frac{2.11 \text{ KSI}}{12.85 \text{ KSI}} = 0.76 < 1.0 \therefore OK$$

STRUT DESIGN

$l = 16.67^{FT}$
$P = 16.67^{FT} \times 7^{K}/_{FT} = 116.7^K$

TRY W14x82
$A = 24.1 in^2$
$r_y = 2.48 in$

$$\frac{P}{A} = \frac{116.7^k}{24.1 in^2} = 4.84 ksi$$

TRY W 12x40

$A = 11.8 in^2$

$r_y = 1.93 in$

$$\frac{l}{r_y} = \frac{16.67^{ft} \times 12^{in}/ft}{1.93} = 104 \quad F_a = 12.47 ksi$$ SEE SHEET NO. 5 OF 5

$$\frac{P}{A} = \frac{116.7^k}{11.8 in^2} = 9.89 ksi < F_a \therefore OK$$

SHEET NO. 5 OF 5

50

$F_y = 36$ ksi

TABLE 3-36
ALLOWABLE STRESS
FOR COMPRESSION MEMBERS OF 36 KSI SPECIFIED YIELD STRESS STEEL

Main and Secondary Members Kl/r not over 120						Main Members Kl/r 121 to 200				Secondary Members[a] l/r 121 to 200			
$\frac{Kl}{r}$	F_a (ksi)	$\frac{Kl}{r}$	F_a (ksi)	$\frac{Kl}{r}$	F_a (ksi)	$\frac{Kl}{r}$	F_a (ksi)	$\frac{Kl}{r}$	F_a (ksi)	$\frac{l}{r}$	F_{as} (ksi)	$\frac{l}{r}$	F_{as} (ksi)
1	21.56	41	19.11	81	15.24	121	10.14	161	5.76	121	10.19	161	7.25
2	21.52	42	19.03	82	15.13	122	9.99	162	5.69	122	10.09	162	7.20
3	21.48	43	18.95	83	15.02	123	9.85	163	5.62	123	10.00	163	7.16
4	21.44	44	18.86	84	14.90	124	9.70	164	5.55	124	9.90	164	7.12
5	21.39	45	18.78	85	14.79	125	9.55	165	5.49	125	9.80	165	7.08
6	21.35	46	18.70	86	14.67	126	9.41	166	5.42	126	9.70	166	7.04
7	21.30	47	18.61	87	14.56	127	9.26	167	5.35	127	9.59	167	7.00
8	21.25	48	18.53	88	14.44	128	9.11	168	5.29	128	9.49	168	6.96
9	21.21	49	18.44	89	14.32	129	8.97	169	5.23	129	9.40	169	6.93
10	21.16	50	18.35	90	14.20	130	8.84	170	5.17	130	9.30	170	6.89
11	21.10	51	18.26	91	14.09	131	8.70	171	5.11	131	9.21	171	6.85
12	21.05	52	18.17	92	13.97	132	8.57	172	5.05	132	9.12	172	6.82
13	21.00	53	18.08	93	13.84	133	8.44	173	4.99	133	9.03	173	6.79
14	20.95	54	17.99	94	13.72	134	8.32	174	4.93	134	8.94	174	6.76
15	20.89	55	17.90	95	13.60	135	8.19	175	4.88	135	8.86	175	6.73
16	20.83	56	17.81	96	13.48	136	8.07	176	4.82	136	8.78	176	6.70
17	20.78	57	17.71	97	13.35	137	7.96	177	4.77	137	8.70	177	6.67
18	20.72	58	17.62	98	13.23	138	7.84	178	4.71	138	8.62	178	6.64
19	20.66	59	17.53	99	13.10	139	7.73	179	4.66	139	8.54	179	6.61
20	20.60	60	17.43	100	12.98	140	7.62	180	4.61	140	8.47	180	6.58
21	20.54	61	17.33	101	12.85	141	7.51	181	4.56	141	8.39	181	6.56
22	20.48	62	17.24	102	12.72	142	7.41	182	4.51	142	8.32	182	6.53
23	20.41	63	17.14	103	12.59	143	7.30	183	4.46	143	8.25	183	6.51
24	20.35	64	17.04	104	12.47	144	7.20	184	4.41	144	8.18	184	6.49
25	20.28	65	16.94	105	12.33	145	7.10	185	4.36	145	8.12	185	6.46
26	20.22	66	16.84	106	12.20	146	7.01	186	4.32	146	8.05	186	6.44
27	20.15	67	16.74	107	12.07	147	6.91	187	4.27	147	7.99	187	6.42
28	20.08	68	16.64	108	11.94	148	6.82	188	4.23	148	7.93	188	6.40
29	20.01	69	16.53	109	11.81	149	6.73	189	4.18	149	7.87	189	6.38
30	19.94	70	16.43	110	11.67	150	6.64	190	4.14	150	7.81	190	6.36
31	19.87	71	16.33	111	11.54	151	6.55	191	4.09	151	7.75	191	6.35
32	19.80	72	16.22	112	11.40	152	6.46	192	4.05	152	7.69	192	6.33
33	19.73	73	16.12	113	11.26	153	6.38	193	4.01	153	7.64	193	6.31
34	19.65	74	16.01	114	11.13	154	6.30	194	3.97	154	7.59	194	6.30
35	19.58	75	15.90	115	10.99	155	6.22	195	3.93	155	7.53	195	6.28
36	19.50	76	15.79	116	10.85	156	6.14	196	3.89	156	7.48	196	6.27
37	19.42	77	15.69	117	10.71	157	6.06	197	3.85	157	7.43	197	6.26
38	19.35	78	15.58	118	10.57	158	5.98	198	3.81	158	7.39	198	6.24
39	19.27	79	15.47	119	10.43	159	5.91	199	3.77	159	7.34	199	6.23
40	19.19	80	15.36	120	10.28	160	5.83	200	3.73	160	7.29	200	6.22

[a] K taken as 1.0 for secondary members.

Note: $C_c = 126.1$

IT CORPORATION
A Member of The IT Group

By PJI Date 10/30/01 Subject AERL HARBOR-AT-HASTINGS SITE Sheet No. 1 of 3

Chkd. By WTC Date 10/30/01 WALER DESIGN-ALT2 Proj. No. 806938.3000000

.25 in. X .25

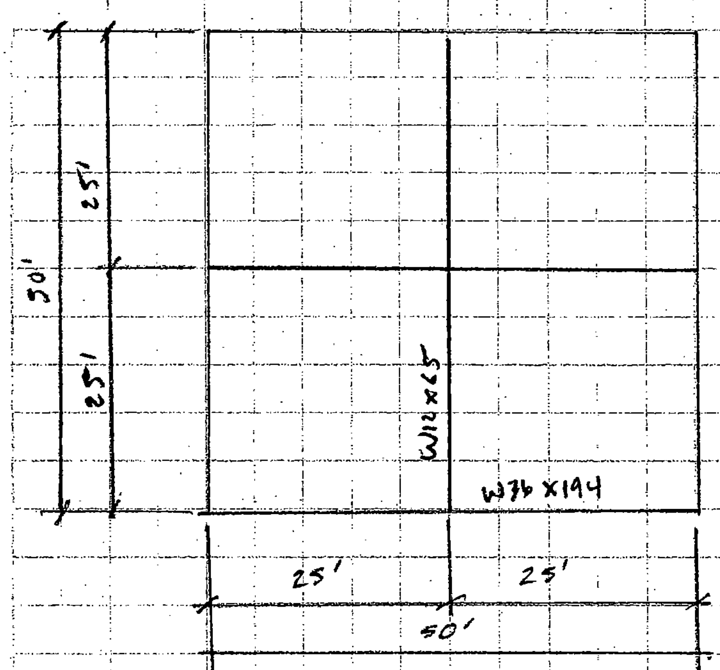
PURPOSE: THE PURPOSE OF THE FOLLOWING CALCULATIONS IS TO DESIGN THE WALERS FOR THE SUBJECT PROJECT (ALTERNATIVE 2)

GIVEN:

1. SHEET PILE SUMMARY BY WTC 10/29/01

2. AREA MEASURES 50' x 50'

SOLUTION: FROM SHEET PILE SUMMARY W = 7000 LB/FT



By PJL Date 10/30/01 Subject AERL HARBOR-AT-HASTINGS SITE Sheet No. 2 of 3

Chkd. By WTC Date 10/30/01 WALER DESIGN - ALT 2 Proj. No. 806938.

.25 in. X .25 in

WALER DESIGN ~

$$M = \frac{1}{8} w l^2 = \frac{1}{8}(7^{K/FT})(25^{FT})^2 = 550^{KFT}$$

$$P = 12.5^{FT} \times 7^{K/FT} = 87.5^{K}$$

TRY W 24x146

$A = 43.0 in^2$ $r_x = 10.3^{IN}$

$r_T = 3.43 in$ $r_y = 3.01^{IN}$

$S_x = 371 in^3$

$$\frac{l}{r_T} = \frac{25^{FT} \times 12^{IN/FT}}{3.43 in} = 87.5$$

$$\therefore F_b = \left[\frac{2}{3} - \frac{F_y (l/r_T)^2}{1530 \times 10^3 C_b}\right] F_y = \left[\frac{2}{3} - \frac{36(87.5)^2}{(1530 \times 10^3 \times 1.0)}\right] 36$$

$$= 17.5 ksi$$

$$f_b = \frac{M}{S_x} = \frac{550^{K-FT} \times 12^{IN/FT}}{371 in^3} = 17.79 > 17.5 ksi \therefore NG$$

TRY W 36x194

$A = 57.0$ $r_x = 14.6 in$

$r_T = 3.07 in$ $r_y = 2.56 in$

$S_x = 664 in^3$

$$\frac{l}{r_T} = \frac{25^{FT} \times 12^{IN/FT}}{3.07} = 98$$

$$F_b = \left[\frac{2}{3} - \frac{36(98)^2}{1530 \times 10^3 \times 110}\right] 36\text{ KSI} = 15.86\text{ KSI}$$

$$f_b = \frac{M}{S_x} = \frac{550^{K\cdot FT} \times 12^{IN}/FT}{664\text{ in}^3} = 9.94\text{ KSI}$$

$$\frac{l}{r_y} = \frac{25^{FT} \times 12^{IN}/FT}{2.56} = 117$$

$$\therefore F_a = 10.71\text{ KSI}$$

$$f_a = \frac{87.5^K}{57.0} = 1.53\text{ KSI}$$

$$\frac{f_b}{F_b} + \frac{f_a}{F_a} = \frac{9.94\text{ KSI}}{15.86\text{ KSI}} + \frac{1.53\text{ KSI}}{10.71\text{ KSI}} = 0.77 \leq 1.0 \therefore OK$$

STRUT DESIGN ~

$$P = 7^K/FT \times 25^{FT} = 175^K$$

TRY W12x58
$A = 17.0\text{ in}^2$
r_y: 2.51

$$\frac{l}{r_y} = \frac{25^{FT} \times 12^{IN}/FT}{2.51} = 120$$

$$F_a = 10.28\text{ KSI}$$

$$f_a = \frac{175^K}{17.0\text{ in}^2} = 10.29\text{ KSI} \approx F_a \therefore OK$$

OR USE 12x65

Hydrostatic Uplift Calculation Sensitivity Analysi

Statement of Problem:

Calculate the maximum depth of excavation using the following the equation stated below and perform a sensitivity ana stratigraphy depth, unit weight of overburden materials, confined aquifer hydrostatic pressure, and factor of safe

General Equation:

*Factor of Safety = Overburden Material Unit Weight (lb/cf) * Overburden Depth (ft)/ (Unit Weight of Water (lb/cf) * Confi*

Actual Site Parameters

Parameter	MW-13	MW-14	MW-15
Depth of Fill (ft)	25	17	34
Depth of Transition Layer (ft)	0	13	0
Depth of Marine Grey Silt (ft)	27	26	26
Unit Weight of fill (lb/cf)	91	91	91
Unit Weight of Transition Fill (lb/cf)	NA	96	NA
Unit Weight of Marine Grey Silt (lb/cf)	110	110	110
Confined Aquifer Head (ft)	51.1	56.2	57.6
Fill Water Head (ft)	4.8	3	5.5

Parameter	MW-13A	MW-14A	MW-15A
Ground Surface Elevation (ft)	5.29	3.37	6.62
Confined Aquifer Elevation Head (ft)	4.39	3.57	4.22
Top of Basal Sands Elevation (ft)	-46.71	-52.63	-53.38

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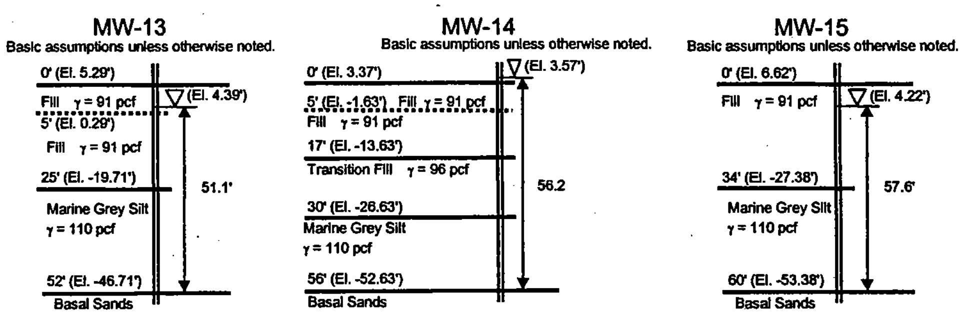
TABLE
SUMMARY OF SENSITIVITY ANALYSIS RESULTS
HARBOR AT HASTINGS
HASTINGS-ON-HUDSON, NEW YORK

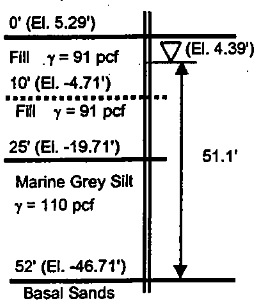
FOS VS. DEPTH CASES	MW-13	MW-14	MW-15
BASE CASE	FOS=1.3 for D=12ft	FOS=1.3 for D=12ft	FOS=1.3 for D=14ft
VARY LOWER FILL UNIT WEIGHT (γ = 91, 95, 100 pcf)	ΔFOS = +0.04	ΔFOS = +0.01	ΔFOS = +0.05
VARY TRANSITION FILL UNIT WEIGHT (γ = 96, 100, 105 pcf)	N/A	ΔFOS = +0.03	N/A
VARY MARINE GREY SILT UNIT WEIGHT (γ = 100, 105, 110 pcf)	ΔFOS = -0.08	ΔFOS = -0.07	ΔFOS = -0.07
VARY CONFINED AQUIFER BASAL SANDS UNIT HEAD h_W = base, 2' ags, 6' ags)	ΔFOS = -0.15	ΔFOS = -0.12	ΔFOS = -0.16
VARY DEPTH TO INTERFACE OF FILL AND MARINE GREY SILT THICKNESS (Δh_{FILL} = 0, 3, 6, 9 ft)	ΔFOS = -0.05	ΔFOS = -0.03	ΔFOS = -0.05
VARY BASAL SANDS ELEVATION $\Delta El_{BASAL\ SANDS}$ = 0, 4, 7 ft)	ΔFOS = -0.07	ΔFOS = -0.06	ΔFOS = -0.06



56

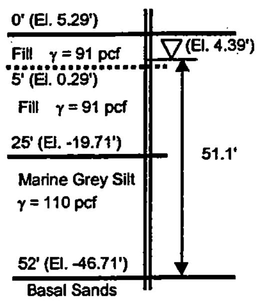
MW-13

Basic assumptions unless otherwise noted.



MW-13

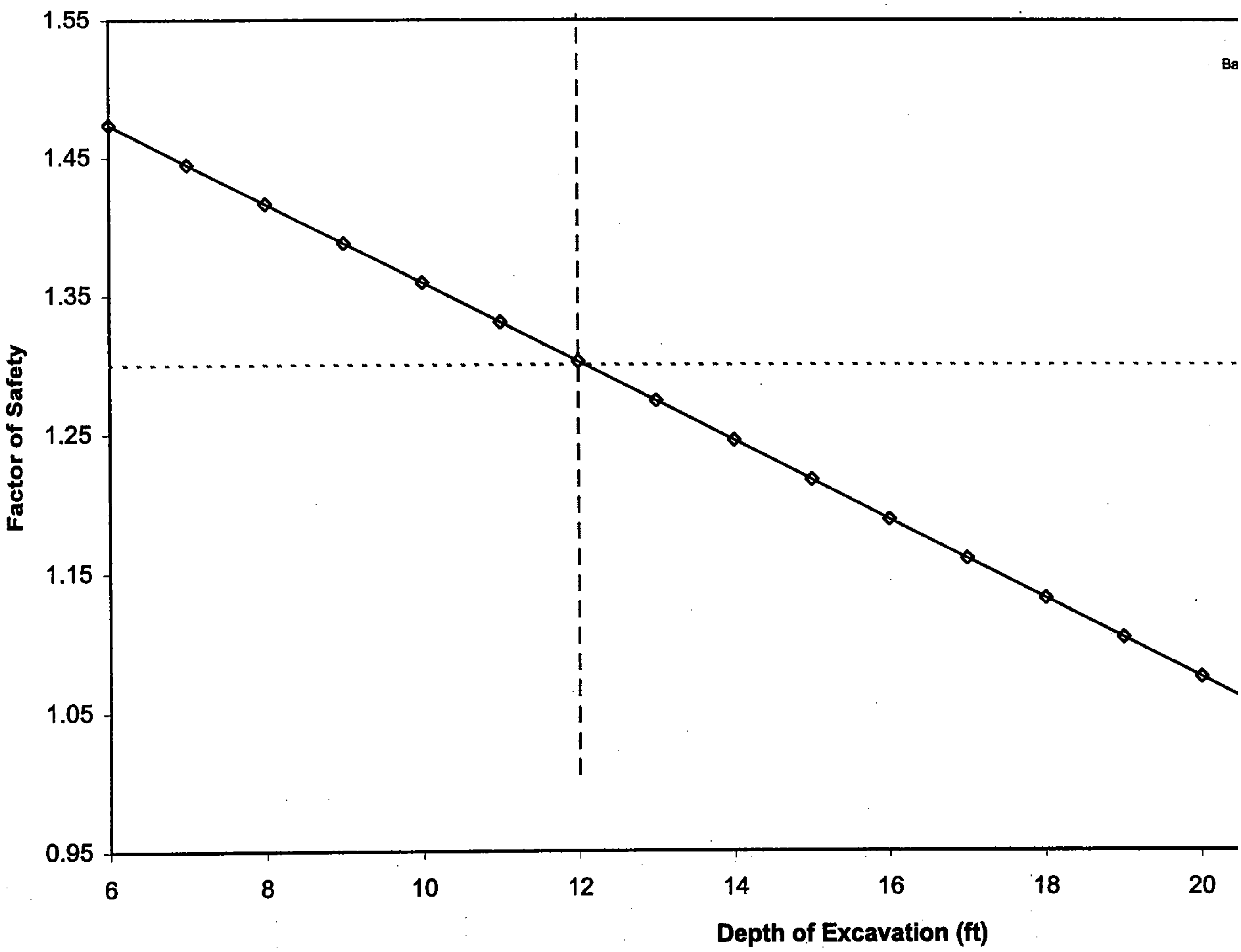
Basic assumptions unless otherwise noted.



Constant Lines			
Depth (ft)	FOS	Depth (ft)	FOS
6	1.3	12	1.6
26	1.3	12	1

MW-13

Sensitivity Analysis - Factor of Safety versus Depth of Excavation - Ba



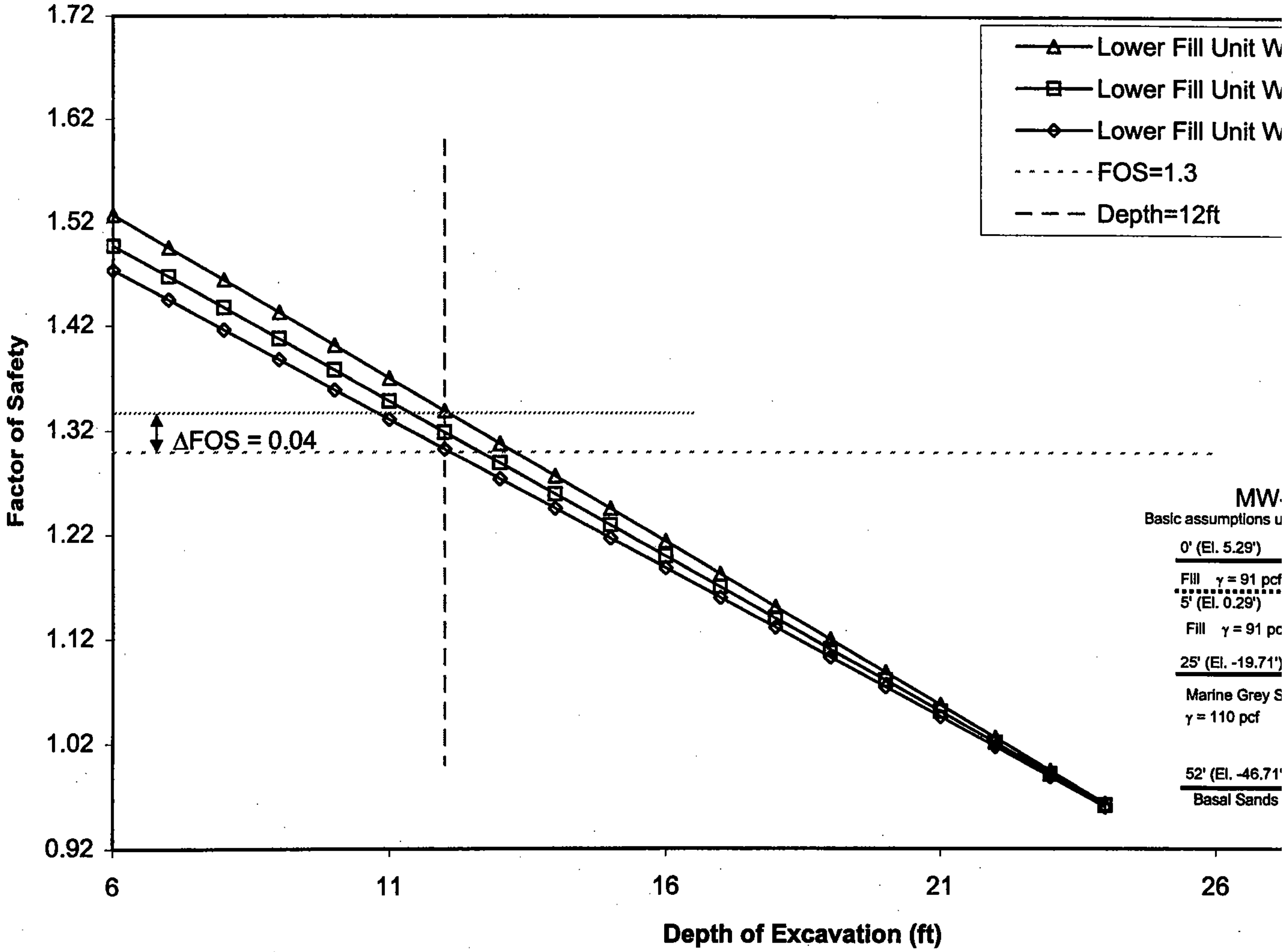
Mw-13.xls
Chart - Base Case

Unit Weight of Fill	Thickness of Fill	Unit Weight of Marine Grey Silt	Thickness of Marine Grey Silt	Unit Weight of Water	Confined Aquifer Head	Dep
91	25	110	27	62.4	51.1	
91	25	110	27	62.4	51.1	
91	25	110	27	62.4	51.1	
91	25	110	27	62.4	51.1	
91	25	110	27	62.4	51.1	
91	25	110	27	62.4	51.1	
91	25	110	27	62.4	51.1	
91	25	110	27	62.4	51.1	
91	25	110	27	62.4	51.1	
91	25	110	27	62.4	51.1	
91	25	110	27	62.4	51.1	
91	25	110	27	62.4	51.1	
91	25	110	27	62.4	51.1	
91	25	110	27	62.4	51.1	
91	25	110	27	62.4	51.1	
91	25	110	27	62.4	51.1	
91	25	110	27	62.4	51.1	
91	25	110	27	62.4	51.1	
91	25	110	27	62.4	51.1	

$$FOS = [(\gamma_{FILL} * (h_{FILL} - d_{EXC})) + (\gamma_{MGS} * h_{MGS})] / (\gamma_W * h_W)$$

Mw-13.xls
Base Case

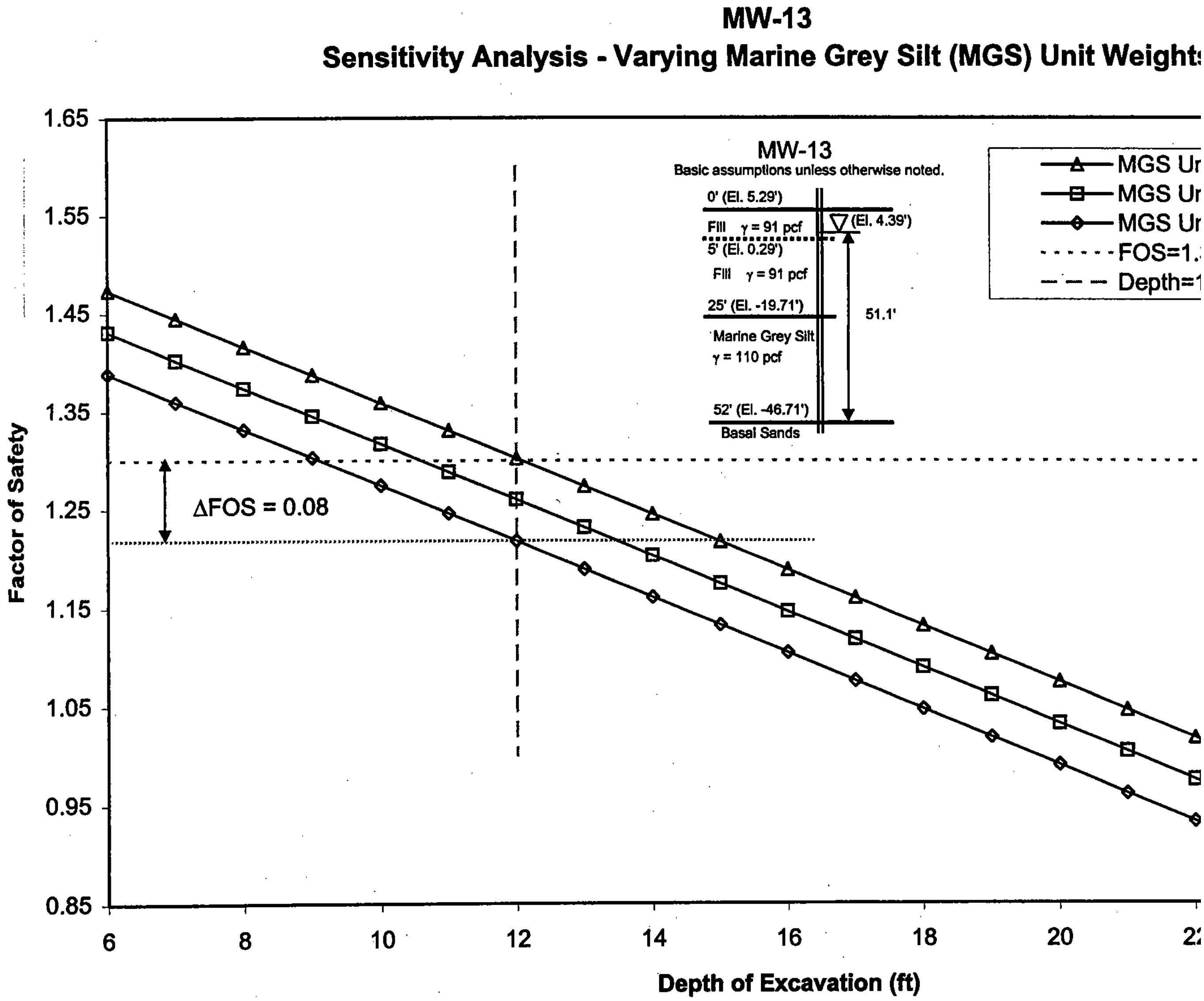
MW-13
Sensitivity Analysis - Varying Lower Fill Unit Weight



Mw-13.xls
Chart - Fill

Unit Weight of Upper Fill	Unit Weight of Lower Fill	Thickness of Upper Fill	Thickness of Lower Fill	Unit Weight of Marine Grey Silt	Thickness of Marine Grey Silt	Unit Weight of Water	Confi Aquifer
91	91	5	20	110	27	62.4	51
91	91	5	20	110	27	62.4	51
91	91	5	20	110	27	62.4	51
91	91	5	20	110	27	62.4	51
91	91	5	20	110	27	62.4	51
91	91	5	20	110	27	62.4	51
91	91	5	20	110	27	62.4	51
91	91	5	20	110	27	62.4	51
91	91	5	20	110	27	62.4	51
91	91	5	20	110	27	62.4	51
91	91	5	20	110	27	62.4	51
91	91	5	20	110	27	62.4	51
91	91	5	20	110	27	62.4	51
91	91	5	20	110	27	62.4	51
91	91	5	20	110	27	62.4	51
91	91	5	20	110	27	62.4	51
91	91	5	20	110	27	62.4	51
91	91	5	20	110	27	62.4	51
91	91	5	20	110	27	62.4	51
91	95	5	20	110	27	62.4	51
91	95	5	20	110	27	62.4	51
91	95	5	20	110	27	62.4	51
91	95	5	20	110	27	62.4	51
91	95	5	20	110	27	62.4	51
91	95	5	20	110	27	62.4	51
91	95	5	20	110	27	62.4	51
91	95	5	20	110	27	62.4	51
91	95	5	20	110	27	62.4	51
91	95	5	20	110	27	62.4	51
91	95	5	20	110	27	62.4	51
91	95	5	20	110	27	62.4	51
91	95	5	20	110	27	62.4	51
91	95	5	20	110	27	62.4	51
91	95	5	20	110	27	62.4	51
91	95	5	20	110	27	62.4	51
91	95	5	20	110	27	62.4	51
91	95	5	20	110	27	62.4	51
91	95	5	20	110	27	62.4	51
91	100	5	20	110	27	62.4	51
91	100	5	20	110	27	62.4	51

Unit Weight of Upper Fill	Unit Weight of Lower Fill	Thickness of Upper Fill	Thickness of Lower Fill	Unit Weight of Marine Grey Silt	Thickness of Marine Grey Silt	Unit Weight of Water	Conf Aquife
91	100	5	20	110	27	62.4	51
91	100	5	20	110	27	62.4	51
91	100	5	20	110	27	62.4	51
91	100	5	20	110	27	62.4	51
91	100	5	20	110	27	62.4	51
91	100	5	20	110	27	62.4	51
91	100	5	20	110	27	62.4	51
91	100	5	20	110	27	62.4	51
91	100	5	20	110	27	62.4	51
91	100	5	20	110	27	62.4	51
91	100	5	20	110	27	62.4	51
91	100	5	20	110	27	62.4	51
91	100	5	20	110	27	62.4	51
91	100	5	20	110	27	62.4	51
91	100	5	20	110	27	62.4	51
91	100	5	20	110	27	62.4	51
91	100	5	20	110	27	62.4	51



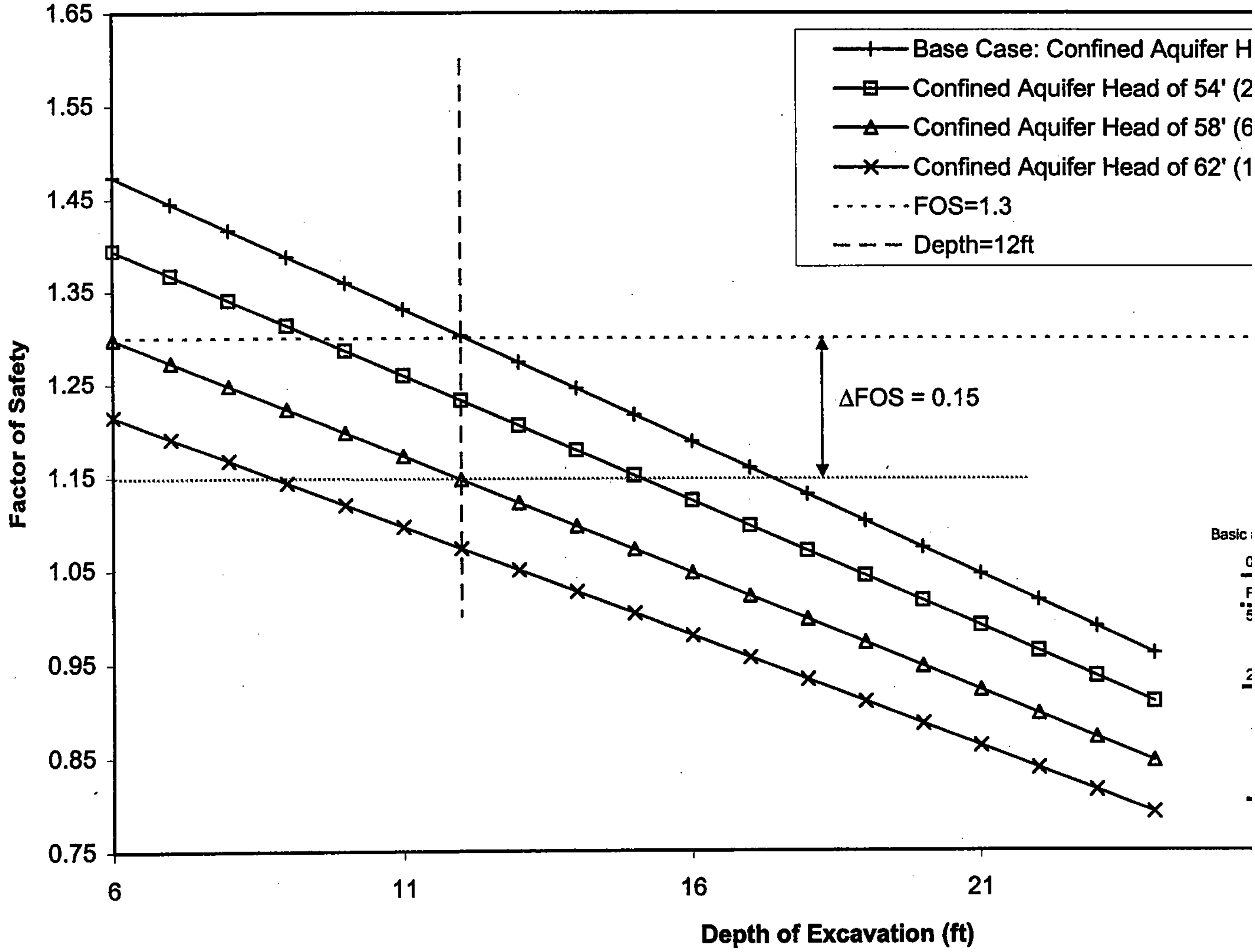
Mw-13.xls
Chart - MGS

Unit Weight of Fill	Thickness of Fill	Unit Weight of Marine Grey Silt	Thickness of Marine Grey Silt	Unit Weight of Water	Confined Aquifer Head	Dep
91	25	100	27	62.4	51.1	
91	25	100	27	62.4	51.1	
91	25	100	27	62.4	51.1	
91	25	100	27	62.4	51.1	
91	25	100	27	62.4	51.1	
91	25	100	27	62.4	51.1	
91	25	100	27	62.4	51.1	
91	25	100	27	62.4	51.1	
91	25	100	27	62.4	51.1	
91	25	100	27	62.4	51.1	
91	25	100	27	62.4	51.1	
91	25	100	27	62.4	51.1	
91	25	100	27	62.4	51.1	
91	25	100	27	62.4	51.1	
91	25	100	27	62.4	51.1	
91	25	100	27	62.4	51.1	
91	25	100	27	62.4	51.1	
91	25	100	27	62.4	51.1	
91	25	100	27	62.4	51.1	
91	25	105	27	62.4	51.1	
91	25	105	27	62.4	51.1	
91	25	105	27	62.4	51.1	
91	25	105	27	62.4	51.1	
91	25	105	27	62.4	51.1	
91	25	105	27	62.4	51.1	
91	25	105	27	62.4	51.1	
91	25	105	27	62.4	51.1	
91	25	105	27	62.4	51.1	
91	25	105	27	62.4	51.1	
91	25	105	27	62.4	51.1	
91	25	105	27	62.4	51.1	
91	25	105	27	62.4	51.1	
91	25	105	27	62.4	51.1	
91	25	105	27	62.4	51.1	
91	25	105	27	62.4	51.1	
91	25	105	27	62.4	51.1	
91	25	105	27	62.4	51.1	

Unit Weight of Fill	Thickness of Fill	Unit Weight of Marine Grey Silt	Thickness of Marine Grey Silt	Unit Weight of Water	Confined Aquifer Head	Dep
91	25	105	27	62.4	51.1	
91	25	110	27	62.4	51.1	
91	25	110	27	62.4	51.1	
91	25	110	27	62.4	51.1	
91	25	110	27	62.4	51.1	
91	25	110	27	62.4	51.1	
91	25	110	27	62.4	51.1	
91	25	110	27	62.4	51.1	
91	25	110	27	62.4	51.1	
91	25	110	27	62.4	51.1	
91	25	110	27	62.4	51.1	
91	25	110	27	62.4	51.1	
91	25	110	27	62.4	51.1	
91	25	110	27	62.4	51.1	
91	25	110	27	62.4	51.1	
91	25	110	27	62.4	51.1	
91	25	110	27	62.4	51.1	
91	25	110	27	62.4	51.1	
91	25	110	27	62.4	51.1	
91	25	110	27	62.4	51.1	

MW-13

Sensitivity Analysis - Varying Confined Aquifer Basal Sands Unit He

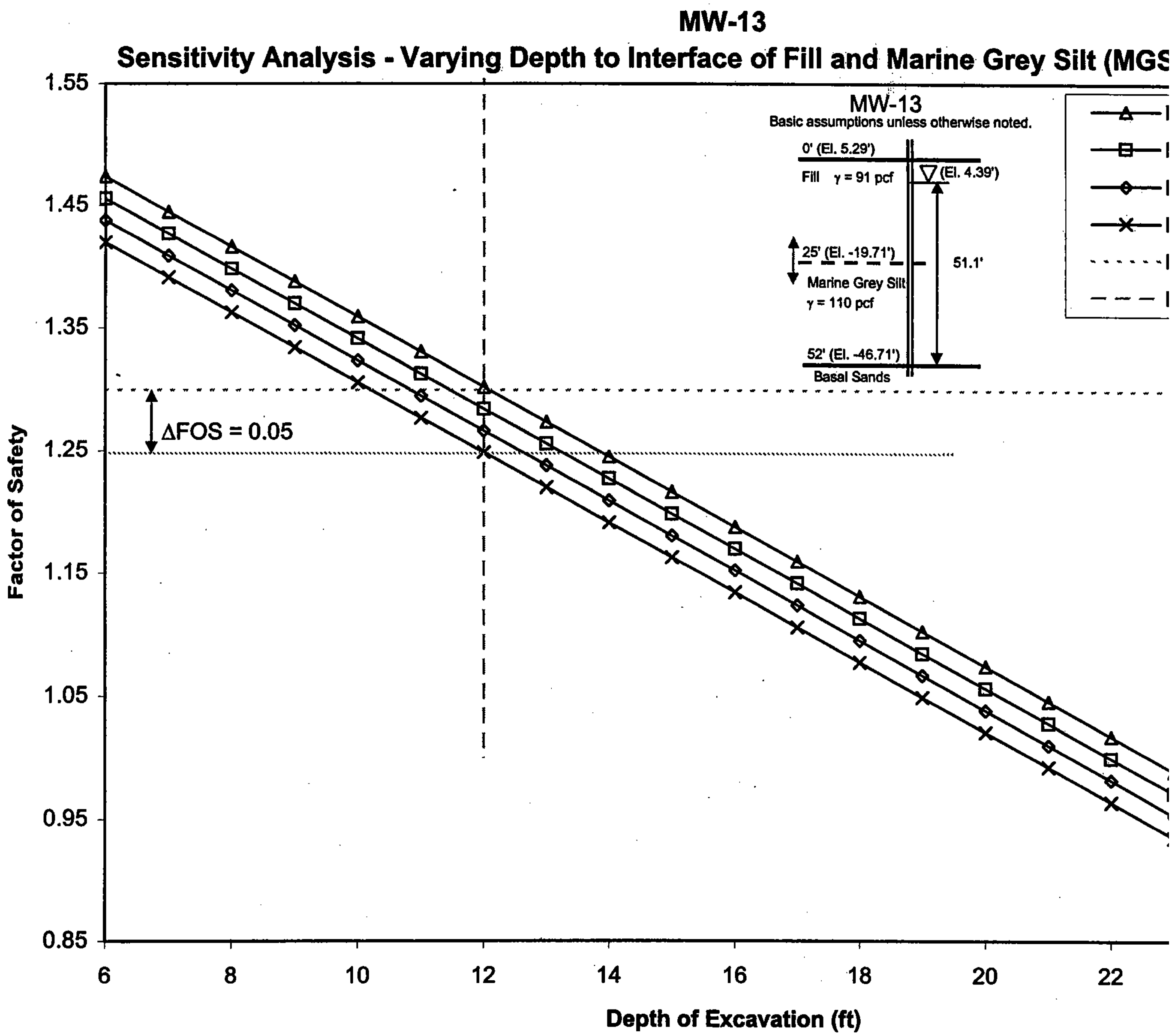


Mw-13.xls
Chart - Conf. Aquifer Head

Unit Weight of Fill	Thickness of Fill	Unit Weight of Marine Grey Silt	Thickness of Marine Grey Silt	Unit Weight of Water	Confined Aquifer Head	Depth of Excavatio
91	25	110	27	62.4	50	6
91	25	110	27	62.4	50	7
91	25	110	27	62.4	50	8
91	25	110	27	62.4	50	9
91	25	110	27	62.4	50	10
91	25	110	27	62.4	50	11
91	25	110	27	62.4	50	12
91	25	110	27	62.4	50	13
91	25	110	27	62.4	50	14
91	25	110	27	62.4	50	15
91	25	110	27	62.4	50	16
91	25	110	27	62.4	50	17
91	25	110	27	62.4	50	18
91	25	110	27	62.4	50	19
91	25	110	27	62.4	50	20
91	25	110	27	62.4	50	21
91	25	110	27	62.4	50	22
91	25	110	27	62.4	50	23
91	25	110	27	62.4	50	24
91	25	110	27	62.4	51.1	6
91	25	110	27	62.4	51.1	7
91	25	110	27	62.4	51.1	8
91	25	110	27	62.4	51.1	9
91	25	110	27	62.4	51.1	10
91	25	110	27	62.4	51.1	11
91	25	110	27	62.4	51.1	12
91	25	110	27	62.4	51.1	13
91	25	110	27	62.4	51.1	14
91	25	110	27	62.4	51.1	15
91	25	110	27	62.4	51.1	16
91	25	110	27	62.4	51.1	17
91	25	110	27	62.4	51.1	18
91	25	110	27	62.4	51.1	19
91	25	110	27	62.4	51.1	20
91	25	110	27	62.4	51.1	21
91	25	110	27	62.4	51.1	22
91	25	110	27	62.4	51.1	23
91	25	110	27	62.4	51.1	24
91	25	110	27	62.4	54	6
91	25	110	27	62.4	54	7
91	25	110	27	62.4	54	8
91	25	110	27	62.4	54	9
91	25	110	27	62.4	54	10

Unit Weight of Fill	Thickness of Fill	Unit Weight of Marine Grey Silt	Thickness of Marine Grey Silt	Unit Weight of Water	Confined Aquifer Head	Depth of Excavatic
91	25	110	27	62.4	54	11
91	25	110	27	62.4	54	12
91	25	110	27	62.4	54	13
91	25	110	27	62.4	54	14
91	25	110	27	62.4	54	15
91	25	110	27	62.4	54	16
91	25	110	27	62.4	54	17
91	25	110	27	62.4	54	18
91	25	110	27	62.4	54	19
91	25	110	27	62.4	54	20
91	25	110	27	62.4	54	21
91	25	110	27	62.4	54	22
91	25	110	27	62.4	54	23
91	25	110	27	62.4	54	24
91	25	110	27	62.4	58	6
91	25	110	27	62.4	58	7
91	25	110	27	62.4	58	8
91	25	110	27	62.4	58	9
91	25	110	27	62.4	58	10
91	25	110	27	62.4	58	11
91	25	110	27	62.4	58	12
91	25	110	27	62.4	58	13
91	25	110	27	62.4	58	14
91	25	110	27	62.4	58	15
91	25	110	27	62.4	58	16
91	25	110	27	62.4	58	17
91	25	110	27	62.4	58	18
91	25	110	27	62.4	58	19
91	25	110	27	62.4	58	20
91	25	110	27	62.4	58	21
91	25	110	27	62.4	58	22
91	25	110	27	62.4	58	23
91	25	110	27	62.4	58	24
91	25	110	27	62.4	62	6
91	25	110	27	62.4	62	7
91	25	110	27	62.4	62	8
91	25	110	27	62.4	62	9
91	25	110	27	62.4	62	10
91	25	110	27	62.4	62	11
91	25	110	27	62.4	62	12
91	25	110	27	62.4	62	13
91	25	110	27	62.4	62	14
91	25	110	27	62.4	62	15

Unit Weight of Fill	Thickness of Fill	Unit Weight of Marine Grey Silt	Thickness of Marine Grey Silt	Unit Weight of Water	Confined Aquifer Head	Depth of Excavatic
91	25	110	27	62.4	62	16
91	25	110	27	62.4	62	17
91	25	110	27	62.4	62	18
91	25	110	27	62.4	62	19
91	25	110	27	62.4	62	20
91	25	110	27	62.4	62	21
91	25	110	27	62.4	62	22
91	25	110	27	62.4	62	23
91	25	110	27	62.4	62	24



Mw-13.xls
Chart - Depth Fill & MGS

Unit Weight of Upper Fill	Unit Weight of Lower Fill	Thickness of Upper Fill	Thickness of Lower Fill	Unit Weight of Marine Grey Silt	Thickness of Marine Grey Silt	Unit Weight of Water	Confi Aquifer
91	91	5	20	110	27	62.4	51
91	91	5	20	110	27	62.4	51
91	91	5	20	110	27	62.4	51
91	91	5	20	110	27	62.4	51
91	91	5	20	110	27	62.4	51
91	91	5	20	110	27	62.4	51
91	91	5	20	110	27	62.4	51
91	91	5	20	110	27	62.4	51
91	91	5	20	110	27	62.4	51
91	91	5	20	110	27	62.4	51
91	91	5	20	110	27	62.4	51
91	91	5	20	110	27	62.4	51
91	91	5	20	110	27	62.4	51
91	91	5	20	110	27	62.4	51
91	91	5	20	110	27	62.4	51
91	91	5	20	110	27	62.4	51
91	91	5	20	110	27	62.4	51
91	91	5	20	110	27	62.4	51
91	91	5	20	110	27	62.4	51
91	91	5	21	110	26	62.4	51
91	91	5	21	110	26	62.4	51
91	91	5	21	110	26	62.4	51
91	91	5	21	110	26	62.4	51
91	91	5	21	110	26	62.4	51
91	91	5	21	110	26	62.4	51
91	91	5	21	110	26	62.4	51
91	91	5	21	110	26	62.4	51
91	91	5	21	110	26	62.4	51
91	91	5	21	110	26	62.4	51
91	91	5	21	110	26	62.4	51
91	91	5	21	110	26	62.4	51
91	91	5	21	110	26	62.4	51
91	91	5	21	110	26	62.4	51
91	91	5	21	110	26	62.4	51
91	91	5	21	110	26	62.4	51
91	91	5	21	110	26	62.4	51
91	91	5	21	110	26	62.4	51
91	91	5	21	110	26	62.4	51
91	91	5	22	110	25	62.4	51
91	91	5	22	110	25	62.4	51

Unit Weight of Upper Fill	Unit Weight of Lower Fill	Thickness of Upper Fill	Thickness of Lower Fill	Unit Weight of Marine Grey Silt	Thickness of Marine Grey Silt	Unit Weight of Water	Confi Aquifer
91	91	5	22	110	25	62.4	51
91	91	5	22	110	25	62.4	51
91	91	5	22	110	25	62.4	51
91	91	5	22	110	25	62.4	51
91	91	5	22	110	25	62.4	51
91	91	5	22	110	25	62.4	51
91	91	5	22	110	25	62.4	51
91	91	5	22	110	25	62.4	51
91	91	5	22	110	25	62.4	51
91	91	5	22	110	25	62.4	51
91	91	5	22	110	25	62.4	51
91	91	5	22	110	25	62.4	51
91	91	5	22	110	25	62.4	51
91	91	5	22	110	25	62.4	51
91	91	5	22	110	25	62.4	51
91	91	5	22	110	25	62.4	51
91	91	5	22	110	25	62.4	51
91	91	5	23	110	24	62.4	51
91	91	5	23	110	24	62.4	51
91	91	5	23	110	24	62.4	51
91	91	5	23	110	24	62.4	51
91	91	5	23	110	24	62.4	51
91	91	5	23	110	24	62.4	51
91	91	5	23	110	24	62.4	51
91	91	5	23	110	24	62.4	51
91	91	5	23	110	24	62.4	51
91	91	5	23	110	24	62.4	51
91	91	5	23	110	24	62.4	51
91	91	5	23	110	24	62.4	51
91	91	5	23	110	24	62.4	51
91	91	5	23	110	24	62.4	51
91	91	5	23	110	24	62.4	51
91	91	5	23	110	24	62.4	51
91	91	5	23	110	24	62.4	51
91	91	5	23	110	24	62.4	51
91	91	5	23	110	24	62.4	51
91	91	5	24	110	23	62.4	51
91	91	5	24	110	23	62.4	51
91	91	5	24	110	23	62.4	51
91	91	5	24	110	23	62.4	51

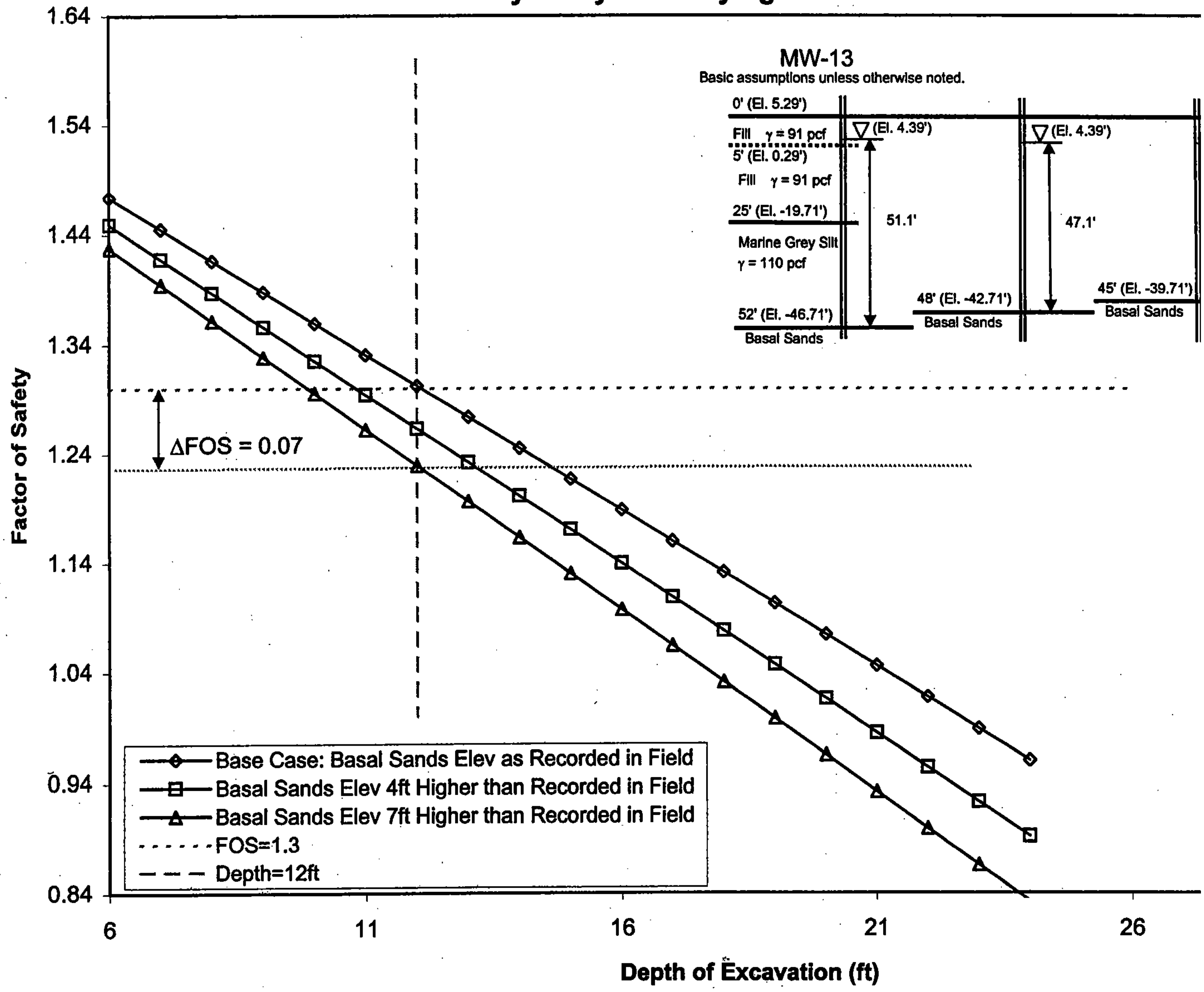
Unit Weight of Upper Fill	Unit Weight of Lower Fill	Thickness of Upper Fill	Thickness of Lower Fill	Unit Weight of Marine Grey Silt	Thickness of Marine Grey Silt	Unit Weight of Water	Confi Aquifer
91	91	5	24	110	23	62.4	51
91	91	5	24	110	23	62.4	51
91	91	5	24	110	23	62.4	51
91	91	5	24	110	23	62.4	51
91	91	5	24	110	23	62.4	51
91	91	5	24	110	23	62.4	51
91	91	5	24	110	23	62.4	51
91	91	5	24	110	23	62.4	51
91	91	5	24	110	23	62.4	51
91	91	5	24	110	23	62.4	51
91	91	5	24	110	23	62.4	51
91	91	5	24	110	23	62.4	51
91	91	5	24	110	23	62.4	51
91	91	5	24	110	23	62.4	51
91	91	5	24	110	23	62.4	51
91	91	5	25	110	22	62.4	51
91	91	5	25	110	22	62.4	51
91	91	5	25	110	22	62.4	51
91	91	5	25	110	22	62.4	51
91	91	5	25	110	22	62.4	51
91	91	5	25	110	22	62.4	51
91	91	5	25	110	22	62.4	51
91	91	5	25	110	22	62.4	51
91	91	5	25	110	22	62.4	51
91	91	5	25	110	22	62.4	51
91	91	5	25	110	22	62.4	51
91	91	5	25	110	22	62.4	51
91	91	5	25	110	22	62.4	51
91	91	5	25	110	22	62.4	51
91	91	5	25	110	22	62.4	51
91	91	5	25	110	22	62.4	51
91	91	5	25	110	22	62.4	51
91	91	5	25	110	22	62.4	51
91	91	5	25	110	22	62.4	51
91	91	5	26	110	21	62.4	51
91	91	5	26	110	21	62.4	51
91	91	5	26	110	21	62.4	51
91	91	5	26	110	21	62.4	51
91	91	5	26	110	21	62.4	51
91	91	5	26	110	21	62.4	51

Unit Weight of Upper Fill	Unit Weight of Lower Fill	Thickness of Upper Fill	Thickness of Lower Fill	Unit Weight of Marine Grey Silt	Thickness of Marine Grey Silt	Unit Weight of Water	Confi Aquifer
91	91	5	26	110	21	62.4	51
91	91	5	26	110	21	62.4	51
91	91	5	26	110	21	62.4	51
91	91	5	26	110	21	62.4	51
91	91	5	26	110	21	62.4	51
91	91	5	26	110	21	62.4	51
91	91	5	26	110	21	62.4	51
91	91	5	26	110	21	62.4	51
91	91	5	26	110	21	62.4	51
91	91	5	26	110	21	62.4	51
91	91	5	26	110	21	62.4	51
91	91	5	26	110	21	62.4	51
91	91	5	26	110	21	62.4	51
91	91	5	27	110	20	62.4	51
91	91	5	27	110	20	62.4	51
91	91	5	27	110	20	62.4	51
91	91	5	27	110	20	62.4	51
91	91	5	27	110	20	62.4	51
91	91	5	27	110	20	62.4	51
91	91	5	27	110	20	62.4	51
91	91	5	27	110	20	62.4	51
91	91	5	27	110	20	62.4	51
91	91	5	27	110	20	62.4	51
91	91	5	27	110	20	62.4	51
91	91	5	27	110	20	62.4	51
91	91	5	27	110	20	62.4	51
91	91	5	27	110	20	62.4	51
91	91	5	27	110	20	62.4	51
91	91	5	27	110	20	62.4	51
91	91	5	27	110	20	62.4	51
91	91	5	27	110	20	62.4	51
91	91	5	27	110	20	62.4	51
91	91	5	28	110	19	62.4	51
91	91	5	28	110	19	62.4	51
91	91	5	28	110	19	62.4	51
91	91	5	28	110	19	62.4	51
91	91	5	28	110	19	62.4	51
91	91	5	28	110	19	62.4	51
91	91	5	28	110	19	62.4	51
91	91	5	28	110	19	62.4	51

Unit Weight of Upper Fill	Unit Weight of Lower Fill	Thickness of Upper Fill	Thickness of Lower Fill	Unit Weight of Marine Grey Silt	Thickness of Marine Grey Silt	Unit Weight of Water	Confi Aquifer
91	91	5	28	110	19	62.4	51.
91	91	5	28	110	19	62.4	51.
91	91	5	28	110	19	62.4	51.
91	91	5	28	110	19	62.4	51.
91	91	5	28	110	19	62.4	51.
91	91	5	28	110	19	62.4	51.
91	91	5	28	110	19	62.4	51.
91	91	5	28	110	19	62.4	51.
91	91	5	28	110	19	62.4	51.
91	91	5	28	110	19	62.4	51.
91	91	5	28	110	19	62.4	51.
91	91	5	29	110	18	62.4	51.
91	91	5	29	110	18	62.4	51.
91	91	5	29	110	18	62.4	51.
91	91	5	29	110	18	62.4	51.
91	91	5	29	110	18	62.4	51.
91	91	5	29	110	18	62.4	51.
91	91	5	29	110	18	62.4	51.
91	91	5	29	110	18	62.4	51.
91	91	5	29	110	18	62.4	51.
91	91	5	29	110	18	62.4	51.
91	91	5	29	110	18	62.4	51.
91	91	5	29	110	18	62.4	51.
91	91	5	29	110	18	62.4	51.
91	91	5	29	110	18	62.4	51.
91	91	5	29	110	18	62.4	51.
91	91	5	29	110	18	62.4	51.
91	91	5	29	110	18	62.4	51.
91	91	5	29	110	18	62.4	51.
91	91	5	29	110	18	62.4	51.
91	91	5	30	110	17	62.4	51
91	91	5	30	110	17	62.4	51
91	91	5	30	110	17	62.4	51
91	91	5	30	110	17	62.4	51
91	91	5	30	110	17	62.4	51
91	91	5	30	110	17	62.4	51
91	91	5	30	110	17	62.4	51
91	91	5	30	110	17	62.4	51
91	91	5	30	110	17	62.4	51
91	91	5	30	110	17	62.4	51

Unit Weight of Upper Fill	Unit Weight of Lower Fill	Thickness of Upper Fill	Thickness of Lower Fill	Unit Weight of Marine Grey Silt	Thickness of Marine Grey Silt	Unit Weight of Water	Confin Aquifer I
91	91	5	30	110	17	62.4	51.
91	91	5	30	110	17	62.4	51.
91	91	5	30	110	17	62.4	51.
91	91	5	30	110	17	62.4	51.
91	91	5	30	110	17	62.4	51.
91	91	5	30	110	17	62.4	51
91	91	5	30	110	17	62.4	51.
91	91	5	30	110	17	62.4	51
91	91	5	30	110	17	62.4	51.
91	91	5	31	110	16	62.4	51.
91	91	5	31	110	16	62.4	51.
91	91	5	31	110	16	62.4	51.
91	91	5	31	110	16	62.4	51.
91	91	5	31	110	16	62.4	51.
91	91	5	31	110	16	62.4	51.
91	91	5	31	110	16	62.4	51.
91	91	5	31	110	16	62.4	51.
91	91	5	31	110	16	62.4	51.
91	91	5	31	110	16	62.4	51.
91	91	5	31	110	16	62.4	51.
91	91	5	31	110	16	62.4	51.
91	91	5	31	110	16	62.4	51.
91	91	5	31	110	16	62.4	51.
91	91	5	31	110	16	62.4	51.
91	91	5	31	110	16	62.4	51.
91	91	5	31	110	16	62.4	51.
91	91	5	31	110	16	62.4	51.
91	91	5	31	110	16	62.4	51.

MW-13
Sensitivity Analysis - Varying Basal Sands Elevation



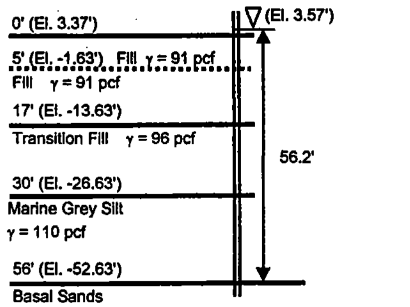
Mw-13.xls
Chart - Elev Basal Sands

Unit Weight of Upper Fill	Unit Weight of Lower Fill	Thickness of Upper Fill	Thickness of Lower Fill	Unit Weight of Marine Grey Silt	Thickness of Marine Grey Silt	Unit Weight of Water	Confi Aquifer
91	91	5	20	110	27	62.4	51.
91	91	5	20	110	27	62.4	51.
91	91	5	20	110	27	62.4	51.
91	91	5	20	110	27	62.4	51.
91	91	5	20	110	27	62.4	51.
91	91	5	20	110	27	62.4	51.
91	91	5	20	110	27	62.4	51.
91	91	5	20	110	27	62.4	51.
91	91	5	20	110	27	62.4	51.
91	91	5	20	110	27	62.4	51.
91	91	5	20	110	27	62.4	51.
91	91	5	20	110	27	62.4	51.
91	91	5	20	110	27	62.4	51.
91	91	5	20	110	27	62.4	51.
91	91	5	20	110	27	62.4	51.
91	91	5	20	110	27	62.4	51.
91	91	5	20	110	27	62.4	51.
91	91	5	20	110	27	62.4	51.
91	91	5	20	110	27	62.4	51.
91	91	5	20	110	23	62.4	47.
91	91	5	20	110	23	62.4	47.
91	91	5	20	110	23	62.4	47.
91	91	5	20	110	23	62.4	47.
91	91	5	20	110	23	62.4	47.
91	91	5	20	110	23	62.4	47.
91	91	5	20	110	23	62.4	47.
91	91	5	20	110	23	62.4	47
91	91	5	20	110	23	62.4	47
91	91	5	20	110	23	62.4	47
91	91	5	20	110	23	62.4	47
91	91	5	20	110	23	62.4	47
91	91	5	20	110	23	62.4	47
91	91	5	20	110	23	62.4	47
91	91	5	20	110	23	62.4	47
91	91	5	20	110	23	62.4	47
91	91	5	20	110	23	62.4	47
91	91	5	20	110	23	62.4	47
91	91	5	20	110	23	62.4	47
91	91	5	20	110	20	62.4	44
91	91	5	20	110	20	62.4	44

Unit Weight of Upper Fill	Unit Weight of Lower Fill	Thickness of Upper Fill	Thickness of Lower Fill	Unit Weight of Marine Grey Silt	Thickness of Marine Grey Silt	Unit Weight of Water	Confi Aquifer
91	91	5	20	110	20	62.4	44.
91	91	5	20	110	20	62.4	44.
91	91	5	20	110	20	62.4	44.
91	91	5	20	110	20	62.4	44.
91	91	5	20	110	20	62.4	44.
91	91	5	20	110	20	62.4	44.
91	91	5	20	110	20	62.4	44.
91	91	5	20	110	20	62.4	44.
91	91	5	20	110	20	62.4	44.
91	91	5	20	110	20	62.4	44.
91	91	5	20	110	20	62.4	44.
91	91	5	20	110	20	62.4	44.
91	91	5	20	110	20	62.4	44.
91	91	5	20	110	20	62.4	44.
91	91	5	20	110	20	62.4	44.
91	91	5	20	110	20	62.4	44.
91	91	5	20	110	20	62.4	44.

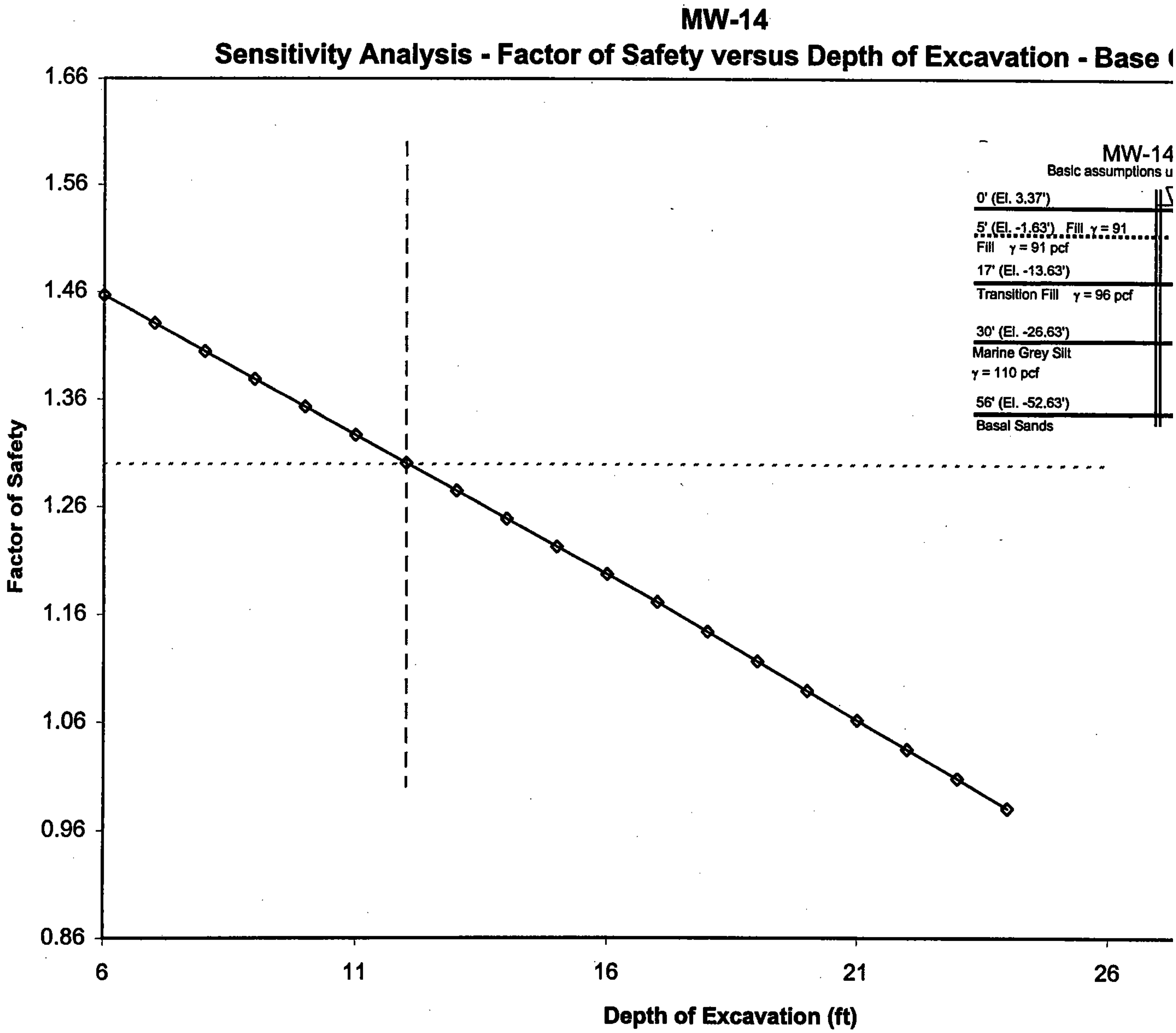
MW-14

Basic assumptions unless otherwise noted.



Constant Lines			
Depth (ft)	FOS	Depth (ft)	FOS
6	1.3	12	1.6
26	1.3	12	1

Mw-14
Basic Assumptions



Mw-14.xls
Chart - Base Case

Unit Weight of Upper Fill	Unit Weight of Lower Fill	Thickness of Upper Fill	Thickness of Lower Fill	Unit Weight of the Transition Fill	Thickness of Transition Fill	Unit Weight of Marine Grey Silt	Thickness of Marine Grey Silt	Unit Weight of Water	Co Aquif
91	91	5	12	96	13	110	26	62.4	5
91	91	5	12	96	13	110	26	62.4	5
91	91	5	12	96	13	110	26	62.4	5
91	91	5	12	96	13	110	26	62.4	5
91	91	5	12	96	13	110	26	62.4	5
91	91	5	12	96	13	110	26	62.4	5
91	91	5	12	96	13	110	26	62.4	5
91	91	5	12	96	13	110	26	62.4	5
91	91	5	12	96	13	110	26	62.4	5
91	91	5	12	96	13	110	26	62.4	5
91	91	5	12	96	13	110	26	62.4	5
91	91	5	12	96	13	110	26	62.4	5
91	91	5	12	96	13	110	26	62.4	5
91	91	5	12	96	13	110	26	62.4	5
91	91	5	12	96	13	110	26	62.4	5
91	91	5	12	96	13	110	26	62.4	5
91	91	5	12	96	13	110	26	62.4	5
91	91	5	12	96	13	110	26	62.4	5
91	91	5	12	96	13	110	26	62.4	5

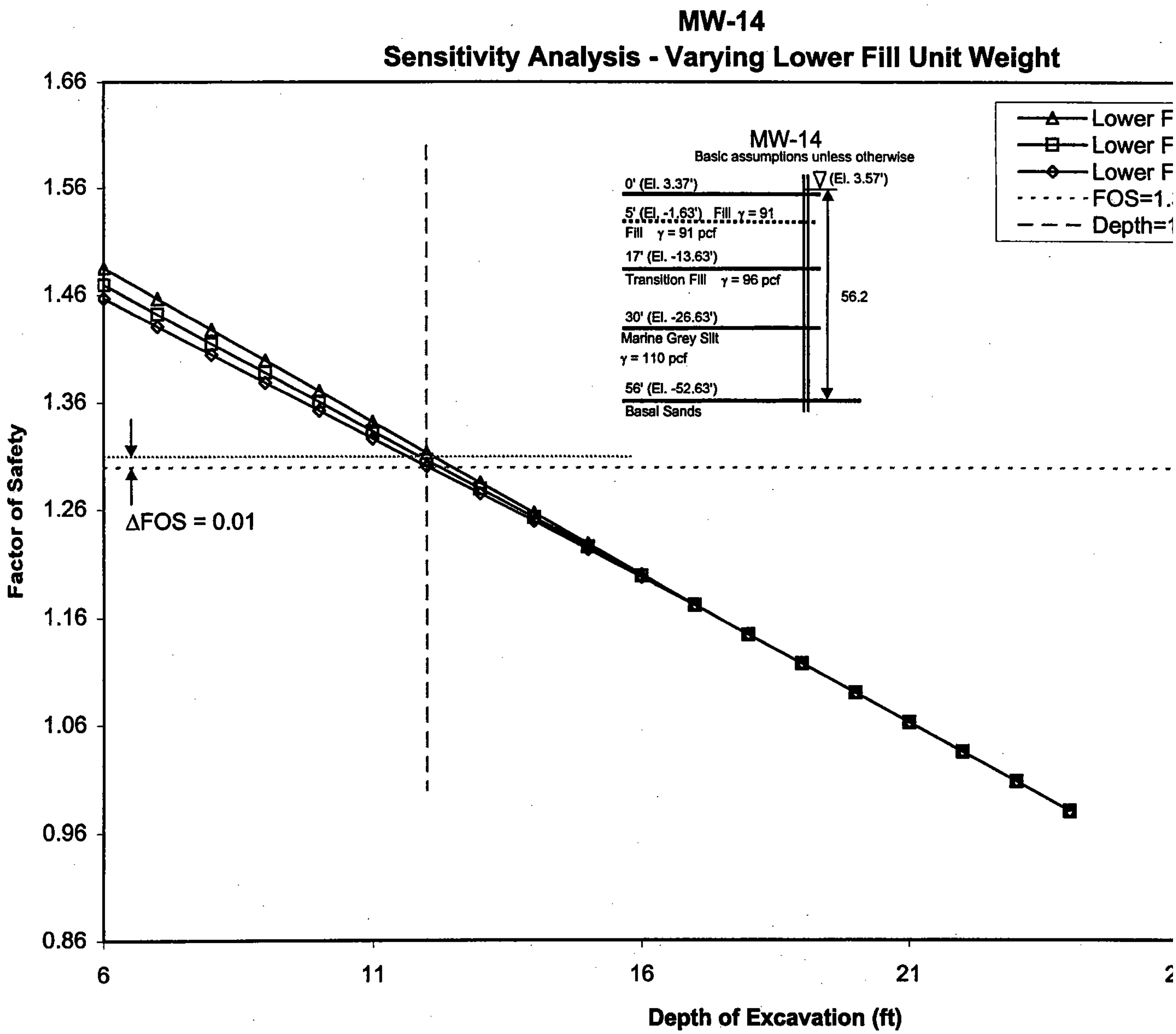
When $d_{EXC} =< h_{FILL}$:

$$FOS = [(\gamma_{FILL} * (h_{FILL} - d_{EXC})) + (\gamma_{TRANSITION\ FILL} + h_{TRANSITION\ FILL}) + (\gamma_{MGS} * h_{MGS})] / (\gamma_W$$

When $d_{EXC} > h_{FILL}$:

$$FOS = [(\gamma_{TRANSITION\ FILL} * (h_{FILL} + h_{TRANSITION\ FILL} - d_{EXC})) + (\gamma_{MGS} * h_{MGS})] / (\gamma_W * h_W)$$

Mw-14
Base Case



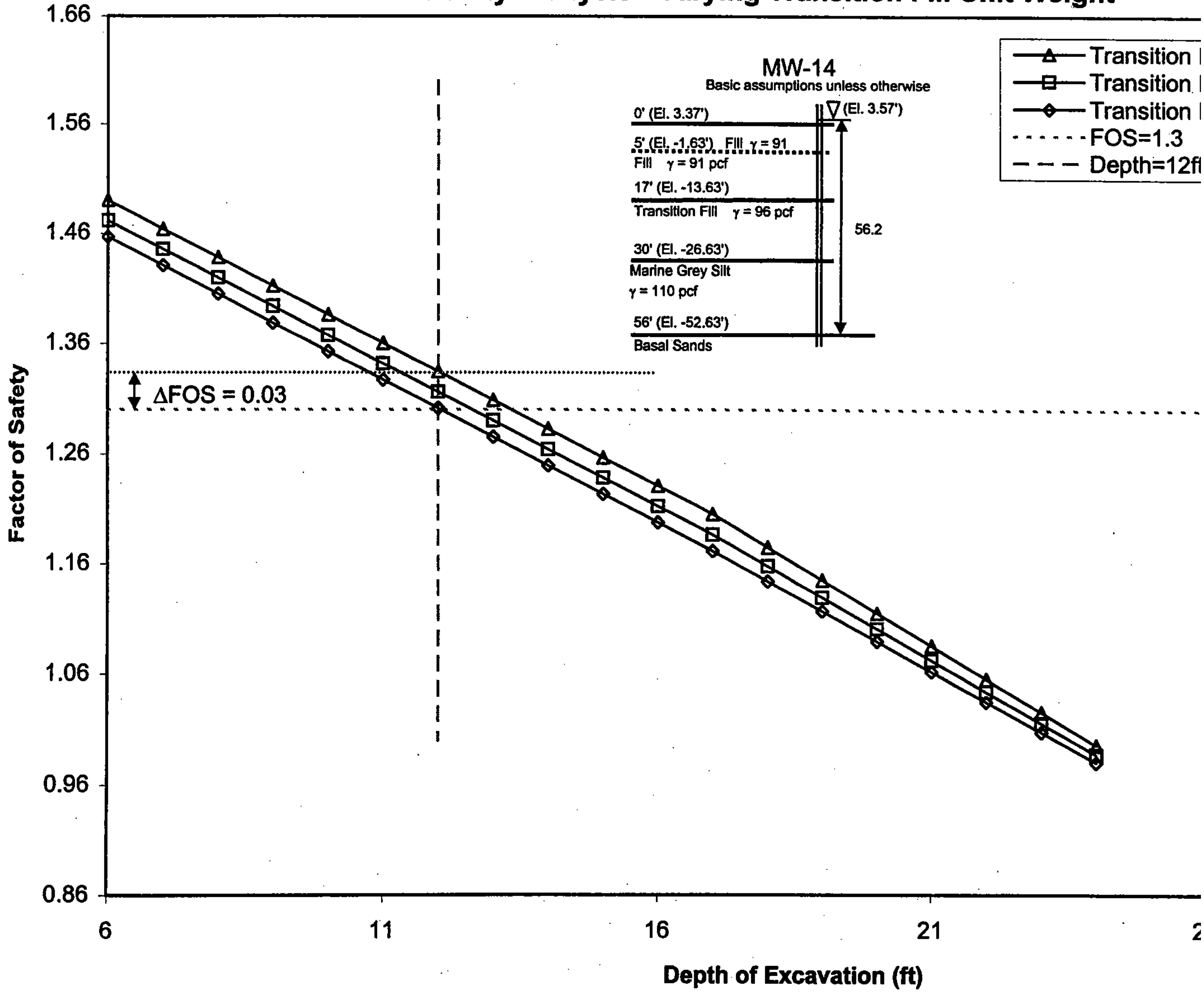
Mw-14.xls
Chart - Fill

Unit Weight of Upper Fill	Unit Weight of Lower Fill	Thickness of Upper Fill	Thickness of Lower Fill	Unit Weight of the Transition Fill	Thickness of Transition Fill	Unit Weight of Marine Grey Silt	Thickness of Marine Grey Silt	Unit Weight of Water	C Aq
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	95	5	12	96	13	110	26	62.4	
91	95	5	12	96	13	110	26	62.4	
91	95	5	12	96	13	110	26	62.4	
91	95	5	12	96	13	110	26	62.4	
91	95	5	12	96	13	110	26	62.4	
91	95	5	12	96	13	110	26	62.4	
91	95	5	12	96	13	110	26	62.4	
91	95	5	12	96	13	110	26	62.4	
91	95	5	12	96	13	110	26	62.4	
91	95	5	12	96	13	110	26	62.4	

91	95	5	12	96	13	110	26	62.4
91	95	5	12	96	13	110	26	62.4
91	95	5	12	96	13	110	26	62.4
91	95	5	12	96	13	110	26	62.4
91	95	5	12	96	13	110	26	62.4
91	95	5	12	96	13	110	26	62.4
91	95	5	12	96	13	110	26	62.4
91	95	5	12	96	13	110	26	62.4
91	95	5	12	96	13	110	26	62.4
91	100	5	12	96	13	110	26	62.4
91	100	5	12	96	13	110	26	62.4
91	100	5	12	96	13	110	26	62.4
91	100	5	12	96	13	110	26	62.4
91	100	5	12	96	13	110	26	62.4
91	100	5	12	96	13	110	26	62.4
91	100	5	12	96	13	110	26	62.4
91	100	5	12	96	13	110	26	62.4
91	100	5	12	96	13	110	26	62.4
91	100	5	12	96	13	110	26	62.4
91	100	5	12	96	13	110	26	62.4
91	100	5	12	96	13	110	26	62.4
91	100	5	12	96	13	110	26	62.4
91	100	5	12	96	13	110	26	62.4
91	100	5	12	96	13	110	26	62.4
91	100	5	12	96	13	110	26	62.4
91	100	5	12	96	13	110	26	62.4
91	100	5	12	96	13	110	26	62.4
91	100	5	12	96	13	110	26	62.4

Mw-14
Unit Wt - Fill

MW-14
Sensitivity Analysis - Varying Transition Fill Unit Weight

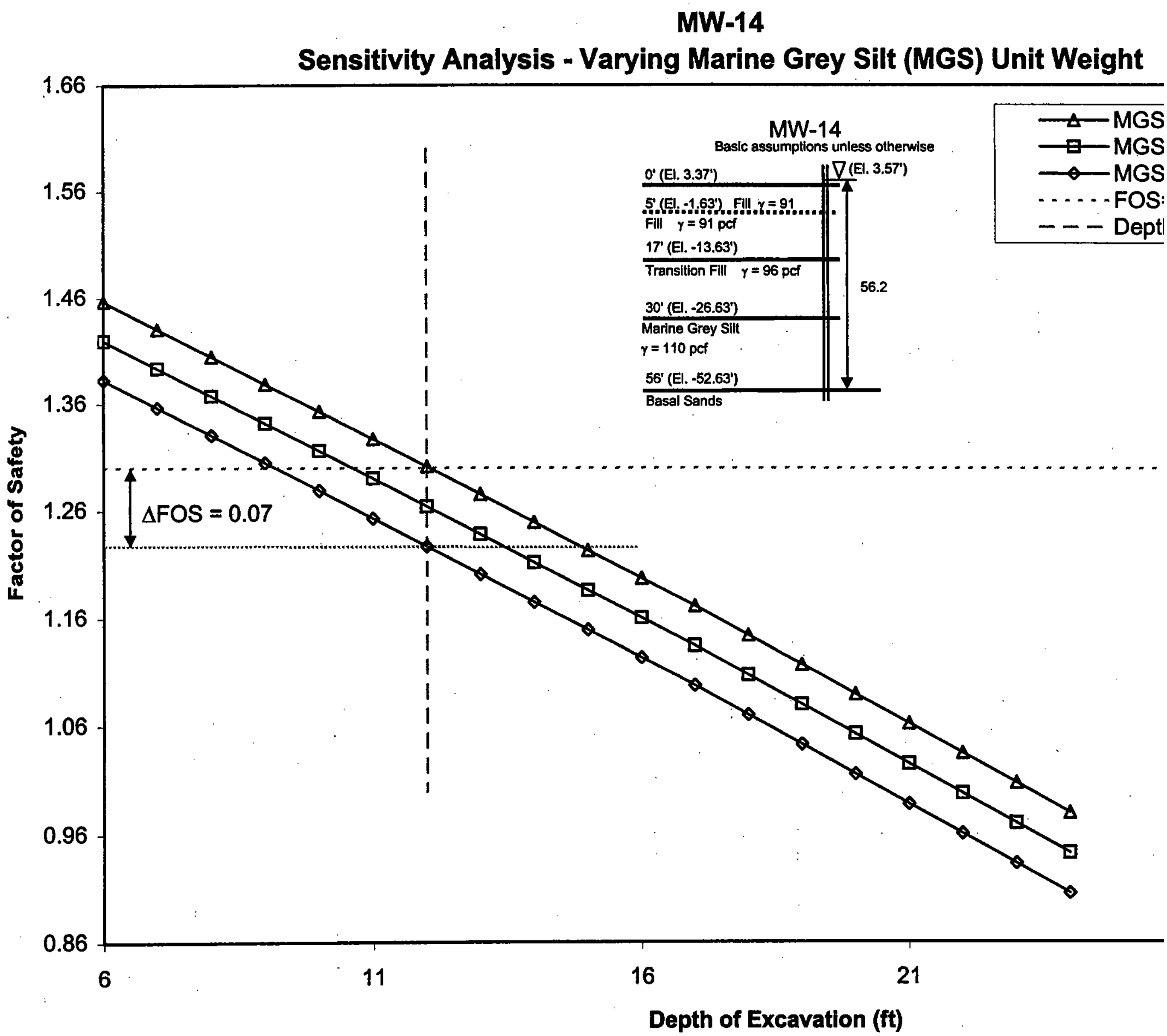


Mw-14.xls
Chart - Transition Fill

Unit Weight of Upper Fill	Unit Weight of Lower Fill	Thickness of Upper Fill	Thickness of Lower Fill	Unit Weight of the Transition Fill	Thickness of Transition Fill	Unit Weight of Marine Grey Silt	Thickness of Marine Grey Silt	Unit Weight of Water	A
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	100	13	110	26	62.4	
91	91	5	12	100	13	110	26	62.4	
91	91	5	12	100	13	110	26	62.4	
91	91	5	12	100	13	110	26	62.4	
91	91	5	12	100	13	110	26	62.4	
91	91	5	12	100	13	110	26	62.4	
91	91	5	12	100	13	110	26	62.4	
91	91	5	12	100	13	110	26	62.4	
91	91	5	12	100	13	110	26	62.4	
91	91	5	12	100	13	110	26	62.4	

Mw-14
Unit Wt - Transition Fill

91	91	5	12	100	13	110	26	62.4	56.2	16	1.21
91	91	5	12	100	13	110	26	62.4	56.2	17	1.19
91	91	5	12	100	13	110	26	62.4	56.2	18	1.16
91	91	5	12	100	13	110	26	62.4	56.2	19	1.13
91	91	5	12	100	13	110	26	62.4	56.2	20	1.10
91	91	5	12	100	13	110	26	62.4	56.2	21	1.07
91	91	5	12	100	13	110	26	62.4	56.2	22	1.04
91	91	5	12	100	13	110	26	62.4	56.2	23	1.02
91	91	5	12	100	13	110	26	62.4	56.2	24	0.99
91	91	5	12	105	13	110	26	62.4	56.2	6	1.49
91	91	5	12	105	13	110	26	62.4	56.2	7	1.46
91	91	5	12	105	13	110	26	62.4	56.2	8	1.44
91	91	5	12	105	13	110	26	62.4	56.2	9	1.41
91	91	5	12	105	13	110	26	62.4	56.2	10	1.39
91	91	5	12	105	13	110	26	62.4	56.2	11	1.36
91	91	5	12	105	13	110	26	62.4	56.2	12	1.33
91	91	5	12	105	13	110	26	62.4	56.2	13	1.31
91	91	5	12	105	13	110	26	62.4	56.2	14	1.28
91	91	5	12	105	13	110	26	62.4	56.2	15	1.26
91	91	5	12	105	13	110	26	62.4	56.2	16	1.23
91	91	5	12	105	13	110	26	62.4	56.2	17	1.20
91	91	5	12	105	13	110	26	62.4	56.2	18	1.17
91	91	5	12	105	13	110	26	62.4	56.2	19	1.14
91	91	5	12	105	13	110	26	62.4	56.2	20	1.11
91	91	5	12	105	13	110	26	62.4	56.2	21	1.09
91	91	5	12	105	13	110	26	62.4	56.2	22	1.06
91	91	5	12	105	13	110	26	62.4	56.2	23	1.03
91	91	5	12	105	13	110	26	62.4	56.2	24	1.00



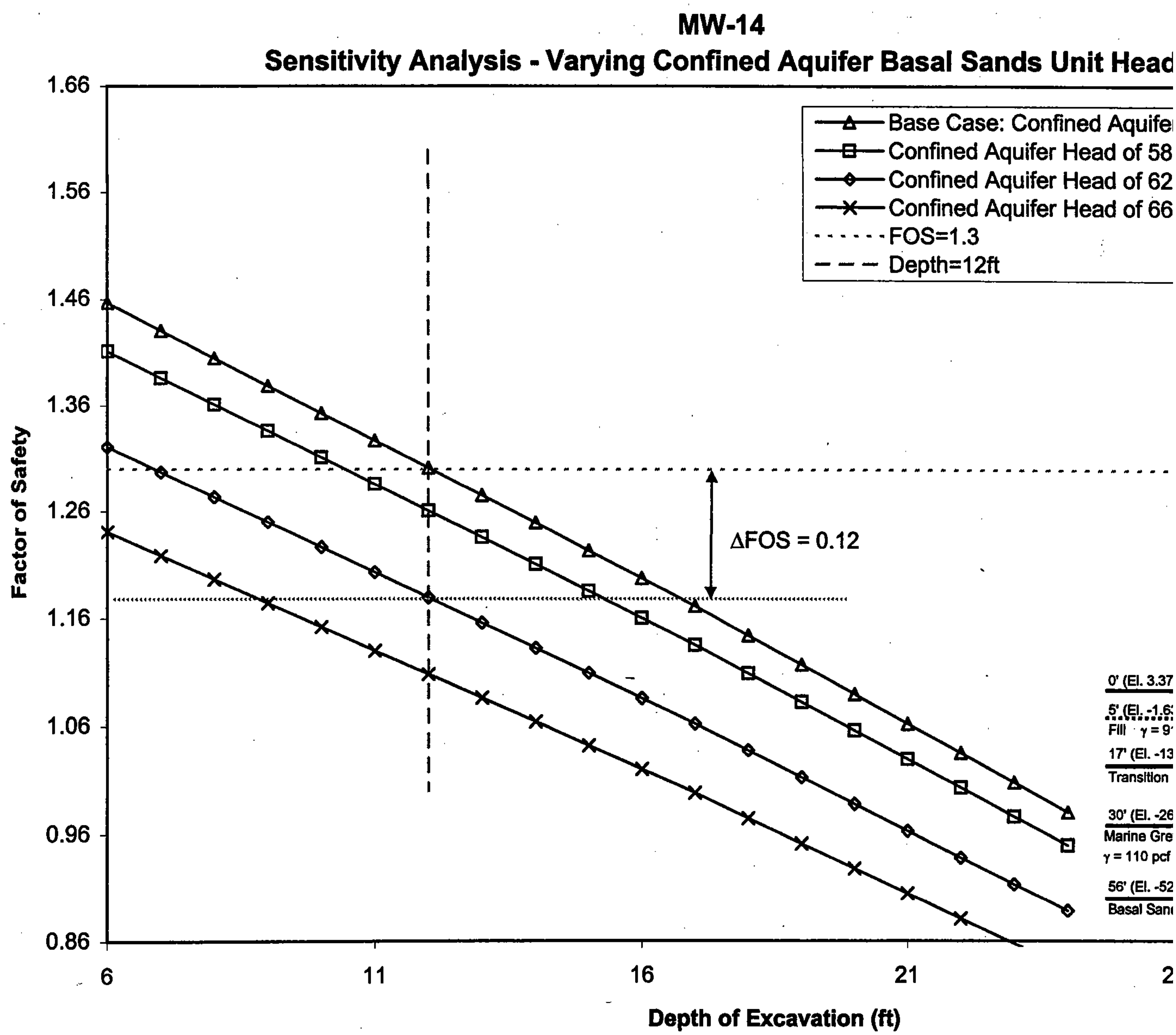
Mw-14.xls
Chart - MGS

Unit Weight of Upper Fill	Unit Weight of Lower Fill	Thickness of Upper Fill	Thickness of Lower Fill	Unit Weight of the Transition Fill	Thickness of Transition Fill	Unit Weight of Marine Grey Silt	Thickness of Marine Grey Silt	Unit Weight of Water	C Aq
91	91	5	12	96	13	100	26	62.4	
91	91	5	12	96	13	100	26	62.4	
91	91	5	12	96	13	100	26	62.4	
91	91	5	12	96	13	100	26	62.4	
91	91	5	12	96	13	100	26	62.4	
91	91	5	12	96	13	100	26	62.4	
91	91	5	12	96	13	100	26	62.4	
91	91	5	12	96	13	100	26	62.4	
91	91	5	12	96	13	100	26	62.4	
91	91	5	12	96	13	100	26	62.4	
91	91	5	12	96	13	100	26	62.4	
91	91	5	12	96	13	100	26	62.4	
91	91	5	12	96	13	100	26	62.4	
91	91	5	12	96	13	100	26	62.4	
91	91	5	12	96	13	100	26	62.4	
91	91	5	12	96	13	100	26	62.4	
91	91	5	12	96	13	100	26	62.4	
91	91	5	12	96	13	100	26	62.4	
91	91	5	12	96	13	100	26	62.4	
91	91	5	12	96	13	105	26	62.4	
91	91	5	12	96	13	105	26	62.4	
91	91	5	12	96	13	105	26	62.4	
91	91	5	12	96	13	105	26	62.4	
91	91	5	12	96	13	105	26	62.4	
91	91	5	12	96	13	105	26	62.4	
91	91	5	12	96	13	105	26	62.4	
91	91	5	12	96	13	105	26	62.4	
91	91	5	12	96	13	105	26	62.4	
91	91	5	12	96	13	105	26	62.4	

Mw-14
Unit Wt- MGS

91	91	5	12	96	13	105	26	62.4
91	91	5	12	96	13	105	26	62.4
91	91	5	12	96	13	105	26	62.4
91	91	5	12	96	13	105	26	62.4
91	91	5	12	96	13	105	26	62.4
91	91	5	12	96	13	105	26	62.4
91	91	5	12	96	13	105	26	62.4
91	91	5	12	96	13	105	26	62.4
91	91	5	12	96	13	105	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4

Mw-14
Unit Wt- MGS



Mw-14.xls
Chart - Conf. Aquifer Head

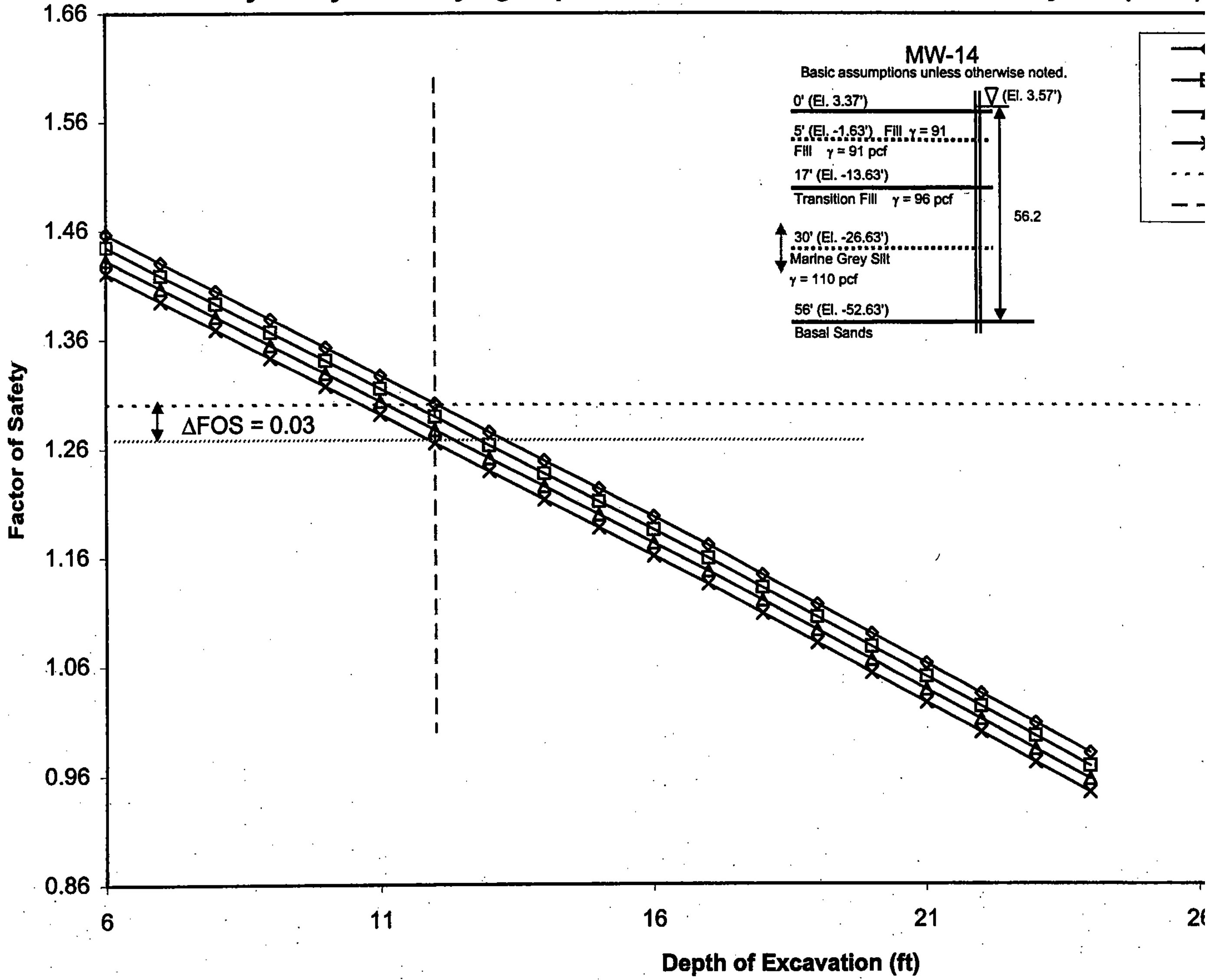
Unit Weight of Upper Fill	Unit Weight of Lower Fill	Thickness of Upper Fill	Thickness of Lower Fill	Unit Weight of the Transition Fill	Thickness of Transition Fill	Unit Weight of Marine Grey Silt	Thickness of Marine Grey Silt	Unit Weight of Water	A
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	

Mw-14
Confined Aquifer Head

91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4

Mw-14
Confined Aquifer Head

MW-14
Sensitivity Analysis - Varying Depth to Interface of Fill and Marine Grey Silt (MGS)



Mw-14.xls
Chart - Depth Trans. Fill & MGS

Unit Weight of Upper Fill	Unit Weight of Lower Fill	Thickness of Upper Fill	Thickness of Lower Fill	Unit Weight of the Transition Fill	Thickness of Transition Fill	Unit Weight of Marine Grey Silt	Thickness of Marine Grey Silt	Unit Weight of Water
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	13	110	26	62.4
91	91	5	12	96	16	110	23	62.4
91	91	5	12	96	16	110	23	62.4
91	91	5	12	96	16	110	23	62.4
91	91	5	12	96	16	110	23	62.4
91	91	5	12	96	16	110	23	62.4
91	91	5	12	96	16	110	23	62.4
91	91	5	12	96	16	110	23	62.4
91	91	5	12	96	16	110	23	62.4
91	91	5	12	96	16	110	23	62.4
91	91	5	12	96	16	110	23	62.4
91	91	5	12	96	16	110	23	62.4
91	91	5	12	96	16	110	23	62.4
91	91	5	12	96	16	110	23	62.4
91	91	5	12	96	16	110	23	62.4
91	91	5	12	96	16	110	23	62.4
91	91	5	12	96	16	110	23	62.4
91	91	5	12	96	16	110	23	62.4
91	91	5	12	96	16	110	23	62.4
91	91	5	12	96	16	110	23	62.4

Mw-14
Depth Trans. Fill & MGS

91	91	5	12	96	19	110	20	62.4
91	91	5	12	96	19	110	20	62.4
91	91	5	12	96	19	110	20	62.4
91	91	5	12	96	19	110	20	62.4
91	91	5	12	96	19	110	20	62.4
91	91	5	12	96	19	110	20	62.4
91	91	5	12	96	19	110	20	62.4
91	91	5	12	96	19	110	20	62.4
91	91	5	12	96	19	110	20	62.4
91	91	5	12	96	19	110	20	62.4
91	91	5	12	96	19	110	20	62.4
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91	91	5	12	96	19	110	20	62.4
91	91	5	12	96	19	110	20	62.4
91	91	5	12	96	19	110	20	62.4
91	91	5	12	96	19	110	20	62.4
91	91	5	12	96	19	110	20	62.4
91	91	5	12	96	19	110	20	62.4
91	91	5	12	96	19	110	20	62.4
91	91	5	12	96	22	110	17	62.4
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91	91	5	12	96	22	110	17	62.4
91	91	5	12	96	22	110	17	62.4
91	91	5	12	96	22	110	17	62.4
91	91	5	12	96	22	110	17	62.4
91	91	5	12	96	22	110	17	62.4
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91	91	5	12	96	22	110	17	62.4
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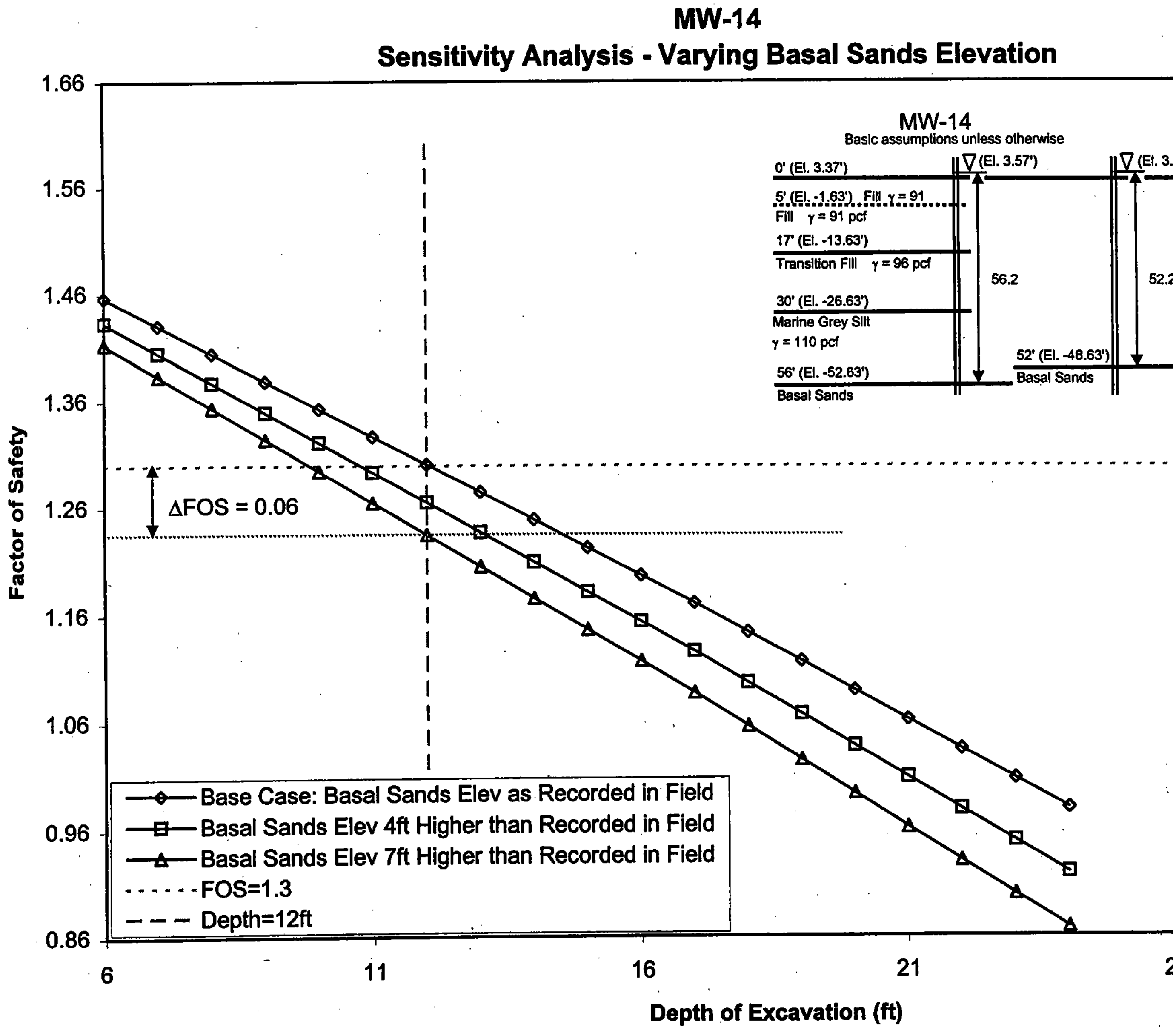
91	91	5	12	96	22	110	17	62.4
91	91	5	12	96	22	110	17	62.4
91	91	5	12	96	22	110	17	62.4
91	91	5	12	96	22	110	17	62.4

Mw-14
Depth Trans. Fill & MGS



Mw-14.xls
Chart - Elev Basal Sands

Unit Weight of Upper Fill	Unit Weight of Lower Fill	Thickness of Upper Fill	Thickness of Lower Fill	Unit Weight of the Transition Fill	Thickness of Transition Fill	Unit Weight of Marine Grey Silt	Thickness of Marine Grey Silt	Unit Weight of Water	A
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
91	91	5	12	96	13	110	26	62.4	
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91	91	5	12	96	13	110	26	62.4	
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91	91	5	12	96	13	110	26	62.4	
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91	91	5	12	96	13	110	22	62.4	
91	91	5	12	96	13	110	22	62.4	
91	91	5	12	96	13	110	22	62.4	
91	91	5	12	96	13	110	22	62.4	
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91	91	5	12	96	13	110	19	62.4	
91	91	5	12	96	13	110	19	62.4	
91	91	5	12	96	13	110	19	62.4	

Mw-14
Elev Basal Sands

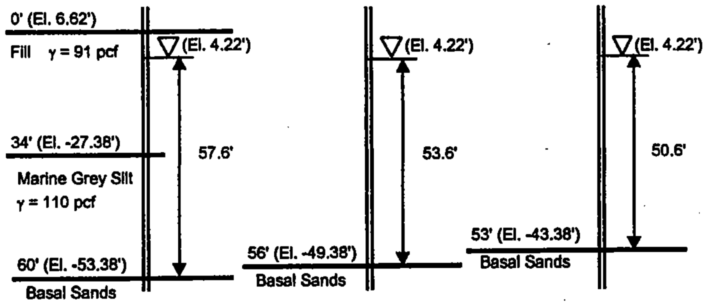
91	91	5	12	96	13	110	19	62.4
91	91	5	12	96	13	110	19	62.4
91	91	5	12	96	13	110	19	62.4
91	91	5	12	96	13	110	19	62.4
91	91	5	12	96	13	110	19	62.4
91	91	5	12	96	13	110	19	62.4
91	91	5	12	96	13	110	19	62.4
91	91	5	12	96	13	110	19	62.4
91	91	5	12	96	13	110	19	62.4
91	91	5	12	96	13	110	19	62.4
91	91	5	12	96	13	110	19	62.4
91	91	5	12	96	13	110	19	62.4
91	91	5	12	96	13	110	19	62.4

Mw-14
Elev Basal Sands

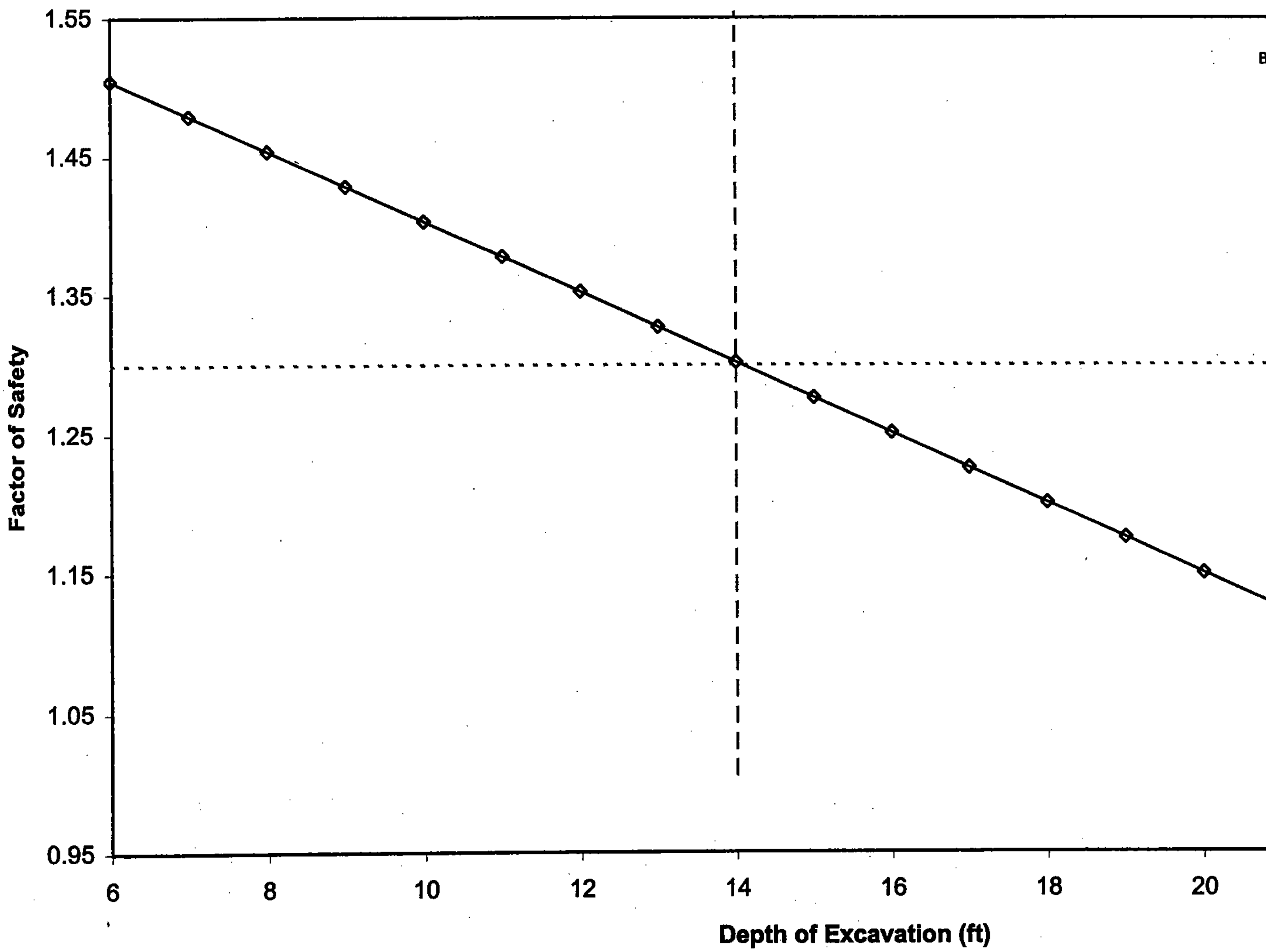
Constant Lines			
Depth (ft)	FOS	Depth (ft)	FOS
6	1.3	14	1.6
26	1.3	14	1

MW-15

Basic assumptions unless otherwise noted.



MW-15
Sensitivity Analysis - Factor of Safety versus Depth of Excavation - Bas



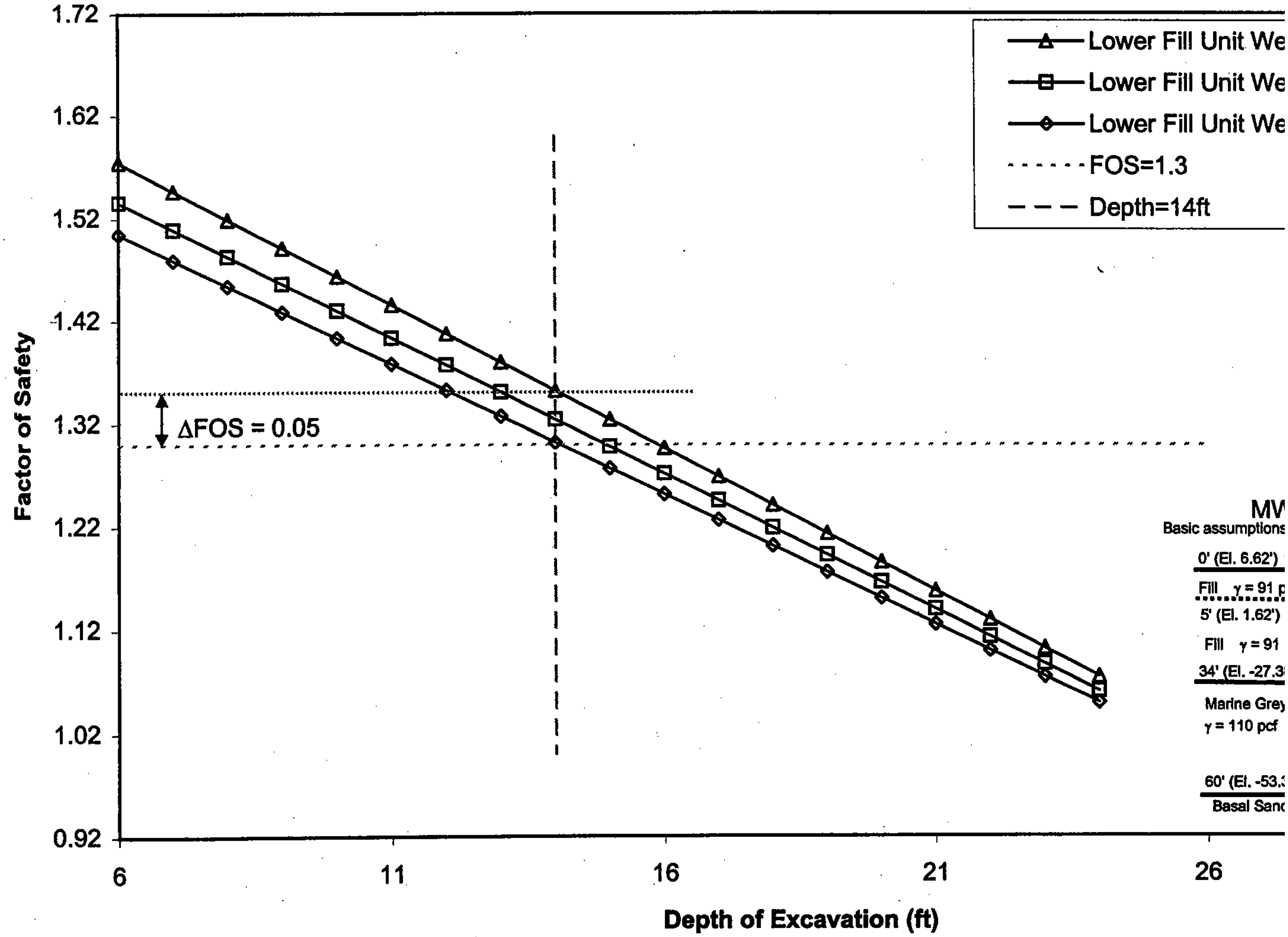
Mw-15.xls
Chart - Base Case

Unit Weight of Fill	Thickness of Fill	Unit Weight of Marine Grey Silt	Thickness of Marine Grey Silt	Unit Weight of Water	Confined Aquifer Head	Dep
91	34	110	26	62.4	57.6	
91	34	110	26	62.4	57.6	
91	34	110	26	62.4	57.6	
91	34	110	26	62.4	57.6	
91	34	110	26	62.4	57.6	
91	34	110	26	62.4	57.6	
91	34	110	26	62.4	57.6	
91	34	110	26	62.4	57.6	
91	34	110	26	62.4	57.6	
91	34	110	26	62.4	57.6	
91	34	110	26	62.4	57.6	
91	34	110	26	62.4	57.6	
91	34	110	26	62.4	57.6	
91	34	110	26	62.4	57.6	
91	34	110	26	62.4	57.6	
91	34	110	26	62.4	57.6	
91	34	110	26	62.4	57.6	
91	34	110	26	62.4	57.6	
91	34	110	26	62.4	57.6	

$$FOS = [(\gamma_{FILL} * (h_{FILL} - d_{EXC})) + (\gamma_{MGS} * h_{MGS})] / (\gamma_{W} *$$

Mw-15.xls
Base Case

MW-15
Sensitivity Analysis - Varying Lower Fill Unit Weight



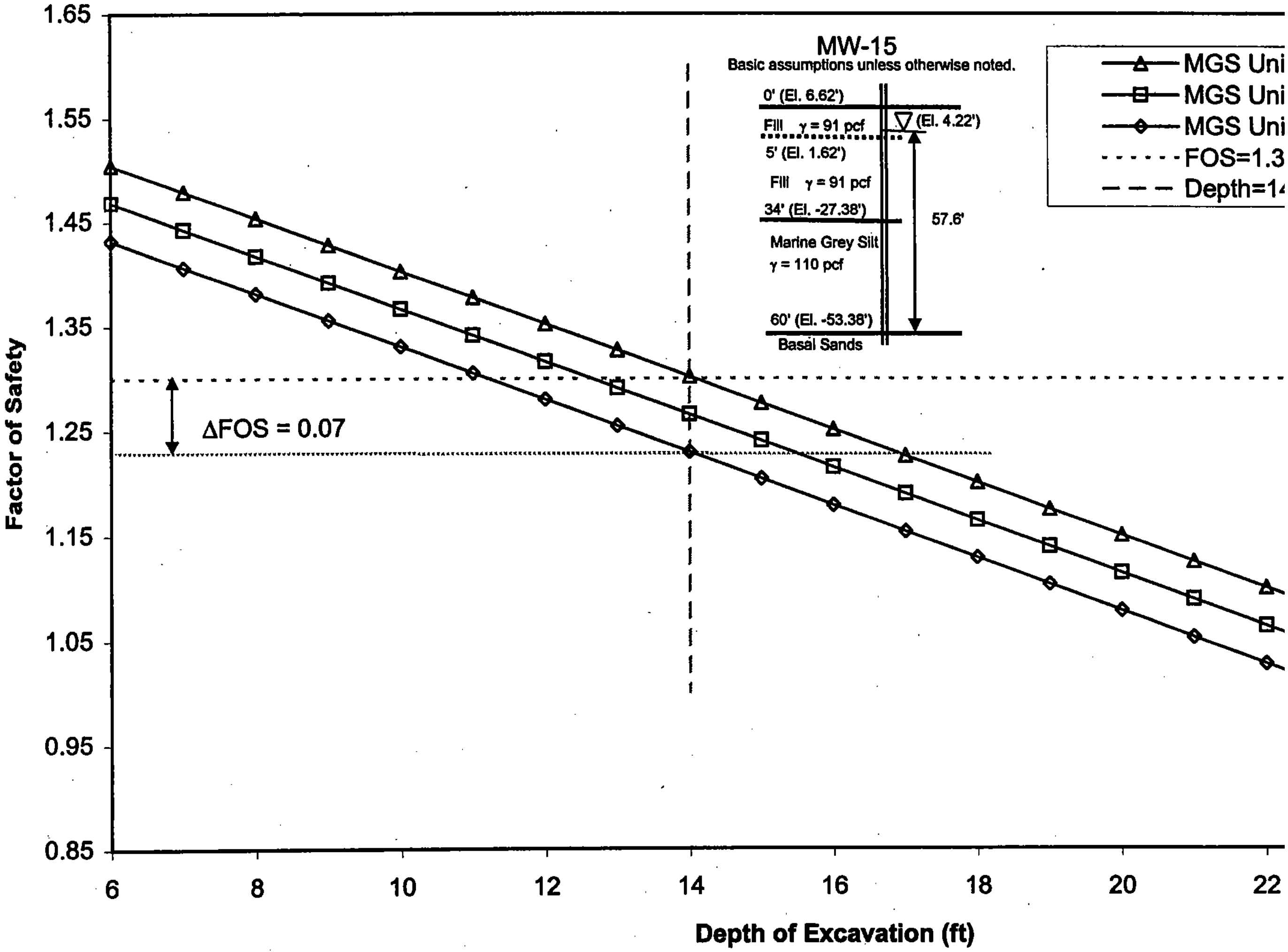
Mw-15.xls
Chart - Fill

Unit Weight of Upper Fill	Unit Weight of Lower Fill	Thickness of Upper Fill	Thickness of Lower Fill	Unit Weight of Marine Grey Silt	Thickness of Marine Grey Silt	Unit Weight of Water	Confin Aquifer H
91	91	5	29	110	26	62.4	57.6
91	91	5	29	110	26	62.4	57.6
91	91	5	29	110	26	62.4	57.6
91	91	5	29	110	26	62.4	57.6
91	91	5	29	110	26	62.4	57.6
91	91	5	29	110	26	62.4	57.6
91	91	5	29	110	26	62.4	57.6
91	91	5	29	110	26	62.4	57.6
91	91	5	29	110	26	62.4	57.6
91	91	5	29	110	26	62.4	57.6
91	91	5	29	110	26	62.4	57.6
91	91	5	29	110	26	62.4	57.6
91	91	5	29	110	26	62.4	57.6
91	91	5	29	110	26	62.4	57.6
91	91	5	29	110	26	62.4	57.6
91	91	5	29	110	26	62.4	57.6
91	91	5	29	110	26	62.4	57.6
91	91	5	29	110	26	62.4	57.6
91	91	5	29	110	26	62.4	57.6
91	95	5	29	110	26	62.4	57.6
91	95	5	29	110	26	62.4	57.6
91	95	5	29	110	26	62.4	57.6
91	95	5	29	110	26	62.4	57.6
91	95	5	29	110	26	62.4	57.6
91	95	5	29	110	26	62.4	57.6
91	95	5	29	110	26	62.4	57.6
91	95	5	29	110	26	62.4	57.6
91	95	5	29	110	26	62.4	57.6
91	95	5	29	110	26	62.4	57.6
91	95	5	29	110	26	62.4	57.6
91	95	5	29	110	26	62.4	57.6
91	95	5	29	110	26	62.4	57.6
91	95	5	29	110	26	62.4	57.6
91	95	5	29	110	26	62.4	57.6
91	95	5	29	110	26	62.4	57.6
91	95	5	29	110	26	62.4	57.6
91	95	5	29	110	26	62.4	57.6
91	95	5	29	110	26	62.4	57.6
91	100	5	29	110	26	62.4	57.6
91	100	5	29	110	26	62.4	57.6

Mw-15.xls
Unit Wt - Fill

Unit Weight of Upper Fill	Unit Weight of Lower Fill	Thickness of Upper Fill	Thickness of Lower Fill	Unit Weight of Marine Grey Silt	Thickness of Marine Grey Silt	Unit Weight of Water	Confin Aquifer H
91	100	5	29	110	26	62.4	57.6
91	100	5	29	110	26	62.4	57.6
91	100	5	29	110	26	62.4	57.6
91	100	5	29	110	26	62.4	57.6
91	100	5	29	110	26	62.4	57.6
91	100	5	29	110	26	62.4	57.6
91	100	5	29	110	26	62.4	57.6
91	100	5	29	110	26	62.4	57.6
91	100	5	29	110	26	62.4	57.6
91	100	5	29	110	26	62.4	57.6
91	100	5	29	110	26	62.4	57.6
91	100	5	29	110	26	62.4	57.6
91	100	5	29	110	26	62.4	57.6
91	100	5	29	110	26	62.4	57.6
91	100	5	29	110	26	62.4	57.6
91	100	5	29	110	26	62.4	57.6
91	100	5	29	110	26	62.4	57.6

MW-15
Sensitivity Analysis - Varying Marine Grey Silt (MGS) Unit Weights



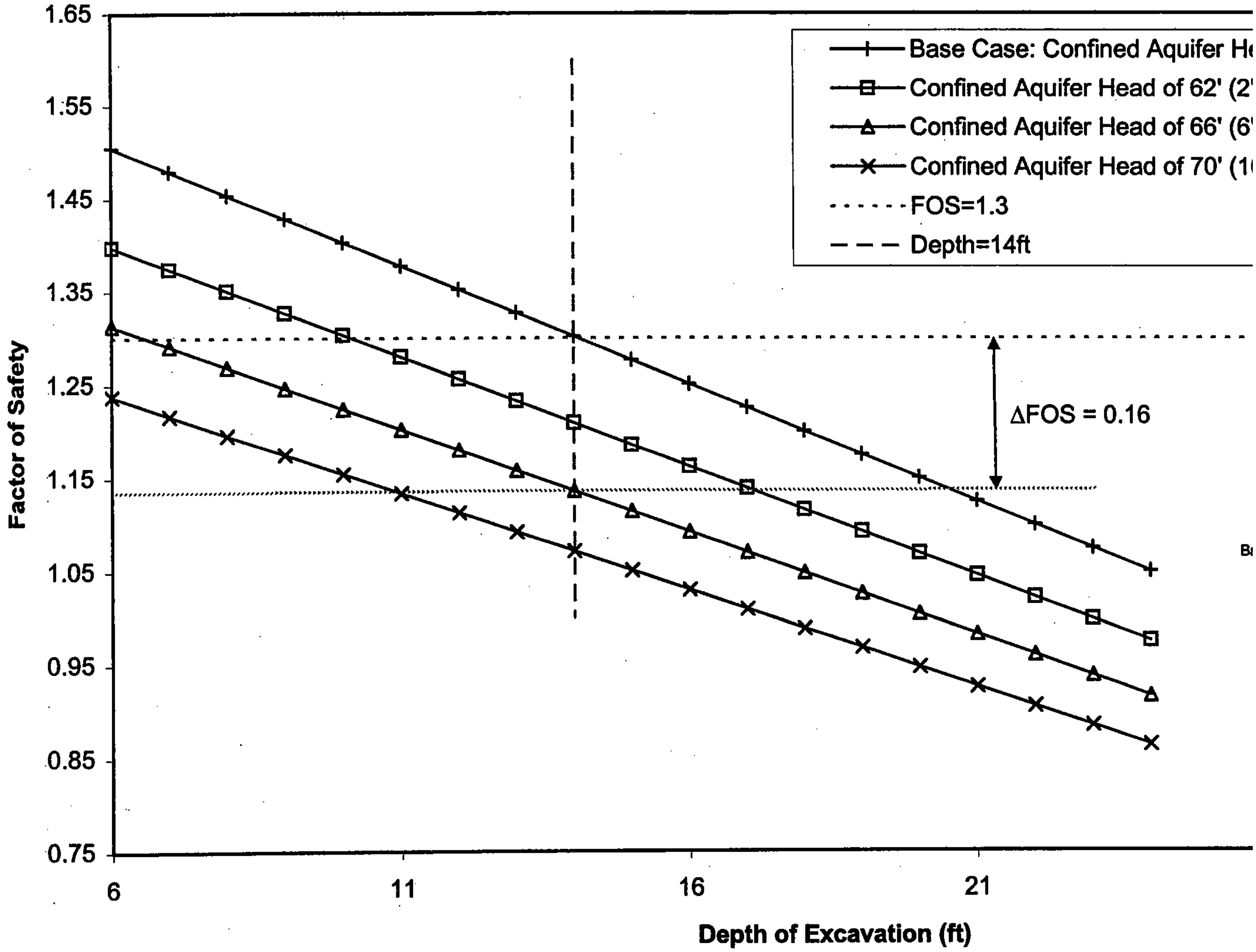
Mw-15.xls
Chart - MGS

Unit Weight of Fill	Thickness of Fill	Unit Weight of Marine Grey Silt	Thickness of Marine Grey Silt	Unit Weight of Water	Confined Aquifer Head	Dep
91	34	100	26	62.4	57.6	
91	34	100	26	62.4	57.6	
91	34	100	26	62.4	57.6	
91	34	100	26	62.4	57.6	
91	34	100	26	62.4	57.6	
91	34	100	26	62.4	57.6	
91	34	100	26	62.4	57.6	
91	34	100	26	62.4	57.6	
91	34	100	26	62.4	57.6	
91	34	100	26	62.4	57.6	
91	34	100	26	62.4	57.6	
91	34	100	26	62.4	57.6	
91	34	100	26	62.4	57.6	
91	34	100	26	62.4	57.6	
91	34	100	26	62.4	57.6	
91	34	100	26	62.4	57.6	
91	34	100	26	62.4	57.6	
91	34	100	26	62.4	57.6	
91	34	100	26	62.4	57.6	
91	34	105	26	62.4	57.6	
91	34	105	26	62.4	57.6	
91	34	105	26	62.4	57.6	
91	34	105	26	62.4	57.6	
91	34	105	26	62.4	57.6	
91	34	105	26	62.4	57.6	
91	34	105	26	62.4	57.6	
91	34	105	26	62.4	57.6	
91	34	105	26	62.4	57.6	
91	34	105	26	62.4	57.6	
91	34	105	26	62.4	57.6	
91	34	105	26	62.4	57.6	
91	34	105	26	62.4	57.6	
91	34	105	26	62.4	57.6	
91	34	105	26	62.4	57.6	
91	34	105	26	62.4	57.6	
91	34	105	26	62.4	57.6	
91	34	105	26	62.4	57.6	

Mw-15.xls
Unit Wt - MGS

Unit Weight of Fill	Thickness of Fill	Unit Weight of Marine Grey Silt	Thickness of Marine Grey Silt	Unit Weight of Water	Confined Aquifer Head	Dep
91	34	105	26	62.4	57.6	
91	34	110	26	62.4	57.6	
91	34	110	26	62.4	57.6	
91	34	110	26	62.4	57.6	
91	34	110	26	62.4	57.6	
91	34	110	26	62.4	57.6	
91	34	110	26	62.4	57.6	
91	34	110	26	62.4	57.6	
91	34	110	26	62.4	57.6	
91	34	110	26	62.4	57.6	
91	34	110	26	62.4	57.6	
91	34	110	26	62.4	57.6	
91	34	110	26	62.4	57.6	
91	34	110	26	62.4	57.6	
91	34	110	26	62.4	57.6	
91	34	110	26	62.4	57.6	
91	34	110	26	62.4	57.6	
91	34	110	26	62.4	57.6	
91	34	110	26	62.4	57.6	
91	34	110	26	62.4	57.6	

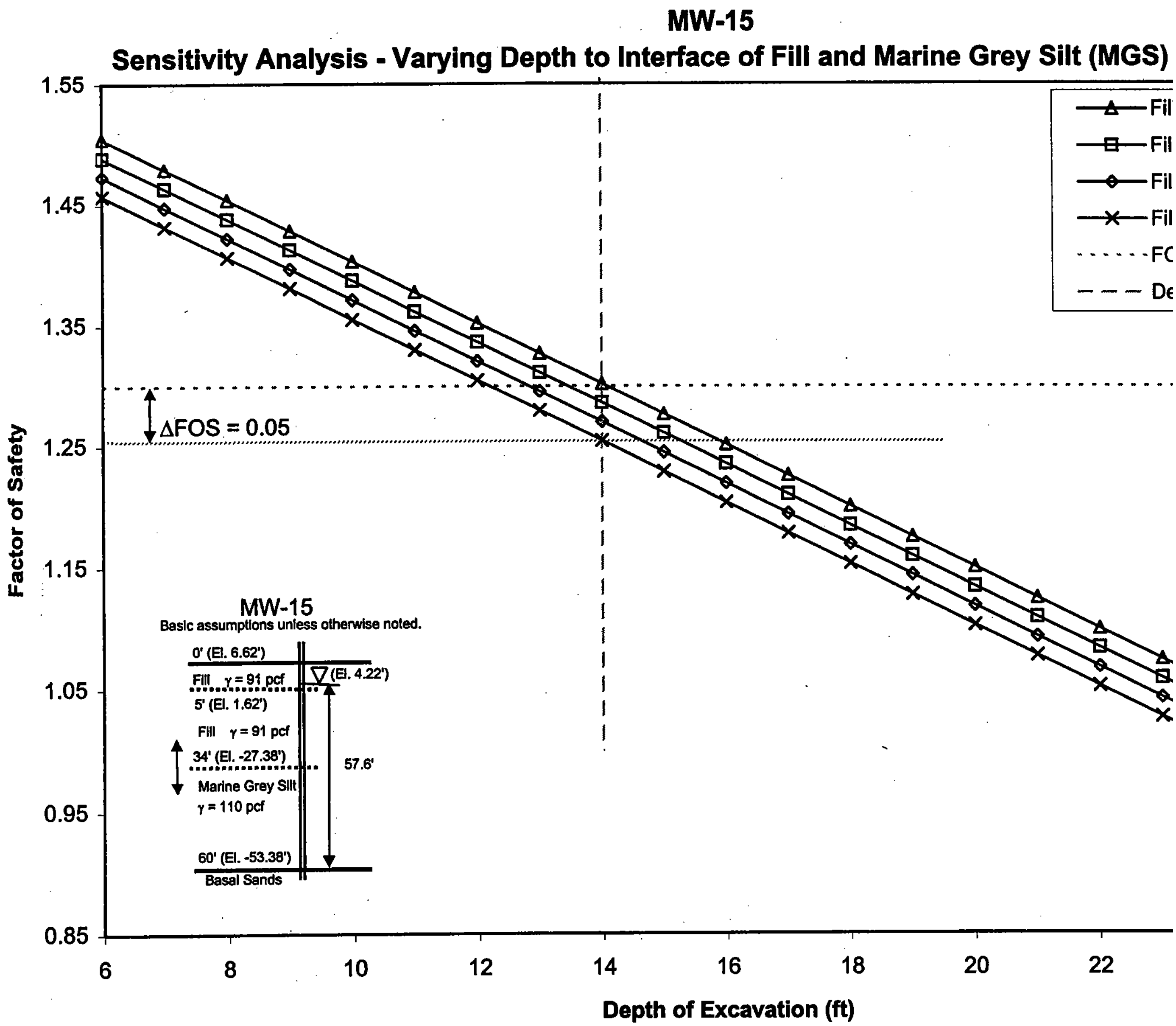
MW-15
Sensitivity Analysis - Varying Confined Aquifer Basal Sands Unit Hea



Mw-15.xls
Chart - Conf. Aquifer Head

Unit Weight of Fill	Thickness of Fill	Unit Weight of Marine Grey Silt	Thickness of Marine Grey Silt	Unit Weight of Water	Confined Aquifer Head	Depth of Excavatio
91	34	110	26	62.4	57.6	6
91	34	110	26	62.4	57.6	7
91	34	110	26	62.4	57.6	8
91	34	110	26	62.4	57.6	9
91	34	110	26	62.4	57.6	10
91	34	110	26	62.4	57.6	11
91	34	110	26	62.4	57.6	12
91	34	110	26	62.4	57.6	13
91	34	110	26	62.4	57.6	14
91	34	110	26	62.4	57.6	15
91	34	110	26	62.4	57.6	16
91	34	110	26	62.4	57.6	17
91	34	110	26	62.4	57.6	18
91	34	110	26	62.4	57.6	19
91	34	110	26	62.4	57.6	20
91	34	110	26	62.4	57.6	21
91	34	110	26	62.4	57.6	22
91	34	110	26	62.4	57.6	23
91	34	110	26	62.4	57.6	24
91	34	110	26	62.4	62	6
91	34	110	26	62.4	62	7
91	34	110	26	62.4	62	8
91	34	110	26	62.4	62	9
91	34	110	26	62.4	62	10
91	34	110	26	62.4	62	11
91	34	110	26	62.4	62	12
91	34	110	26	62.4	62	13
91	34	110	26	62.4	62	14
91	34	110	26	62.4	62	15
91	34	110	26	62.4	62	16
91	34	110	26	62.4	62	17
91	34	110	26	62.4	62	18
91	34	110	26	62.4	62	19
91	34	110	26	62.4	62	20
91	34	110	26	62.4	62	21
91	34	110	26	62.4	62	22
91	34	110	26	62.4	62	23
91	34	110	26	62.4	62	24
91	34	110	26	62.4	66	6
91	34	110	26	62.4	66	7
91	34	110	26	62.4	66	8
91	34	110	26	62.4	66	9
91	34	110	26	62.4	66	10

Unit Weight of Fill	Thickness of Fill	Unit Weight of Marine Grey Silt	Thickness of Marine Grey Silt	Unit Weight of Water	Confined Aquifer Head	Depth of Excavation
91	34	110	26	62.4	66	11
91	34	110	26	62.4	66	12
91	34	110	26	62.4	66	13
91	34	110	26	62.4	66	14
91	34	110	26	62.4	66	15
91	34	110	26	62.4	66	16
91	34	110	26	62.4	66	17
91	34	110	26	62.4	66	18
91	34	110	26	62.4	66	19
91	34	110	26	62.4	66	20
91	34	110	26	62.4	66	21
91	34	110	26	62.4	66	22
91	34	110	26	62.4	66	23
91	34	110	26	62.4	66	24
91	34	110	26	62.4	70	6
91	34	110	26	62.4	70	7
91	34	110	26	62.4	70	8
91	34	110	26	62.4	70	9
91	34	110	26	62.4	70	10
91	34	110	26	62.4	70	11
91	34	110	26	62.4	70	12
91	34	110	26	62.4	70	13
91	34	110	26	62.4	70	14
91	34	110	26	62.4	70	15
91	34	110	26	62.4	70	16
91	34	110	26	62.4	70	17
91	34	110	26	62.4	70	18
91	34	110	26	62.4	70	19
91	34	110	26	62.4	70	20
91	34	110	26	62.4	70	21
91	34	110	26	62.4	70	22
91	34	110	26	62.4	70	23
91	34	110	26	62.4	70	24



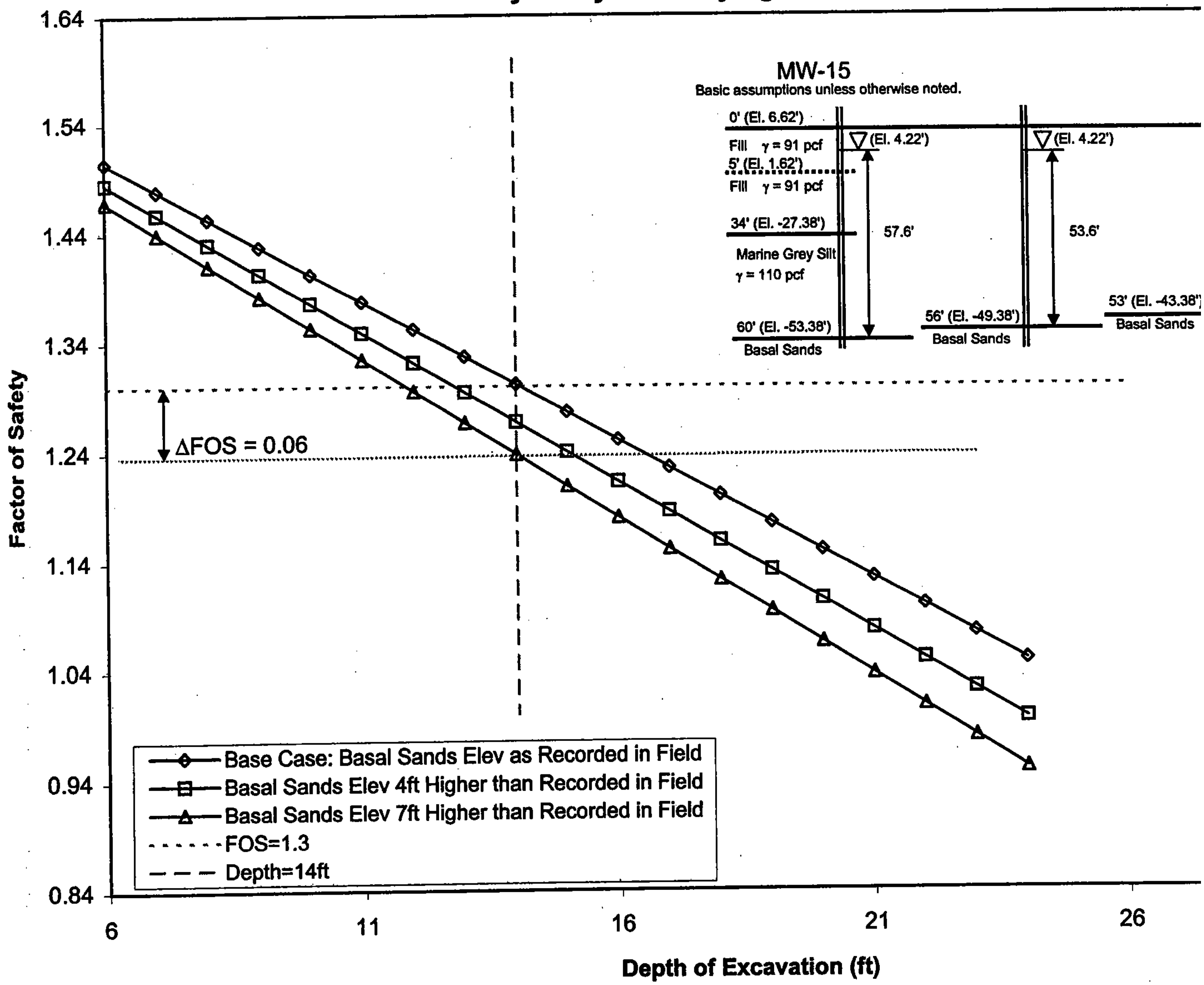
Mw-15.xls
Chart - Depth Fill & MGS

Thickness of Marine Grey Silt	Unit Weight of Water	Confined Aquifer Head	Depth of Excavation	Factor of Safety
26	62.4	57.6	6	1.50
26	62.4	57.6	7	1.48
26	62.4	57.6	8	1.45
26	62.4	57.6	9	1.43
26	62.4	57.6	10	1.40
26	62.4	57.6	11	1.38
26	62.4	57.6	12	1.35
26	62.4	57.6	13	1.33
26	62.4	57.6	14	1.30
26	62.4	57.6	15	1.28
26	62.4	57.6	16	1.25
26	62.4	57.6	17	1.23
26	62.4	57.6	18	1.20
26	62.4	57.6	19	1.18
26	62.4	57.6	20	1.15
26	62.4	57.6	21	1.12
26	62.4	57.6	22	1.10
26	62.4	57.6	23	1.07
26	62.4	57.6	24	1.05
25	62.4	57.6	6	1.50
25	62.4	57.6	7	1.47
25	62.4	57.6	8	1.45
25	62.4	57.6	9	1.42
25	62.4	57.6	10	1.40
25	62.4	57.6	11	1.37
25	62.4	57.6	12	1.35
25	62.4	57.6	13	1.32
25	62.4	57.6	14	1.30
25	62.4	57.6	15	1.27
25	62.4	57.6	16	1.25
25	62.4	57.6	17	1.22
25	62.4	57.6	18	1.20
25	62.4	57.6	19	1.17
25	62.4	57.6	20	1.14
25	62.4	57.6	21	1.12
25	62.4	57.6	22	1.09
25	62.4	57.6	23	1.07
25	62.4	57.6	24	1.04
24	62.4	57.6	6	1.49
24	62.4	57.6	7	1.47
24	62.4	57.6	8	1.44
24	62.4	57.6	9	1.42
24	62.4	57.6	10	1.39
24	62.4	57.6	11	1.37
24	62.4	57.6	12	1.34
24	62.4	57.6	13	1.32
24	62.4	57.6	14	1.29
24	62.4	57.6	15	1.27
24	62.4	57.6	16	1.24
24	62.4	57.6	17	1.22
24	62.4	57.6	18	1.19
24	62.4	57.6	19	1.16
24	62.4	57.6	20	1.14
24	62.4	57.6	21	1.11
24	62.4	57.6	22	1.09
24	62.4	57.6	23	1.06
24	62.4	57.6	24	1.04
23	62.4	57.6	6	1.49
23	62.4	57.6	7	1.46
23	62.4	57.6	8	1.44
23	62.4	57.6	9	1.41
23	62.4	57.6	10	1.39
23	62.4	57.6	11	1.36
23	62.4	57.6	12	1.34
23	62.4	57.6	13	1.31
23	62.4	57.6	14	1.29
23	62.4	57.6	15	1.26
23	62.4	57.6	16	1.24
23	62.4	57.6	17	1.21
23	62.4	57.6	18	1.18
23	62.4	57.6	19	1.16
23	62.4	57.6	20	1.13
23	62.4	57.6	21	1.11
23	62.4	57.6	22	1.08
23	62.4	57.6	23	1.06
23	62.4	57.6	24	1.03
22	62.4	57.6	6	1.48
22	62.4	57.6	7	1.46
22	62.4	57.6	8	1.43
22	62.4	57.6	9	1.41

Unit Weight of Upper Fill	Unit Weight of Lower Fill	Thickness of Upper Fill	Thickness of Lower Fill	Unit Weight of Marine Grey Silt	Thickness of Marine Grey Silt	Unit Weight of Water	Confined Aquifer Head	Depth of Excavation	Factor of Safety
91	91	5	33	110	22	62.4	57.6	10	1.38
91	91	5	33	110	22	62.4	57.6	11	1.36
91	91	5	33	110	22	62.4	57.6	12	1.33
91	91	5	33	110	22	62.4	57.6	13	1.31
91	91	5	33	110	22	62.4	57.6	14	1.28
91.	91	5	33	110	22	62.4	57.6	15	1.26
91	91	5	33	110	22	62.4	57.6	16	1.23
91	91	5	33	110	22	62.4	57.6	17	1.20
91	91	5	33	110	22	62.4	57.6	18	1.18
91	91	5	33	110	22	62.4	57.6	19	1.15
91	91	5	33	110	22	62.4	57.6	20	1.13
91	91	5	33	110	22	62.4	57.6	21	1.10
91	91	5	33	110	22	62.4	57.6	22	1.08
91	91	5	33	110	22	62.4	57.6	23	1.05
91	91	5	33	110	22	62.4	57.6	24	1.03
91	91	5	34	110	21	62.4	57.6	6	1.48
91	91	5	34	110	21	62.4	57.6	7	1.45
91	91	5	34	110	21	62.4	57.6	8	1.43
91	91	5	34	110	21	62.4	57.6	9	1.40
91	91	5	34	110	21	62.4	57.6	10	1.38
91	91	5	34	110	21	62.4	57.6	11	1.35
91	91	5	34	110	21	62.4	57.6	12	1.33
91	91	5	34	110	21	62.4	57.6	13	1.30
91	91	5	34	110	21	62.4	57.6	14	1.28
91	91	5	34	110	21	62.4	57.6	15	1.25
91	91	5	34	110	21	62.4	57.6	16	1.23
91	91	5	34	110	21	62.4	57.6	17	1.20
91	91	5	34	110	21	62.4	57.6	18	1.17
91	91	5	34	110	21	62.4	57.6	19	1.15
91	91	5	34	110	21	62.4	57.6	20	1.12
91	91	5	34	110	21	62.4	57.6	21	1.10
91	91	5	34	110	21	62.4	57.6	22	1.07
91	91	5	34	110	21	62.4	57.6	23	1.05
91	91	5	34	110	21	62.4	57.6	24	1.02
91	91	5	35	110	20	62.4	57.6	6	1.47
91	91	5	35	110	20	62.4	57.6	7	1.45
91	91	5	35	110	20	62.4	57.6	8	1.42
91	91	5	35	110	20	62.4	57.6	9	1.40
91	91	5	35	110	20	62.4	57.6	10	1.37
91	91	5	35	110	20	62.4	57.6	11	1.35
91	91	5	35	110	20	62.4	57.6	12	1.32
91	91	5	35	110	20	62.4	57.6	13	1.30
91	91	5	35	110	20	62.4.	57.6	14	1.27
91	91	5	35	110	20	62.4	57.6	15	1.25
91	91	5	35	110	20	62.4	57.6	16	1.22
91	91	5	35	110	20	62.4	57.6	17	1.19
91	91	5	35	110	20	62.4	57.6	18	1.17
91	91	5	35	110	20	62.4	57.6	19	1.14
91	91	5	35	110	20	62.4	57.6	20	1.12
91	91	5	35	110	20	62.4	57.6	21	1.09
91	91	5	35	110	20	62.4	57.6	22	1.07
91	91	5	35	110	20	62.4	57.6	23	1.04
91	91	5	35	110	20	62.4	57.6	24	1.02
91	91	5	36	110	19	62.4	57.6	6	1.47
91	91	5	36	110	19	62.4	57.6	7	1.44
91	91	5	36	110	19	62.4	57.6	8	1.42
91	91	5	36	110	19	62.4	57.6	9	1.39
91	91	5	36	110	19	62.4	57.6	10	1.37
91	91	5	36	110	19	62.4	57.6	11	1.34
91	91	5	36	110	19	62.4	57.6	12	1.32
91	91	5	36	110	19	62.4	57.6	13	1.29
91	91	5	36	110	19	62.4	57.6	14	1.27
91	91	5	36	110	19	62.4	57.6	15	1.24
91	91	5	36	110	19	62.4	57.6	16	1.21
91	91	5	36	110	19	62.4	57.6	17	1.19
91	91	5	36	110	19	62.4	57.6	18	1.16
91	91	5	36	110	19	62.4	57.6	19	1.14
91	91	5	36	110	19	62.4	57.6	20	1.11
91	91	5	36	110	19	62.4	57.6	21	1.09
91	91	5	36	110	19	62.4	57.6	22	1.06
91	91	5	36	110	19	62.4	57.6	23	1.04
91	91	5	36	110	19	62.4	57.6	24	1.01

Thickness of Marine Grey Silt	Unit Weight of Water	Confined Aquifer Head	Depth of Excavation	Factor of Safety
18	62.4	57.6	6	1.46
18	62.4	57.6	7	1.44
18	62.4	57.6	8	1.41
18	62.4	57.6	9	1.39
18	62.4	57.6	10	1.36
18	62.4	57.6	11	1.34
18	62.4	57.6	12	1.31
18	62.4	57.6	13	1.29
18	62.4	57.6	14	1.26
18	62.4	57.6	15	1.23
18	62.4	57.6	16	1.21
18	62.4	57.6	17	1.18
18	62.4	57.6	18	1.16
18	62.4	57.6	19	1.13
18	62.4	57.6	20	1.11
18	62.4	57.6	21	1.08
18	62.4	57.6	22	1.06
18	62.4	57.6	23	1.03
18	62.4	57.6	24	1.01
17	62.4	57.6	6	1.46
17	62.4	57.6	7	1.43
17	62.4	57.6	8	1.41
17	62.4	57.6	9	1.38
17	62.4	57.6	10	1.36
17	62.4	57.6	11	1.33
17	62.4	57.6	12	1.31
17	62.4	57.6	13	1.28
17	62.4	57.6	14	1.25
17	62.4	57.6	15	1.23
17	62.4	57.6	16	1.20
17	62.4	57.6	17	1.18
17	62.4	57.6	18	1.15
17	62.4	57.6	19	1.13
17	62.4	57.6	20	1.10
17	62.4	57.6	21	1.08
17	62.4	57.6	22	1.05
17	62.4	57.6	23	1.03
17	62.4	57.6	24	1.00
16	62.4	57.6	6	1.45
16	62.4	57.6	7	1.43
16	62.4	57.6	8	1.40
16	62.4	57.6	9	1.38
16	62.4	57.6	10	1.35
16	62.4	57.6	11	1.33
16	62.4	57.6	12	1.30
16	62.4	57.6	13	1.27
16	62.4	57.6	14	1.25
16	62.4	57.6	15	1.22
16	62.4	57.6	16	1.20
16	62.4	57.6	17	1.17
16	62.4	57.6	18	1.15
16	62.4	57.6	19	1.12
16	62.4	57.6	20	1.10
16	62.4	57.6	21	1.07
16	62.4	57.6	22	1.05
16	62.4	57.6	23	1.02
16	62.4	57.6	24	1.00
15	62.4	57.6	6	1.45
15	62.4	57.6	7	1.42
15	62.4	57.6	8	1.40
15	62.4	57.6	9	1.37
15	62.4	57.6	10	1.35
15	62.4	57.6	11	1.32
15	62.4	57.6	12	1.29
15	62.4	57.6	13	1.27
15	62.4	57.6	14	1.24
15	62.4	57.6	15	1.22
15	62.4	57.6	16	1.19
15	62.4	57.6	17	1.17
15	62.4	57.6	18	1.14
15	62.4	57.6	19	1.12
15	62.4	57.6	20	1.09
15	62.4	57.6	21	1.07
15	62.4	57.6	22	1.04
15	62.4	57.6	23	1.02
15	62.4	57.6	24	0.99

MW-15
Sensitivity Analysis - Varying Basal Sands Elevation



Mw-15.xls
Chart - Elev Basal Sands

Unit Weight of Upper Fill	Unit Weight of Lower Fill	Thickness of Upper Fill	Thickness of Lower Fill	Unit Weight of Marine Grey Silt	Thickness of Marine Grey Silt	Unit Weight of Water	Confin Aquifer H
91	91	5	29	110	26	62.4	57.6
91	91	5	29	110	26	62.4	57.6
91	91	5	29	110	26	62.4	57.6
91	91	5	29	110	26	62.4	57.6
91	91	5	29	110	26	62.4	57.6
91	91	5	29	110	26	62.4	57.6
91	91	5	29	110	26	62.4	57.6
91	91	5	29	110	26	62.4	57.6
91	91	5	29	110	26	62.4	57.6
91	91	5	29	110	26	62.4	57.6
91	91	5	29	110	26	62.4	57.6
91	91	5	29	110	26	62.4	57.6
91	91	5	29	110	26	62.4	57.6
91	91	5	29	110	26	62.4	57.6
91	91	5	29	110	26	62.4	57.6
91	91	5	29	110	26	62.4	57.6
91	91	5	29	110	26	62.4	57.6
91	91	5	29	110	26	62.4	57.6
91	91	5	29	110	26	62.4	57.6
91	91	5	29	110	22	62.4	53.6
91	91	5	29	110	22	62.4	53.6
91	91	5	29	110	22	62.4	53.6
91	91	5	29	110	22	62.4	53.6
91	91	5	29	110	22	62.4	53.6
91	91	5	29	110	22	62.4	53.6
91	91	5	29	110	22	62.4	53.6
91	91	5	29	110	22	62.4	53.6
91	91	5	29	110	22	62.4	53.6
91	91	5	29	110	22	62.4	53.6
91	91	5	29	110	22	62.4	53.6
91	91	5	29	110	22	62.4	53.6
91	91	5	29	110	22	62.4	53.6
91	91	5	29	110	22	62.4	53.6
91	91	5	29	110	22	62.4	53.6
91	91	5	29	110	22	62.4	53.6
91	91	5	29	110	22	62.4	53.6
91	91	5	29	110	22	62.4	53.6
91	91	5	29	110	22	62.4	53.6
91	91	5	29	110	19	62.4	50.
91	91	5	29	110	19	62.4	50.

Unit Weight of Upper Fill	Unit Weight of Lower Fill	Thickness of Upper Fill	Thickness of Lower Fill	Unit Weight of Marine Grey Silt	Thickness of Marine Grey Silt	Unit Weight of Water	Confine Aquifer H
91	91	5	29	110	19	62.4	50.6
91	91	5	29	110	19	62.4	50.6
91	91	5	29	110	19	62.4	50.6
91	91	5	29	110	19	62.4	50.6
91	91	5	29	110	19	62.4	50.6
91	91	5	29	110	19	62.4	50.6
91	91	5	29	110	19	62.4	50.6
91	91	5	29	110	19	62.4	50.6
91	91	5	29	110	19	62.4	50.6
91	91	5	29	110	19	62.4	50.6
91	91	5	29	110	19	62.4	50.6
91	91	5	29	110	19	62.4	50.6
91	91	5	29	110	19	62.4	50.6
91	91	5	29	110	19	62.4	50.6
91	91	5	29	110	19	62.4	50.6
91	91	5	29	110	19	62.4	50.6
91	91	5	29	110	19	62.4	50.6

OBJECTIVE: Determine the settlement magnitude and time of the Marine Grey Silt due to the effect of dewatering an excavation.

REFERENCES: 1. "Foundation Analysis and Design", Fourth Edition, Bowles, 1988
2. Geotechnical Lab Testing Results

CALCULATIONS: Assume that the three sample locations (MW-13, MW-14, MW-15) are representative of the entire soil profile.

	MW-13	MW-14	MW-15
FILL UNIT	$\bar{\gamma}_T$ = 94.7 pcf	95.7 pcf	87.5 pcf
	-25'	-17'	-34'
MARINE GREY SILT UNIT	$\bar{\gamma}_T$ = 109.5 pcf	106.6 pcf	115.2 pcf
	Sampled at: 30'-32'; 40'-42'; 50'-52'	34'-36'; 40'-42'; 48'-50'	44'-46'; 54'-56'
	-52'	-56'	-60'
BASAL SAND UNIT			

1. Determine the initial confining pressures at the sample locations and depths.

Sample			σ_{vo}'
MW-13B	30 32	94.7(25') + 109.5(7') - 62.4(32') = 1137.2 PSF =	0.57 T
MW-13	40 42	94.7(25') + 109.5(7') - 62.4(42') = 1608.2 PSF =	0.80 TSF
MW-13	50 52	94.7(25') + 109.5(27') - 62.4(52') = 2079.2 PSF =	1.04 TSF
MW-14B	34 36	95.7(17') + 106.6(19') - 62.4(36') = 1405.9 PSF =	0.70 TSF
MW-14A	40 42	95.7(17') + 106.6(25') - 62.4(42') = 1671.1 PSF =	0.83 TSF
MW-14A	48 50	95.7(17') + 106.6(33') - 62.4(50') = 2024.7 PSF =	1.01 TSF
MW-15A	44 46	87.5(34') + 115.2(12') - 62.4(46') = 1487.0 PSF =	0.74 TS
MW-15A	54 56	87.5(34') + 115.2(22') - 62.4(56') = 2015.0 PSF =	1.01 TSF

2. Determine whether the sample locations and depths are, normally consolidated or overconsolidated, using P_c' from the consolidation curves.

Sample		$P_c \div P_o$		OCR		
MW-13B	30 32	2.6 TSF/0.57 TSF	=	4.6	Overconsolidated	⇒ use C_r
MW-13	40 42	1.2 TSF/0.80 TSF	=	1.5	Overconsolidated	⇒ use C_r
MW-13	50 52	1.8 TSF/1.04 TSF	=	1.7	Overconsolidated	⇒ use C_r
MW-14B	34 36	0.58 TSF/0.70 TSF	=	0.83	Normally Consol.	⇒ use C_c
MW-14A	40 42	0.70 TSF/0.83 TSF	=	0.84	Normally Consol.	⇒ use C_c
MW-14A	48 50	2.2 TSF/1.01 TSF	=	2.2	Overconsolidated	⇒ use C_r
MW-15A	44 46	1.9 TSF/0.74 TSF	=	2.6	Overconsolidated	⇒ use C_r

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.25 in. X .25

3. Determine the Final Stresses at the sample locations and depths. Assume the top of water table is at the bottom of the planned excavation.

For MW-13 ▽ = -8.0'
MW-14 ▽ = -7.5'
MW-15 ▽ = -10.5'

Sample			σ'_{v_f}
MW-13B 3032	94.7(25') + 109.5(7') - 62.4(24') = 1636.4 PSF	=	0.82 TSF
MW-13 4042	94.7(25') + 109.5(17') - 62.4(34') = 2107.4 PSF	=	1.05 TSF
MW-13 5052	94.7(25') + 109.5(27') - 62.4(44') = 2578.4 PSF	=	1.29 TSF
MW-14B 3436	95.7(17') + 106.6(19') - 62.4(28.5') = 1873.9 PSF	=	0.94 TSF
MW-14A 4042	95.7(17') + 106.6(25') - 62.4(34.5') = 2139.1 PSF	=	1.07 TSF
MW-14A 4850	95.7(17') + 106.6(33') - 62.4(42.5') = 2492.7 PSF	=	1.25 TSF
MW-15A 4446	87.5(34') + 115.2(12') - 62.4(38.5') = 1955.0 PSF	=	0.98 TSF
MW-15A 5456	87.5(34') + 115.2(22') - 62.4(48.5') = 2483.0 PSF	=	1.24 TSF

4. Determine the magnitude of settlement for MW-13.

A. For MW-13, all samples are overconsolidated. Therefore use the average C_r. Three values of C_r were taken from the consolidation curves and averaged together. (See Ref. 1 for C_r determination method)

Sample		C_r	
MW-13 B 30 32	$(0.980 - 0.560) \div \log(50/0.1) =$	0.16	Average $C_r = 0.20$
MW-13 40 42	$(1.45 - 0.85) \div \log(40/0.1) =$	0.23	
MW-13 50 52	$(1.245 - 0.675) \div \log(50/0.1) =$	0.21	

B. Use an average initial void ratio, e_o, from the consolidation tests.

Sample	e_o	
MW-13B 30 32	1.03	Average $e_o = 1.25$
MW-13 40 42	1.52	
MW-13 50 52	1.21	

C. Use an average σ_{v_0}', and σ_{v_F}'.

Sample	σ_{v_0}'		σ_{v_F}'	
MW-13 B 30 32	0.57 TSF	Average $\sigma_{v_0}' = 0.80$ TSF	0.82 TSF	Average $\sigma_{v_F}' = 1.0$
MW-13 40 42	0.80 TSF		1.05 TSF	

D. Calculate the settlement for MW-13.

$$\rho = \frac{C_r}{1+e_o} H \log\left(\frac{\sigma_{v_f}'}{\sigma_{v_o}'}\right)$$

$$\rho = \frac{0.20}{1+1.25}(27') \log\left(\frac{1.05}{0.80}\right) = 0.28 \text{ ft}$$

5. Determine the magnitude of settlement for MW-14.

A. For MW-14, the upper two samples are normally consolidated and the lower sample is overconsolidated. Therefore the Marine Grey Silt will be divided into two layers. The first is located at a depth of 17' to 45'. The second is from 45' to 56'.

<u>17'-45' layer, use C_c</u>

			C_c	
MW-14B	34 36	$(1.55-0.65) \div \log(20/0.2)$ =	0.45	Average C_c = 0.46
MW-14A	40 42	$(1.445-0.645) \div \log(20/0.4)$ =	0.47	

<u>45'-56' layer, use C_r</u>

			C_r
MW-14A	48 50	$(1.495-0.825) \div \log(50/0.1)$ =	0.25

Average the C_c and C_r values for MW-14

$$\frac{0.46(28') + 0.25(11')}{39'} = 0.40 = C_c = C_r$$

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.25 in. X .25

B. Use an average initial void ratio, e_o, from the consolidation tests.

Sample	e_o	
MW-14B 34 36	1.56	Average e_o = 1.56
MW-14A 40 42	1.57	
MW-14A 48 50	1.56	

C. Use an average σ_{v_o}' and σ_{v_F}'.

Sample	σ_{v_o}'		σ_{v_F}'	
MW-14B 34 36	0.70 TSF	Average σ_{v_o}' = 0.85 TSF	0.94 TSF	Average σ_{v_F}' = 1.(
MW-14A 40 42	0.83 TSF		1.07 TSF	
MW-14A 48 50	1.01 TSF		1.25 TSF	

D. Calculate the settlement for MW-14

$$\rho = \frac{0.40}{1+1.56}(39')\log\left(\frac{1.09}{0.85}\right) = 0.66\ ft$$

6. Determine the magnitude of settlement for MW-15.

A. For MW-15, both samples are over consolidated. Therefore use the average C_r. Two values of C_r were taken from the consolidation curves and averaged together.

Sample		C_r
MW-15A 44-46	$(1.33-0.77) \div \log(50/0.1) =$	0.21
MW-15A 54-56	$(1.40-0.77) \div \log(50/0.1) =$	0.23

Average $C_r = 0.22$

B. Use an average initial void ratio, e_o, from the consolidation tests.

Sample	e_o
MW-15A 44-46	1.39
MW-15A 54-56	1.38

Average $e_o = 1.39$

C. Use an average σ_{vo}' and σ_{vp}'.

Sample	σ_{vo}'	σ_{vp}'
MW-15A 44-46	0.74 TSF	0.98 TSF
MW-15A 54-56	1.01 TSF	1.24 TSF

Average $\sigma_{vo}' = 0.88$ TSF

Average $\sigma_{vp}' = 1.11$

D. Calculate the settlement for MW-15.

$$\rho = \frac{0.22}{1+1.39}(26')\log\left(\frac{1.1}{0.88}\right) = 0.24\,ft$$

7. Determine the time required for 50% consolidation, $t = \frac{TH^2}{C_v}$

Assume T = 0.197 (from Table 24, Ref. 1)

Use average values of C_v taken from consolidation results.

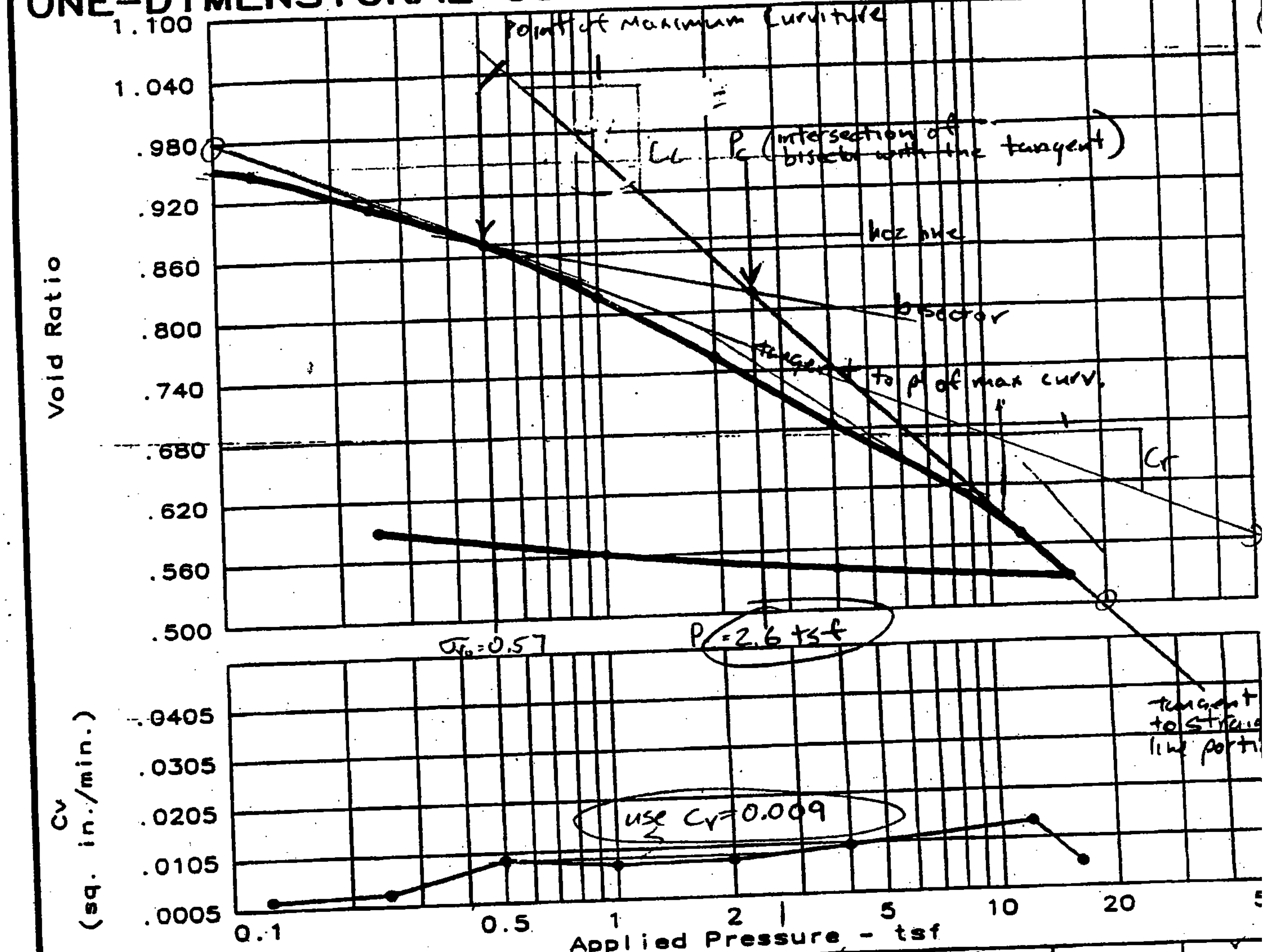
Sample	C_v	
MW-13B 30-32	0.009	Average C_v = 0.027
MW-13 40-42	0.008	
MW-13 50-52	0.063	
MW-14B 34-36	0.015	Average C_v = 0.027
MW-14A 40-42	0.010	
MW-14A 48-50	0.055	
MW-15A 44-46	0.010	Average C_v = 0.016
MW-15A 54-56	0.022	

For MW-13 $t = \frac{0.197(13.5' \times 12\frac{in}{ft})^2}{0.027\frac{in^2}{min}} \div 60\frac{min}{hr} \div 24\frac{hr}{day} = 133$ days

For MW-14 $t = \frac{0.197(19.5' \times 12\frac{in}{ft})^2}{0.027\frac{in^2}{min}} \div 60\frac{min}{hr} \div 24\frac{hr}{day} = 277$ days

For MW-15 $t = \frac{0.197(13' \times 12\frac{in}{ft})^2}{0.016} \div 60\frac{min}{hr} \div 24\frac{hr}{day} = 208$ days

ONE-DIMENSIONAL CONSOLIDATION ASTM D 2435



Natural Saturation	Natural Moisture	Dry Density	LL	PI	Sp.Gr.	Precons. press.	Cc	eo
100.6 %	39.0	81.5	32	9	2.65	0.92	0.35	1.02

TEST RESULTS

Compression Index = 0.35

ETDC Project Name: ARCO Hastings
ETDC Project No.: 806938.4000000
ETDC Sample No.: 9788
Client Sample No.: MW-13B3032

MATERIAL DESCRIPTION
Sandy lean CLAY

Class: CL

Remarks:
Testing begun 9/12/0
Testing completed 9/27/2001

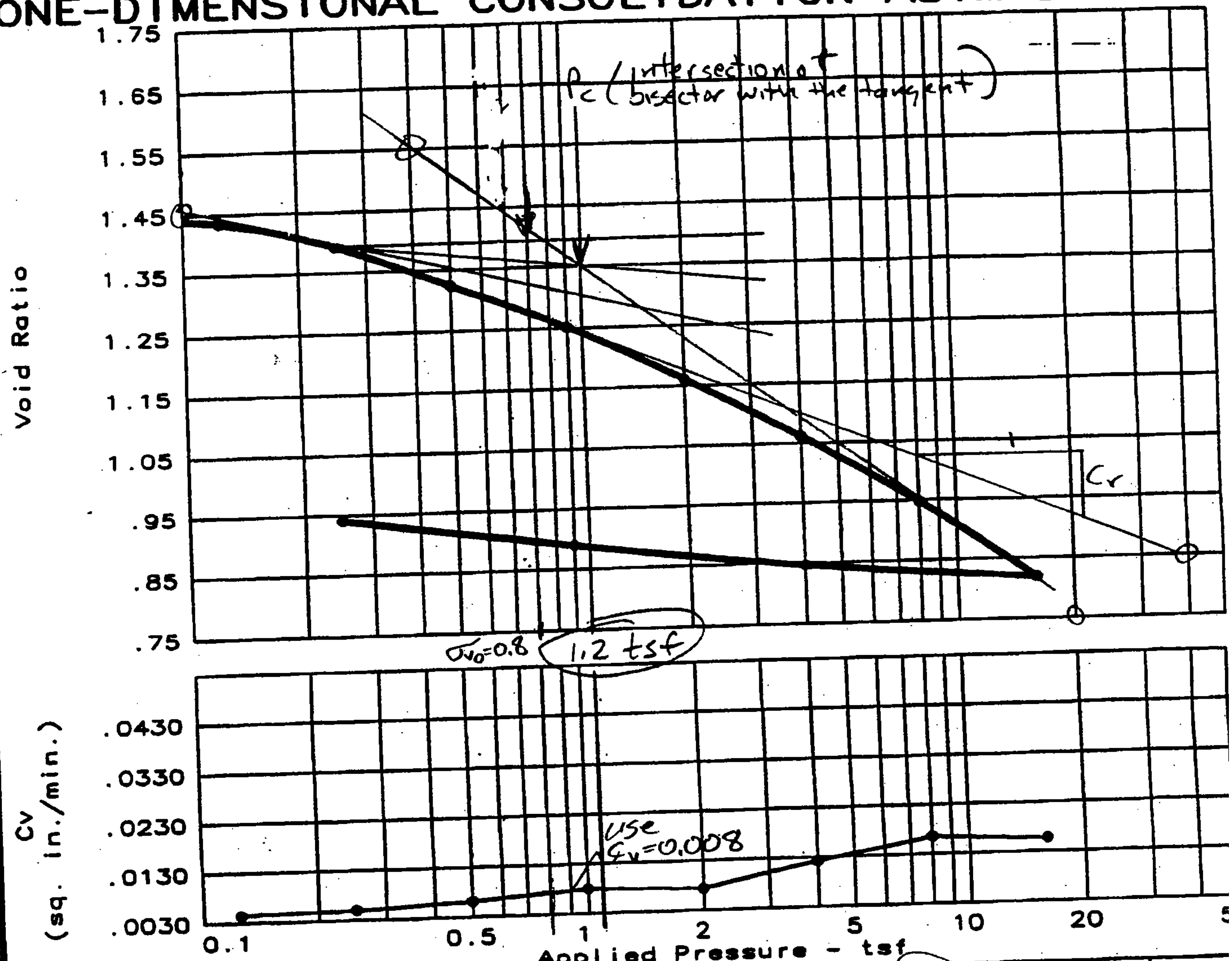
Spec gravity assumed

ONE-DIMENSIONAL CONSOLIDATION ASTM D 2435

IT Corp. - GEOTECHNICAL LABORATORY

$94.7(25) + 109.5(7) - 62.4 \times 32 = 1137.2$
$= 0.57$ TSF

ONE-DIMENSIONAL CONSOLIDATION ASTM D 2435



Natural Saturation	Natural Moisture	Dry Density	LL	PI	Sp.Gr.	Precons. press.	C_c	e_o
101.5 %	58.3	65.8			2.65	0.69	0.43	1.52

TEST RESULTS	MATERIAL DESCRIPTION
Compression Index = 0.43	

ETDC Project Name: ARCO Hastings
ETDC Project No.: 806938.4000000
ETDC Sample No.: 9802
Client Sample No.: MW-13 4042

ONE-DIMENSIONAL CONSOLIDATION ASTM D 2435

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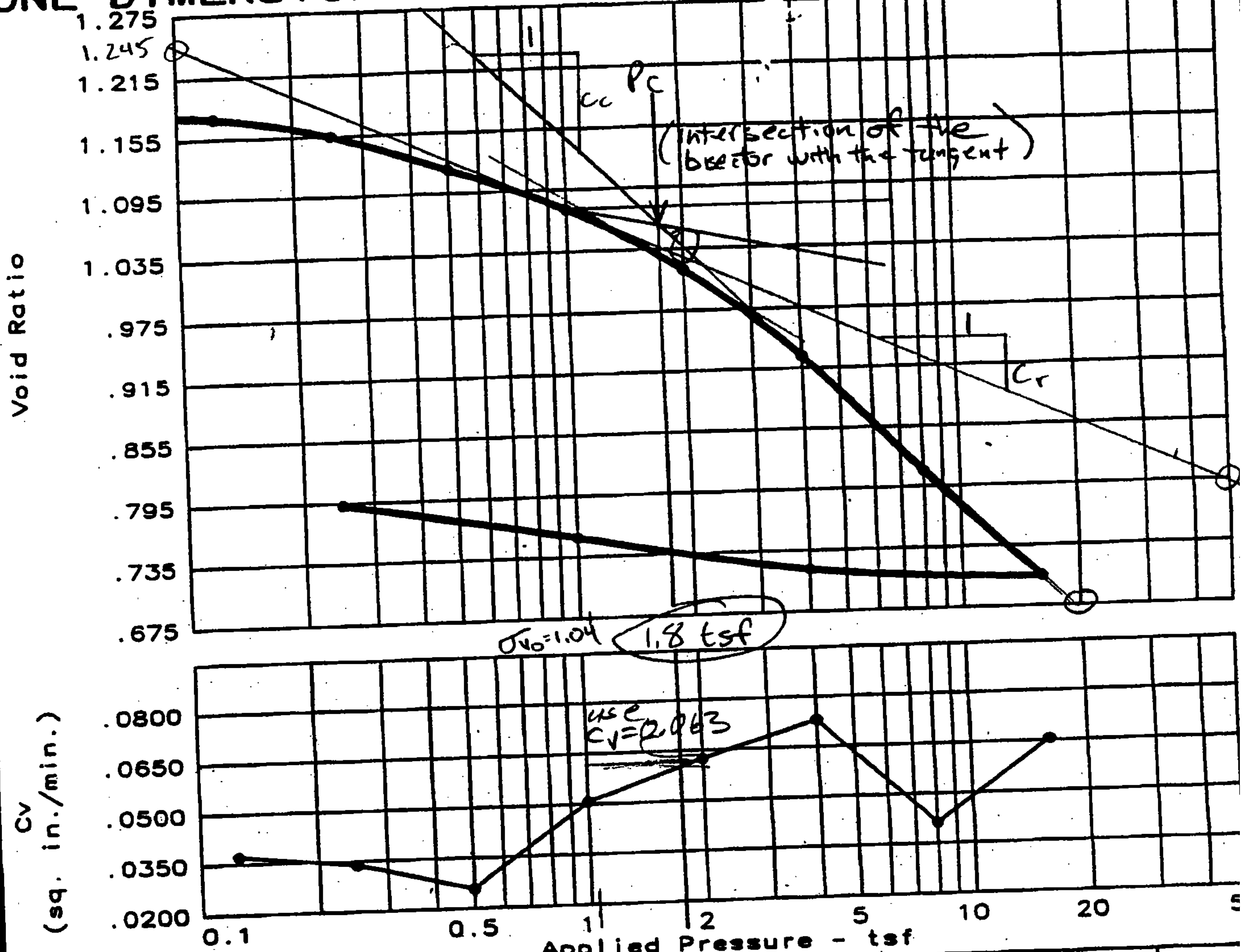
Remarks:
Testing begun 9/28/0
Testing completed
10/5/2001

Spec gravity assumed

$\sigma_o = 94.7(25) + 109.5(17) - 62.4 \times 42 = 1608.2 = 0.8$ TSF

ONE-DIMENSIONAL CONSOLIDATION ASTM D 2435



Natural Saturation	Natural Moisture	Dry Density	LL	PI	Sp.Gr.	Precons. press.	Cc	eo
101.8 %	46.5	75.2			2.65	3.59	0.37	1.20

TEST RESULTS

Compression Index = 0.37

MATERIAL DESCRIPTION

ETDC Project Name: ARCO Hastings
ETDC Project No.: 806938.4000000
ETDC Sample No.: 9803
Client Sample No.: MW-13 5052

Remarks:
Testing begun 9/28/0
Testing completed 10/5/2001

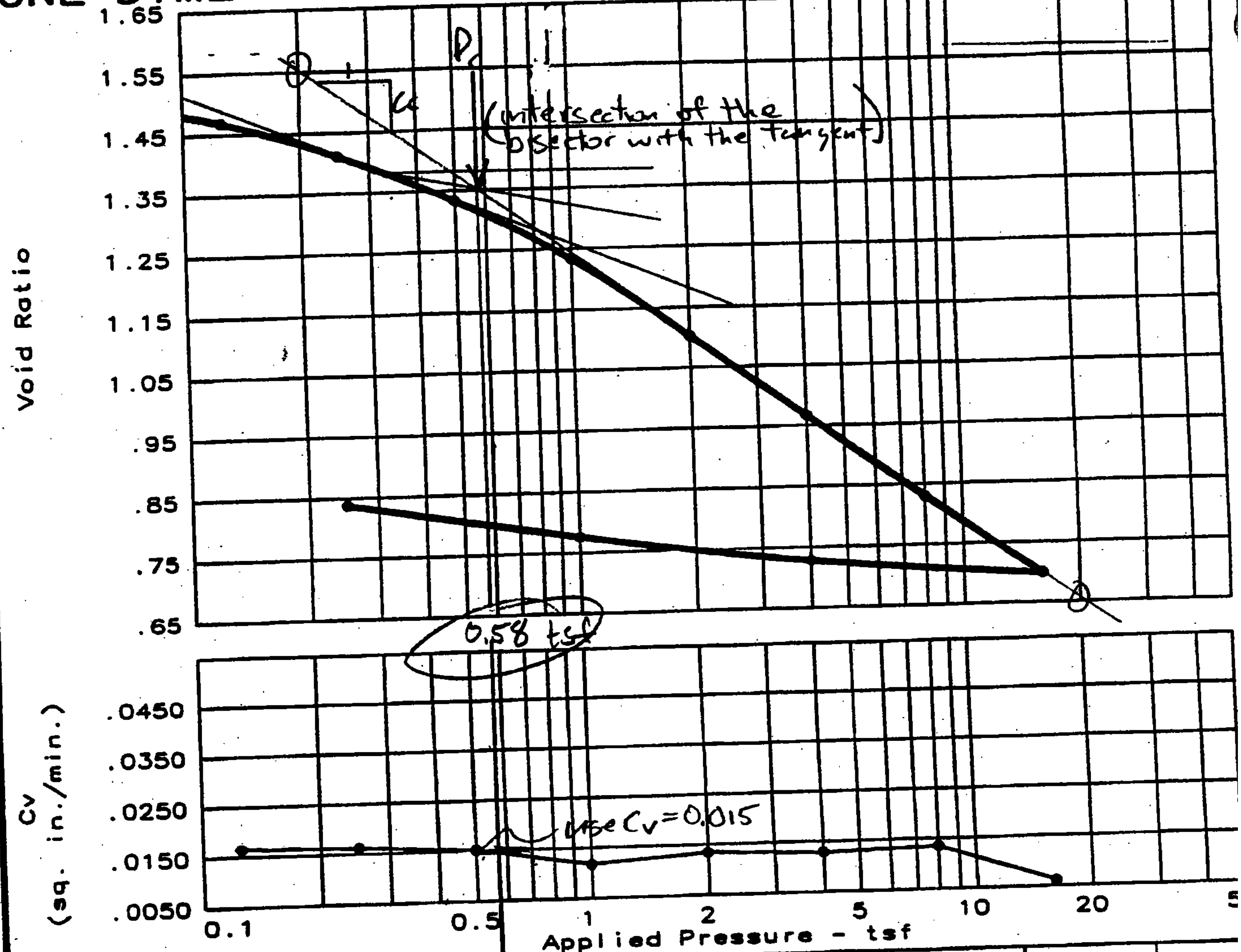
Spec gravity assumed

ONE-DIMENSIONAL CONSOLIDATION ASTM D 2435

IT Corp. - GEOTECHNICAL LABORATORY

$\sigma_0 = 94.7(25) + 109.5(27) - 62.4 \times (52) = 2079.2 = 1.04$ TSF

ONE-DIMENSIONAL CONSOLIDATION ASTM D 2435



Natural Saturation	Natural Moisture	Dry Density	LL	PI	Sp.Gr.	Precons. press.	C_c	e_o
102.4 %	60.5	644.5	36	12	2.65	0.84	0.44	1.56

TEST RESULTS

Compression Index = 0.44

MATERIAL DESCRIPTION

Lean CLAY with sand

Class: CL

Remarks:

Testing begun 9/12/0
Testing completed 9/27/2001

Spec gravity assumed

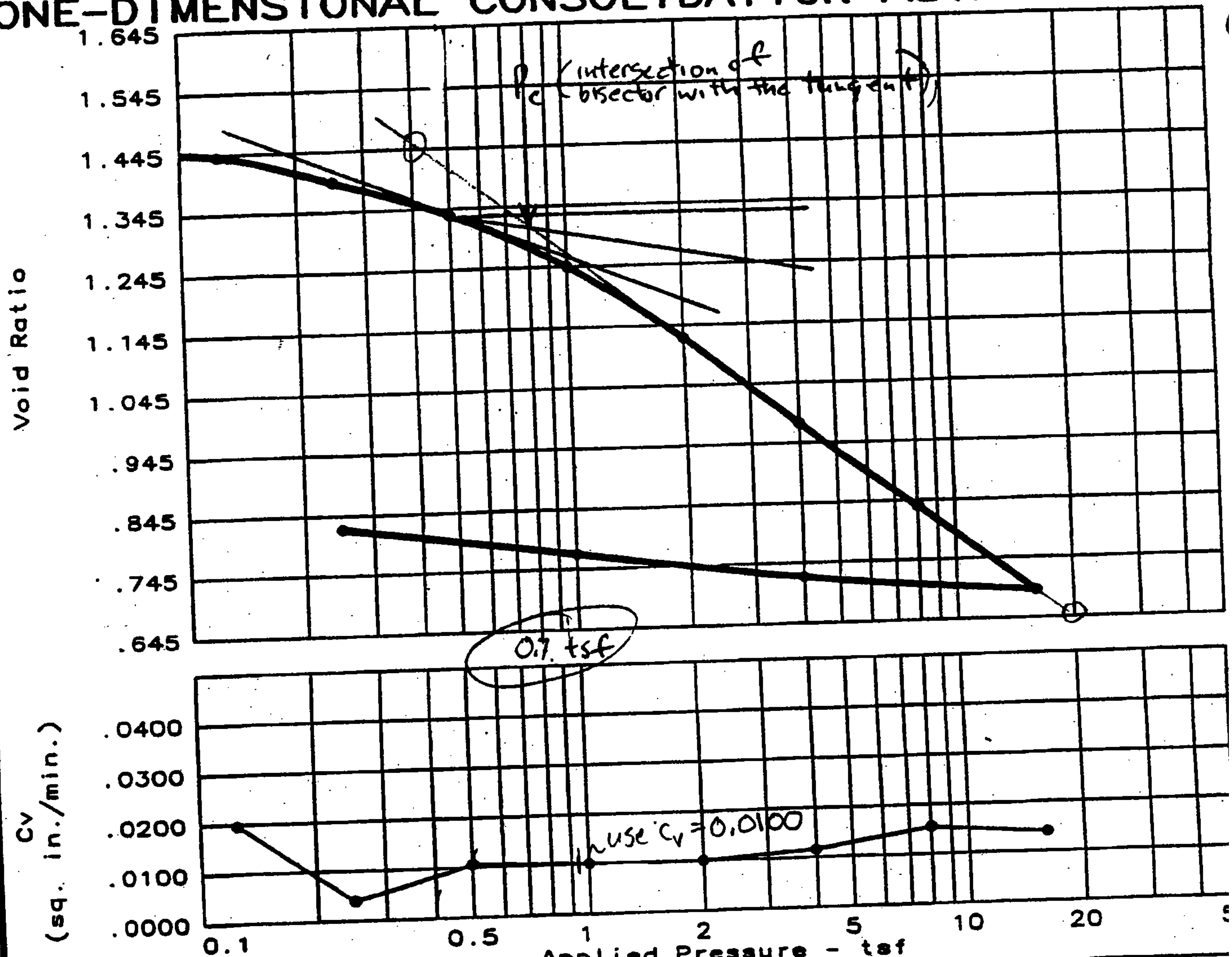
ETDC Project Name: ARCO Hastings
ETDC Project No.: 806938.4000000
ETDC Sample No.: 9789
Client Sample No.: MW-14B3436

ONE-DIMENSIONAL CONSOLIDATION ASTM D 2435

IT Corp. - GEOTECHNICAL LABORATORY

$\sigma_o = 95.7(17) + 106.6(19) - 62.4(36) = 1405.9$ psf
0.70 tsf

ONE-DIMENSIONAL CONSOLIDATION ASTM D 2435



Natural Saturation	Natural Moisture	Dry Density	LL	PI	Sp.Gr.	Precons. press.	C_c	e_o
106.9 %	63.3	64.7			2.65	0.46	0.48	1.56

TEST RESULTS

Compression Index = 0.48

MATERIAL DESCRIPTION

ETDC Project Name: ARCO Hastings
ETDC Project No.: 806938.4000000
ETDC Sample No.: 9801
Client Sample No.: MW-14A4042

Remarks:
Testing begun 9/28/0
Testing completed 10/5/2001

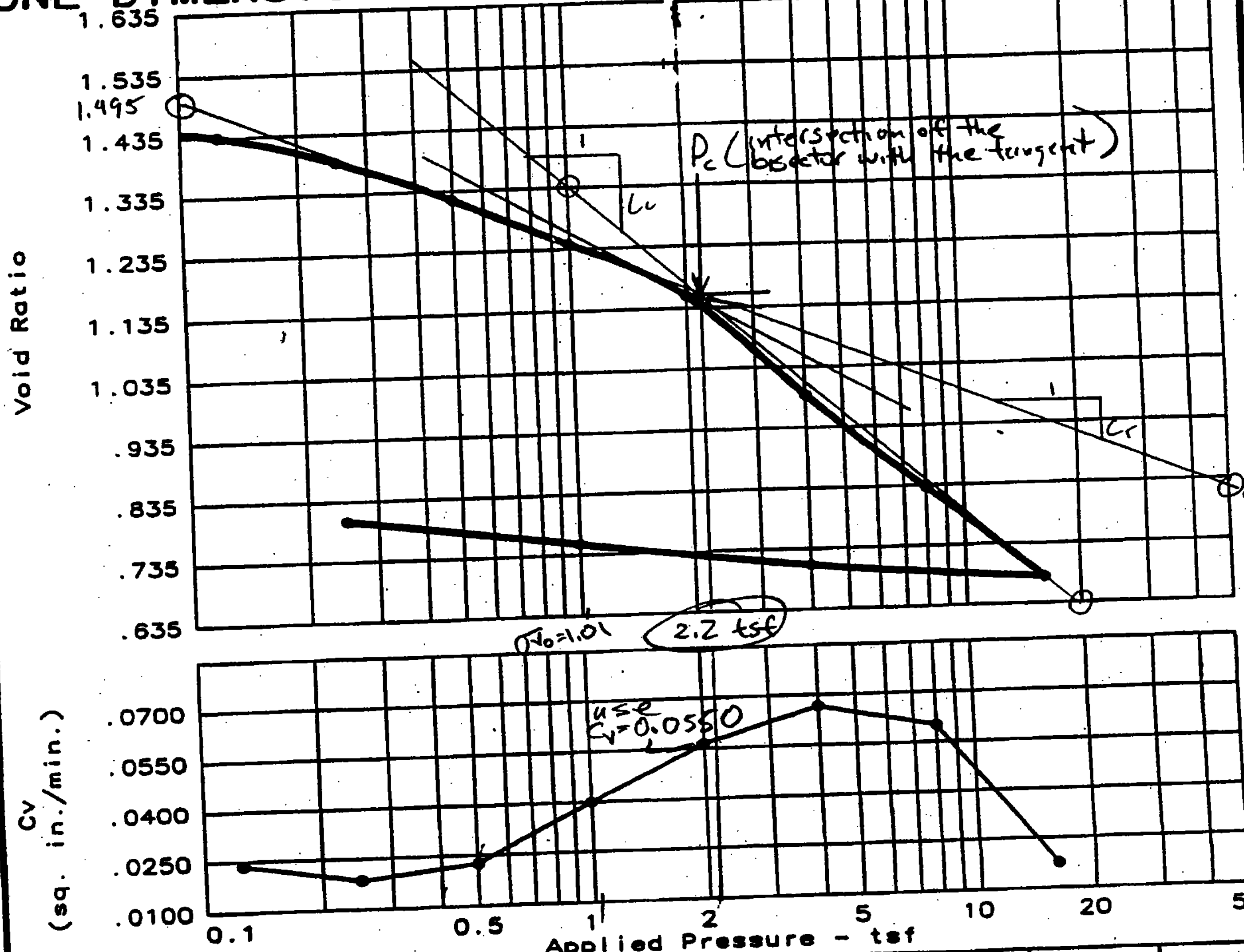
Spec gravity assumed

ONE-DIMENSIONAL CONSOLIDATION ASTM D 2435

IT Corp. - GEOTECHNICAL LABORATORY

$\sigma_o = 95.7(17) + 106.6(25) - 62.4(42) = 1671.1$ psf
0.83 tsf

ONE-DIMENSIONAL CONSOLIDATION ASTM D 2435



Natural Saturation	Natural Moisture	Dry Density	LL	PI	Sp.Gr.	Precons. press.	C_c	e_o
101.9 %	60.1	64.9			2.65	1.95	0.54	1.56

TEST RESULTS

Compression Index = 0.54

MATERIAL DESCRIPTION

ETDC Project Name: ARCO Hastings
ETDC Project No.: 806938.4000000
ETDC Sample No.: 9804
Client Sample No.: MW14A 4850

Remarks:
Testing begun 10/1/0
Testing completed 10/5/2001

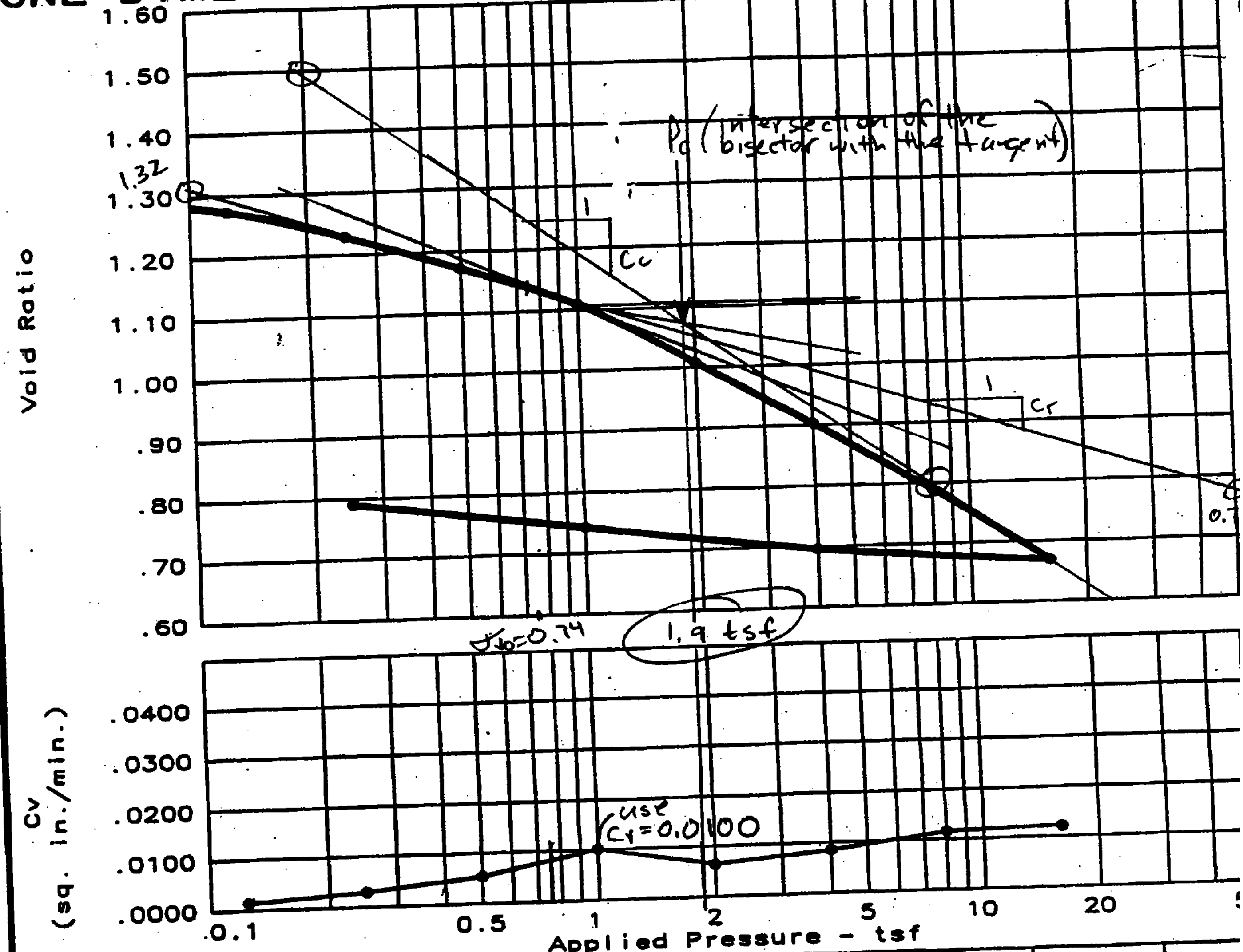
Spec gravity assumed

ONE-DIMENSIONAL CONSOLIDATION ASTM D 2435

IT Corp. - GEOTECHNICAL LABORATORY

$\sigma_o = 95.7(17) + 106.6(33) - 62.4(50) = 2024.7$ psf
1.01 tsf

ONE-DIMENSIONAL CONSOLIDATION ASTM D 2435



Natural Saturation	Natural Moisture	Dry Density	LL	PI	Sp.Gr.	Precons. press.	C_c	e_o
103.6 %	54.5	69.9			2.65	1.44	0.40	1.39

TEST RESULTS

Compression Index = 0.40

MATERIAL DESCRIPTION

ETDC Project Name: ARCO Hastings
ETDC Project No.: 806938.4000000
ETDC Sample No.: 9805
Client Sample No.: MW15A 4446

ONE-DIMENSIONAL CONSOLIDATION ASTM D 2435

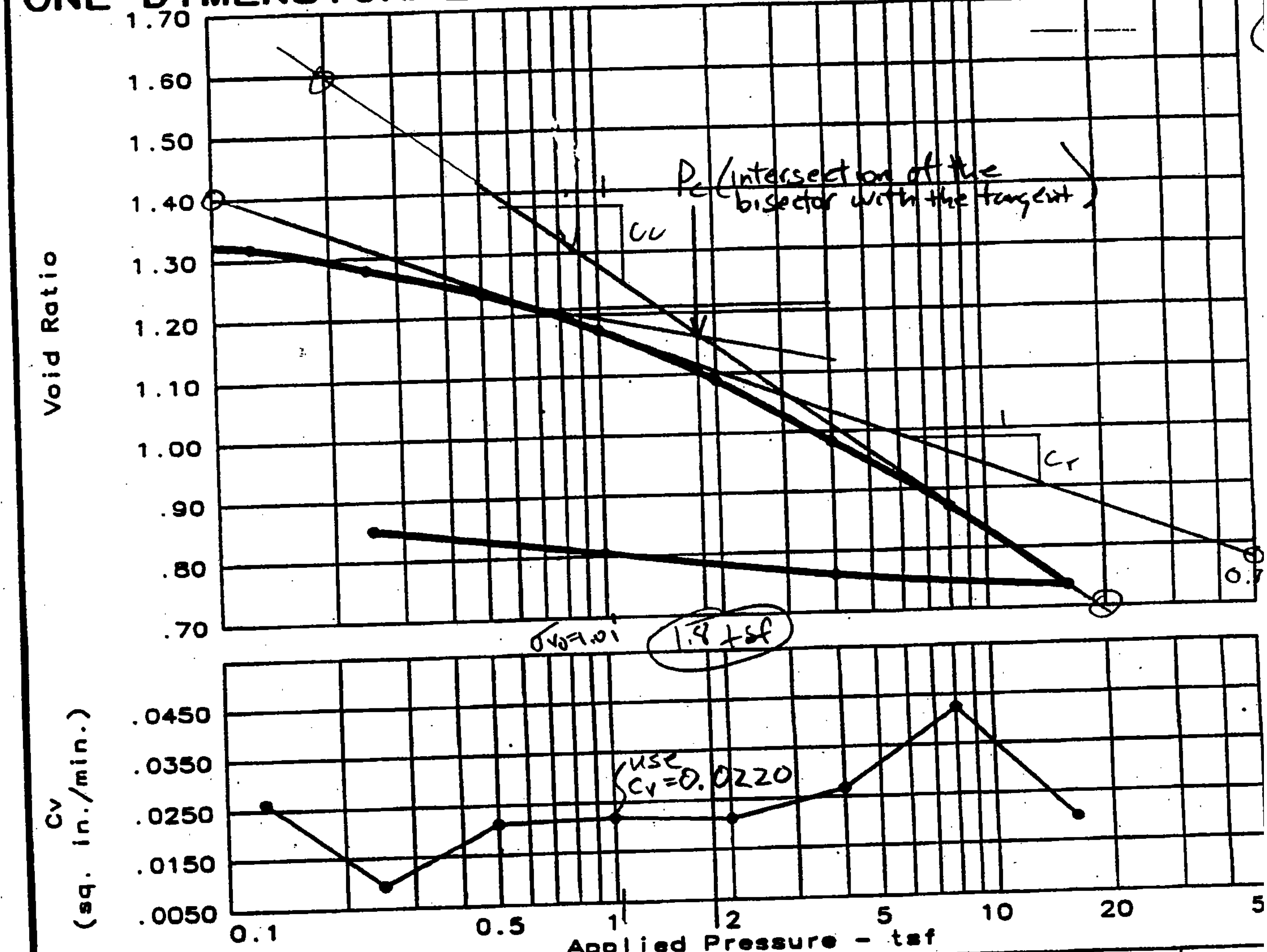
IT Corp. - GEOTECHNICAL LABORATORY

Remarks:
Testing begun 10/1/0
Testing completed 10/5/2001

Spec gravity assumed

$\sigma_o = 87.5(34) + 115.2(12) - 62.4(46) = 1487$ psf
0.74 tsf

ONE-DIMENSIONAL CONSOLIDATION ASTM D 2435



Natural Saturation	Natural Moisture	Dry Density	LL	PI	Sp.Gr.	Precons. press.	Cc	eo
98.2 %	51.1	69.8			2.65	0.89	0.45	1.38

TEST RESULTS	MATERIAL DESCRIPTION
Compression Index = 0.45	

ETDC Project Name: ARCO Hastings
ETDC Project No.: 806938.4000000
ETDC Sample No.: 9806
Client Sample No.: MW15A 5456

ONE-DIMENSIONAL CONSOLIDATION ASTM D 2435

IT Corp. - GEOTECHNICAL LABORATORY

Remarks:
Testing begun 10/1/01
Testing completed 10/5/2001

Spec gravity assumed

$\sigma_0 = 87.5(34) + 115.2(22) - 62.4(56) = 2015$ psf
1.01 tsf

used. Values of t_{50} should compare by the two methods, but in real soils large differences are sometimes obtained. The $\sqrt{\text{time}}$ method is more rapid, since the test for that load increment can be terminated when D_{90} is found; however, if secondary compression is to be estimated, the semilog plot should be used.

The Coefficient of Consolidation c_v

The t_{50} data are used to compute the coefficient of consolidation c_v as

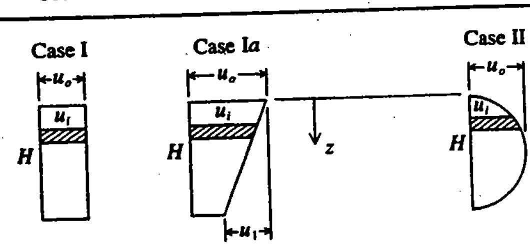
$$c_v = \frac{T_i H^2}{t_i} \tag{2-28}$$

where T_i = time factor (see Table 2-4)
H = length of longest drainage path for a particle of water; in the laboratory it is the half sample thickness when drainage is from both faces
t_i = time for i percent consolidation to take place—t_{50} is usually used

There is some opinion [Olson et al. (1974)] that better c_v valves are obtained using t from the $\sqrt{t}$ plot. Case I of Table 2-4 is usually assumed in the conventional

TABLE 2-4
Time factors for indicated pressure distribution

U, %	Case I	Case II
0	0.000	0.000
10	0.008	0.048
20	0.031	0.090
30	0.071	0.115
40	0.126	0.207
50	0.197	0.281
60	0.287	0.371
70	0.403	0.488
80	0.567	0.652
90	0.848	0.933
100	∞	∞



Pore-pressure distribution for case I usually assumed for case Ia [Taylor (1948)]

Pore-pressure distribution for case II

18/22

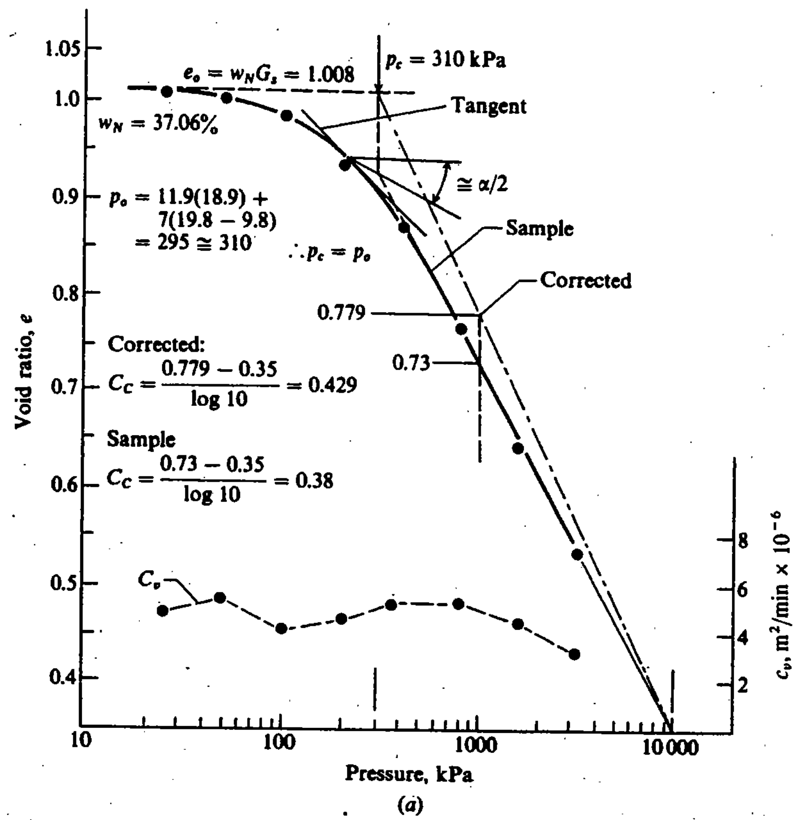


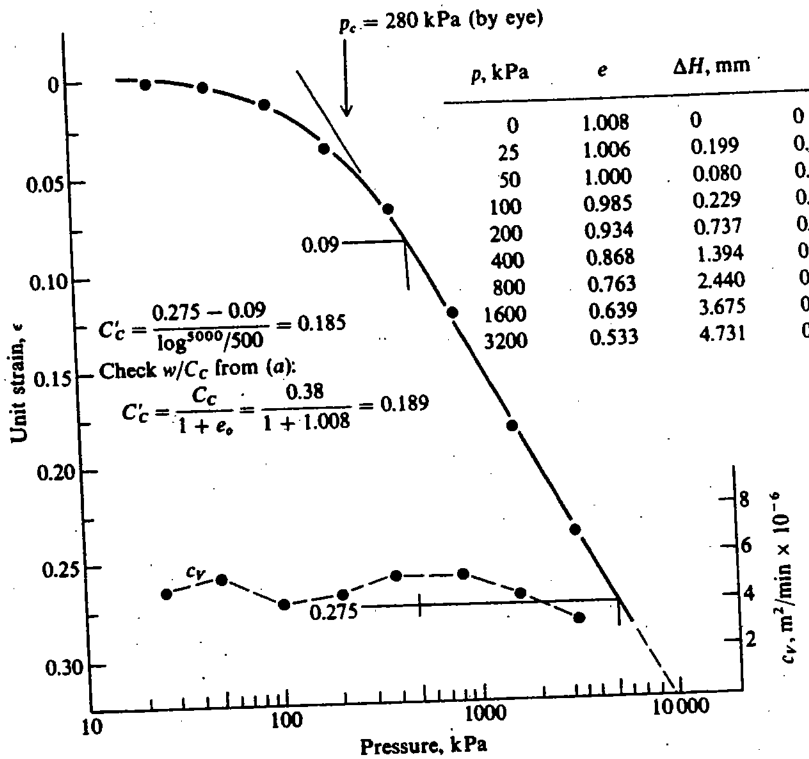
FIGURE 2-14 Methods of presenting settlement data to obtain settlement parameters C_c and C_c'. Method of correcting a normally consolidated clay [*after Schmertmann (1955)*] is shown on (*a*). Data used to plot both curves are shown on (*b*). Slight discrepancy between C_c' values due to plotting.

laboratory test. For 50 percent consolidation Eq. (2-28) becomes

$$c_v = \frac{0.197H^2}{t_{50}} \tag{2-28a}$$

The several load increments give separate values of c_v which can be plotted on the void ratio or strain versus log p curve shown in Fig. 2-14*a*. The plot is usually very erratic because of changes in void ratio, temperature, and S. The curve can be smoothed somewhat by using a small vertical scale—beyond this it is an exercise in engineering judgment to determine the value of c_v to use for estimating field settlements. The time for a given settlement to take place in the field for the layer thickness drainage path H_f at some time t_i by rearranging Eq. (2-28) to obtain

$$t_i = \frac{T_i H_f^2}{c_v}$$



p, kPa	e	ΔH, mm	ϵ
0	1.008	0	0
25	1.006	0.199	0.0010
50	1.000	0.080	0.0040
100	0.985	0.229	0.0115
200	0.934	0.737	0.0368
400	0.868	1.394	0.0697
800	0.763	2.440	0.1220
1600	0.639	3.675	0.1838
3200	0.533	4.731	0.2365

(*b*)

The Compression Index

The amount of primary consolidation settlement is computed using either the *compression index* C_c obtained as a plot of void ratio versus log pressure or from a *compression ratio* C'_c obtained as a plot of strain versus log pressure as on Fig. 2-14*a*, *b*. The void ratio or strain is computed based on initial sample conditions and the settlement under the current load increment to D_{100}. Some persons have used the total settlement under the load increment to compute the current void ratio or strain but current practice favors using only the sample settlement to D_{100}. This value plots a slightly larger (and more conservative) value for the compression index C_c or C'_c.

The initial branch of the e versus log p (and for ϵ versus log p) plot represents recompression of the sample back to the in situ state from the expansion which occurred during recovery (refer also to Fig. 2-15). If the soil is preconsolidated that slope between current p'_o and p'_c, drawn by eye as a best fit since it is usually curved, is designated the recompression index C_r or ratio C'_r.

At the end of primary consolidation—usually taken as 24 h—the dial gauge reading for settlement measurement should have not changed appreciably for a considerable period of time. We say this state represents the end of primary consolidation when the excess pore pressure in the sample is zero (very nearly so) and we are somewhat into secondary compression to be considered later. The value of D_{100} of the previous section is arbitrarily taken as the primary settlement and the corresponding time as that for it to occur.

When the sample recompresses along the recompression branch of the e vs. log p curve it reaches the point where its previous stress history has been imprinted. From this point on it compresses along the curve as a new load (this branch is called the "virgin" curve since it has not been previously traversed). Of much interest is the transition from recompression to the virgin branch. For normally consolidated soils the transition is the current overburden effective pressure p'_o. For preconsolidated soils this point represents the preconsolidation stress imprint p'_c. It should be evident that all stresses involved here are effective stresses—in situ we have K_o conditions and in the laboratory by definition the excess pore pressure is zero when we complete the data for any given load increment on the sample.

The transition point may be a gradual curve, one rather well defined, or in fact, a sharp break. We may identify the transition as a most probable value by eye (rather common practice) or use a method proposed by Casagrande[3] (1936) as shown on Fig. 2-14*a* to determine p'_c. Steps in this method are:

1. Determine by eye the sharpest curvature and draw a tangent.
2. Draw a horizontal line through the tangent and bisect the angle α thus produced.
3. Extend the end slope of the e vs. log p curve to intersect the bisector of step 2.
4. Take the intersection of step 3 as the preconsolidation pressure p_c.

This method is applicable for either an e versus log p or an ϵ versus log p plot. The value of p'_c (usually p_c or p_o on plots as Fig. 2-15) from this is compared to the existing overburden effective pressure p'_o and if:

a. p'_o is within about ± 10 percent of p'_c the soil is probably normally consolidated;
b. $p'_o > p'_c$ sample may have excessive disturbance or there is a computation error;
c. $p'_o < p'_c$ soil is preconsolidated and you may compute OCR $= p'_c/p'_o$.

The settlement indices are computed from the void ratio or strain versus log curve along the virgin branch as:

$$C_c = \frac{\Delta e}{\log p_2/p_1} \qquad C'_c = \frac{\Delta \epsilon}{\log p_2/p_1} \tag{2-29}$$

The *recompression indices* C_r, C'_r are computed similarly but for the branch between p'_o and p'_c. It is common, where possible, to extend the slope so that one log cycle is intercepted so that $\log p_2/p_1 = \log 10 = 1$ to simplify computations.

[3] Casagrande, at the Settlement Conference at Northwestern University in 1964, stated he had never used this method himself.

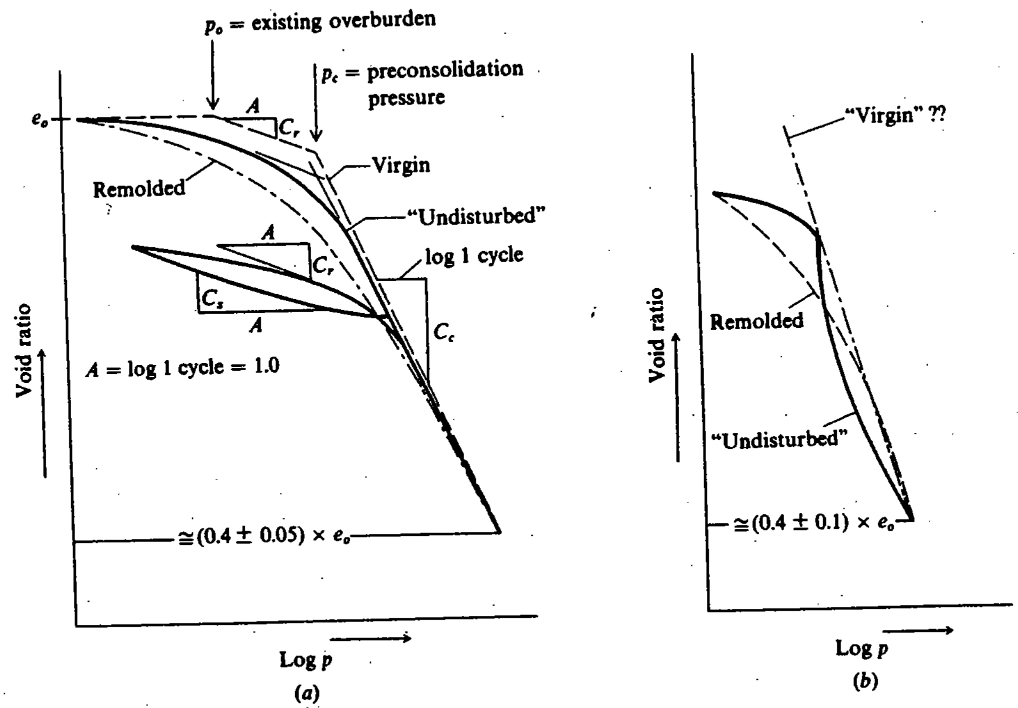


FIGURE 2-15 Void ratio versus log p curves. (*a*) General plot for a preconsolidated soil with method shown to correct for sample disturbance using C_r. (*b*) C_c is not clearly identified when the soil structure collapses to produce a sharp break in curve.

During the initial development of the consolidation theory, it was found that a completely remolded sample produced a curve which always falls beneath an "undisturbed" sample as qualitatively shown on Fig. 2-15*a*. It was also noted that soils with an unstable structure (often with $w_N > w_L$) exhibit behavior as in Fig. 2-15*b* where, beyond the current in situ load, the soil structure collapses. This latter soil requires considerable engineering judgment in making any settlement estimate. It is possible, however, to make an improvement in the compression index C_c or C_c' for the soils shown in Fig. 2-15*a* using a method proposed by Schmertmann (1955) who analyzed a large number of consolidation tests to develop the procedure which is basically as follows:

1. Extend the straight-line portion of the end branch until it intersects the void ratio abscissa at about 0.4 (this is about the minimum void ratio for most soils).
2. In some manner obtain the initial void ratio of the in situ soil. The rebound (or swell) value is too high but you can probably get a fair estimate using G_s and w_N ($e = w_N G_s$) since the in situ soil is saturated.
3. In some manner determine the in situ effective overburden pressure p_o'. Refer to

Sec. 2-9 and Fig. 2-8 for typical computations. You may have to estimate some—or all—of the unit weights.

4. At the intersection of p'_o and e_o extend a straight line to intersect the point located in step 1.
5. The slope of the line drawn in step 4 is the corrected value of C_c for a normally consolidated clay.

For a preconsolidated soil one may estimate a corrected C_c as follows: Steps 1–3 are the same as for a normally consolidated clay.

4. At the intersection of p'_o and e_o draw a line that is parallel to the actual e vs. log p curve as a best fit by eye (see Fig. 2-15*a*).
5. At the intersection of step 4 and p'_c draw a line to the point established in step 1.
6. The slope of the line from step 5 is the approximate corrected value of C_c for the curve branch beyond p'_c.

Sample disturbance always reduces the field value of C_c to a lesser value with a completely remolded sample representing the minimum. As a consequence even corrected values tend to be somewhat lower than true values. Holtz et al. (1986) report results from hand carved block samples versus high quality piston samples. While there was not a great difference between these two recovery procedures it was found that any disturbance reduces C_c. In passing, note that if we obtain a horizontally and vertically oriented sample from a hand carved block and do two consolidation tests we can compute K_o as

$$K_o = p'_{c,H}/p'_{c,V}$$

We may define the following terms:

a. From the straight line part of an e versus p plot at $p \geqq p_c$ the *coefficient of compressibility* a_v is

$$a_v = \frac{\Delta e}{\Delta p}$$

b. The *coefficient of volume compressibility* m_v is

$$m_v = \frac{\Delta e}{\Delta p(1 + e_o)} = \frac{a_v}{1 + e_o} \tag{2-30}$$

From the settlement ratio shown on Fig. 2-16 obtain the settlement as

$$\Delta H = \frac{\Delta e}{1 + e_o} H = m_v(\Delta p)H \tag{2-31}$$

Since the strain $\epsilon = \Delta e/(1 + e_o)$ and m_v is equivalent to $1/E_s$ we have simply

$$\Delta H = \epsilon H \tag{2-31a}$$

HALEY & ALDRICH

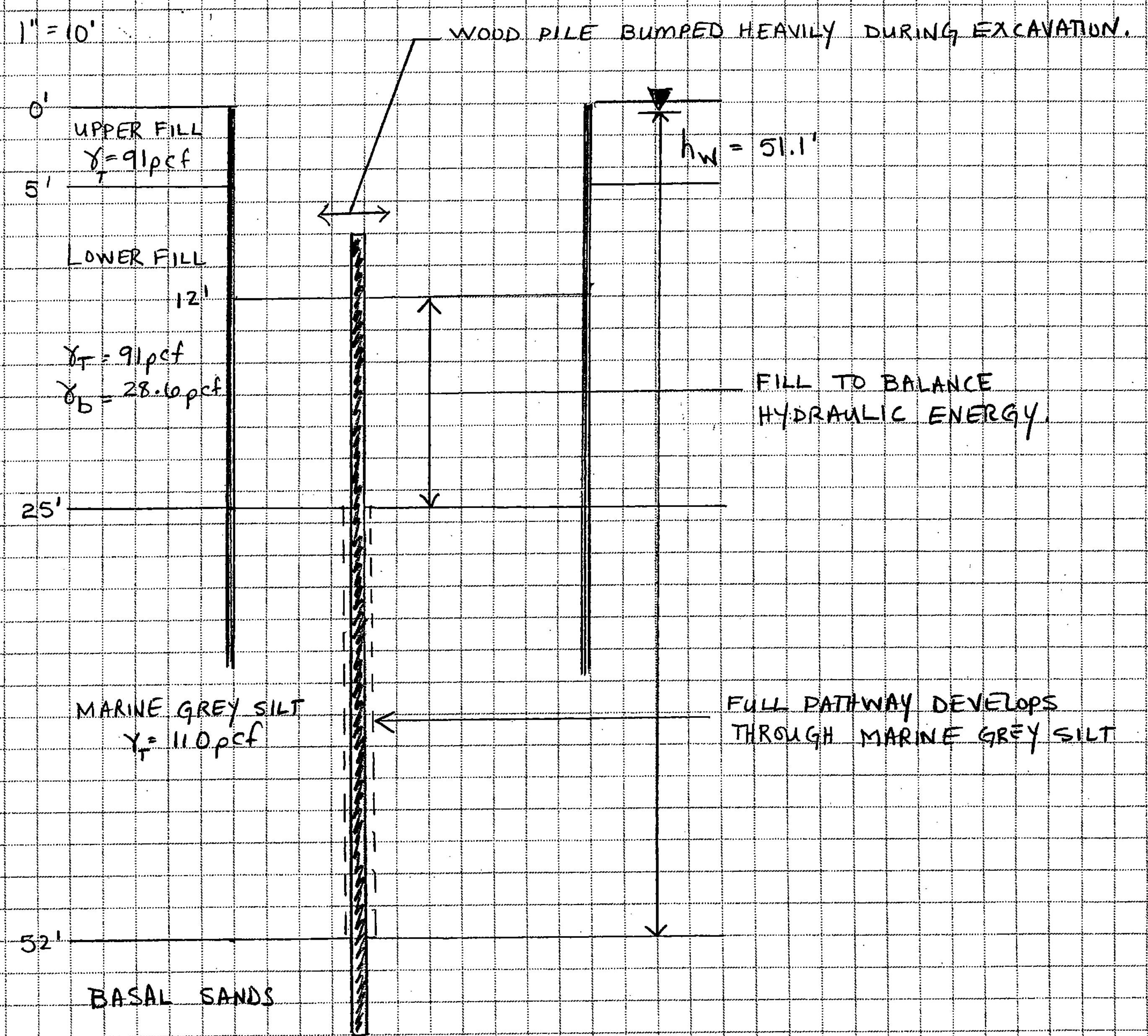
CALCULATIONS

File No.	28612-001
Sheet	1 of 3
Date	17 July 02
Computed By	CAL
Checked By	

Client: Atlantic Richfield Company

Project: Hastings-on-Hudson

Subject: Piping Calculation for MW-13A Soil Profile.



$$FOS = \frac{\gamma_b}{\gamma_w}\left(\frac{\text{flow distance}}{\text{hydraulic head}}\right) = \frac{28.6\,pcf}{62.4\,pcf}\left(\frac{25' - 12'}{51.1' - 27'}\right) = 0.247 < 1.5$$

NO GOOD!

HALEY & ALDRICH

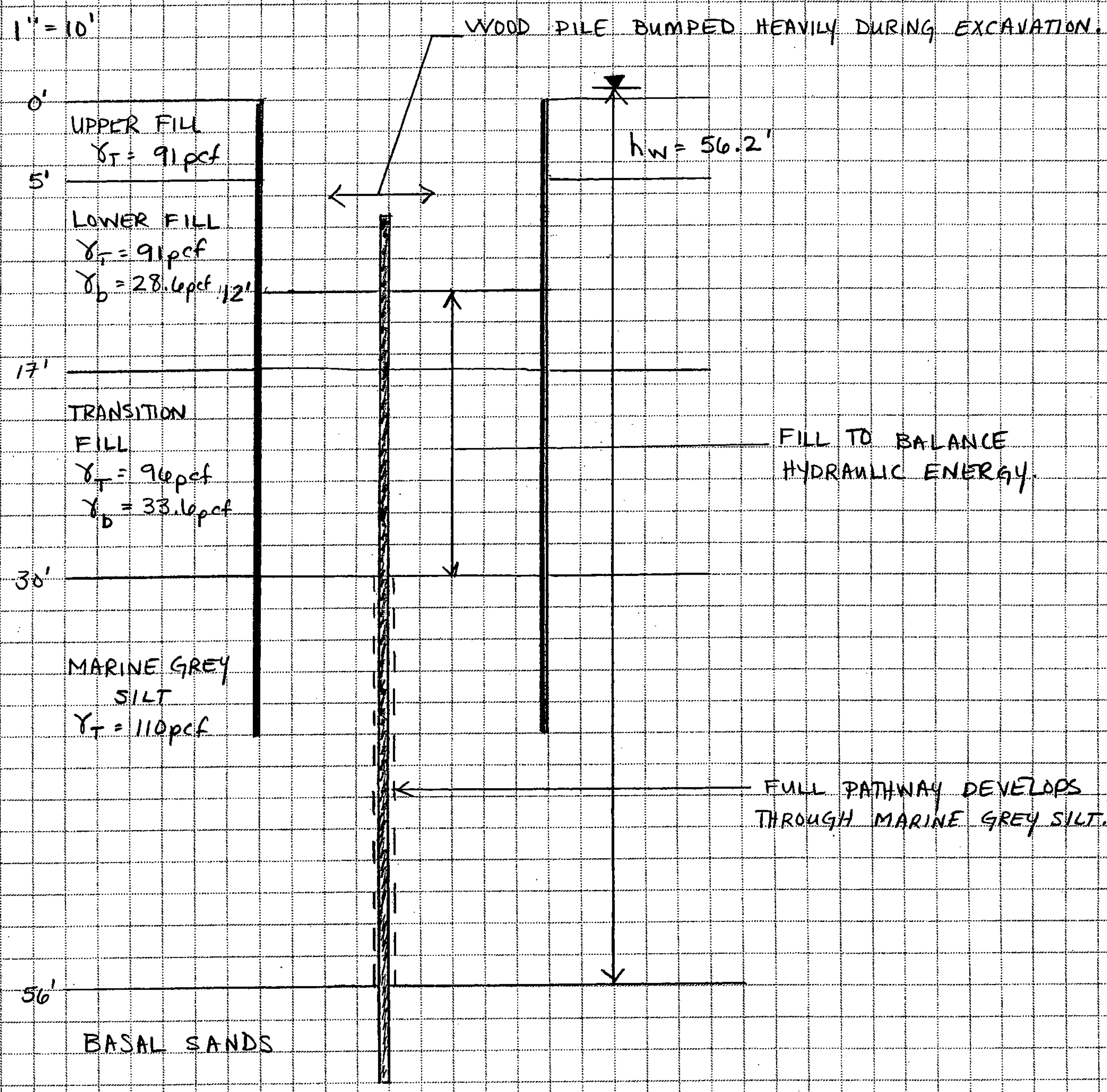
CALCULATIONS

File No.	28612-001
Sheet	2 of 3
Date	17 July 2002
Computed By	CAL
Checked By	

Client: Atlantic Richfield Company

Project: Hastings-on-Hudson

Subject: Piping Calculation for MW-14A SOIL PROFILE



$$FOS = \frac{\gamma_b}{\gamma_w}\left(\frac{\text{flow distance}}{\text{hydraulic head}}\right)$$

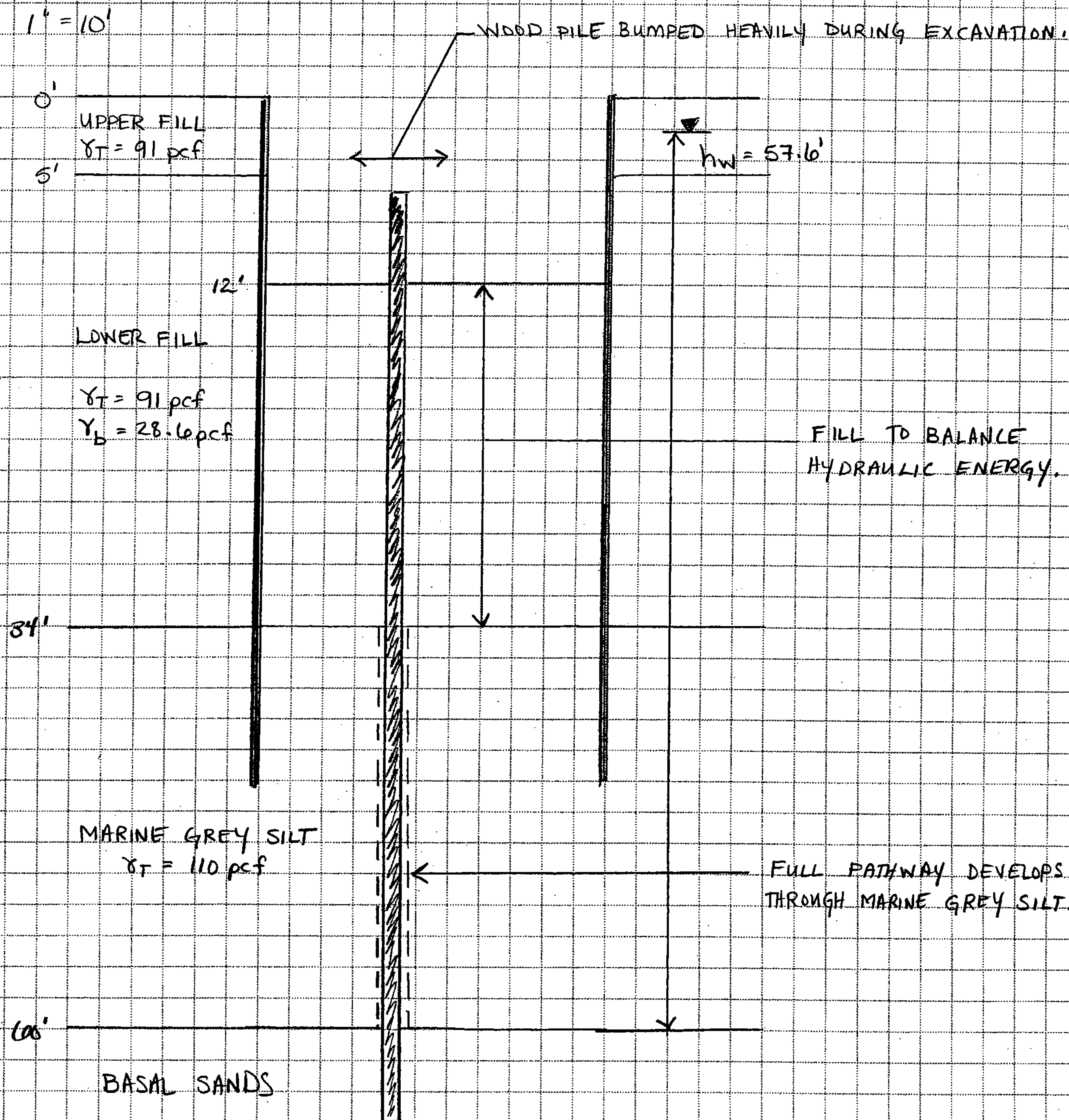
$$\gamma_b = \left[(28.6\,pcf)(5') + (33.6\,pcf)(13')\right] / 18' = 32.2\,pcf$$

$$FOS = \frac{32.2\,pcf}{62.4\,pcf}\left(\frac{30' - 12'}{56.2' - 26'}\right) = 0.308 < 1.5 \rightarrow \text{NO GOOD!}$$

HALEY & ALDRICH

CALCULATIONS

Client	Atlantic Richfield Company	File No.	28612-001
Project	Hastings-on-Hudson	Sheet	3 of 3
Subject	Piping Calculation for MW-15A Soil Profile	Date	17 July 02
		Computed By	CAL
		Checked By	



$$FOS = \frac{\gamma_b}{\gamma_w}\left(\frac{\text{flow distance}}{\text{hydraulic head}}\right) = \left(\frac{28.6\,pcf}{62.4\,pcf}\right)\left(\frac{34' - 12'}{57.6' - 26'}\right) = 0.319 < 1.5 \rightarrow \text{NO GOOD!}$$

APPENDIX C

EVALUATION OF DEWATERING DISCHARGE QUANTITIES

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EVALUATION OF DEWATERING DISCHARGE QUANTITIES

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EVALUATION OF DEWATERING DISCHARGE QUANTITIES

Evaluation of Dewatering Discharge Quantities

PROBLEM STATEMENT:

1- Estimate the current mass of PCBs entering the Hudson River from the Harbor-at-Hastings Site. Two scenarios were evaluated: (A)- discharge along the entire waterfront, and (B)- discharge along the waterfront at the Water Tower and Northwest Corner Areas (approximately 700 feet). For each scenario evaluated, estimate the PCB mass loading using (1) the solubility concentration of PCBs (3.1 μg/L) (USEPA Superfund Public Health Evaluation Manual, EPA/540/1-86/060); and (2) a filtered fill water concentration of 0.91 μg/L (MW-12, as reported in Remedial Investigation Report, IT 2000).

2- Estimate the mass of PCBs that would be discharged to the River as a result of excavation dewatering and treatment. Two scenarios were evaluated: (A) worst case, water discharged to the River would contain PCBs at the permit level of 0.1 part per billion (pbb), and (B) water discharged to the River would be discharged at one-half of the permit level (0.05 ppb).

3- Compare the estimated PCB discharge under ambient flow conditions to the estimated discharge during implementation of Alternatives 2, 3, 4, 5, 6, 11, and 12 (remedial alternatives that contain an element of excavation and dewatering).

ASSUMPTIONS:

1- Treatment of the excavation water will be necessary regardless of soluble PCB concentrations due to particulate PCB concentrations.
2- Groundwater flux across the entire site is 3,400 ft^3/day (Golder, 1996)
3- Hydraulic conductivity of the northern 700 feet of shoreline is 11.42 ft/day (Golder, 1996)
4- Hydraulic gradient across the northern 700 feet of shoreline is 0.007 ft/ft (Golder, 1996)
5- Excavation dewatering will require the use of five (5) wells pumping at 250 gallons per minute (gpm) each. This assumption is based on preliminary estimates provided by the Tyree Organization, LTD.

CALCULATIONS:

Problem 1: Estimate the current mass of PCBs entering the Hudson River from the Hastings-on-Hudson Site. Two scenarios were evaluated: (A)- discharge along the entire waterfront, and (B)- discharge along the waterfront at the Water Tower and Northwest Corner Areas (approximately 700 feet). For each scenario evaluated, estimate the PCB mass loading using (1) the solubility concentration of PCBs (3.1 μg/L) (USEPA Superfund Public Health Evaluation Manual, EPA/540/1-86/060); and (2) a filtered fill water concentration of 0.91 μg/L (MW-12, as reported in Remedial Investigation Report, IT 2000).

A – Calculate the Mass of PCB currently discharged along the entire waterfront.

1- Assume colloidal filtration with 100% solubility of PCBs, PCB concentration is 3.1 μg/L

$$\left(\frac{mass}{day}\right) = flux * concentration$$

$$\left(\frac{mass}{day}\right) = 3400 ft^3 / day * 3.1 \mu g / L * 28.3 L / ft^3 * 1 kg / 1E9 \mu g * 2.2 lb / kg = \underline{0.0007 lb / day}$$

2- Assume actual fill water filtered PCB concentration, PCB concentration is 0.91 μg/L

$$\left(\frac{mass}{day}\right) = flux * concentration$$

$$\left(\frac{mass}{day}\right) = 3400 ft^3 / day * 0.91 \mu g / L \bullet 28.3 L / ft^3 * 1 kg / 1E9 \mu g * 2.2 lb / kg = \underline{0.00019 lb / day}$$

B – Calculate the Mass of PCB currently discharged along the waterfront at the Water Tower and Northwest Corner Areas (approximately 700 feet of shoreline).

1- Assume colloidal filtration with 100% solubility of PCBs, PCB concentration is 3.1 μg/L

$$\left(\frac{mass}{day}\right) = flux * concentration$$

$$flux = KLW \, {}^{dh}\!/_{dl}$$

Where:

K = hydraulic conductivity ft/day
L = length of shoreline (ft)
W = depth of shoreline (ft)
dh/dl = hydraulic gradient (ft/ft)

$$flux = 11.42 ft / day * 700 ft * 22 ft * 0.007 ft / ft = 1231.076 ft^3 / day$$

therefore:

$$\left(\frac{mass}{day}\right) = 1231.076 ft^3 / day * 3.1 g / L \bullet 28.3 L / ft^3 * 1 kg / 1E9 \mu g * 2.2 lb / kg = \underline{0.00024 lb / day}$$

2- Assume actual fill water filtered PCB concentration, PCB concentration is 0.91 μg/L

$$\left(\frac{mass}{day}\right) = flux * concentration$$

$$flux = KLW \, {}^{dh}\!/_{dl}$$

Where:

K = hydraulic conductivity ft/day
L = length of shoreline (ft)
W = depth of shoreline (ft)
dh/dl = hydraulic gradient (ft/ft)

$$flux = 11.42 ft/day * 700 ft * 22 ft * 0.007 ft/ft = 1231.076 ft^3/day$$

therefore:

$$\left(\frac{mass}{day}\right) = 1231.076 ft^3/day * 0.91 \mu g/L \bullet 28.3 L/ft^3 * 1kg/1E9 \mu g * 2.2 lb/kg = \underline{0.000075\ lb/day}$$

Problem 2: Estimate the mass of PCBs that would be discharged to the River as a result of excavation dewatering and treatment. Two scenarios were evaluated: (A) worst case, water discharged to the River would contain PCBs at the permit level of 0.1 part per billion (pbb), and (B) water discharged to the River would be discharged at one-half of the permit level (0.05 ppb).

A – Calculate the Mass of PCB that would enter the River via discharge of treated excavation water assuming that the PCB concentration is at the discharge limit of 0.1 ppb.

1- For each day of construction dewatering:

$$total\ flow\ (gpm) = number\ of\ wells * well\ production\ (gpm)$$

$$total\ flow\ (gpm) = 5 * 200\ gpm = 1000\ gpm$$

$$\left(\frac{mass}{day}\right) = flow * concentration$$

$$\left(\frac{mass}{day}\right) = 1000\ \text{gal/min} * 60\ \text{min}/hour * 24 hour/day * 3.78 L/gal * 0.1 \mu g/L * 1kg/1E9 \mu g * 2.2 lb/kg$$

$$= \underline{0.0012\ lb/day}$$

B – Calculate the Mass of PCB that would enter the River via discharge of treated excavation water assuming that the PCB concentration is at the discharge limit of 0.05 ppb.

1- For each day of construction dewatering:

$$total\ flow\ (gpm) = number\ of\ wells * well\ production\ (gpm)$$

$$total\ flow\ (gpm) = 5 * 200\ gpm = 1000\ gpm$$

$$\left(\frac{mass}{day}\right) = flow * concentration$$

$$\left(\frac{mass}{day}\right) = 1000 \ \text{gal}/\min * 60 \min/ \ hour \ * 24 hour. / day * 3.78 L / gal * 0.05 \mu g / L * 1 kg / 1E9 \mu g * 2.2 lb / kg$$

$$= \underline{0.0006 \ lb / day}$$

Problem 3: Compare the estimated PCB discharge under ambient flow conditions to the estimated discharge during implementation of Alternatives 2, 3, 4, 5, 6, 11, and 12 (remedial alternatives that contain an element of excavation and dewatering).

1- Estimate the mass of PCB discharged during implementation of Remedial Alternatives 2, 3, 4, 5, 6, 11, and 12. Using the estimated mass of PCB discharged per day of dewatering (using the range of assumed discharge concentrations), a total mass (range) of PCB discharged was calculated for Alternatives 2, 3, 4, 5, 6, 11, and 12. These calculated ranges of potential PCB mass discharges were then compared to the estimated mass discharge under ambient flow conditions during the period of time associated with the implementation of each of the alternatives evaluated. These results are tabulated below.

Remedial Alternative	Duration of Implementation (days)	Estimated Mass of PCB Discharged During Dewatering (lbs.)[1]	Estimated Mass of PCB Discharged Under Ambient Conditions Along Entire Waterfront (lbs.)	Estimated Mass of PCB Discharged Under Ambient Conditions Along 700' of Shoreline (lbs.)
2	381	0.2286 – 0.4572	0.07239	0.02857
3	885	0.531 – 1.062	0.16815	0.06638
4	381	0.2286 – 0.4572	0.07239	0.02858
5	718	0.431 – 0.862	0.13642	0.05385
6	202	0.121 – 0.242	0.03838	0.01515
11	129	0.0774 – 0.1548	0.02451	0.00968
12	185	0.111 – 0.222	0.03515	0.01388

Note: 1. The range of mass reported reflects the assumed range of discharge concentrations.

Comparing the estimated mass of PCB discharged during implementation of any of the excavation-based remedial alternatives to the estimated mass of PCB discharged under ambient conditions shows that during implementation a potential risk of discharging a greater mass of PCB to the River exists.

APPENDIX D

ALTERNATIVE COST ESTIMATE

APPENDIX D

ALTERNATIVE COST ESTIMATE

Feasibility Study For The Atlantic Richfield Company - Harbor At Hastings Site
Remedial Cost Estimates

Alternative 1: No Action					
No	Item (associated scope contingency, if applicable)	Quantity	Unit	Unit Cost	Total Cost
Facility Access Controls					
1	Perimeter Fencing (15%)	3200	LF	$ 18.23	**$58,336**
	Sub - Total				**$58,336**
Vertical Barrier					
2	Sheet Pile Bulkhead Along Shoreline with Waterloo Barrier or Equivalent, 30' deep (30%)	2,600	LF	$ 2,500.00	**$6,500,000**
	Sub - Total				**$6,500,000**
	Total Construction Cost				**$6,558,336**
	Contingency (30% Scope + 15% Bid)				**$2,951,251**
	Sub-Total: Construction/Contingency Cost				**$9,509,587**
	Engineering & Design (3%)				**$285,288**
	Supervision, Administration & CQA (7%)				**$665,671**
	Sub- Total: Capital Cost				**$10,460,546**
Post-Closure Costs					
3	Annual Security	1	EA	$ 165,000.00	**$165,000**
4	Annual Fence Repairs	320	LF	$ 18.23	**$5,834**
5	Phase Liquid Recovery in Water Tower Area	1	EA	$ 45,000.00	**$45,000**
6	Annual Maintenance of Grading and Cover at Northwest Corner	1	EA	$ 1,000.00	**$1,000**
	Sub-Total				**$216,834**
	Sub-Total: Present Worth - 30 Yr Post Closure Period				**$6,291,122**
	GRAND TOTAL				**$16,751,668**

NOTES:

1 Annual fence maintenance quantity represents 10% of the total perimeter fence.

2 Contingency determined by combining the weighted-by-cost-element scope contingency with a fixed 15% bid contingency. The scope contingency used for each cost element is shown above. The scope contingency summarized in parenthesis is the value of the weighted-by-cost-element contingency.

3 Costs for mobilization and demobilization were included in sheet pile bulkhead unit cost.

Feasibility Study For The Atlantic Richfield Company - Harbor At Hastings Site
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Alternative 2:

Excavation and Off-Site Disposal of all PCB-Impacted Fill and Lead Hot Spots.

No.	Item	Quantity	Unit	Unit Cost	Total Cost	Scope Contingency
General Site Work						
1	Mobilization and Demobilization	1	LS	$ 252,000.00	$ 252,000	0.15
2	Erosion and Sediment Controls	5,620	LF	$ 13.82	$ 77,669	0.15
3	Asphalt Stripping / Disposal	41,962	SY	$ 22.58	$ 947,502	0.15
4	Building Demolition	500,211	SF	$ 4.23	$ 2,115,893	0.15
5	Saw Cut, Remove & Dispose of Concrete	1,111	SY	$ 22.58	$ 25,087	0.15
	Sub-Total				**$ 3,418,151**	
Excavation Shoring and Stabilization						
6	Sheeting - Installation and Removal					
6	To 30' Below Ground Surface	132,000	SF	$ 22.00	$ 2,904,000	0.30
6	To 86' Below Ground Surface	275,200	SF	$ 184.00	$ 50,636,800	0.30
7	Jet Grouting	1,111	CY	$ 400.00	$ 444,400	0.30
	Sub - Total				**$ 53,985,200**	
Excavation and Backfilling Work						
7	Excavation of Fill >1ppm to <10ppm in Top 1'	6,842	CY	$ 16.39	$ 112,141	0.55
8	Excavation of PCB Fill to maximum depth of 40' bgs	103,534	CY	$ 15.43	$ 1,597,530	0.55
9	Excavation of Lead Hotspots	925	CY	$ 15.43	$ 14,273	0.55
10	Backfilling PCB Excavation w/ Clean Soil	110,376	CY	$ 24.41	$ 2,694,279	0.55
11	Backfilling of Lead Hot Spots	925	CY	$ 24.41	$ 22,580	0.55
	Sub - Total				**$ 4,440,803**	
Dewatering / Soil Staging Facility						
12	Select Fill Layer	1,482	CY	$ 29.69	$ 44,001	0.15
13	40 Mil HDPE Liner	40,000	SF	$ 0.49	$ 19,600	0.15
14	Sand Layer	494	CY	$ 22.69	$ 11,209	0.15
15	8" Reinforced Concrete Layer					
15	Form Work	667	SFCA	$ 4.93	$ 3,289	0.15
15	8" Thick Concrete Slab	40,000	SF	$ 3.39	$ 135,600	0.15
15	Reinforcing Steel Mesh	40,000	SF	$ 5.34	$ 213,600	0.15
16	4' High, 12" Thick Concrete Curbs/Walls	1,600	LF	$ 21.92	$ 35,072	0.15
17	Pump System and Piping	381	DAY	$ 170.00	$ 64,770	0.35
	Sub - Total				**$ 527,141**	
Water Treatment						
18	Mobilization and Demobilization	1	LS	$ 44,100.00	$ 44,100	0.15
19	Water Treatment System	381	DAY	$ 4,800.00	$ 1,828,800	0.35
20	Testing of Treatment System Effluent	381	DAY	$ 120.00	$ 45,720	0.35
	Sub - Total				**$ 1,918,620**	
Transportation and Disposal of Excavated Fill						
21	Testing of Excavated Fill Samples	442	EA	$ 254.38	$ 112,310	0.15
22	Testing of Excavated Lead Soils	25	EA	$ 300.00	$ 7,500	0.15
23	Disposal (>1 PPM to <10 PPM)	9,237	TONS	$ 65.00	$ 600,386	0.15
24	Disposal (> or = to 10 PPM)	139,771	TONS	$ 150.00	$ 20,965,635	0.15
25	Disposal (grout spoils, > or = to 10 PPM)	2,250	TONS	$ 150.00	$ 337,467	0.15
26	Additional Disposal for Stabilization Materials (7.5% of total soil quantity, excluding grout spoils)	11,176	TONS	$ 150.00	$ 1,676,400	0.15
27	Disposal of Lead Soils	1,202	TONS	$ 368.00	$ 442,336	0.15
28	Additional Disposal for Stabilization Materials (7.5% of total soil quantity)	91	TONS	$ 368.00	$ 33,488	0.15
	Sub - Total				**$ 24,175,522**	
Site Restoration and Equipment Decon						
29	PPE including Disposal	391	Day	$ 300.00	$ 117,300	0.15
30	Decontamination of Sheeting & Equipment	1	LS	$ 98,000.00	$ 98,000	0.15
31	Stormwater Controls	1	LS	$ 105,000.00	$ 105,000	0.15
32	Site Rail Upgrade	1,500	LF	$ 22.91	$ 34,365	0.15
	Sub - Total				**$ 354,665**	

Feasibility Study For The Atlantic Richfield Company - Harbor At Hastings Site
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Alternative 2: Excavation and Off-Site Disposal of all PCB-Impacted Fill and Lead Hot Spots.						
No.	**Item**	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**	**Scope Contingency**
Vertical Barriers						
33	Sheet Pile Bulkhead Along Shoreline with Waterloo Barrier or Equivalent, 38' deep	2,600	LF	$ 2,500.00	$ 6,500,000	0.30
	Sub - Total				**$ 6,500,000**	
Site Restoration and Institutional Controls						
34	6" Topsoil Layer	41,962	SY	$ 4.83	$ 202,677	0.15
35	Fine Grading, Seeding, Mulch & Fertilizer	41,962	SY	$ 2.99	$ 125,467	0.15
	Sub - Total				**$ 328,144**	
	Total Construction Cost				**$ 95,648,246**	
	Contingency (27% Scope + 15% Bid)				**$ 40,172,263**	
	Sub-Total: Construction/Contingency Cost				**$ 135,820,509**	
	Engineering & Design (3%)				**$ 4,074,616**	
	Supervision, Administration & CQA (7%)				**$ 9,507,436**	
	Sub-Total: Capital Cost				**$ 149,402,561**	
Post-Closure Costs						
36	Annual Fence Maintenance	320	LF	$ 18.23	$ 5,834	
37	Annual Mowing	8.7	AC	$ 681.28	$ 5,928	
	Sub-Total				**$ 11,762**	
Sub-Total: Present Worth - 30 Yr Post Closure Period					**$ 341,257**	
	GRAND TOTAL				**$ 149,743,819**	

NOTES:

1. Contingency determined by combining the weighted-by-cost-element scope contingency with a fixed 15% bid contingency. The scope contingency used for each cost element is shown above. Contingency determined in accordance with *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* , USEPA, July 2000.
2. Engineering and Design Costs represent 3% of the Construction/Contingency Cost.
3. Supervision, Administration & CQA Costs represent 7% of the Construction/Contingency Cost. This percentage is based on a recommendation from "Superfund Remedial Design and Remedial Action Guidance", USEPA, June 1986.
4. To calculate the Total Present Worth O&M, the equation $P = A_1[n(1+i)^{-1}]$ was used, the annual interest rate was assumed to be 6% and the annual inflation rate was calculated to be 2.6% (from "Engineering News Record" web site). The effective interest rate is thus 3.4%.
5. The Annual Final Cover Maintenance Cost represents 3.5% of the Part 360 Cap Construction Cost.
6. The Contact Barrier Maintenance Cost represents 3.5% of the Contact Barrier Construction Cost.
7. Annual fence maintenance quantity represents 10% of the total perimeter fence.
8. Disposal Volumes Derived by Using 1.35 Multiplier to Convert Cubic Yards to Tons.

Feasibility Study For The Atlantic Richfield Company - Harbor At Hastings Site
Remedial Cost Estimates

Alternative 3: Excavation and Off-Site Disposal of All Fill Located Above the Water Table Exceeding TAGM Values and All PCB-Impacted Fill Below the Water Table (> or =10 ppm), Excavation and Off-Site Disposal of Lead Hot Spots.						
No.	**Item**	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**	**Scope Contingency**
General Site Work						
1	Mobilization and Demobilization	1	LS	$ 252,000.00	$ 252,000	0.15
2	Erosion and Sediment Controls	6,510	LF	$ 13.82	$ 89,969	0.15
3	Asphalt Stripping / Disposal	70,645	SY	$ 22.58	$ 1,595,165	0.15
4	Building Demolition	500,211	SF	$ 4.23	$ 2,115,893	0.15
5	Saw Cut, Remove & Dispose of Concrete	1,111	SY	$ 22.58	$ 25,087	0.15
	Sub-Total				**$ 4,078,114**	
Excavation Shoring and Stabilization						
6	Sheeting - Installation and Removal					
6	To 30' Below Ground Surface	132,000	SF	$ 22.00	$ 2,904,000	0.30
6	To 86' Below Ground Surface	275,200	SF	$ 184.00	$ 50,636,800	0.30
7	Jet Grouting	1,111	CY	$ 400.00	$ 444,400	0.30
	Sub - Total				**$ 53,985,200**	
Excavation and Backfilling Work						
8	Excavation of Fill >1ppm to <10ppm in Top 1'	6,842	CY	$ 16.39	$ 112,141	0.55
9	Excavation of PCB Fill to maximum depth of 40' bgs	103,534	CY	$ 15.43	$ 1,597,530	0.55
10	Excavation of TAGM Soils	175,838	CY	$ 16.43	$ 2,889,019	0.55
11	Excavation of Lead Hot Spots	925	CY	$ 15.43	$ 14,273	0.55
12	Backfilling PCB Excavation w/ Clean Soil	110,376	CY	$ 24.41	$ 2,694,279	0.55
13	Backfilling TAGM Excavation	175,838	CY	$ 24.41	$ 4,292,206	0.55
14	Backfilling of Lead Hot Spots	925	CY	$ 24.41	$ 22,580	0.55
	Sub - Total				**$ 11,622,028**	
Dewatering / Soil Staging Facility						
15	Select Fill Layer	1,482	CY	$ 29.69	$ 44,001	0.15
16	40 Mil HDPE Liner	40,000	SF	$ 0.49	$ 19,600	0.15
17	Sand Layer	494	CY	$ 22.69	$ 11,209	0.15
18	8" Reinforced Concrete Layer					
18	Form Work	667	SFCA	$ 4.93	$ 3,289	0.15
18	8" Thick Concrete Slab	40,000	SF	$ 3.39	$ 135,600	0.15
18	Reinforcing Steel Mesh	40,000	SF	$ 5.34	$ 213,600	0.15
19	4' High, 12" Thick Concrete Curbs/Walls	1,600	LF	$ 21.92	$ 35,072	0.15
20	Pump System and Piping	885	DAY	$ 170.00	$ 150,450	0.35
	Sub - Total				**$ 612,821**	
Water Treatment						
21	Mobilization and Demobilization	1	LS	$ 44,100.00	$ 44,100	0.15
22	Water Treatment System	885	DAY	$ 4,800.00	$ 4,248,000	0.35
23	Testing of Treatment System Effluent	885	DAY	$ 120.00	$ 106,200	0.35
	Sub - Total				**$ 4,398,300**	
Transportation and Disposal of Excavated Fill						
24	Testing of Excavated Fill Samples	1,145	EA	$ 254.38	$ 291,229	0.15
25	Testing of Excavated Lead Soils	25	EA	$ 300.00	$ 7,500	0.15
26	Disposal (>1 PPM to <10 PPM)	9,237	TONS	$ 65.00	$ 600,386	0.15
27	Disposal (> or = to 10 PPM)	377,152	TONS	$ 150.00	$ 56,572,830	0.15
28	Disposal (grout spoils, > or = to 10 PPM)	2,250	TONS	$ 150.00	$ 337,467	0.15
29	Additional Disposal for Stabilization Materials (7.5% of total soil quantity, excluding grout spoils)	28,980	TONS	$ 150.00	$ 4,347,000	0.15
30	Disposal of Lead Soils	1,202	TONS	$ 368.00	$ 442,336	0.15
31	Additional Disposal for Stabilization Materials (7.5% of total soil quantity)	91	TONS	$ 368.00	$ 33,488	0.15
	Sub - Total				**$ 62,632,236**	
Site Restoration and Equipment Decon						
32	PPE including Disposal	895	Day	$ 300.00	$ 268,500	0.15
33	Decontamination of Sheeting & Equipment	1	LS	$ 98,000.00	$ 98,000	0.15
34	Stormwater Controls	1	LS	$ 105,000.00	$ 105,000	0.15
35	Site Rail Upgrade	1,500	LF	$ 22.91	$ 34,365	0.15
	Sub - Total				**$ 505,865**	

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Alternative 3:

Excavation and Off-Site Disposal of All Fill Located Above the Water Table Exceeding TAGM Values and All PCB-Impacted Fill Below the Water Table (> or =10 ppm), Excavation and Off-Site Disposal of Lead Hot Spots.

No.	Item	Quantity	Unit	Unit Cost	Total Cost	Scope Contingency
Vertical Barriers						
36	Sheet Pile Bulkhead Along Shoreline with Waterloo Barrier or Equivalent, 38' deep	2,600	LF	$ 2,500.00	$ 6,500,000	0.30
	Sub - Total				**$ 6,500,000**	
Site Restoration and Institutional Controls						
37	6" Topsoil Layer	135,520	SY	$ 4.83	$ 654,562	0.15
38	Fine Grading, Seeding, Mulch & Fertilizer	135,520	SY	$ 2.99	$ 405,205	0.15
	Sub - Total				**$ 1,059,767**	
	Total Construction Cost				**$ 145,394,331**	
	Contingency (25% Scope + 15% Bid)				**$ 58,157,732**	
	Sub-Total: Construction/Contingency Cost				**$ 203,552,063**	
	Engineering & Design (3%)				**$ 6,106,562**	
	Supervision, Administration & CQA (7%)				**$ 14,248,645**	
	Sub-Total: Capital Cost				**$ 223,907,270**	
Post-Closure Costs						
39	Annual Fence Maintenance	320	LF	$ 18.23	$ 5,834	
40	Annual Mowing	28	AC	$ 681.28	$ 19,076	
	Sub-Total				**$ 24,910**	
Sub-Total: Present Worth - 30 Yr Post Closure Period					**$ 722,716**	
	GRAND TOTAL				**$ 224,629,986**	

NOTES:

1 Contingency determined by combining the weighted-by-cost-element scope contingency with a fixed 15% bid contingency. The scope contingency used for each cost element is shown above. Contingency determined in accordance with *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*, USEPA, July 2000.

2 Engineering and Design Costs represent 3% of the Construction/Contingency Cost.

3 Supervision, Administration & CQA Costs represent 7% of the Construction/Contingency Cost. This percentage is based on a recommendation from "Superfund Remedial Design and Remedial Action Guidance", USEPA, June 1986.

4 To calculate the Total Present Worth O&M, the equation $P = A_1[n(1+i)^{-1}]$ was used, the annual interest rate was assumed to be 6% and the annual inflation rate was calculated to be 2.6% (from "Engineering News Record" web site). The effective interest rate is thus 3.4%.

5 The Annual Final Cover Maintenance Cost represents 3.5% of the Part 360 Cap Construction Cost.

6 The Contact Barrier Maintenance Cost represents 3.5% of the Contact Barrier Construction Cost.

7 Annual fence maintenance quantity represents 10% of the total perimeter fence.

8 Disposal Volumes Derived by Using 1.35 Multiplier to Convert Cubic Yards to Tons.

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Alternative 4: Excavation and Off-Site Disposal of All PCB-Impacted Fill (> or = to 10 ppm), Excavation and Off-Site Disposal of Lead Hot Spots and Construction of a Multi-Layered Cap System over the Entire Site						
No.	**Item**	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**	**Scope Contingency**
General Site Work						
1	Mobilization and Demobilization	1	LS	$ 252,000.00	$ 252,000	0.15
2	Erosion and Sediment Controls	5,620	LF	$ 13.82	$ 77,669	0.15
3	Asphalt Stripping / Disposal	41,962	SY	$ 22.58	$ 947,502	0.15
4	Building Demolition	500,211	SF	$ 4.23	$ 2,115,893	0.15
5	Saw Cut, Remove & Dispose of Concrete	1,111	SY	$ 22.58	$ 25,087	0.15
	Sub-Total				**$ 3,418,151**	
Excavation Shoring and Stabilization						
6	Sheeting - Installation and Removal					
6	To 30' Below Ground Surface	132,000	SF	$ 22.00	$ 2,904,000	0.30
6	To 86' Below Ground Surface	275,200	SF	$ 184.00	$ 50,636,800	0.30
7	Jet Grouting	1,111	CY	$ 400.00	$ 444,400	0.30
	Sub - Total				**$ 53,985,200**	
Excavation and Backfilling Work						
8	Excavation of Fill >1ppm to <10ppm in Top 1'	6,842	CY	$ 16.39	$ 112,141	0.55
9	Excavation of PCB Fill to maximum depth of 40' bgs	103,534	CY	$ 15.43	$ 1,597,530	0.55
10	Excavation of Lead Hotspots	925	CY	$ 15.43	$ 14,273	0.55
11	Backfilling PCB Excavation w/ Clean Soil	110,376	CY	$ 24.41	$ 2,694,279	0.55
12	Backfilling of Lead Hot Spots	925	CY	$ 24.41	$ 22,580	0.55
	Sub - Total				**$ 4,440,803**	
Dewatering / Soil Staging Facility						
13	Select Fill Layer	1,482	CY	$ 29.69	$ 44,001	0.15
14	40 Mil HDPE Liner	40,000	SF	$ 0.49	$ 19,600	0.15
15	Sand Layer	494	CY	$ 22.69	$ 11,209	0.15
16	8" Reinforced Concrete Layer					
16	Form Work	667	SFCA	$ 4.93	$ 3,289	0.15
16	8" Thick Concrete Slab	40,000	SF	$ 3.39	$ 135,600	0.15
16	Reinforcing Steel Mesh	40,000	SF	$ 5.34	$ 213,600	0.15
17	4' High, 12" Thick Concrete Curbs/Walls	1,600	LF	$ 21.92	$ 35,072	0.15
18	Pump System and Piping	381	DAY	$ 170.00	$ 64,770	0.35
	Sub - Total				**$ 527,141**	
Water Treatment						
19	Mobilization and Demobilization	1	LS	$ 44,100.00	$ 44,100	0.15
20	Water Treatment System	381	DAY	$ 4,800.00	$ 1,828,800	0.35
21	Testing of Treatment System Effluent	381	DAY	$ 120.00	$ 45,720	0.35
	Sub - Total				**$ 1,918,620**	
Transportation and Disposal of Excavated Fill						
22	Testing of Excavated Fill Samples	442	EA	$ 254.38	$ 112,310	0.15
23	Testing of Excavated Lead Soils	25	EA	$ 300.00	$ 7,500	0.15
24	Disposal (>1 PPM to <10 PPM)	9,237	TONS	$ 65.00	$ 600,386	0.15
25	Disposal (> or = to 10 PPM)	139,771	TONS	$ 150.00	$ 20,965,635	0.15
26	Disposal (grout spoils, > or = to 10 PPM)	2,250	TONS	$ 150.00	$ 337,467	0.15
27	Additional Disposal for Stabilization Materials (7.5% of total soil quantity, excluding grout spoils)	11,176	TONS	$ 150.00	$ 1,676,400	0.15
28	Disposal of Lead Soils	1,202	TONS	$ 368.00	$ 442,336	0.15
29	Additional Disposal for Stabilization Materials (7.5% of total soil quantity)	91	TONS	$ 368.00	$ 33,488	0.15
	Sub - Total				**$ 24,175,522**	
Site Restoration and Equipment Decon						
30	PPE including Disposal	391	Day	$ 300.00	$ 117,300	0.15
31	Decontamination of Sheeting & Equipment	1	LS	$ 98,000.00	$ 98,000	0.15
32	Stormwater Controls	1	LS	$ 105,000.00	$ 105,000	0.15
33	Site Rail Upgrade	1,500	LF	$ 22.91	$ 34,365	0.15
	Sub - Total				**$ 354,665**	

Alternative 4: Excavation and Off-Site Disposal of All PCB-Impacted Fill (> or = to 10 ppm), Excavation and Off-Site Disposal of Lead Hot Spots and Construction of a Multi-Layered Cap System over the Entire Site						
No.	**Item**	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**	**Scope Contingency**
Multi-Layered Cap						
34	Subgrade Preparation	90,347	CY	$ 21.74	$ 1,964,144	0.15
35	40 Mil Textured HDPE Liner	1,219,680	SF	$ 0.49	$ 597,644	0.15
36	6" Drainage Layer	22,587	CY	$ 23.48	$ 530,343	0.15
37	18" Layer of Low Permeability Soil	67,760	CY	$ 30.48	$ 2,065,325	0.15
38	6" Layer of Topsoil	135,520	SY	$ 4.83	$ 654,562	0.15
39	Fine Grading, Seeding, Mulch & Fertilizer	135,520	SY	$ 2.99	$ 405,205	0.15
40	Monitoring Wells					
40	Shallow Monitoring Wells	30	EA	$ 2,000.00	$ 60,000	0.15
40	Deep Monitoring Wells	6	EA	$ 4,000.00	$ 24,000	0.15
40	Continuous Water Level System (for 1-yr)	15	EA	$ 2,000.00	$ 30,000	0.15
	Sub-Total				**$ 6,331,223**	
41	Sheet Pile Bulkhead Along Shoreline with Waterloo Barrier or Equivalent, 38' deep	2,600	LF	$ 2,500.00	$ 6,500,000	0.30
	Sub - Total				**$ 6,500,000**	
Facility Access Controls						
42	Perimeter Fencing Around Contained Area	3,200	LF	$ 18.23	$ 58,336	0.15
	Sub - Total				**$ 58,336**	
	Total Construction Cost				**$ 101,709,661**	
	Contingency (26% Scope + 15% Bid)				**$ 41,700,961**	
	Sub-Total: Construction/Contingency Cost				**$ 143,410,622**	
	Engineering & Design (3%)				**$ 4,302,319**	
	Supervision, Administration & CQA (7%)				**$ 10,038,744**	
	Sub-Total: Capital Cost				**$ 157,751,685**	
Post-Closure Costs						
43	Annual Mowing	28	AC	$ 681.28	$ 19,076	
44	Annual Fence Maintenance	320	LF	$ 18.23	$ 5,834	
45	Annual Groundwater Monitoring Program	1	LS	$ 63,000.00	$ 63,000	
46	Annual Final Cover Maintenance	1	LS	$ 221,593.00	$ 221,593	
47	Annual Site Inspection	1	EA	$ 1,900.00	$ 1,900	
	Sub-Total				**$ 311,403**	
Sub-Total: Present Worth - 30 Yr Post Closure Period					**$ 9,034,903**	
	GRAND TOTAL				**$ 166,786,588**	

NOTES:

1 Contingency determined by combining the weighted-by-cost-element scope contingency with a fixed 15% bid contingency. The scope contingency used for each cost element is shown above. Contingency determined in accordance with *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*, USEPA, July 2000.

2 Engineering and Design Costs represent 3% of the Construction/Contingency Cost.

3 Supervision, Administration & CQA Costs represent 7% of the Construction/Contingency Cost. This percentage is based on a recommendation from "Superfund Remedial Design and Remedial Action Guidance", USEPA, June 1986.

4 To calculate the Total Present Worth O&M, the equation $P = A_1[n(1+i)^{-1}]$ was used, the annual interest rate was assumed to be 6% and the annual inflation rate was calculated to be 2.6% (from "Engineering News Record" web site). The effective interest rate is thus 3.4%.

5 The Annual Final Cover Maintenance Cost represents 3.5% of the Part 360 Cap Construction Cost.

6 The Contact Barrier Maintenance Cost represents 3.5% of the Contact Barrier Construction Cost.

7 Annual fence maintenance quantity represents 10% of the total perimeter fence.

8 Disposal Volumes Derived by Using 1.35 Multiplier to Convert Cubic Yards to Tons.

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Alternative 5: **Excavation and Off-Site Disposal of Fill Containing the "Rubbery Matrix" and Lead Hot Spots, Complete Containment of the Water Tower and Northwest Corner Areas, Excavation and Off-Site Disposal of Impacted Fill (> or = to 10 ppm) Located Outside the Limits of the Containment.**						
No.	**Item**	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**	**Scope Contingency**
General Site Work						
1	Mobilization and Demobilization	1	LS	$ 252,000.00	$ 252,000	0.15
2	Erosion and Sediment Controls	6,510	LF	$ 13.82	$ 89,969	0.15
3	Asphalt Stripping / Disposal	70,645	SY	$ 22.58	$ 1,595,165	0.15
4	Building Demolition	500,211	SF	$ 4.23	$ 2,115,893	0.15
5	Saw Cut, Remove & Dispose of Concrete	1,111	SY	$ 22.58	$ 25,087	0.15
	Sub-Total				**$ 4,078,114**	
Excavation Shoring and Stabilization						
6	Sheeting - Installation and Removal					
6	To 30' Below Ground Surface	15,000	SF	$ 22.00	$ 330,000	0.30
6	To 86' Below Ground Surface	275,200	SF	$ 184.00	$ 50,636,800	0.30
7	Jet Grouting	1,111	CY	$ 400.00	$ 444,400	0.30
	Sub - Total				**$ 51,411,200**	
Excavation and Backfilling Work						
8	Excavation of PCB Fill Outside Cap Area	3,256	CY	$ 15.41	$ 50,175	0.55
9	Excavation Rubbery Matrix	27,778	CY	$ 15.43	$ 428,615	0.55
10	Excavation of TAGM Soils	175,838	CY	$ 15.41	$ 2,709,664	0.55
11	Excavation of Lead Hotspots	925	CY	$ 15.43	$ 14,273	0.55
12	Backfillilng of PCB Excavation w/ Clean Soil	31,034	CY	$ 24.41	$ 757,540	0.55
13	Backfilling TAGM Excavation	175,838	CY	$ 24.41	$ 4,292,206	0.55
14	Backfilling of Lead Hot Spots	925	CY	$ 24.41	$ 22,580	0.55
	Sub - Total				**$ 8,275,053**	
Dewatering / Soil Staging Facility						
15	Select Fill Layer	1,482	CY	$ 29.69	$ 44,001	0.15
16	40 Mil HDPE Liner	40,000	SF	$ 0.49	$ 19,600	0.15
17	Sand Layer	494	CY	$ 22.69	$ 11,209	0.15
18	8" Reinforced Concrete Layer					
18	Form Work	667	SFCA	$ 4.93	$ 3,289	0.15
18	8" Thick Concrete Slab	40,000	SF	$ 3.39	$ 135,600	0.15
18	Reinforcing Steel Mesh	40,000	SF	$ 5.34	$ 213,600	0.15
19	4' High, 12" Thick Concrete Curbs/Walls	1,600	LF	$ 21.92	$ 35,072	0.15
20	Pump System and Piping	718	DAY	$ 170.00	$ 122,060	0.35
	Sub - Total				**$ 584,431**	
Water Treatment						
21	Mobilization and Demobilization	1	LS	$ 44,100.00	$ 44,100	0.15
22	Water Treatment System	718	DAY	$ 4,800.00	$ 3,446,400	0.35
23	Testing of Treatment System Effluent	718	DAY	$ 120.00	$ 86,160	0.35
	Sub - Total				**$ 3,576,660**	
Transportation and Disposal of Excavated Fill						
24	Testing of Excavated Fill Samples	827	EA	$ 254.38	$ 210,497	0.15
25	Testing of Excavated Lead Soils	25	EA	$ 300.00	$ 7,500	0.15
26	Disposal of non-PCB Soils	237,381	TONS	$ 65.00	$ 15,429,785	0.15
27	Disposal of PCB Soils	41,896	TONS	$ 150.00	$ 6,284,385	0.15
28	Disposal (grout spoils, > or = to 10 PPM)	2,250	TONS	$ 150.00	$ 337,467	0.15
29	Additional Disposal for Stabilization Materials (7.5% of total soil quantity, excluding grout spoils)	20,946	TONS	$ 150.00	$ 3,141,900	0.15
30	Disposal of Lead Soils	1,202	TONS	$ 368.00	$ 442,336	0.15
31	Additional Disposal for Stabilization Materials (7.5% of total soil quantity)	91	TONS	$ 368.00	$ 33,488	0.15
	Sub - Total				**$ 25,887,358**	
Site Restoration and Equipment Decon						
32	PPE including Disposal	728	Day	$ 300.00	$ 218,400	0.15
33	Decontamination of Sheeting & Equipment	1	LS	$ 98,000.00	$ 98,000	0.15
34	Stormwater Controls	1	LS	$ 105,000.00	$ 105,000	0.15
35	Site Rail Upgrade	1,500	LF	$ 22.91	$ 34,365	0.15
	Sub - Total				**$ 455,765**	

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Alternative 5: Excavation and Off-Site Disposal of Fill Containing the "Rubbery Matrix" and Lead Hot Spots, Complete Containment of the Water Tower and Northwest Corner Areas, Excavation and Off-Site Disposal of Impacted Fill (> or = to 10 ppm) Located Outside the Limits of the Containment.						
No.	**Item**	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**	**Scope Contingency**
Multi-Layered Cap over North End						
36	Subgrade Preparation	17,000	CY	$ 21.74	$ 369,580	0.15
37	40 Mil Textured HDPE Liner	229,500	SF	$ 0.49	$ 112,455	0.15
38	6" Drainage Layer	4,250	CY	$ 23.48	$ 99,790	0.15
39	18" Layer of Low Permeability Soil	12,750	CY	$ 30.48	$ 388,620	0.15
40	6" Layer of Topsoil	25,500	SY	$ 4.83	$ 123,165	0.15
41	Fine Grading, Seeding, Mulch & Fertilizer	25,500	SY	$ 2.99	$ 76,245	0.15
42	Monitoring Wells					
42	Shallow Monitoring Wells	16	EA	$ 2,000.00	$ 32,000	0.15
42	Deep Monitoring Wells	2	EA	$ 4,000.00	$ 8,000	0.15
42	Continuous Water Level System (for 1-yr)	8	EA	$ 2,000.00	$ 16,000	0.15
	Sub-Total				**$ 1,225,855**	
Vertical Barriers						
43	Soil / Bentonite Slurry Trench - 3' wide, 30' deep	990	LF	$ 526.50	$ 521,235	0.30
44	Sheet Pile Bulkhead Along Shoreline with Waterloo Barrier or Equivalent, 38' deep	2,600	LF	$ 2,500.00	$ 6,500,000	0.30
	Sub - Total				**$ 7,021,235**	
Site Restoration and Facility Access Controls						
45	6" Topsoil Layer	45,145	SY	$ 4.83	$ 218,051	0.15
46	Fine Grading, Seeding, Mulch & Fertilizer	45,145	SY	$ 2.99	$ 134,984	0.15
47	Perimeter Fencing Around Contained Area	1,000	LF	$ 18.23	$ 18,230	0.15
	Sub - Total				**$ 371,265**	
	Total Construction Cost				**$ 102,886,936**	
	Contingency (28% Scope + 15% Bid)				**$ 44,241,382**	
	Sub-Total: Construction/Contingency Cost				**$ 147,128,318**	
	Engineering & Design (3%)				**$ 4,413,850**	
	Supervision, Administration & CQA (7%)				**$ 10,298,983**	
	Sub-Total: Capital Cost				**$ 161,841,151**	
Post-Closure Costs						
48	Annual Mowing	28	AC	$ 681.28	$ 19,076	
49	Annual Fence Maintenance	100	LF	$ 18.23	$ 1,823	
50	Annual Groundwater Monitoring Program	1	LS	$ 45,000.00	$ 45,000	
51	Annual Final Cover Maintenance	1	LS	$ 42,905.00	$ 42,905	
52	Annual Site Inspection	1	EA	$ 1,900.00	$ 1,900	
	Sub-Total				**$ 110,704**	
Sub-Total: Present Worth - 30 Yr Post Closure Period					**$ 3,211,915**	
	GRAND TOTAL				**$ 165,053,066**	

NOTES:

1 Contingency determined by combining the weighted-by-cost-element scope contingency with a fixed 15% bid contingency. The scope contingency used for each cost element is shown above. Contingency determined in accordance with *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* , USEPA, July 2000.

2 Engineering and Design Costs represent 3% of the Construction/Contingency Cost.

3 Supervision, Administration & CQA Costs represent 7% of the Construction/Contingency Cost. This percentage is based on a recommendation from "Superfund Remedial Design and Remedial Action Guidance", USEPA, June 1986.

4 To calculate the Total Present Worth O&M, the equation $P = A_1[n(1+i)^{-1}]$ was used, the annual interest rate was assumed to be 6% and the annual inflation rate was calculated to be 2.6% (from "Engineering News Record" web site). The effective interest rate is thus 3.4%.

5 The Annual Final Cover Maintenance Cost represents 3.5% of the Part 360 Cap Construction Cost.

6 The Contact Barrier Maintenance Cost represents 3.5% of the Contact Barrier Construction Cost.

7 Annual fence maintenance quantity represents 10% of the total perimeter fence.

8 Disposal Volumes Derived by Using 1.35 Multiplier to Convert Cubic Yards to Tons.

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Alternative 6: Excavation and Off-Site Disposal of Fill Containing the "Rubbery Matrix" and Lead Hot Spots, Complete Containment of the Water Tower and Northwest Corner Areas, Construction of a Multi-Layered Cap over the Entire Site.						
No.	**Item**	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**	**Scope Contingency**
General Site Work						
1	Mobilization and Demobilization	1	LS	$ 252,000.00	$ 252,000	0.15
2	Erosion and Sediment Controls	5,620	LF	$ 13.82	$ 77,669	0.15
3	Asphalt Stripping / Disposal	70,645	SY	$ 22.58	$ 1,595,165	0.15
4	Building Demolition	500,211	SF	$ 4.23	$ 2,115,893	0.15
5	Saw Cut, Remove & Dispose of Concrete	1,111	SY	$ 22.58	$ 25,087	0.15
	Sub-Total				**$ 4,065,814**	
Excavation Shoring and Stabilization						
6	Sheeting - Installation and Removal					
7	To 30' Below Ground Surface	15,000	SF	$ 22.00	$ 330,000	0.30
8	To 86' Below Ground Surface	275,200	SF	$ 184.00	$ 50,636,800	0.30
9	Jet Grouting	1,111	CY	$ 400.00	$ 444,400	0.30
	Sub - Total				**$ 51,411,200**	
Excavation and Backfilling Work						
10	Excavation of Rubbery Matrix	27,778	CY	$ 15.43	$ 428,615	0.55
11	Excavation of Lead Hotspots	925	CY	$ 15.43	$ 14,273	0.55
12	Backfilling PCB Excavation w/ Clean Soil	27,778	CY	$ 24.41	$ 678,061	0.55
13	Backfilling of Lead Hot Spots	925	CY	$ 24.41	$ 22,580	0.55
	Sub - Total				**$ 1,143,529**	
Dewatering / Soil Staging Facility						
14	Select Fill Layer	1,482	CY	$ 29.69	$ 44,001	0.15
15	40 Mil HDPE Liner	40,000	SF	$ 0.49	$ 19,600	0.15
16	Sand Layer	494	CY	$ 22.69	$ 11,209	0.15
17	8" Reinforced Concrete Layer					
17	Form Work	667	SFCA	$ 4.93	$ 3,289	0.15
17	8" Thick Concrete Slab	40,000	SF	$ 3.39	$ 135,600	0.15
17	Reinforcing Steel Mesh	40,000	SF	$ 5.34	$ 213,600	0.15
18	4' High, 12" Thick Concrete Curbs/Walls	1,600	LF	$ 21.92	$ 35,072	0.15
19	Pump System and Piping	202	DAY	$ 170.00	$ 34,340	0.35
	Sub - Total				**$ 496,711**	
Water Treatment						
20	Mobilization and Demobilization	1	LS	$ 44,100.00	$ 44,100	0.15
21	Water Treatment System	202	DAY	$ 4,800.00	$ 969,600	0.35
22	Testing of Treatment System Effluent	202	DAY	$ 120.00	$ 24,240	0.35
	Sub - Total				**$ 1,037,940**	
Transportation and Disposal of Excavated Fill						
23	Testing of Excavated Fill Samples	111	EA	$ 254.38	$ 28,265	0.15
24	Testing of Excavated Lead Soils	25	EA	$ 300.00	$ 7,500	0.15
25	Disposal of Rubbery Matrix	37,500	TONS	$ 150.00	$ 5,625,045	0.15
26	Disposal (grout spoils, > or = to 10 PPM)	2,250	TONS	$ 150.00	$ 337,467	0.15
27	Additional Disposal for Stabilization Materials (7.5% of total soil quantity, excluding grout spoils)	2,813	TONS	$ 150.00	$ 421,950	0.15
28	Disposal of Lead Soils	1,202	TONS	$ 368.00	$ 442,336	0.15
29	Additional Disposal for Stabilization Materials (7.5% of total soil quantity)	91	TONS	$ 368.00	$ 33,488	0.15
	Sub - Total				**$ 6,896,051**	
Site Restoration and Equipment Decon						
30	PPE including Disposal	212	Day	$ 300.00	$ 63,600	0.15
31	Decontamination of Sheeting & Equipment	1	LS	$ 98,000.00	$ 98,000	0.15
32	Stormwater Controls	1	LS	$ 105,000.00	$ 105,000	0.15
33	Site Rail Upgrade	1,500	LF	$ 22.91	$ 34,365	0.15
	Sub - Total				**$ 300,965**	

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Alternative 6:

Excavation and Off-Site Disposal of Fill Containing the "Rubbery Matrix" and Lead Hot Spots, Complete Containment of the Water Tower and Northwest Corner Areas, Construction of a Multi-Layered Cap over the Entire Site.

No.	Item	Quantity	Unit	Unit Cost	Total Cost	Scope Contingency
Multi-Layered Cap						
34	Subgrade Preparation	90,347	CY	$ 21.74	$ 1,964,144	0.15
35	40 Mil Textured HDPE Liner	1,219,680	SF	$ 0.49	$ 597,644	0.15
36	6" Drainage Layer	22,587	CY	$ 23.48	$ 530,343	0.15
37	18" Layer of Low Permeability Soil	67,760	CY	$ 30.48	$ 2,065,325	0.15
38	6" Layer of Topsoil	135,520	SY	$ 4.83	$ 654,562	0.15
39	Fine Grading, Seeding, Mulch & Fertilizer	135,520	SY	$ 2.99	$ 405,205	0.15
40	Monitoring Wells					
41	Shallow Monitoring Wells	30	EA	$ 2,000.00	$ 60,000	0.15
42	Deep Monitoring Wells	6	EA	$ 4,000.00	$ 24,000	0.15
43	Continuous Water Level System (for 1-yr)	15	EA	$ 2,000.00	$ 30,000	0.15
	Sub-Total				**$ 6,331,223**	
Vertical Barriers						
44	Soil / Bentonite Slurry Trench - 3' wide, 30' deep	990	LF	$ 526.50	$ 521,235	0.30
45	Sheet Pile Bulkhead Along Shoreline with Waterloo Barrier or Equivalent, 38' deep	2,600	LF	$ 2,500.00	$ 6,500,000	0.30
	Sub - Total				**$ 7,021,235**	
Facility Access Controls						
46	Perimeter Fencing Around Contained Area	1,800	LF	$ 18.23	$ 32,814	0.15
	Sub - Total				**$ 32,814**	
	Total Construction Cost				**$ 78,737,482**	
	Contingency (27% Scope + 15% Bid)				**$ 33,069,742**	
	Sub-Total: Construction/Contingency Cost				**$ 111,807,224**	
	Engineering & Design (3%)				**$ 3,354,217**	
	Supervision, Administration & CQA (7%)				**$ 7,826,506**	
	Sub-Total: Capital Cost				**$ 122,987,947**	
Post-Closure Costs						
47	Annual Mowing	28	AC	$ 681.28	$ 19,076	
48	Annual Fence Maintenance	180	LF	$ 18.23	$ 3,282	
49	Annual Groundwater Monitoring Program	1	LS	$ 63,000.00	$ 63,000	
50	Annual Final Cover Maintenance	1	LS	$ 221,593.00	$ 221,593	
51	Annual Site Inspection	1	EA	$ 1,900.00	$ 1,900	
	Sub-Total				**$ 308,851**	
	Sub-Total: Present Worth - 30 Yr Post Closure Period				**$ 8,960,861**	
	GRAND TOTAL				**$ 131,948,808**	

NOTES:

1 Contingency determined by combining the weighted-by-cost-element scope contingency with a fixed 15% bid contingency. The scope contingency used for each cost element is shown above. Contingency determined in accordance with *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*, USEPA, July 2000.

2 Engineering and Design Costs represent 3% of the Construction/Contingency Cost.

3 Supervision, Administration & CQA Costs represent 7% of the Construction/Contingency Cost. This percentage is based on a recommendation from "Superfund Remedial Design and Remedial Action Guidance", USEPA, June 1986.

4 To calculate the Total Present Worth O&M, the equation $P = A_1[n(1+i)^{-1}]$ was used, the annual interest rate was assumed to be 6% and the annual inflation rate was calculated to be 2.6% (from "Engineering News Record" web site). The effective interest rate is thus 3.4%.

5 The Annual Final Cover Maintenance Cost represents 3.5% of the Part 360 Cap Construction Cost.

6 The Contact Barrier Maintenance Cost represents 3.5% of the Contact Barrier Construction Cost.

7 Annual fence maintenance quantity represents 10% of the total perimeter fence.

8 Disposal Volumes Derived by Using 1.35 Multiplier to Convert Cubic Yards to Tons.

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Alternative 7: Excavation and Off-Site Disposal of Shallow PCB-Impacted Fill (> or = to 10 ppm) and Lead Hot Spots. Complete Containment of the Water Tower and Northwest Corner Areas. Construction of a Contact Barrier and Soil Cover System.						
No.	**Item**	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**	**Scope Contingency**
General Site Work						
1	Mobilization and Demobilization	1	LS	$ 100,000.00	$ 100,000	0.15
2	Erosion and Sediment Controls	5,620	LF	$ 13.82	$ 77,669	0.15
3	Asphalt Stripping / Disposal	41,962	SY	$ 22.58	$ 947,502	0.15
4	Building Demolition	500,211	SF	$ 4.23	$ 2,115,893	0.15
5	Saw Cut, Remove & Dispose of Concrete	1,111	SY	$ 22.58	$ 25,087	0.15
Sub-Total					**$ 3,266,151**	
Excavation and Backfilling Work						
6	Excavation of Fill >1ppm to < 10ppm in Top 1'	6,842	CY	$ 16.39	$ 112,141	0.55
7	Excavation of PCB Fill to Water Table	33,956	CY	$ 15.43	$ 523,942	0.55
8	Excavation of Lead Hot Spots	925	CY	$ 15.43	$ 14,273	0.55
9	Backfilling PCB Excavations	40,798	CY	$ 24.41	$ 995,880	0.55
10	Backfilling of Lead Hot Spots	925	CY	$ 24.41	$ 22,580	0.55
Sub - Total					**$ 1,668,816**	
Transportation and Disposal of Excavated Fill						
11	Testing of Excavated Fill Samples	112	EA	$ 254.38	$ 28,491	0.15
12	Testing of Excavated Lead Samples	25	EA	$ 300.00	$ 7,500	0.15
13	Disposal (>1 PPM to <10 PPM)	9,237	TONS	$ 150.00	$ 1,385,505	0.15
14	Disposal (> or = to 10 PPM)	45,841	TONS	$ 150.00	$ 6,876,090	0.15
15	Additional Disposal for Stabilization Materials (7.5% of total soil quantity)	4,131	TONS	$ 150.00	$ 619,650	0.15
16	Disposal of Lead Soils	1,202	TONS	$ 368.00	$ 442,336	0.15
17	Additional Disposal for Stabilization Materials (7.5% of total soil quantity)	91	TONS	$ 368.00	$ 33,488	0.15
Sub - Total					**$ 9,393,060**	
Site Restoration and Equipment Decon						
18	PPE including Disposal	130	Day	$ 300.00	$ 39,000	0.15
19	Decontamination of Sheeting & Equipment	1	LS	$ 98,000.00	$ 98,000	0.15
20	Stormwater Controls	1	LS	$ 105,000.00	$ 105,000	0.15
21	Site Rail Upgrade	1,500	LF	$ 22.91	$ 34,365	0.15
Sub - Total					**$ 276,365**	
Monitoring Wells						
22	Shallow Monitoring Wells	16	EA	$ 3,000.00	$ 48,000	0.15
23	Deep Monitoring Wells	2	EA	$ 5,000.00	$ 10,000	0.15
24	Continuous Water Level System (for 1-yr)	8	EA	$ 2,000.00	$ 16,000	0.15
Sub-Total					**$ 74,000**	
Contact Barrier and Cover System						
25	Subgrade Preparation	35,337	CY	$ 21.74	$ 768,227	0.15
26	6" Asphalt Layer	135,520	SY	$ 12.43	$ 1,684,514	0.15
27	12" Soil Layer	45,174	CY	$ 20.48	$ 925,164	0.15
28	6" Topsoil Layer	135,520	SY	$ 4.83	$ 654,562	0.15
29	Fine Grading, Seeding, Mulch & Fertilizer	135,520	SY	$ 2.99	$ 405,205	0.15
Sub-Total					**$ 4,437,672**	
Vertical Barriers						
30	Soil / Bentonite Slurry Trench - 3' wide, 30' deep	990	LF	$ 526.50	$ 521,235	0.30
31	Sheet Pile Bulkhead Along Shoreline with Waterloo Barrier or Equivalent, 38' deep	2,600	LF	$ 2,500.00	$ 6,500,000	0.30
Sub - Total					**$ 7,021,235**	
Facility Access Controls						
32	Perimeter Fencing Around Contained Area	1,000	LF	$ 18.23	$ 18,230	0.15
Sub - Total					**$ 18,230**	

Alternative 7:
Excavation and Off-Site Disposal of Shallow PCB-Impacted Fill (> or = to 10 ppm) and Lead Hot Spots. Complete Containment of the Water Tower and Northwest Corner Areas. Construction of a Contact Barrier and Soil Cover System.

Total Construction Cost					**$**	**26,155,529**
Contingency (22% Scope + 15% Bid)					**$**	**9,677,546**
Sub-Total: Construction/Contingency Cost					**$**	**35,833,075**
Engineering & Design (3%)					**$**	**1,074,993**
Supervision, Administration & CQA (7%)					**$**	**2,508,316**
Sub-Total: Capital Cost					**$**	**39,416,384**
Post-Closure Costs						
33	Annual Mowing	28	AC	$ 681.28	$	19,076
34	Annual Groundwater Monitoring Program	1	LS	$ 45,000.00	$	45,000
35	Annual Contact Barrier Maintenance	1	LS	$ 155,319.00	$	155,319
36	Annual Site Inspection	1	EA	$ 1,900.00	$	1,900
Sub-Total					**$**	**221,295**
Sub-Total: Present Worth - 30 Yr Post Closure Period					**$**	**6,420,551**
GRAND TOTAL					**$**	**45,836,935**

NOTES:

1 Contingency determined by combining the weighted-by-cost-element scope contingency with a fixed 15% bid contingency. The scope contingency used for each cost element is shown above. Contingency determined in accordance with *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* , USEPA, July 2000.

2 Engineering and Design Costs represent 3% of the Construction/Contingency Cost.

3 Supervision, Administration & CQA Costs represent 7% of the Construction/Contingency Cost. This percentage is based on a recommendation from "Superfund Remedial Design and Remedial Action Guidance", USEPA, June 1986.

4 To calculate the Total Present Worth O&M, the equation $P = A_1[n(1+i)^{-1}]$ was used, the annual interest rate was assumed to be 6% and the annual inflation rate was calculated to be 2.6% (from "Engineering News Record" web site). The effective interest rate is thus 3.4%.

5 Disposal Volumes Derived by Using 1.35 Multiplier to Convert Cubic Yards to Tons.

Alternative 8: Containment of the Water Tower and Northwest Corner Areas, Excavation and Off-Site Disposal of PCB-Impacted Fill (> or = to 10 ppm) and Lead Hot Spots Located Outside the Limits of the Containment. Construction of a Contact Barrier and Soil Cover System.						
No.	**Item**	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**	**Scope Contingency**
General Site Work						
1	Mobilization and Demobilization	1	LS	$ 50,000.00	$ 50,000	0.15
2	Erosion and Sediment Controls	5,620	LF	$ 13.82	$ 77,669	0.15
3	Asphalt Stripping / Disposal	41,962	SY	$ 22.58	$ 947,502	0.15
4	Building Demolition	500,211	SF	$ 4.23	$ 2,115,893	0.15
5	Saw Cut, Remove & Dispose of Concrete	1,111	SY	$ 22.58	$ 25,087	0.15
	Sub - Total				**$ 3,216,151**	
Excavation and Backfilling Work						
6	Excavation of Fill >1ppm to < 10ppm in Top 1'	6,842	CY	$ 16.39	$ 112,141	0.55
7	Excavation of PCB Fill Above Water Table >10ppm	2,444	CY	$ 15.43	$ 37,711	0.55
8	Excavation of Lead Hot Spots	925	CY	$ 15.43	$ 14,273	0.55
9	Backfilling of PCB Excavations	9,286	CY	$ 24.41	$ 226,672	0.55
10	Backfilling of Lead Hot Spots	925	CY	$ 24.41	$ 22,580	0.55
	Sub - Total				**$ 413,377**	
Transportation and Disposal of Excavated Fill						
11	Testing of Excavated Fill Samples	37	EA	$ 254.38	$ 9,449	0.15
12	Testing of Excavated Lead Samples	25	EA	$ 300.00	$ 7,500	0.15
13	Disposal (>1 PPM to <10 PPM)	9,237	TONS	$ 65.00	$ 600,386	0.15
14	Disposal (> or = to 10 PPM)	3,299	TONS	$ 150.00	$ 494,910	0.15
15	Additional Disposal for Stabilization Materials (7.5% of total soil quantity)	941	TONS	$ 150.00	$ 141,150	0.15
16	Disposal of Lead Soils	1,202	TONS	$ 368.00	$ 442,336	0.15
17	Additional Disposal for Stabilization Materials (7.5% of total soil quantity)	91	TONS	$ 368.00	$ 33,488	0.15
	Sub - Total				**$ 1,729,219**	
Site Restoration and Equipment Decon						
18	PPE including Disposal	37	Day	$ 300.00	$ 11,100	0.15
19	Decontamination of Sheeting & Equipment	1	LS	$ 98,000.00	$ 98,000	0.15
20	Stormwater Controls	1	LS	$ 105,000.00	$ 105,000	0.15
21	Site Rail Upgrade	1,500	LF	$ 22.91	$ 34,365	0.15
	Sub - Total				**$ 248,465**	
Monitoring Wells						
22	Shallow Monitoring Wells	16	EA	$ 3,000.00	$ 48,000	0.15
23	Deep Monitoring Wells	2	EA	$ 5,000.00	$ 10,000	0.15
24	Continuous Water Level System (for 1-yr)	8	EA	$ 2,000.00	$ 16,000	0.15
	Sub-Total				**$ 74,000**	
Contact Barrier and Cover System						
25	Subgrade Preparation	35,337	CY	$ 21.74	$ 768,227	0.15
26	6" Asphalt Layer	135,520	SY	$ 12.43	$ 1,684,514	0.15
27	12" Soil Layer	45,174	CY	$ 20.48	$ 925,164	0.15
28	6" Topsoil Layer	135,520	SY	$ 4.83	$ 654,562	0.15
29	Fine Grading, Seeding, Mulch & Fertilizer	135,520	SY	$ 2.99	$ 405,205	0.15
	Sub-Total				**$ 4,437,672**	
Vertical Barriers						
30	Soil / Bentonite Slurry Trench - 3' wide, 30' deep	990	LF	$ 526.50	$ 521,235	0.30
31	Sheet Pile Bulkhead Along Shoreline with Waterloo Barrier or Equivalent, 38' deep	2,600	LF	$ 2,500.00	$ 6,500,000	0.30
	Sub - Total				**$ 7,021,235**	
Facility Access Controls						
32	Perimeter Fencing Around Capped Area	1,000	LF	$ 18.23	$ 18,230	0.15
	Sub - Total				**$ 18,230**	
	Total Construction Cost				**$ 17,158,349**	
	Contingency (22% Scope + 15% Bid)				**6,348,589.13**	
	Sub-Total: Construction/Contingency Cost				**$ 23,506,938**	
	Engineering & Design (3%)				**$ 705,209**	
	Supervision, Administration & CQA (7%)				**$ 1,645,486**	
	Sub-Total: Capital Cost				**$ 25,857,633**	

No.	Item	Quantity	Unit	Unit Cost	Total Cost	Scope Contingency
Alternative 8: Containment of the Water Tower and Northwest Corner Areas, Excavation and Off-Site Disposal of PCB-Impacted Fill (> or = to 10 ppm) and Lead Hot Spots Located Outside the Limits of the Containment. Construction of a Contact Barrier and Soil Cover System.						
Post-Closure Costs						
33	Annual Mowing	28	AC	$ 681.28	$ 19,076	
34	Annual Groundwater Monitoring Program	1	LS	$ 70,000.00	$ 70,000	
35	Annual Contact Barrier Maintenance	1	LS	$ 155,319.00	$ 155,319	
36	Annual Site Inspection	1	EA	$ 1,900.00	$ 1,900	
	Sub-Total				**$ 246,295**	
Sub-Total: Present Worth - 30 Yr Post Closure Period					**$ 7,145,890**	
	GRAND TOTAL				**$ 33,003,523**	

NOTES:

1 Contingency determined by combining the weighted-by-cost-element scope contingency with a fixed 15% bid contingency. The scope contingency used for each cost element is shown above. Contingency determined in accordance with *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* , USEPA, July 2000.

2 Engineering and Design Costs represent 3% of the Construction/Contingency Cost.

3 Supervision, Administration & CQA Costs represent 7% of the Construction/Contingency Cost. This percentage is based on a recommendation from "Superfund Remedial Design and Remedial Action Guidance", USEPA, June 1986.

4 To calculate the Total Present Worth O&M, the equation $P = A_1[n(1+i)^{-1}]$ was used, the annual interest rate was assumed to be 6% and the annual inflation rate was calculated to be 2.6% (from "Engineering News Record" web site). The effective interest rate is thus 3.4%.

5 Disposal Volumes Derived by Using 1.35 Multiplier to Convert Cubic Yards to Tons.

Feasibility Study For The Atlantic Richfield Company - Harbor At Hastings Site
Remedial Cost Estimates

Alternative 9: In-situ Stabilization/Solidification of the "Liquid Rubbery Matrix", Containment of the Water Tower and Northwest Corner Areas, Excavation and Off-Site Disposal of PCB-Impacted Fill (>or= 10 ppm) and Lead Hot Spots Located Above the Water Table and Outside the Limits of the Containment, and Construction of a Contact Barrier and Soil Cover System.						
No.	**Item**	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**	**Scope Contingency**
General Site Work						
1	Mobilization and Demobilization	1	LS	$ 100,000.00	$ 100,000	0.15
2	Erosion and Sediment Controls	5,620	LF	$ 13.82	$ 77,669	0.15
3	Asphalt Stripping / Disposal	41,962	SY	$ 22.58	$ 947,502	0.15
4	Building Demolition	500,211	SF	$ 4.23	$ 2,115,893	0.15
5	Saw Cut, Remove & Dispose of Concrete	1,111	SY	$ 22.58	$ 25,087	0.15
	Sub - Total				**$ 3,266,151**	
Excavation and Backfilling Work						
6	Excavation of Fill >1ppm to < 10ppm in Top 1'	6,842	CY	$ 16.39	$ 112,141	0.55
7	Excavation of PCB Fill Above Water Table >10ppm	2,444	CY	$ 20.03	$ 48,961	0.55
8	Excavation of Lead Hotspots	925	CY	$ 15.43	$ 14,273	0.55
9	Backfilling of PCB Excavations	9,286	CY	$ 31.73	$ 294,673	0.55
10	Backfilling of Lead Hot Spots	925	CY	$ 24.41	$ 22,580	0.55
	Sub - Total				**$ 492,628**	
Dewatering / Soil Staging Facility						
11	Select Fill Layer	371	CY	$ 29.69	$ 11,001	0.15
12	40 Mil HDPE Liner	10,000	SF	$ 0.49	$ 4,900	0.15
13	4" Sand Layer	124	CY	$ 22.69	$ 2,803	0.15
14	8" Reinforced Concrete Layer					
14	Form Work	167	SFCA	$ 4.93	$ 823	0.15
14	8" Thick Concrete Slab	10,000	SF	$ 3.39	$ 33,900	0.15
14	Reinforcing Steel Mesh	10,000	SF	$ 5.34	$ 53,400	0.15
15	4' High, 12" Thick Concrete Curbs/Walls	400	LF	$ 21.92	$ 8,768	0.15
16	Pump System and Piping	27	DAY	$ 170.00	$ 4,590	0.35
	Sub - Total				**$ 120,185**	
Water Treatment						
17	Mobilization and Demobilization	1	LS	$ 10,000.00	$ 10,000	0.15
18	Water Treatment System	27	DAY	$ 3,500.00	$ 94,500	0.35
19	Testing of Treatment System Effluent	27	DAY	$ 120.00	$ 3,240	0.35
	Sub - Total				**$ 107,740**	
Transportation and Disposal of Excavated Fill						
20	Testing of Excavated Fill Samples	37	EA	$ 254.38	$ 9,449	0.15
21	Testing of Excavated Lead Soils	25	EA	$ 300.00	$ 7,500	0.15
22	Disposal (>1 PPM to <10 PPM)	9,237	TONS	$ 65.00	$ 600,386	0.15
23	Disposal (10 PPM to <1000 PPM)	3,299	TONS	$ 150.00	$ 494,910	0.15
24	Additional Disposal for Stabilization Materials (7.5% of total soil quantity)	941	TONS	$ 150.00	$ 141,150	0.15
25	Disposal of Lead Soils	1,202	TONS	$ 368.00	$ 442,336	0.15
26	Additional Disposal for Stabilization Materials (7.5% of total soil quantity)	91	TONS	$ 368.00	$ 33,488	0.15
	Sub - Total				**$ 1,729,219**	
In-Situ Stabilization/Solidification						
27	Soil Mixing System	41,667	CY	$ 42.00	$ 1,750,014	0.15
28	Portland Cement	16,875	TN	$ 75.00	$ 1,265,625	0.15
	Sub - Total				**$ 3,015,639**	
Site Restoration and Equipment Decon						
29	PPE including Disposal	250	Day	$ 300.00	$ 75,000	0.15
30	Decontamination of Sheeting & Equipment	1	LS	$ 98,000.00	$ 98,000	0.15
31	Stormwater Controls	1	LS	$ 105,000.00	$ 105,000	0.15
32	Site Rail Upgrade	1,500	LF	$ 22.91	$ 34,365	0.15
	Sub - Total				**$ 312,365**	
Monitoring Wells						
33	Shallow Monitoring Wells	16	EA	$ 2,000.00	$ 32,000	0.15
34	Deep Monitoring Wells	2	EA	$ 4,000.00	$ 8,000	0.15
35	Continuous Water Level System (for 1-yr)	8	EA	$ 2,000.00	$ 16,000	0.15
	Sub-Total				**$ 56,000**	

Feasibility Study For The Atlantic Richfield Company - Harbor At Hastings Site
Remedial Cost Estimates

Alternative 9: In-situ Stabilization/Solidification of the "Liquid Rubbery Matrix", Containment of the Water Tower and Northwest Corner Areas, Excavation and Off-Site Disposal of PCB-Impacted Fill (>or= 10 ppm) and Lead Hot Spots Located Above the Water Table and Outside the Limits of the Containment, and Construction of a Contact Barrier and Soil Cover System.						
No.	**Item**	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**	**Scope Contingency**
Contact Barrier and Cover System						
36	Subgrade Preparation	35,337	CY	$ 21.74	$ 768,227	0.15
37	6" Asphalt Layer	135,520	SY	$ 12.43	$ 1,684,514	0.15
38	12" Soil Layer	45,174	CY	$ 20.48	$ 925,164	0.15
39	6" Topsoil Layer	135,520	SY	$ 4.83	$ 654,562	0.15
40	Fine Grading, Seeding, Mulch & Fertilizer	135,520	SY	$ 2.99	$ 405,205	0.15
	Sub-Total				**$ 4,437,672**	
Vertical Barriers						
41	Soil / Bentonite Slurry Trench - 3' wide, 30' deep	990	LF	$ 526.50	$ 521,235	0.30
42	Sheet Pile Bulkhead Along Shoreline with Waterloo Barrier or Equivalent, 38' deep	2,600	LF	$ 2,500.00	$ 6,500,000	0.30
	Sub - Total				**$ 7,021,235**	
Facility Access Controls						
43	Perimeter Fencing Around Capped Area	1,000	LF	$ 18.23	$ 18,230	0.15
	Sub - Total				**$ 18,230**	
	Total Construction Cost				**$ 20,577,064**	
	Contingency (21% Scope + 15% Bid)				**$ 7,407,743**	
	Sub-Total: Construction/Contingency Cost				**$ 27,984,807**	
	Engineering & Design (3%)				**$ 839,545**	
	Supervision, Administration & CQA (7%)				**$ 1,958,937**	
	Sub-Total: Capital Cost				**$ 30,783,289**	
Post-Closure Costs						
44	Annual Mowing	28	AC	$ 681.28	$ 19,076	
45	Annual Groundwater Monitoring Program	1	LS	$ 45,000.00	$ 45,000	
46	Annual Contact Barrier Maintenance	1	LS	$ 155,319.00	$ 155,319	
47	Annual Site Inspection	1	EA	$ 1,900.00	$ 1,900	
	Sub-Total				**$ 221,295**	
Sub-Total: Present Worth - 30 Yr Post Closure Period					**$ 6,420,551**	
	GRAND TOTAL				**$ 37,203,840**	

NOTES:

1. Contingency determined by combining the weighted-by-cost-element scope contingency with a fixed 15% bid contingency. The scope contingency used for each cost element is shown above. Contingency determined in accordance with *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* , USEPA, July 2000.
2. Engineering and Design Costs represent 3% of the Construction/Contingency Cost.
3. Supervision, Administration & CQA Costs represent 7% of the Construction/Contingency Cost. This percentage is based on a recommendation from "Superfund Remedial Design and Remedial Action Guidance", USEPA, June 1986.
4. To calculate the Total Present Worth O&M, the equation $P = A_1[n(1+i)^{-1}]$ was used, the annual interest rate was assumed to be 6% and the annual inflation rate was calculated to be 2.6% (from "Engineering News Record" web site). The effective interest rate is thus 3.4%.
5. The Annual Final Cover Maintenance Cost represents 3.5% of the Part 360 Cap Construction Cost.
6. The Contact Barrier Maintenance Cost represents 3.5% of the Contact Barrier Construction Cost.
7. Annual fence maintenance quantity represents 10% of the total perimeter fence.
8. Soil Mixing System costs assumes water provided on-site by owner for batch plant slurrying of reagent.
9. Disposal Volumes Derived by Using 1.35 Multiplier to Convert Cubic Yards to Tons.

Feasibility Study For The Atlantic Richfield Company - Hastings At Hudson Site Remedial Cost Estimates

Alternative 10: Construction of a Contact Barrier and Soil Cover System over the Entire Site, Excavation and Off-Site Disposal of Lead Hot Spots.						
No.	Item	Quantity	Unit	Unit Cost	Total Cost	Scope Contingency
General Site Work						
1	Mobilization and Demobilization	1	LS	$ 50,000.00	$ 50,000	0.15
2	Erosion and Sediment Controls	5,620	LF	$ 13.82	$ 77,669	0.15
3	Building Demolition	500,211	SF	$ 4.23	$ 2,115,893	0.15
4	Site Rail Upgrade	1,500	LF	$ 22.91	$ 34,365	0.15
	Sub - Total				**$ 2,277,927**	
Excavation and Backfilling Work						
5	Excavation of Lead Hotspots	925	CY	$ 15.43	$ 14,273	0.55
6	Backfilling of Lead Hot Spots	925	CY	$ 24.41	$ 22,580	0.55
	Sub - Total				**$ 36,853**	
Transportation and Disposal of Excavated Fill						
7	Testing of Excavated Lead Soils	25	EA	$ 300.00	$ 7,500	0.15
8	Disposal of Lead Soils	1,202	TONS	$ 368.00	$ 442,336	0.15
9	Additional Disposal for Stabilization Materials (7.5% of total soil quantity)	91	TONS	$ 368.00	$ 33,488	0.15
	Sub - Total				**$ 483,324**	
Monitoring Wells						
10	Shallow Monitoring Wells	28	EA	$ 2,000.00	$ 56,000	0.15
11	Deep Monitoring Wells	2	EA	$ 4,000.00	$ 8,000	0.15
12	Continuous Water Level System (for 1-yr)	14	EA	$ 2,000.00	$ 28,000	0.15
	Sub-Total				**$ 92,000**	
Contact Barrier and Cover System						
13	Subgrade Preparation	35,337	CY	$ 21.74	$ 768,227	0.15
14	6" Asphalt Layer	135,500	SY	$ 12.43	$ 1,684,265	0.15
15	12" Soil Layer	45,175	CY	$ 20.48	$ 925,184	0.15
16	6" Topsoil Layer	135,525	SY	$ 4.83	$ 654,586	0.15
17	Fine Grading, Seeding, Mulch & Fertilizer	135,525	SY	$ 2.99	$ 405,220	0.15
	Sub-Total				**$ 4,437,482**	
	Total Construction Cost				**$ 7,327,586**	
	Contingency (15% Scope + 15% Bid)				**$2,198,276**	
	Sub-Total: Construction/Contingency Cost				**$ 9,525,862**	
	Engineering & Design (3%)				**$ 285,776**	
	Supervision, Administration & CQA (7%)				**$ 666,811**	
	Sub-Total: Capital Cost				**$ 10,478,449**	
Post-Closure Costs						
18	Annual Mowing	28	AC	$ 681.28	$ 19,076	
20	Annual Contact Barrier Maintenance	1	LS	$ 155,312.00	$ 155,312	
21	Annual Site Inspection	1	EA	$ 1,900.00	$ 1,900	
	Sub-Total				**$ 246,288**	
	Sub-Total: Present Worth - 30 Yr Post Closure Period				**$ 7,145,687**	
	GRAND TOTAL				**$ 17,624,135**	

NOTES:

1 Contingency determined by combining the weighted-by-cost-element scope contingency with a fixed 15% bid contingency. The scope contingency used for each cost element is shown above. Contingency determined in accordance with *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*, USEPA, July 2000.

2 Engineering and Design Costs represent 3% of the Construction/Contingency Cost.

3 Supervision, Administration & CQA Costs represent 7% of the Construction/Contingency Cost. This percentage is based on a recommendation from "Superfund Remedial Design and Remedial Action Guidance", USEPA, June 1986.

4 To calculate the Total Present Worth O&M, the equation $P = A_1[n(1+i)^{-1}]$ was used, the annual interest rate was assumed to be 6% and the annual inflation rate was calculated to be 2.6% (from "Engineering News Record" web site). The effective interest rate is thus 3.4%.

5 The Annual Final Cover Maintenance Cost represents 3.5% of the Part 360 Cap Construction Cost.

6 The Contact Barrier Maintenance Cost represents 3.5% of the Contact Barrier Construction Cost.

7 Annual fence maintenance quantity represents 10% of the total perimeter fence.

8 Disposal Volumes Derived by Using 1.35 Multiplier to Convert Cubic Yards to Tons.

Feasibility Study For The Atlantic Richfield Company - Harbor At Hastings Site
Remedial Cost Estimates

Alternative 11: Complete Containment of the Water Tower and Northwest Corner Areas, Excavation at Multiple Depths (3-feet bgs, 9-feet bgs, and 12-feet bgs (with grout stablization)) and Off-Site Disposal of PCB-Impacted Fill Located within the Containment, Excavation and Off-Site Disposal of PCB-Impacted Fill > 10 ppm and Lead Hot Spots Located Outside of the Containment, Construction of a Contact Barrier and Soil Cover System.						
No.	**Item**	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**	**Scope Contingency**
General Site Work						
1	Mobilization and Demobilization	1	LS	$ 110,000.00	$ 110,000	0.15
2	Erosion and Sediment Controls	5,620	LF	$ 13.82	$ 77,669	0.15
3	Asphalt Stripping / Disposal	41,962	SY	$ 22.58	$ 947,502	0.15
4	Building Demolition	500,211	SF	$ 4.23	$ 2,115,893	0.15
	Sub-Total				**$ 3,251,064**	
Excavation Shoring and Stabilization						
5	Sheeting - Installation and Removal					
5.1	To 30' Below Ground Surface	147,000	SF	$ 22.00	$ 3,234,000	0.30
6.1	Jet Grouting	1,111	CY	$ 400.00	$ 444,400	0.30
	Sub - Total				**$ 3,678,400**	
Excavation and Backfilling Work						
7.1	Excavation of Fill >1ppm to <10ppm in Top 1'	6,842	CY	$ 16.39	$ 112,141	0.55
8.1	Excavation of PCB Fill to maximum depth of 12' bgs	40,478	CY	$ 15.43	$ 624,576	0.55
9.1	Excavation of Lead Hot Spots	925	CY	$ 15.43	$ 14,273	0.55
10	Backfilling of Lead Hot Spots	925	CY	$ 24.41	$ 22,580	0.55
11	Backfilling PCB Excavation w/ Clean Soil	47,320	CY	$ 24.41	$ 1,155,082	0.55
	Sub - Total				**$ 1,928,652**	
Dewatering / Soil Staging Facility						
12	Select Fill Layer	1,482	CY	$ 29.69	$ 44,001	0.15
13	40 Mil HDPE Liner	40,000	SF	$ 0.49	$ 19,600	0.15
14	Sand Layer	494	CY	$ 22.69	$ 11,209	0.15
15	8" Reinforced Concrete Layer					
15	Form Work	667	SFCA	$ 4.93	$ 3,289	0.15
15	8" Thick Concrete Slab	40,000	SF	$ 3.39	$ 135,600	0.15
15	Reinforcing Steel Mesh	40,000	SF	$ 5.34	$ 213,600	0.15
16	4' High, 12" Thick Concrete Curbs/Walls	1,600	LF	$ 21.92	$ 35,072	0.15
17	Pump System and Piping	129	DAY	$ 170.00	$ 21,930	0.35
	Sub - Total				**$ 484,301**	
Water Treatment						
18	Mobilization and Demobilization	1	LS	$ 44,100.00	$ 44,100	0.15
19	Water Treatment System	129	DAY	$ 2,400.00	$ 309,600	0.35
20	Testing of Treatment System Effluent	129	DAY	$ 120.00	$ 15,480	0.35
	Sub - Total				**$ 369,180**	
Transportation and Disposal of Excavated Fill						
21	Testing of Excavated PCB Fill Samples	312	EA	$ 254.38	$ 79,367	0.15
22	Testing of Excavated Lead Soils	25	EA	$ 300.00	$ 7,500	0.15
23	Disposal (>1 PPM to <10 PPM)	9,237	TONS	$ 65.00	$ 600,386	0.15
24	Disposal (> or = to 10 PPM)	54,645	TONS	$ 150.00	$ 8,196,795	0.15
25	Disposal (grout spoils, > or = to 10 PPM)	2,250	TONS	$ 150.00	$ 337,467	0.15
26	Additional Disposal for Stabilization Materials (7.5% of total soil quantity, excluding grout spoils)	4,792	TONS	$ 150.00	$ 718,800	0.15
27	Disposal of Lead Soils	1,202	TONS	$ 368.00	$ 442,336	0.15
28	Additional Disposal for Stabilization Materials (7.5% of total soil quantity)	91	TONS	$ 368.00	$ 33,488	0.15
	Sub - Total				**$ 10,416,139**	
Site Restoration and Equipment Decon						
29	PPE including Disposal	139	Day	$ 300.00	$ 41,700	0.15
30	Decontamination of Sheeting & Equipment	1	LS	$ 98,000.00	$ 98,000	0.15
31	Stormwater Controls	1	LS	$ 105,000.00	$ 105,000	0.15
32	Site Rail Upgrade	1,500	LF	$ 22.91	$ 34,365	0.15
	Sub - Total				**$ 279,065**	

Feasibility Study For The Atlantic Richfield Company - Harbor At Hastings Site
Remedial Cost Estimates

Alternative 11:

Complete Containment of the Water Tower and Northwest Corner Areas, Excavation at Multiple Depths (3-feet bgs, 9-feet bgs, and 12-feet bgs (with grout stablization)) and Off-Site Disposal of PCB-Impacted Fill Located within the Containment, Excavation and Off-Site Disposal of PCB-Impacted Fill ≥ 10 ppm and Lead Hot Spots Located Outside of the Containment, Construction of a Contact Barrier and Soil Cover System.

No.	Item	Quantity	Unit	Unit Cost	Total Cost	Scope Contingency
Monitoring Wells						
33	Shallow Monitoring Wells	16	EA	$ 3,000.00	$ 48,000	0.15
34	Deep Monitoring Wells	2	EA	$ 5,000.00	$ 10,000	0.15
35	Continuous Water Level System (for 1-yr)	8	EA	$ 2,000.00	$ 16,000	0.15
	Sub-Total				**$ 74,000**	
Contact Barrier and Cover System						
36	Subgrade Preparation	35,337	CY	$ 21.74	$ 768,227	0.15
37	6" Asphalt Layer	135,520	SY	$ 12.43	$ 1,684,514	0.15
38	12" Soil Layer	45,174	CY	$ 20.48	$ 925,164	0.15
39	6" Topsoil Layer	135,520	SY	$ 4.83	$ 654,562	0.15
40	Fine Grading, Seeding, Mulch & Fertilizer	135,520	SY	$ 2.99	$ 405,205	0.15
	Sub-Total				**$ 4,437,672**	
Vertical Barriers						
41	Soil / Bentonite Slurry Trench - 3' wide, 30' deep	990	LF	$ 526.50	$ 521,235	0.30
42	Sheet Pile Bulkhead Along Shoreline with Waterloo Barrier or Equivalent, 38' deep	2,600	LF	$ 2,500.00	$ 6,500,000	0.30
	Sub - Total				**$ 7,021,235**	
Facility Access Controls						
43	Perimeter Fencing Around Contained Area	1,000	LF	$ 18.23	$ 18,230	0.15
	Sub - Total				**$ 18,230**	
	Total Construction Cost				**$ 31,957,938**	
	Contingency (16% Scope + 15% Bid)				**$ 9,906,961**	
	Sub-Total: Construction/Contingency Cost				**$ 41,864,899**	
	Engineering & Design (3%)				**$ 1,255,947**	
	Supervision, Administration & CQA (7%)				**$ 2,930,543**	
	Sub-Total: Capital Cost				**$ 46,051,389**	
Post-Closure Costs						
44	Annual Mowing	28	AC	$ 681.28	$ 19,076	
45	Annual Groundwater Monitoring Program	1	LS	$ 45,000.00	$ 45,000	
46	Annual Contact Barrier Maintenance	1	LS	$ 155,319.00	$ 155,319	
47	Annual Site Inspection	1	EA	$ 1,900.00	$ 1,900	
	Sub-Total				**$ 221,295**	
Sub-Total: Present Worth - 30 Yr Post Closure Period					**$ 6,420,551**	
	GRAND TOTAL				**$ 52,471,940**	

NOTES:

1 Contingency determined by combining the weighted-by-cost-element scope contingency with a fixed 15% bid contingency. The scope contingency used for each cost element is shown above. Contingency determined in accordance with *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*, USEPA, July 2000.

2 Engineering and Design Costs represent 3% of the Construction/Contingency Cost.

3 Supervision, Administration & CQA Costs represent 7% of the Construction/Contingency Cost. This percentage is based on a recommendation from "Superfund Remedial Design and Remedial Action Guidance", USEPA, June 1986.

4 To calculate the Total Present Worth O&M, the equation $P = A_1[n(1+i)^{-1}]$ was used, the annual interest rate was assumed to be 6% and the annual inflation rate was calculated to be 2.6% (from "Engineering News Record" web site). The effective interest rate is thus 3.4%.

5 The Annual Final Cover Maintenance Cost represents 3.5% of the Part 360 Cap Construction Cost.

6 The Contact Barrier Maintenance Cost represents 3.5% of the Contact Barrier Construction Cost.

7 Annual fence maintenance quantity represents 10% of the total perimeter fence.

8 Disposal Volumes Derived by Using 1.35 Multiplier to Convert Cubic Yards to Tons.

Feasibility Study For The Atlantic Richfield Company - Harbor At Hastings Site
Remedial Cost Estimates

Alternative 12: Complete Containment of the Water Tower and Northwest Corner Areas, Excavation at 9-foot and 12-foot Depths with Grout Stablization and Off-Site Disposal of PCB-Impacted Fill Located within the Containment, Excavation and Off-Site Disposal of PCB-Impacted Fill ≥ 10 ppm and Lead Hot Spots Located Outside the Contaiment, Construction of a Contact Barrier and Soil Cover System.						
No.	**Item**	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**	**Scope Contingency**
General Site Work						
1	Mobilization and Demobilization	1	LS	$ 115,000.00	$ 115,000	0.15
2	Erosion and Sediment Controls	5,620	LF	$ 13.82	$ 77,669	0.15
3	Asphalt Stripping / Disposal	41,962	SY	$ 22.58	$ 947,502	0.15
4	Building Demolition	500,211	SF	$ 4.23	$ 2,115,893	0.15
	Sub-Total				**$ 3,256,064**	
Excavation Shoring and Stabilization						
5	Sheeting - Installation and Removal					
5.1	To 30' Below Ground Surface	228,000	SF	$ 22.00	$ 5,016,000	0.30
6	Jet Grouting	9,630	CY	$ 400.00	$ 3,852,000	0.30
	Sub - Total				**$ 8,868,000**	
Excavation and Backfilling Work						
7	Excavation of Fill >1ppm to <10ppm in Top 1'	6,842	CY	$ 16.39	$ 112,141	0.55
8	Excavation of PCB Fill to maximum depth of 12' bgs	59,645	CY	$ 15.43	$ 920,323	0.55
9	Excavation of Lead Hotspots	925	CY	$ 15.43	$ 14,273	0.55
10	Backfilling PCB Excavation w/ Clean Soil	66,487	CY	$ 24.41	$ 1,622,948	0.55
11	Backfilling of Lead Hot Spots	925	CY	$ 24.41	$ 22,580	0.55
	Sub - Total				**$ 2,692,265**	
Dewatering / Soil Staging Facility						
12	Select Fill Layer	1,482	CY	$ 29.69	$ 44,001	0.15
13	40 Mil HDPE Liner	40,000	SF	$ 0.49	$ 19,600	0.15
14	Sand Layer	494	CY	$ 22.69	$ 11,209	0.15
15	8" Reinforced Concrete Layer					
15	Form Work	667	SFCA	$ 4.93	$ 3,289	0.15
15	8" Thick Concrete Slab	40,000	SF	$ 3.39	$ 135,600	0.15
15	Reinforcing Steel Mesh	40,000	SF	$ 5.34	$ 213,600	0.15
16	4' High, 12" Thick Concrete Curbs/Walls	1,600	LF	$ 21.92	$ 35,072	0.15
17	Pump System and Piping	185	DAY	$ 170.00	$ 31,450	0.35
	Sub - Total				**$ 493,821**	
Water Treatment						
18	Mobilization and Demobilization	1	LS	$ 44,100.00	$ 44,100	0.15
19	Water Treatment System	185	DAY	$ 2,400.00	$ 444,000	0.35
20	Testing of Treatment System Effluent	185	DAY	$ 120.00	$ 22,200	0.35
	Sub - Total				**$ 510,300**	
Transportation and Disposal of Excavated Fill						
21	Testing of Excavated Fill Samples	312	EA	$ 254.38	$ 79,367	0.15
22	Testing of Excavated Lead Soils	25	EA	$ 300.00	$ 7,500	0.15
23	Disposal (>1 PPM to <10 PPM)	9,237	TONS	$ 65.00	$ 600,386	0.15
24	Disposal (> or = to 10 PPM)	80,521	TONS	$ 150.00	$ 12,078,113	0.15
25	Disposal (grout spoils, > or = to 10 PPM)	19,501	TONS	$ 150.00	$ 2,925,113	0.15
26	Additional Disposal for Stabilization Materials (7.5% of total soil quantity, excluding grout spoils)	6,732	TONS	$ 150.00	$ 1,009,800	0.15
27	Disposal of Lead Soils	1,202	TONS	$ 368.00	$ 442,336	0.15
28	Additional Disposal for Stabilization Materials (7.5% of total soil quantity)	91	TONS	$ 368.00	$ 33,488	0.15
	Sub - Total				**$ 17,176,103**	
Site Restoration and Equipment Decon						
29	PPE including Disposal	195	Day	$ 300.00	$ 58,500	0.15
30	Decontamination of Sheeting & Equipment	1	LS	$ 98,000.00	$ 98,000	0.15
31	Stormwater Controls	1	LS	$ 105,000.00	$ 105,000	0.15
32	Site Rail Upgrade	1,500	LF	$ 22.91	$ 34,365	0.15
	Sub - Total				**$ 295,865**	
Monitoring Wells						
33	Shallow Monitoring Wells	16	EA	$ 3,000.00	$ 48,000	0.15
34	Deep Monitoring Wells	2	EA	$ 5,000.00	$ 10,000	0.15
35	Continuous Water Level System (for 1-yr)	8	EA	$ 2,000.00	$ 16,000	0.15
	Sub-Total				**$ 74,000**	

Feasibility Study For The Atlantic Richfield Company - Harbor At Hastings Site
Remedial Cost Estimates

Alternative 12:
Complete Containment of the Water Tower and Northwest Corner Areas, Excavation at 9-foot and 12-foot Depths with Grout Stablization and Off-Site Disposal of PCB-Impacted Fill Located within the Containment, Excavation and Off-Site Disposal of PCB-Impacted Fill ≥ 10 ppm and Lead Hot Spots Located Outside the Contaiment, Construction of a Contact Barrier and Soil Cover System.

No.	Item	Quantity	Unit	Unit Cost	Total Cost	Scope Contingency
Contact Barrier and Cover System						
36	Subgrade Preparation	35,337	CY	$ 21.74	$ 768,227	0.15
37	6" Asphalt Layer	135,520	SY	$ 12.43	$ 1,684,514	0.15
38	12" Soil Layer	45,174	CY	$ 20.48	$ 925,164	0.15
39	6" Topsoil Layer	135,520	SY	$ 4.83	$ 654,562	0.15
40	Fine Grading, Seeding, Mulch & Fertilizer	135,520	SY	$ 2.99	$ 405,205	0.15
	Sub-Total				**$ 4,437,672**	
Vertical Barriers						
41	Soil / Bentonite Slurry Trench - 3' wide, 30' deep	990	LF	$ 526.50	$ 521,235	0.30
42	Sheet Pile Bulkhead Along Shoreline with Waterloo Barrier or Equivalent, 38' deep	2,600	LF	$ 2,500.00	$ 6,500,000	0.30
	Sub - Total				**$ 7,021,235**	
Facility Access Controls						
43	Perimeter Fencing Around Contained Area	1,000	LF	$ 18.23	$ 18,230	0.15
	Sub - Total				**$ 18,230**	
	Total Construction Cost				**$ 44,843,555**	
	Contingency (23% Scope + 15% Bid)				**$ 17,040,551**	
	Sub-Total: Construction/Contingency Cost				**$ 61,884,106**	
	Engineering & Design (3%)				**$ 1,856,524**	
	Supervision, Administration & CQA (7%)				**$ 4,331,888**	
	Sub-Total: Capital Cost				**$ 68,072,518**	
Post-Closure Costs						
44	Annual Mowing	28	AC	$ 681.28	$ 19,076	
45	Annual Groundwater Monitoring Program	1	LS	$ 45,000.00	$ 45,000	
46	Annual Contact Barrier Maintenance	1	LS	$ 155,319.00	$ 155,319	
47	Annual Site Inspection	1	EA	$ 1,900.00	$ 1,900	
	Sub-Total				**$ 221,295**	
Sub-Total: Present Worth - 30 Yr Post Closure Period					**$ 6,420,551**	
	GRAND TOTAL				**$ 74,493,069**	

NOTES:

1. Contingency determined by combining the weighted-by-cost-element scope contingency with a fixed 15% bid contingency. The scope contingency used for each cost element is shown above. Contingency determined in accordance with *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* , USEPA, July 2000.
2. Engineering and Design Costs represent 3% of the Construction/Contingency Cost.
3. Supervision, Administration & CQA Costs represent 7% of the Construction/Contingency Cost. This percentage is based on a recommendation from "Superfund Remedial Design and Remedial Action Guidance", USEPA, June 1986.
4. To calculate the Total Present Worth O&M, the equation $P = A_1[n(1+i)^{-1}]$ was used, the annual interest rate was assumed to be 6% and the annual inflation rate was calculated to be 2.6% (from "Engineering News Record" web site). The effective interest rate is thus 3.4%.
5. The Annual Final Cover Maintenance Cost represents 3.5% of the Part 360 Cap Construction Cost.
6. The Contact Barrier Maintenance Cost represents 3.5% of the Contact Barrier Construction Cost.
7. Annual fence maintenance quantity represents 10% of the total perimeter fence.
8. Disposal Volumes Derived by Using 1.35 Multiplier to Convert Cubic Yards to Tons.

APPENDIX E

REMEDY IMPLEMENTATION RISK EVALUATION

APPENDIX E

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REMEDY IMPLEMENTATION RISK EVALUATION

Prepared for

ARCO Environmental Remediation, LLC
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Prepared by

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Princeton, New Jersey

January 2001

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APPENDIX E

TABLE

FIGURES

ATTACHMENTS

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(continued)

APPENDIX E

Remedy Implementation Risk Evaluation
For the Harbor-at-Hastings Site

E.1. Introduction

Remedies being considered in the FS for the Harbor-at-Hastings Site (the Site) include both excavation-based and containment-based remedies. These remediation alternatives are being evaluated in the FS using the following criteria specified by the 1990 National Oil and Hazardous Substances Pollution Contingency Plan (NCP):

- Overall Protection of Human Health and the Environment;
- Compliance with Applicable or Relevant and Appropriate Requirements (ARARs);
- Long-Term Effectiveness and Permanence;
- Reduction of Toxicity, Mobility, or Volume through Treatment;
- Short-Term Effectiveness;
- Implementability; and
- Cost.

The 1990 NCP explicitly identifies potential remedy implementation risk as an important consideration in the remedy selection process at contaminated sites (USEPA 1990). In addition, the USEPA has determined that a quantitative evaluation is useful at those sites where exposure levels are expected to change significantly as a result of remediation activities (USEPA 1991, 1998). This report has been prepared to evaluate potential risks associated with the implementation of excavation-based and containment-based remedial alternatives for the Harbor-at-Hastings Site.

E.2. Consideration of Implementation Risks in the Remedy Selection Process

Guidelines for evaluating remedy implementation risks are presented in *Risk Assessment Guidance for Superfund: Volume I, Human Health Evaluation Manual (Part C, Risk Evaluation* *of Remedial Alternatives)* (USEPA 1991) and in *Risk Assessment Guidance for Superfund: Volume I, Human Health Evaluation Manual (Part D, Standardized Planning, Reporting, and Review of Superfund Risk Assessments)* (USEPA 1998). According to USEPA (1991, 1998), the risks posed to workers and the community during remedy implementation can be evaluated either qualitatively or quantitatively, depending on conditions at the site. Specifically, "when short-term risks are not expected to be a problem for a site, a more qualitative evaluation generally is appropriate. In these cases, a qualitative evaluation of the magnitude, duration and/or likelihood of the exposures and risks should be conducted and as such could describe short-term risks in a qualitative manner relative to the results of the baseline risk assessment. A quantitative evaluation of short-term risks is most likely to be useful when the types, levels and/or availability of hazardous substances are expected to change significantly as a result of remediation" (USEPA 1991).

Failure to adequately evaluate implementation risk during the remedy selection process can result in unanticipated risks to workers and nearby residents during cleanup, and in costly delays associated with substantial remedy modifications or abandonment of an incomplete remedy. Thus, short-term implementation risks, such as those posed by extensive excavation activities and transportation of waste/backfill material, must be carefully evaluated and weighed against any long-term risk reduction that may be achieved.

Intrusive remedies pose an increased risk of physical injury to workers, and in some cases heat stress/heat stroke, and fires and explosions. Similarly, transportation of excavated materials and backfill materials generate high traffic volumes that can result in both spills and traffic accidents. It is recognized that excavation and treatment remedies have been successfully implemented at many sites, although the costs and implementation times for such remedies are often higher than originally anticipated. However, as demonstrated at several notable Superfund sites, such remedies may offer little, if any, additional long-term risk reduction in comparison to containment-based remedies.

Accordingly, the scope and potential risks of such remedies should be assessed in detail prior to remedial decision making. For example, previous evaluations at various Superfund sites, including the Hardage, Lone Pine Landfill, Tyson's Lagoon, and American Chemical Service (ACS) Superfund sites demonstrate that the short-term remedy implementation risks posed by excavation can be significant, and can outweigh any long-term risk reduction afforded by such intrusive remedies. At each of these sites, *in situ* remedies based on containment, with limited or no excavation, were ultimately selected.

E.3. Approach to Assessing Remedy Implementation Risks

The specific remedial alternatives evaluated in the FS for the Site are as follows:

- **Alternative 1:** No action
- **Alternative 2:** Excavation and off-site disposal of all PCB-impacted fill
- **Alternative 3:** Excavation and off-site disposal of all fill located above the water table exceeding TAGM values and all PCB-impacted fill located below the water table ≥ 10 ppm
- **Alternative 4:** Excavation and off-site disposal of all PCB-impacted fill and construction of a contact barrier and soil cover system over the entire Site
- **Alternative 5:** Excavation and off-site disposal of fill containing the "rubbery matrix", complete containment of the water tower and northwest corner areas, excavation and off-site disposal of impacted fill located outside the limits of the containment
- **Alternative 6:** Excavation and off-site disposal of fill containing the "rubbery matrix", complete containment of the water tower and northwest corner areas, and construction of a multi-layered cap over the entire Site
- **Alternative 7:** Excavation and off-site disposal of shallow PCB-impacted fill. (≥ 50 ppm), containment of the water tower and northwest corner areas, and construction of a contact barrier and soil cover system
- **Alternative 8:** Containment of the water tower and northwest corner areas, excavation and off-site disposal of PCB-impacted fill (≥50 ppm) located outside the limits of the containment, and construction of a contact barrier and soil cover system
- **Alternative 9:** In-situ stabilization/solidification of the "liquid rubbery matrix", containment of the water tower and northwest corner areas, excavation and off-site disposal of all other PCB-impacted fill (≥50 ppm) outside the limits of the containment, and construction of a contact barrier and soil cover system
- **Alternative 10:** Construction of a contact barrier and soil cover system over the entire Site

Of these alternatives, Alternatives 2, 3, 4, 5, 6 and 7 (especially Alternatives 2, 3, 4 and 5) include very large volumes of soil excavation and/or very deep excavations and Alternatives 8, 9 and 10 are based on containment with limited or no excavation. To evaluate the potential remedy implementation risks for the Site and to compare and contrast the different accident risks involved, a quantitative comparative assessment has been performed of representative alternatives: Alternative 3 representing the deep excavation-based remedies, Alternative 7 as the shallow excavation-based remedy, and Alternative 8 representing the containment-based remedies.

Consistent with the NCP and USEPA guidance for quantitative analysis of remedy implementation risks (USEPA 1991, 1998), the potential for on-site worker fatalities related to physical hazards and the potential for off-site transportation-related fatalities related to disposal of excavated soils, and the importation of backfill, contact barrier and soil cover materials have been evaluated in this comparative assessment. Simplifying assumptions made in the assessment were as follows:

- On-site worker and off-site resident exposure to emissions of vapors and particulates during disturbance, excavation, and/or handling of contaminated soils were not considered since volatile contaminants are not COPCs at the Site and it was assumed that particulate emissions would be controlled by wetting;

- Increased hazards to on-site workers associated with use of personal protective equipment (e.g., heat stress) were not considered, since it was assumed that the bulk of the remediation under either alternative would be conducted using Modified Level D, with the exception of the building demolition task, where Level C would be used during asbestos abatement and decontamination activities;

- Transport of equipment and sheet piling for the bulkhead reconstruction and materials movements associated with slurry wall installation have not been included in the off-site transportation analysis, since they are either common to all remedies under evaluation or are considered of less significance than the excavation, backfill, contact barrier and soil cover materials; and

- To simplify the analysis, the transportation analysis excluded the risks posed by spills of waste materials, and both the transportation and worker risk analysis focused on fatal accidents only (as opposed to other non-fatal accidents). The on-site worker analysis is based on the methodology presented in Hoskin et al. (1994), while the off-site transportation analysis is based on the methodology presented in FEMA (1993).

On-Site Worker Analysis

Physical hazards during site remediation (e.g., accidents involving falls) are often similar in nature to those encountered during other types of construction or industrial activities. For example, accidents in an excavation area may be caused by a number of factors, including:

- Holes;
- Slippery surfaces (such as muddy areas caused by precipitation and/or dust suppression);
- Steep grades;
- Uneven terrain; and
- Unstable surfaces (such as settling land cover).

To quantify the risks of physical hazards during remediation activities at the Site, the probability of having at least one fatality occur during remedy implementation was evaluated. This evaluation was conducted based on published fatal accident rate statistics and site-specific information regarding the type and duration of activities to take place during remediation (Hoskin et al. 1994). This evaluation relies on estimates of worker-years for specific remediation activities (e.g., materials handling, excavation, backfilling) developed in Attachment E-A based on data available in standard construction cost handbooks (Means 1999) for similar tasks, and supplemented with data available in environmental cost handbooks (ECHOS 1996) and information provided by vendors. The fatality rate data used in this assessment are based on the construction industry as a whole, and are not specific to site remediation, because there is no separate reporting of fatality statistics for the hazardous waste industry. The man-hour estimates for asbestos removal and decontamination during the building demolition task, however, were adjusted upwards by a factor of 1.8 (ECHOS 1996) to reflect the use of modified Level C PPE. The man-hour estimates for all other remediation tasks were adjusted upwards by a factor of 1.2 (ECHOS 1996) to reflect the use of modified Level D PPE. This is consistent with the COPCs at the Site being of low volatility, e.g., PCBs, PAHs, metals and the principal health and safety concerns being associated with dermal contact.

Off-Site Transportation Analysis

Remediation of hazardous waste sites typically involves both on-site and off-site transportation. Inherent in the transport of materials to and from the Site is the risk of an accident during transit, which may involve a fatality, injury and/or spill. The risks of an accident occurring during transport of waste or equipment may be significant, especially if large quantities of waste must be transported off-site for disposal, and/or correspondingly large quantities of backfill imported to the Site. An analysis of potential transportation-related fatalities, was conducted for off-site transportation associated with the deep excavation remedy (Alternative 3), the shallow excavation remedy (Alternative 7), and the containment remedy (Alternative 8) based on fatality rates involving truck and train transport for off-site waste transportation, and barge transport for incoming backfill and cover materials. The routing, mode of transport, and travel distances involved in each case are described in Attachment E-B.

Based on these travel distances, remedy-specific fatality rates were calculated based on overall fatality statistics for trucks (USDOT 1997, 1999), trains (FRA 1999) and barges (PBQ&D 1999). In the case of truck transport, fatal accident rates were calculated both for travel on local roads (i.e., from River Street to Farragut Parkway) and for the rest of the travel route.

E.4. Results of Risk Evaluation

On-Site Worker Fatalities

Based on the manpower requirements described in Attachment E-A, Alternative 3 (deep excavation) has a total labor-time of approximately 245.3 man-years which can be contrasted with Alternative 7 (shallow excavation) and Alternative 8 (containment) with a total labor-time of approximately 104.3 and 98.9 man-years, respectively. Application of fatal accident statistics to the estimated man-years of each labor category is summarized in Attachment E-B, and results in estimated fatality rates of: 5.4×10^{-2} or 1 in 19 for Alternative 3, 2.2×10^{-2} or 1 in 45 for Alternative 7, and 2.1×10^{-2} or 1 in 47 for Alternative 8, as shown graphically in Figure E-1. Thus, the fatality risk for Alternative 3 is approximately a factor of 2 higher than for Alternatives 7 and 8.

The breakdown of fatality risks by individual task contribution is shown on Figure E-l and is presented in further detail in Figures E-C.1, E-C.2, and E-C.3 for Alternatives 3, 7 and 8, respectively. Note that the implementation risks associated with building demolition and bulkhead installation, which are common to all three remedy alternatives, make up over 90% of the risk associated with Alternatives 7 and 8. If these elements are subtracted, so that only those tasks that are not common to the three alternatives are compared, the estimated fatality rates are 3.4×10^{-2} or 1 in 30 for Alternative 3, 1.8×10^{-3} or 1 in 559 for Alternative 7, and 6.5×10^{-4} or 1 in 1,545 for Alternative 8. Using this comparison, the fatality risk for Alternative 3 is approximately 19 times higher than that for Alternative 7 and approximately 52 times higher than that for Alternative 8. The fatality risk for Alternative 7 is approximately 2.8 times higher than that for Alternative 8.

Off-Site Transportation-Related Fatalities

Based on the transportation routes and modes of transport described in Attachment E-C-2, Alternative 3 (the excavation remedy) has the following vehicle movements:

- 8,986,167 truck-miles for excavated soil/demolition debris (57,708 of which are on local roads);
- 303,000 rail-miles for excavated soil; and
- 77,250 river-miles for backfill/topsoil.

Alternative 7 (the shallow excavation remedy) has the following vehicle movements:

- 972,385 truck-miles for excavated soil/demolition debris (8,992 of which are on local roads);
- 45,450 rail-miles for excavated soil; and
- 15,600 river-miles for backfill, contact barrier and soil cover materials (i.e., soil, topsoil and asphalt).

Alternative 8 (the containment remedy) has the following vehicle movements:

- 1,008,817 truck-miles for excavated soil/demolition debris (9,168 of which are on local roads); and
- 11,250 river-miles for backfill, contact barrier and soil cover materials (i.e., soil, topsoil and asphalt).

Application of fatality statistics by mode to the vehicle-miles as summarized in Attachment E-C.2 results in remedy-specific fatality rates as shown in Table E.1 and summarized graphically in Figures E-2, E-3 and E-4. The predicted incidence of fatalities is 1 for Alternative 3, 0.18 (or 1 in 6) for Alternative 7, and 0.079 (or 1 in 13) for Alternative 8.

Table E.1 Predicted Incidence of Off-Site Transportation-Related Fatalities					
Alternative	**Local Roads**	**Highways**	**Rail**	**Barge**	**Total**
3	0.0002 1 in 4,332	0.036 1 in 28	0.45 1 in 2	0.52 1 in 2	1.0 1 in 1
7	0.000036 1 in 27,802	0.004 1 in 259	0.067 1 in 15	0.10 1 in 10	0.18 1 in 6
8	0.000037 1 in 27,269	0.004 1 in 250		0.075 1 in 13	0.079 1 in 13

Overall, the fatal accident frequency for Alternative 3 (deep excavation) is about 6 times greater than for Alternative 7 (shallow excavation), and about 13 times greater than for Alternative 8 (containment). The fatal accident frequency for Alternative 7 (shallow excavation) is about 2 times greater than for Alternative 8 (containment). The major sources of fatalities under Alternative 3 are associated with rail transport (1 in 2) of the very large volume of excavated soil, and with barge transport (1 in 2) of the correspondingly large volume of backfill. In addition, the predicted incidence of fatalities on local roads for Alternative 3, 7 and 8 are 2×10^{-4} or 1 in 4,332, 3.6×10^{-5} or 1 in 27,802, and 3.7×10^{-5} or 1 in 27,269, respectively. Thus, the incidence of fatalities on local roads for Alternative 3 (deep excavation) is about 6 times greater than that for Alternative 7 (shallow excavation) and Alternative 8 (containment).

E.5. Conclusions

Assuming long-term engineering and/or institutional controls will be maintained, little, if any, additional long-term risk reduction will be associated with the excavation-based remedies. Alternative 3 (deep excavation), Alternative 7 (shallow excavation) and Alternative 8 (containment) would eliminate the potential for direct contact with soils above remediation goals. As a result, the long-term post-remediation risks posed by a containment-based remedy would be virtually equivalent to those associated with the deep excavation and shallow excavation remedies, and there is thus little or no additional long-term risk reduction provided by the excavation remedies.

However, while the difference in long-term risk reduction between the three alternatives (deep excavation, shallow excavation and containment) is minimal, the short-term risks associated with the excavation-based remedies are greater than those for a containment-based remedy. Specifically, the off-site fatal accident frequency for Alternative 3 (excavation) is about 13 times greater than for Alternative 8 (containment), and the off-site fatal accident frequency for Alternative 7 (shallow excavation) is about 2 times greater than for Alternative 8 (containment).

Similarly, the on-site fatal accident risk for Alternative 3 is approximately a factor of 2.5 higher than for Alternative 8; or, if the common tasks of building demolition and bulkhead installation are excluded from the on-site risk evaluation, the on-site fatal accident risk for Alternative 3 is approximately 52 times higher than for Alternative 8, and the on-site fatal accident risk for Alternative 7 is approximately 2.8 times higher than for Alternative 8. Further, given the fact that there is little difference in the long term risk reduction at the Site resulting from implementation of excavation rather than a containment remedy, the overall risk (short and long term) associated with the excavation-based remedies, in particular the deep excavation alternative, is significantly greater than that of the containment remedy.

As stated in Section 300.430(e)(9)(iii)(C) and (E) of the 1990 NCP, remedy selection at Superfund sites should consider both short- and long-term effectiveness for protecting human health and the environment. In evaluating overall protection of human health, the risks created by implementing a remedy should be weighed against the long-term risks that persist after the selected remedy has been implemented. Based on the analysis summarized above, the short-term risks associated with an excavation-based remedies will more than offset the long-term risk reduction, if any, achieved by such remedies.

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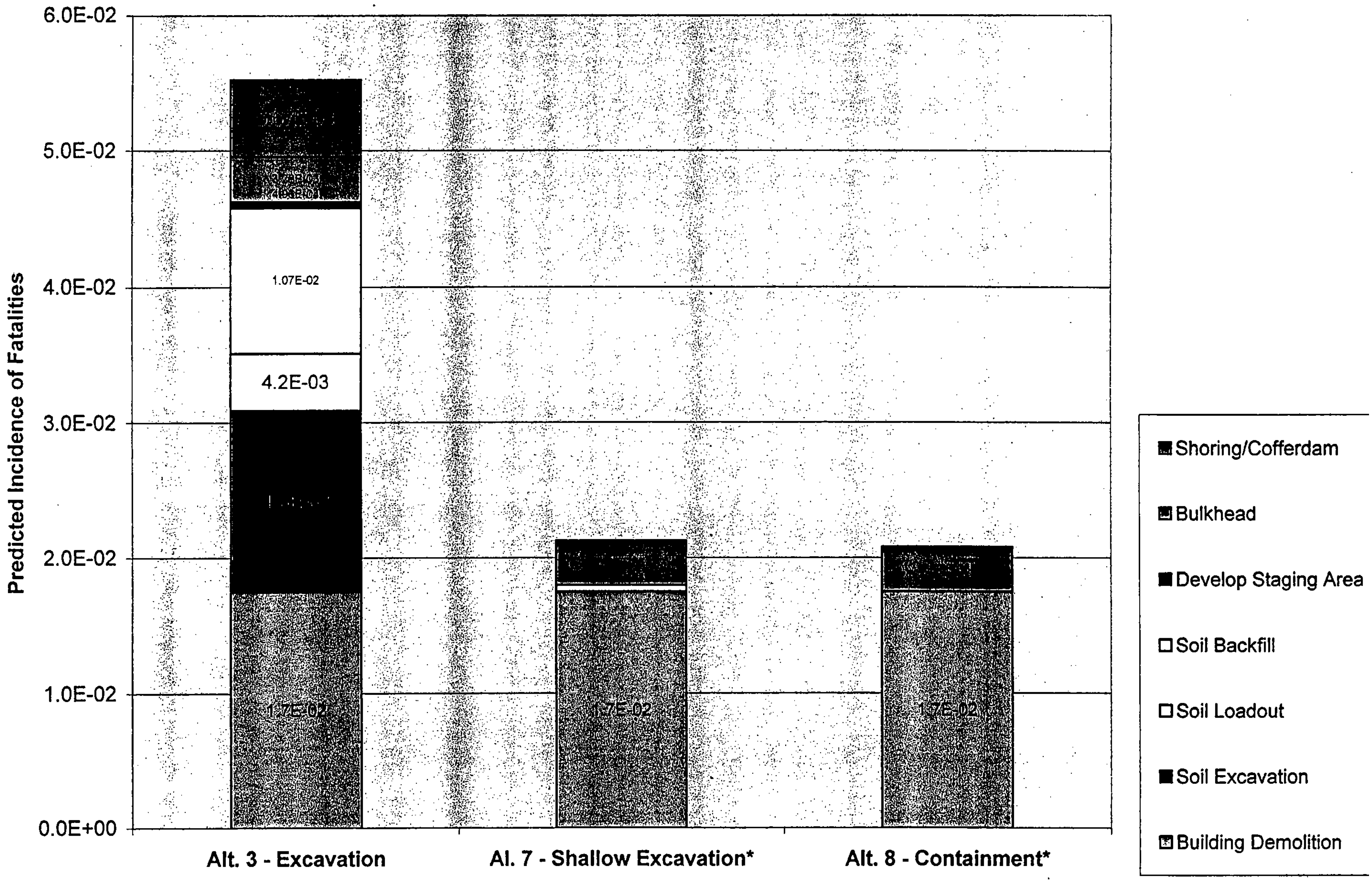
Figure E-1: Predicted Incidence of On-Site Worker Fatalities During Remedy Implementation
Harbor-at-Hastings Site, Hastings-On-Hudson, NY



*There are 6 components of Remedy Alt. 7 and 8 (soil excavation, loadout, developing staging area, contact barrier, slurry wall & well installation) which are not shown as part of Alt. 7 and 8 because they account for less than 6% of expected fatalities.

Figure E-2
Predicted Incidence of Transportation-Related Fatalities
During Remedy Implementation, Alt. 3 - Excavation
Harbor-at-Hastings Site, Hastings-On-Hudston, NY

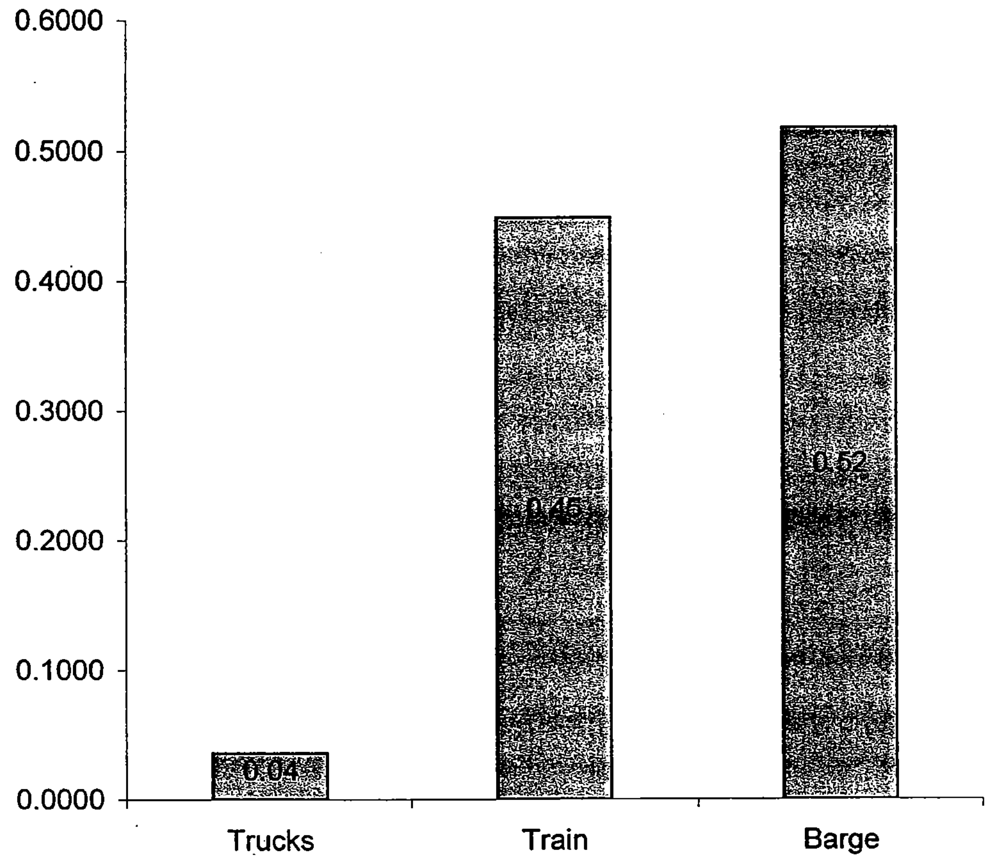


Figure E-3
Predicted Incidence of Transportation-Related Fatalities
During Remedy Implementation, Alt. 7 - Shallow Excavation
Harbor-at-Hastings Site, Hastings-On-Hudston, NY

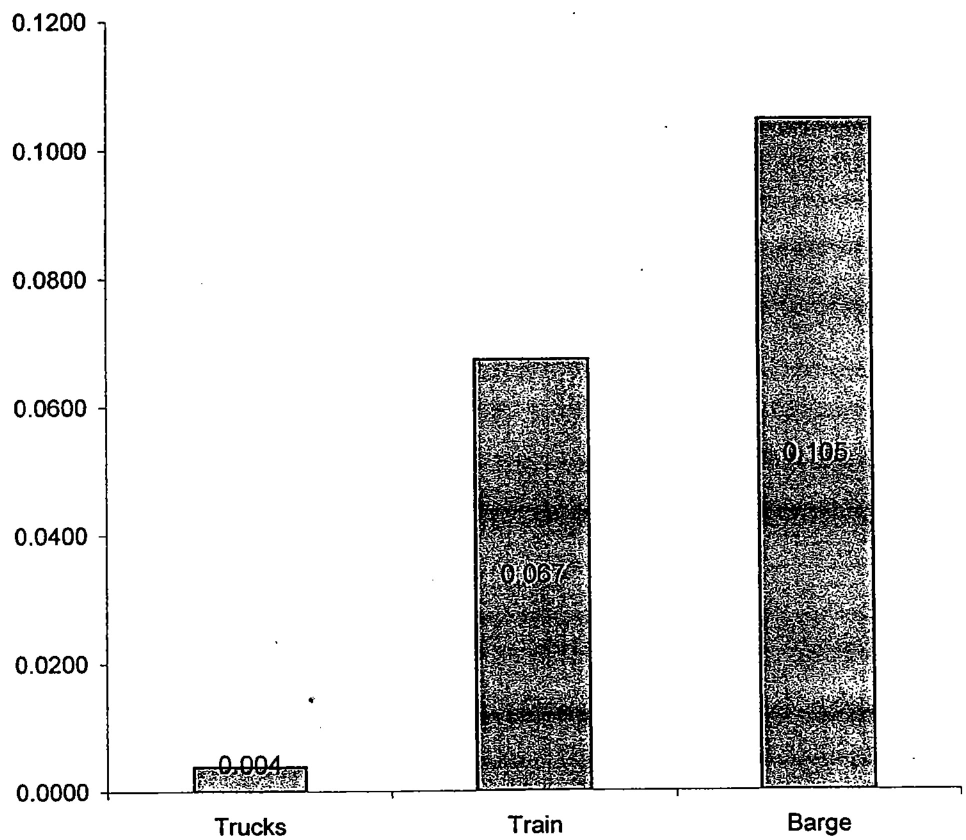
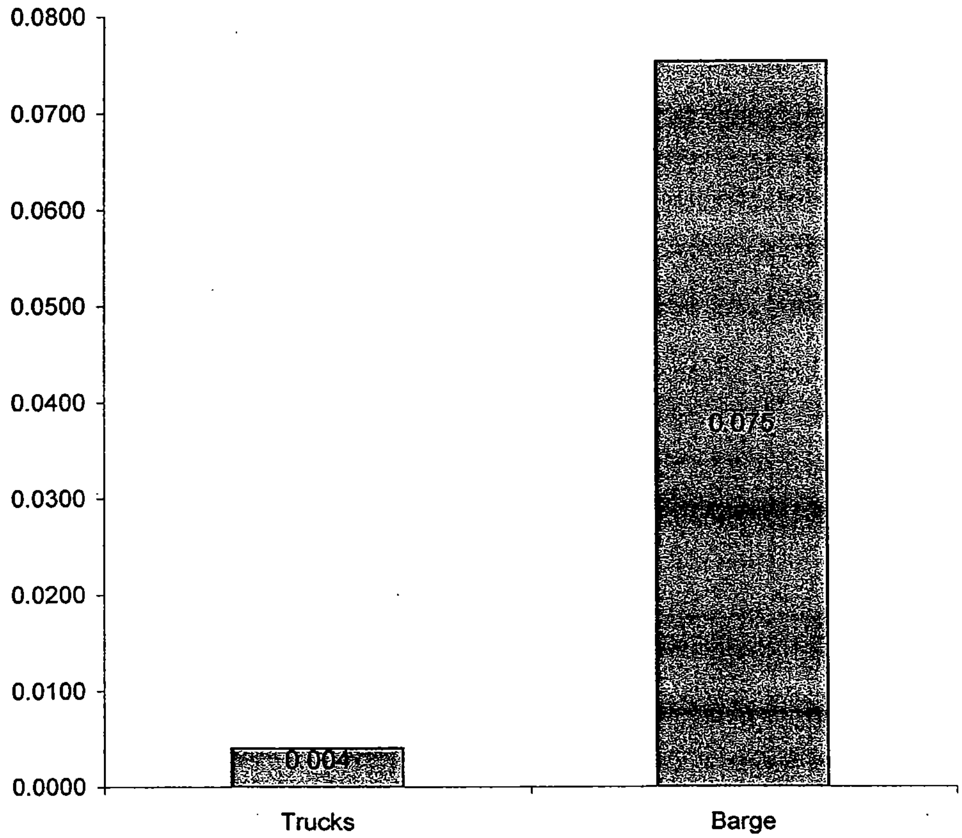


Figure E-4
Predicted Incidence of Transportation-Related Fatalities
During Remedy Implementation, Alt. 8 - Containment
Harbor-at-Hastings Site, Hastings-On-Hudston, NY



ATTACHMENT E-A

Estimated Manpower Requirements
For Remedy Implementation

ATTACHMENT E-A

Estimated Manpower Requirements
For Remedy Implementation

E-A.1 Components of Alternative 3 (Deep Excavation Alternative)

Alternative 3, the excavation alternative, would involve excavation of all subsurface fill above the water table that contains any COPCs exceeding any TAGM value, and all PCB-impacted fill below the water table $\geq$ 10 ppm, as well as reconstruction of the waterfront bulkhead. The excavated materials would be staged and dewatered on-site prior to rail transportation to an appropriate landfill for disposal. The excavated area would be backfilled with clean fill.

Alternative 3 includes the following major tasks that were evaluated quantitatively in the remedy implementation risk assessment

- Building demolition
- Soil excavation/loadout and transfer to staging area
- Soil staging area/dewatering and loadout
- Soil backfilling including barge loadout
- Shoring of excavation and cofferdam construction
- Development of soil staging area
- Bulkhead reconstruction

E-A.2 Components of Alternative 7 (Shallow Excavation Alternative)

Alternative 7, the shallow excavation alternative, would involve excavation of PCB-impacted fill $\geq$ 50 ppm, containment of the water tower and northwest corner areas, and construction of a contact barrier and soil cover system, as well as reconstruction of the waterfront bulkhead. The excavated materials would be staged and dewatered prior to rail transportation to an appropriate landfill for disposal. The containment of the water tower and northwest corner areas would include the reconstructed bulkhead and a slurry wall along the east side of the area.

Alternative 7 includes the following major tasks that were evaluated quantitatively in the remedy implementation risk assessment:

- Building demolition
- Soil excavation/loadout and transfer to staging area
- Soil staging area/dewatering and loadout
- Soil backfilling including barge loadout
- Development of soil staging area
- Installation of contact barrier and soil cover system
- Installation of slurry wall
- Installation of monitoring wells
- Bulkhead reconstruction

E-A.3 Components of Alternative 8 (Containment Alternative)

Alternative 8, a containment alternative, would involve containment of the water tower and northwest corner areas, excavation of PCB-impacted fill ≥ 50 ppm outside the containment area and construction of a contact barrier and soil cover system, as well as reconstruction of the waterfront bulkhead. The excavated materials would be staged and dewatered prior to off-site truck transportation and disposal. The containment of the water tower and northwest corner areas would include the reconstructed bulkhead, and a slurry wall along the east side of the area.

Alternative 8 includes the following major tasks that were evaluated quantitatively in the remedy implementation risk assessment:

- Building demolition
- Soil excavation/loadout and transfer to staging area
- Soil staging area/dewatering and loadout
- Soil backfilling including barge loadout
- Development of soil staging area
- Installation of contact barrier and soil cover system
- Installation of slurry wall
- Installation of monitoring wells
- Bulkhead reconstruction

E-A.4 Manpower Estimates

Manpower estimates were developed for each of the remedy implementation tasks discussed in Sections E-A.1, E-A.2 and E-A.3. Basic manpower estimates were developed from data available in standard construction cost handbooks (Means 1999) for similar tasks, and supplemented with data available in environmental cost handbooks (ECHOS 1996) and information provided by vendors. The following general assumptions were also employed:

- All estimates assume a 5-day workweek and 8-hour workday, and do not account for any monitoring or maintenance that may be performed on weekends.
- All manpower estimates include only on-site personnel; personnel transporting materials (e.g., excavated soil and clean fill) to and from the site are not considered in this evaluation.
- For Alternative 3, excavation rates for soil above 25 ft. (320 cubic yards/day using excavation) and for soil below 25 ft. (128 cubic yards/day using crane/clamshell) were reduced by 1/3 to reflect site conditions (i.e., the presence of subsurface pilings).
- For Alternative 3, the installation of bracing and shoring was based on estimates from Means (1999), reflecting the tradeoff between the high density of obstructions, (e.g., old piles) and the relative ease of driving through the fill material based on recent experience in replacing the southern portion of the bulkhead.
- For both alternatives, manpower requirements for each task or group of related tasks performed concurrently included one regulatory oversight/inspector, one health and safety monitor, one manager/site engineer, and one foreman.
- For both alternatives, one foreman was assumed to be necessary for each task or group of related tasks performed concurrently. In cases where R.S. Means included a foreman or fraction thereof, as part of the labor crew, the number for the foreman was adjusted to equal the default value of 1.

Other assumptions are noted in Tables E-A.1, E-A.2 and E-A.3.

Since safety level requirements affect the productivity of labor and equipment, the base level manpower estimates were adjusted for the expected decrease in productivity due to the use of personal protective equipment (PPE). Based on consideration of the COPCs to which on-site workers might be exposed during remedy implementation, it was assumed that workers involved with asbestos removal and decontamination during building demolition would use Level C PPE and modified Level D PPE would be required for all other tasks in both remedy alternatives. To account for the reduction in worker efficiency associated with the use of PPE, manpower estimates were adjusted by a factor of 1.8 for Level C PPE and a factor of 1.2 for Level D PPE based on manpower data provided in *Environmental Restoration: Unit Cost Book* (ECHOS 1996).

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TABLE E-A-1 Estimated Manpower Requirements for Alternative 3, Excavation Remedy Harbor-at-Hastings Site, Hastings-On-Hudson, NY	Building Demolition						Soil Excavation/Loadout							
	Asbestos Removal		Decontamination		Demolition & Loading		Above 25 feet bgs (hydraulic excavator)		Below 25 feet bgs (crane and clam shell)		Haul Soil to Staging Area (f)		Soil Staging Area Loadout (f)	
Crew (based on Means 1999, unless otherwise noted)	ENVIRON/IT		ENVIRON/IT		ENVIRON/IT		Crew CODEO +dozer		ENVIRON/IT		Crew COEID x 2		Crew CODEO +dozer	
Regulatory oversight/inspector (no. of workers)			1		1		1		1					
Health and safety monitor (no. of workers)	1		1		1		1		1					
Manager/site engineer (no. of workers)	1		1		1		1		1					
Foreman (no. of workers) (a)	1		1		1		1		1					
Excavator/loader operators (no. of workers)			1	1-wheeled loader	1	1-tracked loader and 1-excavator with shears	1	1-excavator	1	1-crane/clamshell excavator			1	1-excavator
Dozer operator (no. of workers)							1	1-dozer	1	1-dozer			1	1-dozer
On-site truck drivers (no. of workers)											2	2-trucks		
Laborers (no. of workers)	5						1		1				1	
Crane/shovel operator (no. of workers)														
Equipment operator (no. of workers)			1		1									
Pile drivers (no. of workers)														
Carpenter (no. of workers)														
Total crew size (no. of workers)	**8.00**		**6.00**		**6.00**		**7.00**		**7.00**		**2.00**		**3.00**	
Quantity/Unit	570,200	sq feet building	570,200	sq feet building	570,200	sq feet building	289,372	cu yards soil	19,444	cu yards soil	308,816	cu yards soil	308,816	cu yards soil
Rate of Work (b)	664.8	asbestos removal (sq feet/day) (i)	3,322.4	building decontamination (sq feet/day) (i)	542.4	building demolition (sq feet/day) (i)	214	soil excavation (cu yards/day) (d)	86	soil excavation (cu yards/day) (d)	392	haul soil (cu yards/day)	320	soil loadout (cu yards/day)
Duration of Work based on Modified Level D P PE (days) (c)	1,544	(j)	309	(j)	1,262		1,626		273		1898.26 (e)		1,158	
Duration of Work (years)	**6.18**		**1.24**		**5.05**		**6.50**		**1.09**		**7.59**		**4.63**	
Crew Manpower Requirements														
Regulatory oversight/inspector (worker-years)			1.236		5.046		6.503		1.090					
Health and safety monitor (worker-years)	6.175		1.236		5.046		6.503		1.090					
Manager/site engineer (worker-years)	6.175		1.236		5.046		6.503		1.090					
Foreman (worker-years)	6.175		1.236		5.046		6.503		1.090					
Excavator/loader operators (worker-years)			1.236		5.046		6.503		1.090				4.632	
Dozer operator (worker-years)							6.503		1.090				4.632	
On-site truck drivers (worker-years)											15.186			
Laborers (worker-years)	30.877						6.503		1.090				4.632	
Crane/shovel operator (worker-years)														
Equipment operator (worker-years)			1.236		5.046									
Pile drivers (worker-years)														
Carpenter (worker-years)														
Total manpower requirements (worker-years)	**49.404**		**7.414**		**30.276**		**45.519**		**7.632**		**15.186**		**13.897**	

TABLE E-A-1 Estimated Manpower Requirements for Alternative 3, Excavation Remedy Harbor-at-Hastings Site, Hastings-On-Hudson, NY	Soil Backfilling				Shoring and Cofferdam							
	Barge Loadout of Soil		Haul Soil to Backfill Area (g)		Bracing and Shoring Excavation Area		Cofferdam Installation		Barge Loadout of Gravel		Haul Gravel to Cofferdam (h)	
Crew (based on Means 1999, unless otherwise noted)	Crew CODEO +dozer		Crew COEID x 4		Crew CPIDV		Crew CPIDV		Crew CODEO + dozer		Crew COEID x 2	
Regulatory oversight/inspector (no. of workers)	1				1		1		1			
Health and safety monitor (no. of workers)	1				1		1		1			
Manager/site engineer (no. of workers)	1				1		1		1			
Foreman (no. of workers) (a)	1								1			
Excavator/loader operators (no. of workers)	1	1-excavator							1	1-excavator		
Dozer operator (no. of workers)	1	1-dozer							1	1-dozer		
On-site truck drivers (no. of workers)			4	4-trucks							2	2-trucks
Laborers (no. of workers)	1				1	1-oilers	1	1-oilers	1			
Crane/shovel operator (no. of workers)					2	1-crane	2	1-crane				
Equipment operator (no. of workers)												
Pile drivers (no. of workers)					3	includes 1 foreman	3	includes 1 foreman				
Carpenter (no. of workers)												
Total crew size (no. of workers)	**7.00**		**4.00**		**9.00**		**9.00**		**7.00**		**2.00**	
Quantity/Unit	308,816	cu yards soil	308,816	cu yards soil	48,300	sq feet bracing	61,800	sq feet steel	4,167	cu yards gravel	4,167	cu yards gravel
Rate of Work (b)	320	barge loadout (cu yards/day)	320	backfilling (cu yards/day)	336	bracing (sq feet/day)	336	install cofferdam (sq feet/day)	320	loadout gravel (cu yards/day)	320	haul gravel (cu yards/day)
Duration of Work based on Modified Level D P PE (days) (c)	1,158		1,158		173		221		16		16	
Duration of Work (years)	**4.63**		**4.63**		**0.69**		**0.88**		**0.06**		**0.06**	
Crew Manpower Requirements												
Regulatory oversight/inspector (worker-years)	4.632				0.690		0.883		0.063			
Health and safety monitor (worker-years)	4.632				0.690		0.883		0.063			
Manager/site engineer (worker-years)	4.632				0.690		0.883		0.063			
Foreman (worker-years)	4.632								0.063			
Excavator/loader operators (worker-years)	4.632								0.063			
Dozer operator (worker-years)	4.632								0.063			
On-site truck drivers (worker-years)			18.529								0.125	
Laborers (worker-years)	4.632				0.690		0.883		0.063			
Crane/shovel operator (worker-years)					1.380		1.766					
Equipment operator (worker-years)												
Pile drivers (worker-years)					2.070		2.649					
Carpenter (worker-years)												
Total manpower requirements (worker-years)	**32.426**		**18.529**		**6.210**		**7.946**		**0.438**		**0.125**	

TABLE E-A-1 Estimated Manpower Requirements for Alternative 3, Excavation Remedy Harbor-at-Hastings Site, Hastings-On-Hudson, NY	Development of Soil Staging Facility													
	Select Fill Layer		Install 40 mil HDPE liner		Install Sand Layer		Prepare Form Work		Pour 8" thick concrete reinforced slab		Install Steel Mesh		Install 4" high by 12" thick concrete curb/wall	
Crew (based on Means 1999, unless otherwise noted)	Crew COFCO		Crew USKCF		Crew COFCO		Crew ACARI		Crew ALABE		Crew SIWRB		Crew ALABG	
Regulatory oversight/inspector (no. of workers)	1		1		1		1		1		1		1	
Health and safety monitor (no. of workers)	1		1		1		1		1		1		1	
Manager/site engineer (no. of workers)	1		1		1		1		1		1		1	
Foreman (no. of workers) (a)	0.75				0.75		0.75				0.5			
Excavator/loader operators (no. of workers)														
Dozer operator (no. of workers)	1	1-dozer			1	1-dozer								
On-site truck drivers (no. of workers)	1	1-truck	1	1-truck	1	1-truck								
Laborers (no. of workers)	0.5		7	includes 1 foreman	0.5		1		5	1-vibrator, 1-generator, 1-cement finisher; includes 1 foreman	2.5	rodmen; includes 0.5 foreman	7	2-vibrators, 1- generator; includes 1-foreman and 1-oilers
Crane/shovel operator (no. of workers)													1	1-crane
Equipment operator (no. of workers)	0.25	1-water tank, 1-roller; includes 0.25 foreman			0.25	1-roller, 1-water tank; includes 0.25 foreman								
Pile drivers (no. of workers)														
Carpenter (no. of workers)							2.25	includes 0.25 foreman						
Total crew size (no. of workers)	**6.50**		**11.00**		**6.50**		**7.00**		**8.00**		**6.00**		**11.00**	
uantity/Unit	1,482	cu yards fill	40,000	sq feet liner	494	cu yards sand	667	sq feet forms	40,000	sq feet concrete slab	40,000	sq feet steel mesh	237.0	cu yards curb (equal to 1600 feet 4' by 12" thick curb)
Rate of Work (b)	2,928	fill layer (cu yards/day)	2,000	install liner (sq feet/day)	2,928	install sand (cu yards/day)	480	form work (sq feet/day)	7,088	pour slab (sq feet/day) (equal to 220 cu yards/day)	2,500	install steel mesh (sq feet/day)	90.0	pour curb (cu yards/day)
Duration of Work based on Modified Level D P PE (days) (c)	0.61		24		0.20		2		7		19		3	
Duration of Work (years)	**0.002**		**0.10**		**0.001**		**0.01**		**0.03**		**0.08**		**0.01**	
Crew Manpower Requirements														
Regulatory oversight/inspector (worker-years)	0.002		0.096		0.001		0.007		0.027		0.077		0.013	
Health and safety monitor (worker-years)	0.002		0.096		0.001		0.007		0.027		0.077		0.013	
Manager/site engineer (worker-years)	0.002		0.096		0.001		0.007		0.027		0.077		0.013	
Foreman (worker-years)	0.002				0.001		0.005				0.038			
Excavator/loader operators (worker-years)														
Dozer operator (worker-years)	0.002				0.001									
On-site truck drivers (worker-years)	0.002		0.096		0.001									
Laborers (worker-years)	0.001		0.672		0.000		0.007		0.135		0.192		0.088	
Crane/shovel operator (worker-years)													0.013	
Equipment operator (worker-years)	0.001				0.000									
Pile drivers (worker-years)														
Carpenter (worker-years)							0.015							
Total manpower requirements (worker-years)	**0.016**		**1.056**		**0.005**		**0.047**		**0.217**		**0.461**		**0.139**	

TABLE E-A-1 Estimated Manpower Requirements for Alternative 3, Excavation Remedy Harbor-at-Hastings Site, Hastings-On-Hudson, NY	Install Bulkhead		Total Manpower Requirements for all Tasks	Notes:
Crew (based on Means 1999, unless otherwise noted)		Crew CPIDV	–	(a) One foreman was assumed to be necessary for each task or group of related tasks performed concurrently. In cases where R.S. Means included a foreman or fraction thereof, as part of the labor crew, the number for the foreman was adjusted to equal the default value of 1.
Regulatory oversight/inspector (no. of workers)	1		–	(b) All rates of work based on 8-hr work day
Health and safety monitor (no. of workers)	1		–	(c) All duration of work estimates include adjustment of 1.2 fold to account for use of modified Level D P PE, unless otherwise noted.
Manager/site engineer (no. of workers)	1		–	(d) Alternative 3 excavation rates (400 cu yards/day above 25 feet bgs; 160 cu yards/day below 25 feet bgs) decreased by 33% to reflect site working conditions (i.e., presence of subsurface pilings).
Foreman (no. of workers) (a)			–	(e) Assume 2 trucks are present during the duration of the excavation process of 1519 days (sum of excavation above and below 25 feet)
Excavator/loader operators (no. of workers)			–	(f) Soil excavation, hauling soil to staging area, and soil staging area loadout are concurrent activities; therefore, the same supervisory personnel assigned for soil excavation are assumed to provide oversight for the concurrent activities.
Dozer operator (no. of workers)			–	(g) Barge loadout of soil and hauling soil to backfill area are concurrent activities; therefore, the same supervisory personnel assigned for barge loadout of soil are assumed to provide oversight for the concurrent activity.
On-site truck drivers (no. of workers)			–	(h) Barge loadout of gravel and hauling gravel to cofferdam are concurrent activities; therefore, the same supervisory personnel assigned for barge loadout of gravel are assumed to provide oversight for the concurrent activity.
Laborers (no. of workers)	1	oilers	–	(i) Building demolition subtasks based on data from prior site experience. IT estimates that level of effort required for additional demolition activity will be approximately twice that for previously demolished buildings as a result of differences in construction type, location, and presence of utilities.
Crane/shovel operator (no. of workers)	2	crane	–	(j) Adjusted by a factor of 1.8 to account for Level C P PE
Equipment operator (no. of workers)			–	
Pile drivers (no. of workers)	3	includes 1 foreman	–	
Carpenter (no. of workers)			–	
Total crew size (no. of workers)	**9.00**		–	
Quantity/Unit	65,000	sq feet steel	–	
Rate of Work (b)	336	install bulkhead (sq feet/day)	–	
Duration of Work based on Modified Level D P PE (days) (c)	232		–	
Duration of Work (years)	**0.93**		–	
Crew Manpower Requirements			–	
Regulatory oversight/inspector (worker-years)	0.929		21.29	
Health and safety monitor (worker-years)	0.929		27.47	
Manager/site engineer (worker-years)	0.929		27.47	
Foreman (worker-years)			24.79	
Excavator/loader operators (worker-years)			23.20	
Dozer operator (worker-years)			16.92	
On-site truck drivers (worker-years)			33.94	
Laborers (worker-years)	0.929		51.39	
Crane/shovel operator (worker-years)	1.857		5.02	
Equipment operator (worker-years)			6.28	
Pile drivers (worker-years)	2.786		7.50	
Carpenter (worker-years)			0.02	
Total manpower requirements (worker-years)	8.357		245.30	

TABLE E-A-2 Estimated Manpower Requirements for Alternative 7, Shallow Excavation Remedy	Building Demolition						Soil Excavation/Loadout				Soil Staging Area Loadout (d)		Soil Backfilling			
	Asbestos Removal		Decontamination		Demolition & Loading		Soil Excavation of Hot Spots		Haul Soil to Staging Area (d)				Barge Loadout		Haul Soil to Backfill Area (e)	
Crew (based on Means 1999, unless otherwise noted)	ENVIRON/IT		ENVIRON/IT		ENVIRON/IT		Crew CODEO +dozer		Crew COEID x 2		Crew CODEO + dozer		Crew CODEO+dozer		Crew COEID x 2	
Regulatory oversight/inspector (no. of workers)			1		1		1						1			
Health and safety monitor (no. of workers)	1		1		1		1						1			
Manager/site engineer (no. of workers)	1		1		1		1						1			
Foreman (no. of workers) (a)	1		1		1		1						1			
Excavator/loader operators (no. of workers)			1	1-wheeled loader	1	1-tracked loader and 1-excavator with shears	1	1-excavator			1	1-excavator	1	1-excavator		
Dozer operator (no. of workers)							1	1-dozer			1	1-dozer	1	1-dozer		
On-site truck drivers (no. of workers)									2	2-trucks					2	2-trucks
Laborers (no. of workers)	5						1				1		1			
Crane/shovel operator (no. of workers)																
Equipment operator (no. of workers)			1		1											
Pile drivers (no. of workers)																
Carpenter (no. of workers)																
Total crew size (no. of workers)	8.00		6.00		6.00		7.00		2.00		3.00		7.00		2.00	
Quantity/Unit	570,200	sq feet building	570,200	sq feet building	570,200	sq feet building	18,170	cu yards soil	18,170	cu yards soil	18,170	cu yards soil	18,170	cu yards soil	18,170	cu yards soil
Rate of Work (b)	664.8	asbestos removal (sq feet/day) (j)	3,322.4	building decontamination (sq feet/day) (j)	542.4	building demolition (sq feet/day) (i)	320	soil excavation (cu yards/day)	392	hauling soil (cu yards/day)	320	soil loadout (cu yards/day)	320	barge loadout (cu yards/day)	320	soil backfilling (cu yards/day)
Duration of Work based on Modified Level D P PE (days) (c)	1,544	(k)	309	(k)	1,262		68.14		55.62		68.14		68.14		68.14	
Duration of Work (years)	6.18		1.24		5.05		0.27		0.22		0.27		0.27		0.27	
Crew Manpower Requirements																
Regulatory oversight/inspector (worker-years)			1.236		5.046		0.273						0.273			
Health and safety monitor (worker-years)	6.175		1.236		5.046		0.273						0.273			
Manager/site engineer (worker-years)	6.175		1.236		5.046		0.273						0.273			
Foreman (worker-years)	6.175		1.236		5.046		0.273						0.273			
Excavator/loader operators (worker-years)			1.236		5.046		0.273				0.273		0.273			
Dozer operator (worker-years)							0.273				0.273		0.273			
On-site truck drivers (worker-years)									0.445						0.545	
Laborers (worker-years)	30.877						0.273				0.273		0.273			
Crane/shovel operator (worker-years)																
Equipment operator (worker-years)			1.236		5.046											
Pile drivers (worker-years)																
Carpenter (worker-years)																
Total manpower requirements (worker-years)	49.404		7.414		30.276		1.908		0.445		0.818		1.908		0.545	

TABLE E-A-2 Estimated Manpower Requirements for Alternative 7, Shallow Excavation Remedy	Development of Soil Staging Facility													
	Select Fill Layer		Install 40 mil liner		Install Sand Layer		Prepare Form Work		Pour 8" thick concrete reinforced slab		Install Steel Mesh		Install 4" high by 12" thick concrete curb/wall	
Crew (based on Means 1999, unless otherwise noted)	Crew COFCO		Crew USKCF		Crew COFCO		Crew ACARI		Crew ALABE		Crew SIWRB		Crew ALABG	
Regulatory oversight/inspector (no. of workers)	1		1		1		1		1		1		1	
Health and safety monitor (no. of workers)	1		1		1		1		1		1		1	
Manager/site engineer (no. of workers)	1		1		1		1		1		1		1	
Foreman (no. of workers) (a)	0.75				0.75		0.75				0.5			
Excavator/loader operators (no. of workers)														
Dozer operator (no. of workers)	1	1-dozer			1	1-dozer								
On-site truck drivers (no. of workers)	1	1-truck	1	1-truck	1	1-truck								
Laborers (no. of workers)	0.5		7	includes 1-foreman	0.5		1		5	1-vibrator, 1-generator, 1-cement finisher; includes 1 foreman	2.5	includes 0.5 foreman, reinforcing work	7	2-vibrators, 1- generator; includes 1 foreman and 1 oilers
Crane/shovel operator (no. of workers)													1	1-crane
Equipment operator (no. of workers)	0.25	1-roller, 1-water tank; includes 0.25 foreman			0.25	1-water tank, 1-roller; includes 0.25 foreman								
Pile drivers (no. of workers)														
Carpenter (no. of workers)							2.25	includes 0.25 foreman						
Total crew size (no. of workers)	**6.50**		**11.00**		**6.50**		**7.00**		**8.00**		**6.00**		**11.00**	
Quantity/Unit	371	cu yards fill	10,000	sq feet liner	124	cu yards sand	167	sq feet forms	10,000	sq feet concrete slab	10,000	sq feet steel mesh	59.3	cu yards curb (equal to 400 feet 4' by 12" thick curb)
Rate of Work (b)	2,928	fill layer (cu yards/day)	2,000	install liner (sq feet/day)	2,928	install layer (cu yards/day)	480	form work (sq feet/day)	7,088	pour slab (sq feet/day) (equal to 219 cu yards/day)	2,500	install steel mesh (sq feet/day)	90.0	pour curb (cu yards/day)
Duration of Work based on Modified Level D P PE (days) (c)	0.15		6.00		0.05		0.42		1.69		4.80		0.79	
Duration of Work (years)	**0.0006**		**0.02**		**0.0002**		**0.0017**		**0.01**		**0.02**		**0.003**	
Crew Manpower Requirements														
Regulatory oversight/inspector (worker-years)	0.0006		0.024		0.0002		0.002		0.007		0.019		0.003	
Health and safety monitor (worker-years)	0.0006		0.024		0.0002		0.002		0.007		0.019		0.003	
Manager/site engineer (worker-years)	0.0006		0.024		0.0002		0.002		0.007		0.019		0.003	
Foreman (worker-years)	0.0005				0.0002		0.001				0.010			
Excavator/loader operators (worker-years)														
Dozer operator (worker-years)	0.0006				0.0002									
On-site truck drivers (worker-years)	0.0006		0.024		0.0002									
Laborers (worker-years)	0.0003		0.168		0.0001		0.002		0.034		0.048		0.022	
Crane/shovel operator (worker-years)													0.003	
Equipment operator (worker-years)	0.0002				0.0001									
Pile drivers (worker-years)														
Carpenter (worker-years)							0.004							
Total manpower requirements (worker-years)	0.0040		0.264		0.0013		0.012		0.054		0.115		0.035	

TABLE E-A-2 Estimated Manpower Requirements for Alternative 7, Shallow Excavation Remedy	Contact Barrier and Cover System (f)							
	Subgrade Preparation		Spread and Compact 6" asphalt layer		Place 12" soil layer		Place 6" topsoil layer	
Crew (based on Means 1999, unless otherwise noted)	Crew COFCR		Crew COFCP		Crew COFCO		Crew CODTG	
Regulatory oversight/inspector (no. of workers)	1		1		1		1	
Health and safety monitor (no. of workers)	1		1		1		1	
Manager/site engineer (no. of workers)	1		1		1		1	
Foreman (no. of workers) (a)			0.75		0.75		0.75	
Excavator/loader operators (no. of workers)								
Dozer operator (no. of workers)	1	1-dozer			1	1-dozer	1	1-dozer
On-site truck drivers (no. of workers)	1	2-trucks		1-truck	1	1-truck		
Laborers (no. of workers)			0.5		0.5			
Crane/shovel operator (no. of workers)								
Equipment operator (no. of workers)	6	2-rollers, 2-compactors, 1-grader; includes 1 foreman	2.25	1-roller; includes 0.25 foreman	0.25	1-water tank, 1-roller; includes 0.25 foreman	0.25	0.25 foreman
Pile drivers (no. of workers)								
Carpenter (no. of workers)								
Total crew size (no. of workers)	**11.00**		**6.50**		**6.50**		**5.00**	
Quantity/Unit	**19,017**	**cu yards soil**	**38,278**	**sq yards asphalt**	**12,534**	**cu yards soil**	**38,278**	**sq yards topsoil**
Rate of Work (b)	13,360	subgrade prep (cu yards/day)	49,296	installing asphalt (sq yards/day)	2,928	place soil (cu yard/day)	3,588	spread topsoil (sq yards/day)
Duration of Work based on Modified Level D P PE (days) (c)	1.71		0.93		5.14		12.80	
Duration of Work (years)	**0.007**		**0.004**		**0.02**		**0.05**	
Crew Manpower Requirements								
Regulatory oversight/inspector (worker-years)	0.007		0.004		0.021		0.051	
Health and safety monitor (worker-years)	0.007		0.004		0.021		0.051	
Manager/site engineer (worker-years)	0.007		0.004		0.021		0.051	
Foreman (worker-years)			0.003		0.015		0.038	
Excavator/loader operators (worker-years)								
Dozer operator (worker-years)	0.007				0.021		0.051	
On-site truck drivers (worker-years)	0.007				0.021			
Laborers (worker-years)			0.002		0.010			
Crane/shovel operator (worker-years)								
Equipment operator (worker-years)	0.041		0.008		0.005		0.013	
Pile drivers (worker-years)								
Carpenter (worker-years)								
Total manpower requirements (worker-years)	0.075		0.024		0.134		0.256	

TABLE E-A-2 Estimated Manpower Requirements for Alternative 7, Shallow Excavation Remedy	Install Slurry Wall Trench											
	Cut/Remove Concrete (g)		Slurry wall excavation (h,i)		Slurry mixing and placement		Soil/bentonite mixing (i)		Slurry trench backfill (i)		Install monitoring well	
Crew (based on Means 1999, unless otherwise noted)	ENVIRON/IT		Crew CODEU		Crew ULABR		Crew CODTU		Crew CODLK		ENVIRON	
Regulatory oversight/inspector (no. of workers)	1				1						1	
Health and safety monitor (no. of workers)	1				1						1	
Manager/site engineer (no. of workers)	1				1						1	
Foreman (no. of workers) (a)	1				0.5							
Excavator/loader operators (no. of workers)							1	1-loader	1	1-loader		
Dozer operator (no. of workers)							2	2-dozer				
On-site truck drivers (no. of workers)	1										1	1-truck
Laborers (no. of workers)	1		2	includes 1-oilers	2.5	includes 0.5 foreman	0.5				1	1-foreman
Crane/shovel operator (no. of workers)			1									
Equipment operator (no. of workers)	3				1	1-grout pump					1	1-drill rig
Pile drivers (no. of workers)												
Carpenter (no. of workers)												
Total crew size (no. of workers)	**9.00**		**3.00**		**7.00**		**3.50**		**1.00**		**6.00**	
Quantity/Unit	9,900	sq feet surface	3,300	cu yards soil	666,467	gallons slurry	3,300	cu yards bentonite	3,300	cu yards backfill	18	total no. wells
Rate of Work (b)	792	(estimated) cut/remove (sq feet/day)	4,160	excavation (cu yards/day)	17,504	pump slurry (gallons/day)	1,168	pour bentonite (cu yard/day)	472	backfill trench (cu yards/day)	2	install wells (no. wells/day)
Duration of Work based on Modified Level D P PE (days) (c)	15.00		0.95		45.69		3.39		8.39		13.50	
Duration of Work (years)	**0.06**		**0.00**		**0.18**		**0.01**		**0.03**		**0.05**	
Crew Manpower Requirements												
Regulatory oversight/inspector (worker-years)	0.060				0.183						0.054	
Health and safety monitor (worker-years)	0.060				0.183						0.054	
Manager/site engineer (worker-years)	0.060				0.183						0.054	
Foreman (worker-years)	0.060				0.091							
Excavator/loader operators (worker-years)							0.014		0.034			
Dozer operator (worker-years)							0.027					
On-site truck drivers (worker-years)	0.060										0.054	
Laborers (worker-years)	0.060		0.01		0.457		0.007				0.054	
Crane/shovel operator (worker-years)			0.00									
Equipment operator (worker-years)	0.180				0.183						0.054	
Pile drivers (worker-years)												
Carpenter (worker-years)												
Total manpower requirements (worker-years)	0.540		0.01		1.279		0.047		0.034		0.324	

TABLE E-A-2
Estimated Manpower Requirements
for Alternative 7, Shallow Excavation Remedy

	Install Bulkhead		Total Manpower Requirements for all Tasks
Crew (based on Means 1999, unless otherwise noted)	Crew CPIDV		–
Regulatory oversight/inspector (no. of workers)	1		–
Health and safety monitor (no. of workers)	1		–
Manager/site engineer (no. of workers)	1		–
Foreman (no. of workers) (a)			–
Excavator/loader operators (no. of workers)			–
Dozer operator (no. of workers)			–
On-site truck drivers (no. of workers)			–
Laborers (no. of workers)	1	1-oilers	–
Crane/shovel operator (no. of workers)	2	crane	–
Equipment operator (no. of workers)			–
Pile drivers (no. of workers)	3	includes 1 foreman	–
Carpenter (no. of workers)			–
Total crew size (no. of workers)	**9.00**		–
Quantity/Unit	65,000	sq feet sheetpile	–
Rate of Work (b)	336	install sheeting (sq feet/day)	–
Duration of Work based on Modified Level D P PE (days) (c)	232.14		–
Duration of Work (years)	**0.93**		–
Crew Manpower Requirements			–
Regulatory oversight/inspector (worker-years)	0.929		**8.19**
Health and safety monitor (worker-years)	0.929		**14.37**
Manager/site engineer (worker-years)	0.929		**14.37**
Foreman (worker-years)			**13.22**
Excavator/loader operators (worker-years)			**7.15**
Dozer operator (worker-years)			**0.92**
On-site truck drivers (worker-years)			**1.16**
Laborers (worker-years)	0.929		**33.49**
Crane/shovel operator (worker-years)	1.857		**1.86**
Equipment operator (worker-years)			**6.77**
Pile drivers (worker-years)	2.786		**2.79**
Carpenter (worker-years)			**0.00**
Total manpower requirements (worker-years)	8.357		**104.28**

Notes:

(a) One foreman was assumed to be necessary for each task or group of related tasks performed concurrently. In cases where R.S. Means included a foreman or fraction thereof, as part of the labor crew, the number for the foreman was adjusted to equal the default value of 1.

(b) All rates of work based on 8-hr work day

(c) All duration of work estimates include adjustment of 1.2 fold to account for use of modified Level D P PE, unless otherwise noted.

(d) Soil excavation, hauling soil to staging area, and soil staging area loadout are concurrent activities; therefore, the same supervisory personnel assigned for soil excavation are assumed to provide oversight for the concurrent activities.

(e) Barge loadout of soil and hauling soil to backfill area are concurrent activities; therefore, the same supervisory personnel assigned for barge loadout of soil are assumed to provide oversight for the concurrent activity.

(f) Area to be covered assumed to be 115,000 sq feet.

(g) Production rate estimated by E NVIRON/IT

(h) Excavated area assumed to be 10 feet wide x 30 feet deep x 990 feet long.

(i) Slurry wall excavation, slurry mixing and placement, soil/bentonite mixing, and slurry trench backfill are concurrent activities; therefore, the same supervisory personnel assigned for slurry mixing and placement are assumed to provide oversight for the concurrent activities.

(j) Building demolition subtasks based on data from prior site experience. IT estimates that level of effort required for additional demolition activity will be approximately twice that for previously demolished buildings as a result of differences in construction type, location, and presence of utilities.

(k) Adjusted by a factor of 1.8 to account for Level C P PE

TABLE E-A-3 Estimated Manpower Requirements for Alternative 8, Containment Remedy Harbor-at-Hastings Site, Hastings-On-Hudson, NY	Building Demolition						Soil Excavation/Loadout						Soil Backfilling			
	Asbestos Removal		Decontamination		Demolition & Loading		Soil Excavation of Hot Spots		Haul Soil to Staging Area (d)		Soil Staging Area Loadout (d)		Barge Loadout		Haul Soil to Backfill Area (e)	
Crew (based on Means 1999, unless otherwise noted)	ENVIRON/IT		ENVIRON/IT		ENVIRON/IT		Crew CODEO +dozer		Crew COEID x 2		Crew CODEO + dozer		Crew CODEO+dozer		Crew COEID x 2	
Regulatory oversight/inspector (no. of workers)			1		1		1						1			
Health and safety monitor (no. of workers)	1		1		1		1						1			
Manager/site engineer (no. of workers)	1		1		1		1						1			
Foreman (no. of workers) (a)	1		1		1		1						1			
Excavator/loader operators (no. of workers)			1	1-wheeled loader	1	1-tracked loader and 1-excavator with shears	1	1-excavator			1	1-excavator	1	1-excavator		
Dozer operator (no. of workers)							1	1-dozer			1	1-dozer	1	1-dozer		
On-site truck drivers (no. of workers)									2	2-trucks					2	2-trucks
Laborers (no. of workers)	5						1				1		1			
Crane/shovel operator (no. of workers)																
Equipment operator (no. of workers)			1		1											
Pile drivers (no. of workers)																
Carpenter (no. of workers)																
Total crew size (no. of workers)	**8.00**		**6.00**		**6.00**		**7.00**		**2.00**		**3.00**		**7.00**		**2.00**	
Quantity/Unit	570,200	sq feet building	570,200	sq feet building	570,200	sq feet building	658	cu yards soil	658	cu yards soil	658	cu yards soil	658	cu yards soil	658	cu yards soil
Rate of Work (b)	664.8	asbestos removal (sq feet/day) (j)	3,322.4	building decontaminatio n (sq feet/day) (j)	542.4	building demolition (sq feet/day) (i)	320	soil excavation (cu yards/day)	392	hauling soil (cu yards/day)	320	soil loadout (cu yards/day)	320	barge loadout (cu yards/day)	320	soil backfilling (cu yards/day)
Duration of Work based on Modified Level D P PE (days) (c)	1,544	(k)	309	(k)	1,262		2.47		2.01		2.47		2.47		2.47	
Duration of Work (years)	**6.18**		**1.24**		**5.05**		**0.01**		**0.01**		**0.01**		**0.01**		**0.01**	
Crew Manpower Requirements																
Regulatory oversight/inspector (worker-years)			1.236		5.046		0.010						0.010			
Health and safety monitor (worker-years)	6.175		1.236		5.046		0.010						0.010			
Manager/site engineer (worker-years)	6.175		1.236		5.046		0.010						0.010			
Foreman (worker-years)	6.175		1.236		5.046		0.010						0.010			
Excavator/loader operators (worker-years)			1.236		5.046		0.010				0.010		0.010			
Dozer operator (worker-years)							0.010				0.010		0.010			
On-site truck drivers (worker-years)									0.016						0.020	
Laborers (worker-years)	30.877						0.010				0.010		0.010			
Crane/shovel operator (worker-years)																
Equipment operator (worker-years)			1.236		5.046											
Pile drivers (worker-years)																
Carpenter (worker-years)																
Total manpower requirements (worker-years)	49.404		7.414		30.276		0.069		0.016		0.030		0.069		0.020	

TABLE E-A-3 Estimated Manpower Requirements for Alternative 8, Containment Remedy Harbor-at-Hastings Site, Hastings-On-Hudson, NY	Development of Soil Staging Facility													
	Select Fill Layer		Install 40 mil liner		Install Sand Layer		Prepare Form Work		Pour 8" thick concrete reinforced slab		Install Steel Mesh		Install 4" high by 12" thick concrete curb/wall	
Crew (based on Means 1999, unless otherwise noted)	Crew COFCO		Crew USKCF		Crew COFCO		Crew ACARI		Crew ALABE		Crew SIWRB		Crew ALABG	
Regulatory oversight/inspector (no. of workers)	1		1		1		1		1		1		1	
Health and safety monitor (no. of workers)	1		1		1		1		1		1		1	
Manager/site engineer (no. of workers)	1		1		1		1		1		1		1	
Foreman (no. of workers) (a)	0.75				0.75		0.75				0.5			
Excavator/loader operators (no. of workers)														
Dozer operator (no. of workers)	1	1-dozer			1	1-dozer								
On-site truck drivers (no. of workers)	1	1-truck	1	1-truck	1	1-truck								
Laborers (no. of workers)	0.5		7	includes 1-foreman	0.5		1		5	1-vibrator, 1-generator, 1-cement finisher; includes 1 foreman	2.5	includes 0.5 foreman, reinforcing work	7	2-vibrators, 1- generator; includes 1 foreman and 1 oilers
Crane/shovel operator (no. of workers)													1	1-crane
Equipment operator (no. of workers)	0.25	1-roller, 1-water tank; includes 0.25 foreman			0.25	1-water tank, 1-roller; includes 0.25 foreman								
Pile drivers (no. of workers)														
Carpenter (no. of workers)							2.25	includes 0.25 foreman						
Total crew size (no. of workers)	**6.50**		**11.00**		**6.50**		**7.00**		**8.00**		**6.00**		**11.00**	
Quantity/Unit	371	cu yards fill	10,000	sq feet liner	124	cu yards sand	167	sq feet forms	10,000	sq feet concrete slab	10,000	sq feet steel mesh	59.3	cu yards curb (equal to 400 feet 4' by 12" thick curb)
Rate of Work (b)	2,928	fill layer (cu yards/day)	2,000	install liner (sq feet/day)	2,928	install layer (cu yards/day)	480	form work (sq feet/day)	7,088	pour slab (sq feet/day) (equal to 219 cu yards/day)	2,500	install steel mesh (sq feet/day)	90.0	pour curb (cu yards/day)
Duration of Work based on Modified Level D P PE (days) (c)	0.15		6.00		0.05		0.42		1.69		4.80		0.79	
Duration of Work (years)	**0.0006**		**0.02**		**0.0002**		**0.0017**		**0.01**		**0.02**		**0.003**	
Crew Manpower Requirements														
Regulatory oversight/inspector (worker-years)	0.0006		0.024		0.0002		0.002		0.007		0.019		0.003	
Health and safety monitor (worker-years)	0.0006		0.024		0.0002		0.002		0.007		0.019		0.003	
Manager/site engineer (worker-years)	0.0006		0.024		0.0002		0.002		0.007		0.019		0.003	
Foreman (worker-years)	0.0005				0.0002		0.001				0.010			
Excavator/loader operators (worker-years)														
Dozer operator (worker-years)	0.0006				0.0002									
On-site truck drivers (worker-years)	0.0006		0.024		0.0002									
Laborers (worker-years)	0.0003		0.168		0.0001		0.002		0.034		0.048		0.022	
Crane/shovel operator (worker-years)													0.003	
Equipment operator (worker-years)	0.0002				0.0001									
Pile drivers (worker-years)														
Carpenter (worker-years)							0.004							
Total manpower requirements (worker-years)	0.0040		0.264		0.0013		0.012		0.054		0.115		0.035	

TABLE E-A-3 Estimated Manpower Requirements for Alternative 8, Containment Remedy Harbor-at-Hastings Site, Hastings-On-Hudson, NY	Contact Barrier and Cover System (f)							
	Subgrade Preparation		Spread and Compact 6" asphalt layer		Place 12" soil layer		Place 6" topsoil layer	
Crew (based on Means 1999, unless otherwise noted)	Crew COFCR		Crew COFCP		Crew COFCO		Crew CODTG	
Regulatory oversight/inspector (no. of workers)	1		1		1		1	
Health and safety monitor (no. of workers)	1		1		1		1	
Manager/site engineer (no. of workers)	1		1		1		1	
Foreman (no. of workers) (a)			0.75		0.75		0.75	
Excavator/loader operators (no. of workers)								
Dozer operator (no. of workers)	1	1-dozer			1	1-dozer	1	1-dozer
On-site truck drivers (no. of workers)	1	2-trucks		1-truck	1	1-truck		
Laborers (no. of workers)			0.5		0.5			
Crane/shovel operator (no. of workers)								
Equipment operator (no. of workers)	6	2-rollers, 2-compactors, 1-grader; includes 1 foreman	2.25	1-roller; includes 0.25 foreman	0.25	1-water tank, 1-roller; includes 0.25 foreman	0.25	0.25 foreman
Pile drivers (no. of workers)								
Carpenter (no. of workers)								
Total crew size (no. of workers)	**11.00**		**6.50**		**6.50**		**5.00**	
Quantity/Unit	19,017	cu yards soil	38,278	sq yards asphalt	12,534	cu yards soil	38,278	sq yards topsoil
Rate of Work (b)	13,360	subgrade prep (cu yards/day)	49,296	installing asphalt (sq yards/day)	2,928	place soil (cu yard/day)	3,588	spread topsoil (sq yards/day)
Duration of Work based on Modified Level D P PE (days) (c)	1.71		0.93		5.14		12.80	
Duration of Work (years)	**0.007**		**0.004**		**0.02**		**0.05**	
Crew Manpower Requirements								
Regulatory oversight/inspector (worker-years)	0.007		0.004		0.021		0.051	
Health and safety monitor (worker-years)	0.007		0.004		0.021		0.051	
Manager/site engineer (worker-years)	0.007		0.004		0.021		0.051	
Foreman (worker-years)			0.003		0.015		0.038	
Excavator/loader operators (worker-years)								
Dozer operator (worker-years)	0.007				0.021		0.051	
On-site truck drivers (worker-years)	0.007				0.021			
Laborers (worker-years)			0.002		0.010			
Crane/shovel operator (worker-years)								
Equipment operator (worker-years)	0.041		0.008		0.005		0.013	
Pile drivers (worker-years)								
Carpenter (worker-years)								
Total manpower requirements (worker-years)	0.075		0.024		0.134		0.256	

TABLE E-A-3 Estimated Manpower Requirements for Alternative 8, Containment Remedy Harbor-at-Hastings Site, Hastings-On-Hudson, NY	Install Slurry Wall Trench										Install monitoring well	
	Cut/Remove Concrete (g)		Slurry wall excavation (h,i)		Slurry mixing and placement		Soil/bentonite mixing (i)		Slurry trench backfill (i)			
Crew (based on Means 1999, unless otherwise noted)	ENVIRON/IT		Crew CODEU		Crew ULABR		Crew CODTU		Crew CODLK		ENVIRON	
Regulatory oversight/inspector (no. of workers)	1				1						1	
Health and safety monitor (no. of workers)	1				1						1	
Manager/site engineer (no. of workers)	1				1						1	
Foreman (no. of workers) (a)	1				0.5							
Excavator/loader operators (no. of workers)							1	1-loader	1	1-loader		
Dozer operator (no. of workers)							2	2-dozer				
On-site truck drivers (no. of workers)	1										1	1-truck
Laborers (no. of workers)	1		2	includes 1-oilers	2.5	includes 0.5 foreman	0.5				1	1-foreman
Crane/shovel operator (no. of workers)			1									
Equipment operator (no. of workers)	3				1	1-grout pump					1	1-drill rig
Pile drivers (no. of workers)												
Carpenter (no. of workers)												
Total crew size (no. of workers)	**9.00**		**3.00**		**7.00**		**3.50**		**1.00**		**6.00**	
Quantity/Unit	9,900	sq feet surface	3,300	cu yards soil	666,467	gallons slurry	3,300	cu yards bentonite	3,300	cu yards backfill	18	total no. wells
Rate of Work (b)	792	(estimated) cut/remove (sq feet/day)	4,160	excavation (cu yards/day)	17,504	pump slurry (gallons/day)	1,168	pour bentonite (cu yard/day)	472	backfill trench (cu yards/day)	2	install wells (no. wells/day)
Duration of Work based on Modified Level D P PE (days) (c)	15.00		0.95		45.69		3.39		8.39		13.50	
Duration of Work (years)	**0.06**		**0.00**		**0.18**		**0.01**		**0.03**		**0.05**	
Crew Manpower Requirements												
Regulatory oversight/inspector (worker-years)	0.060				0.183						0.054	
Health and safety monitor (worker-years)	0.060				0.183						0.054	
Manager/site engineer (worker-years)	0.060				0.183						0.054	
Foreman (worker-years)	0.060				0.091							
Excavator/loader operators (worker-years)							0.014		0.034			
Dozer operator (worker-years)							0.027					
On-site truck drivers (worker-years)	0.060										0.054	
Laborers (worker-years)	0.060		0.01		0.457		0.007				0.054	
Crane/shovel operator (worker-years)			0.00									
Equipment operator (worker-years)	0.180				0.183						0.054	
Pile drivers (worker-years)												
Carpenter (worker-years)												
Total manpower requirements (worker-years)	0.540		0.01		1.279		0.047		0.034		0.324	

TABLE E-A-3
Estimated Manpower Requirements
for Alternative 8, Containment Remedy
Harbor-at-Hastings Site, Hastings-On-Hudson, NY

	Install Bulkhead		Total Manpower Requirements for all Tasks
Crew (based on Means 1999, unless otherwise noted)	Crew CPIDV		–
Regulatory oversight/inspector (no. of workers)	1		–
Health and safety monitor (no. of workers)	1		–
Manager/site engineer (no. of workers)	1		–
Foreman (no. of workers) (a)			–
Excavator/loader operators (no. of workers)			–
Dozer operator (no. of workers)			–
On-site truck drivers (no. of workers)			–
Laborers (no. of workers)	1	1-oilers	–
Crane/shovel operator (no. of workers)	2	crane	–
Equipment operator (no. of workers)			–
Pile drivers (no. of workers)	3	includes 1 foreman	–
Carpenter (no. of workers)			–
Total crew size (no. of workers)	**9.00**		–
Quantity/Unit	65,000	sq feet sheetpile	–
Rate of Work (b)	336	install sheeting (sq feet/day)	–
Duration of Work based on Modified Level D P PE (days) (c)	232.14		–
Duration of Work (years)	**0.93**		–
Crew Manpower Requirements			–
Regulatory oversight/inspector (worker-years)	0.929		**7.66**
Health and safety monitor (worker-years)	0.929		**13.84**
Manager/site engineer (worker-years)	0.929		**13.84**
Foreman (worker-years)			**12.70**
Excavator/loader operators (worker-years)			**6.36**
Dozer operator (worker-years)			**0.14**
On-site truck drivers (worker-years)			**0.20**
Laborers (worker-years)	0.929		**32.71**
Crane/shovel operator (worker-years)	1.857		**1.86**
Equipment operator (worker-years)			**6.77**
Pile drivers (worker-years)	2.786		**2.79**
Carpenter (worker-years)			**0.00**
Total manpower requirements (worker-years)	8.357		**98.86**

Notes:

(a) One foreman was assumed to be necessary for each task or group of related tasks performed concurrently. In cases where R.S. Means included a foreman or fraction thereof, as part of the labor crew, the number for the foreman was adjusted to equal the default value of 1.

(b) All rates of work based on 8-hr work day

(c) All duration of work estimates include adjustment of 1.2 fold to account for use of modified Level D P PE, unless otherwise noted.

(d) Soil excavation, hauling soil to staging area, and soil staging area loadout are concurrent activities; therefore, the same supervisory personnel assigned for soil excavation are assumed to provide oversight for the concurrent activities.

(e) Barge loadout of soil and hauling soil to backfill area are concurrent activities; therefore, the same supervisory personnel assigned for barge loadout of soil are assumed to provide oversight for the concurrent activity.

(f) Area to be covered assumed to be 115,000 sq feet.

(g) Production rate estimated by E NVIRON/IT

(h) Excavated area assumed to be 10 feet wide x 30 feet deep x 990 feet long.

(i) Slurry wall excavation, slurry mixing and placement, soil/bentonite mixing, and slurry trench backfill are concurrent activities; therefore, the same supervisory personnel assigned for slurry mixing and placement are assumed to provide oversight for the concurrent activities.

(j) Building demolition subtasks based on data from prior site experience. IT estimates that level of effort required for additional demolition activity will be approximately twice that for previously demolished buildings as a result of differences in construction type, location, and presence of utilities.

(k) Adjusted by a factor of 1.8 to account for Level C P PE

ATTACHMENT E-B

Materials Routing and Travel Distances for Remedy Implementation

ATTACHMENT E-B

Materials Routing and Travel Distances for Remedy Implementation

E-B.1 Materials Transportation for Alternative 3 (Excavation Alternative)

Alternative 3 would involve the following major materials transportation components:

- Demolition debris by truck as follows:
  - general material to landfills located in either Dunmore, Pennsylvania; Kersey, Pennsylvania; or Johnstown, Pennsylvania (332 miles). For this assessment, it was assumed that all debris is transported to Kersey, Pennsylvania.
  - steel to Bronx, New York
  - wood to Farmington, New York
- Excavated soil containing PCBs ≥10 ppm to Clive, Utah by rail
- Excavated soil containing PCBs <10 ppm to Davidsville, Pennsylvania (near Holesopple), by truck
- Backfill and topsoil by barge from barrier sources within a 75 mile radius

Routing and distances for each of these destinations is summarized below.

<u>Truck Route to Kersey, Pennsylvania</u>

Demolition of on-site buildings is expected to result in 570,200 square feet of demolition debris. Based on IT (2001), 62% of this debris (i.e. 20,905 cubic yards) is expected to be general demolition debris that will be disposed of at one of the following three landfills:

Keystone Landfill in Dunmore, Pennsylvania,
Superior Greentree Landfill in Kersey, Pennsylvania, or
Shade Landfill in Johnstown, Pennsylvania.

Dunmore, Kersey, and Johnstown are located approximately 129, 317 and 332 miles from the Site, respectively. For this assessment, it was assumed that all debris is transported to Superior

Greentree Landfill in Kersey, Pennsylvania.

Assuming that each truck can hold 15 cubic yards, 1,394 trucks will be needed to transport general demolition debris to Kersey, Pennsylvania. Trucks transporting general demolition debris from the Site to Kersey, Pennsylvania are assumed to follow the following route (Expedia.com 2001):

0.1 miles north on River St (North);
less than 0.1 mile east on W Main St;
0.1 miles west on Southside Ave;
0.3 miles east on Washington Ave;
0.2 miles north on US-9 [Broadway];
1.2 miles south-east on Farragut Pky;
3.2 miles south on Saw Mill Pky [Saw Mill River Pky S];
2.4 miles south on SR-9A [Saw Mill Pky];
0.9 miles south on Mosholu Pky S;
0.2 miles south on Ramp;
3.5 miles south on I-87 [Major Deegan Expy];
0.6 miles on Ramp;
5.2 miles south on I-95 [US-1] (enter New Jersey);
0.5 miles on Ramp;
283 miles west on I-80 (enter Pennsylvania);
14.1 miles north on US-219;
0.6 miles east on SR-2003;
1.0 mile north-east on Toby Rd; and
less than 0.2 miles south-east on local roads to arrive at Superior Greentree Landfill.

The total trip one-way is 317 miles. Two miles of this route, from River Street to Farragut Parkway, are considered to be on local roads.

<u>Truck Route to Bronx, New York</u>

Based on IT (2001), 33% of the building debris (i.e. 11,127 cubic yards) is expected to be made up of steel that will be disposed of at PASCAP, Co. in Bronx, NY. Assuming that each truck can hold 15 cubic yards, 742 trucks are needed to transport steel demolition debris to Bronx, NY. Trucks transporting steel demolition debris from the Site to Bronx, NY are expected to follow the following route (Expedia.com 2001):

0.1 miles north on River St;
less than 0.1 mile east on W Main St;
0.1 miles west on Southside Ave;
0.3 miles east on Washington Ave;
0.2 miles north on US-9 [Broadway];
1.2 miles south-east on Farragut Pky;

3.2 miles south on Saw Mill Pky [Saw Mill River Pky S];
0.4 miles south on SR-9A [Saw Mill Pky];
0.4 miles on Ramp;
3.3 miles east on Cross County Pky;
0.5 miles east on Ramp;
1.9 miles south on Hutchinson River Pky S;
0.2 miles south on Ramp;
0.2 miles west on US-1 [Boston Post Rd];
0.2 miles west on Boston Rd; and
less than 0.2 miles south on local roads to PASCAP Co.

The total trip one-way is 12.3 miles. Two miles of this route, from River Street to Farragut Parkway, are considered to be on local roads.

Truck Route to Farmington, NY

Based on IT (2001), 5% of the building demolition debris (i.e. 1,686 cubic yards) is expected to be made up of wood that will be disposed of at Pioneer Millworks in Farmington, NY. Assuming that each truck can hold 15 cubic yards, 112 trucks will be needed to transport wood demolition debris to Farmington, NY. Trucks transporting wood demolition debris from the Site to Farmington, NY are expected to follow the following route (Expedia.com 2001):

0.1 miles north on River St;
less than 0.1 mile east on W Main St;
0.1 miles west on Southside Ave;
0.3 miles east on Washington Ave;
0.2 miles north on US-9 [Broadway];
1.2 miles south-east onto Farragut Pky;
4.5 miles north on Saw Mill Pky [Saw Mill River Pky N];
0.4 miles north-east on ramp;
2.5 miles north on I-87 [New York State Thwy];
0.2 miles north on I-87 [I-287];
7.4 miles north-west on I-87 [I-287];
0.5 miles on Ramp;
12.6 miles north on Palisades Interstate Pky;
2.4 miles north-east on Palisades Pky;
0.2 miles north in local roads;
0.1 mile north-west on local roads;
20.1 miles north on US-6 [7 Lakes Dr];
117 miles north on SR-17;
77.9 miles north-west on I-81 [SR-17];
7.3 miles west on I-690;
38.5 miles west on I-90 [New York State Thwy];
0.5 miles south on SR-14;

19.7 miles west on SR-96;
0.3 miles north on Commercial Drive; and
less than 0.1 mile arrive at Pioneer Mill Works.

The total trip one-way is 314 miles. Two miles of this route, from River Street to Farragut Parkway, are considered to be on local roads.

Train Route to Clive, Utah

Under Remedy Alternative 3 (excavation remedy), 126,136 cubic yards of excavated soil having a PCB concentration greater than 10 ppm will be disposed of at Safety Kleen Grassy Mountain facility in Clive, Utah. The rail-route from the Site to Clive, Utah is approximately 2,525 rail miles from the Site. The rail miles are estimated based on 875 rail miles between New Jersey and Chicago (ENVIRON 2001), and 1,650 rail miles between Chicago and Clive, Utah (BNSF 2001). The rail miles may be slightly underestimated since this estimate does not include the distance between the Site and New Jersey, and Clive and the Grassy Mountain facility. Slightly underestimating rail miles will cause the fatality rate to be slightly underestimated. For comparison purposes, there are 2,188 truck miles from the Site to Salt Lake City, Utah.

In order to transport the PCB contaminated excavated soil from the Site to Clive, Utah, 60 trains will be needed, based on the following assumptions:

- Each container can hold 15 cubic yards;
- Each rail car can hold two containers; and
- Each train carries 70 cars.

Truck Route to Davidsville, PA

Under Remedy Alternative 3 (excavation remedy), 182,680 cubic yards of excavated soil will be disposed at Waste Management in Davidsville, Pennsylvania (near Holeshopple). Assuming that each truck can hold 15 cubic yards, 12,179 trucks will be needed to transport the excavated soil to Davidsville, PA. Trucks transporting excavated soil from the Site to Davidsville, PA are expected to follow the following route (Expedia.com 2001):

0.1 miles north on River St;
less than 0.1 mile east on W Main St;
0.1 miles west on Southside Ave;
0.3 miles east on Washington Ave;
0.2 miles north on US-9 [Broadway];
1.2 miles south-east on Farragut Pky;
3.2 miles south on Saw Mill Pky [Saw Mill River Pky S];
2.4 miles south on SR-9A [Saw Mill Pky];

0.9 miles south on Mosholu Pky S;
0.2 miles south on Ramp;
3.5 miles south on I-87 [Major Deegan Expy];
0.6 miles on Ramp;
6.8 miles south on I-95 [US-1] (enter New Jersey);
11 miles south on I-95 [New Jersey Tpke];
1.7 miles on Ramp;
less than 0.2 miles west on I-78;
136 miles west on I-78 (enter Pennsylvania);
37.4 miles west on I-81;
66.7 miles west on I-76 [Pennsylvania Tpke];
16 miles west on I-70 [I-76];
1.7 miles south on I-99 [US-220];
31.4 miles north-west on US-30 [Lincoln Hwy];
7.6 miles north on US-219;
0.1 miles north on SR-403; and
less than 0.1 mile arrive at S Main Street, Davidsville.

The total trip from the Site to Davidsville one-way is about 329 miles. Note that the actual distance from S. Main Street in Davidsville to the Landfill is not accounted for. This may slightly under or over estimate risk of fatalities, depending on the actual distance. Two miles of this route, from River Street to Farragut Parkway, are considered to be on local roads.

Barge Route from Clean Fill provider to Site

Under Remedy Alternative 3 (excavation remedy), approximately 308,816 cubic yards of clean fill will be transported by barge to the Site. The clean fill supplier is assumed to be 75 river-miles from the Site. Assuming a barge carries 40 containers and each container is 15 cubic yards (PBQ&D 1999), 515 barges will be needed to transport the clean backfill from the supplier to the Site.

E-B.2 Materials Transportation for Alternative 7 (Shallow Excavation Alternative)

Alternative 7 would involve the following major materials transportation components:

- Demolition debris by truck as follows:
  - general material to landfills located in either Dunmore, Pennsylvania; Kersey, Pennsylvania; or Johnstown, Pennsylvania. For this assessment, it was assumed that all debris is transported to Kersey, Pennsylvania.
  - steel to Bronx, New York
  - wood to Farmington, New York
- Excavated soil containing PCBs $\geq$50 ppm to Clive, Utah by rail
- Backfill, contact barrier and soil cover materials by barge from suppliers within a 75 mile radius

Routing and distances for each of these materials is summarized below.

Truck Route to Kersey, Pennsylvania

The amount of material, the number of trucks needed and the truck route is the same as described above for Alternative 3.

Truck Route to Bronx, New York

The amount of material, the number of trucks needed and the truck route is the same as described above for Alternative 3.

Truck Route to Farmington, NY

The amount of material, the number of trucks needed and the truck route is the same as described above for Alternative 3.

Train Route to Clive, Utah

Under Remedy Alternative 7 (shallow excavation remedy), 18,170 cubic yards of excavated soil having a PCB concentration greater than or equal to 50 ppm will be disposed of at the Safety Kleen Grassy Mountain facility in Clive, Utah. As noted above, the rail-route from the Site to Clive, Utah is estimated to be about 2,525 rail miles from the Site.

In order to transport the PCB contaminated excavated soil from the Site to Clive, Utah, 9 trains will be needed, based on the following assumptions:

- Each container can hold 15 cubic yards;
- Each rail car can hold two containers; and
- Each train carries 70 cars.

Barge Route from Clean Fill and Cover Materials provider to Site

Under Remedy Alternative 7 (shallow excavation remedy), a total of 62,480 cubic yards of material will be transported by barge to the Site. This material includes approximately 18,170 cubic yards of clean fill, 31,551 cubic yards of soil, 6,380 cubic yards of topsoil, and 6,380 cubic yards of asphalt. The supplier(s) of clean fill, soil, topsoil and asphalt is assumed to be 75 river-miles from the Site. One hundred and four (104) barges will be needed to carry the material to the Site from the supplier(s), assuming a barge has a capacity for 40 containers and each container holds 15 cubic yards.

E-B.3 Materials Transportation for Alternative 8 (Containment Alternative)

Alternative 8 would involve the following major materials transportation components:

- Demolition debris by truck as follows:
  - general material to landfills located in either Dunmore, Pennsylvania; Kersey, Pennsylvania; or Johnstown, Pennsylvania. For this assessment, it was assumed that all debris is transported to Kersey, Pennsylvania.
  - steel to Bronx, New York
  - wood to Farmington, New York
- Excavated soil to Model City, New York by truck
- Backfill, contact barrier and capping materials by barge from suppliers within a 75 mile radius

Routing and distances for each of these materials is summarized below.

<u>Truck Route to Kersey, Pennsylvania</u>

The amount of material, the number of trucks needed and the truck route is the same as described above for Alternative 3.

<u>Truck Route to Bronx, New York</u>

The amount of material, the number of trucks needed and the truck route is the same as described above for Alternative 3.

<u>Truck Route to Farmington, NY</u>

The amount of material, the number of trucks needed and the truck route is the same as described above for Alternative 3.

<u>Truck Route to Model City, NY</u>

Under Remedy Alternative 8 (containment remedy), 658 cubic yards of excavated soil will be disposed of at the Model City Landfill in Model City, NY. Assuming that each truck can hold 15 cubic yards, 44 trucks will be needed to transport the excavated soil to Model City, NY. Trucks transporting excavated soil from the Site to Model City, NY are expected to follow the following route (Expedia.com 2001):

0.1 miles north on River St;
less than 0.1 mile east on W Main St;

0.1 miles west on Southside Ave;
0.3 miles east on Washington Ave;
0.2 miles north on US-9 [Broadway];
1.2 miles south-east on Farragut Pky;
4.5 miles north on Saw Mill Parkway [Saw Mill River Pkwy N];
0.4 miles north-east on Ramp;
2.5 miles north on I-87 [New York State Thwy];
7.6 miles north-west on I-87 [I-287];
0.5 miles on Ramp;
12.6 miles north on Palisades Interstate Pky;
2.4 miles north-east on Palisades Pky;
0.2 miles north on local roads;
0.1 miles north-west on local roads;
20.1 miles north on US-6 [7 Lakes Dr];
117 miles north on SR-17;
77.9 miles north-west on I-81 [SR-17];
7.3 miles west on I-690;
131.5 miles west on I-90 [New York State Thwy];
0.4 miles on Ramp;
9.5 miles west on Merge onto I-290 [Youngmann Expy];
0.3 miles on Ramp;
0.7 miles west on I-190 [New York State Thwy];
1.1 miles north-west on I-190 [SR-324];
5.0 miles west on I-190 [New York State Thwy];
7.1 miles north on I-190 [SR-324];
0.1 miles on Ramp;
0.1 miles north-west on SR-265 [Military Rd];
2.6 miles north-east on CR-11 [Upper Mountain Rd];
0.5 miles north on CR-11 [Indian Hill Rd];
0.2 miles north on Model City Rd; and
less than 1.0 mile to Model City Landfill.

The total trip from the Site to Model City one-way is about 414 miles. Two miles of this route, from River Street to Farragut Parkway, are considered to be on local roads.

Barge Route from Clean Fill and Cover Materials provider to Site

Under Remedy Alternative 8 (containment remedy), a total of 44,968 cubic yards of material will be transported by barge to the Site. This material includes approximately 658 cubic yards of clean fill 31,551 cubic yards of soil, 6,380 cubic yards of topsoil, and 6,380 cubic yards of asphalt. The supplier(s) of clean fill, soil, topsoil and asphalt is assumed to be 75 river-miles from the Site. Seventy-five (75) barges will be needed to carry the material to the Site from the supplier(s), assuming a barge has a capacity for 40 containers and each container holds 15 cubic yards.

ATTACHMENT E-C

Estimation of On-Site Worker Fatalities and Off-Site Transportation-Related Fatalities

ATTACHMENT E-C

Estimation of On-Site Worker Fatalities and Off-Site Transportation-Related Fatalities

E-C.1 Estimation of On-Site Worker Fatalities

The overall fatal injury incidence rate for a remedy alternative is equal to the weighted average of the individual occupational fatality rates, using the percentage distribution of the labor hour inputs as the weighting factor (Hoskin et al. 1994). Assuming that the incidence of fatal injuries follows a Poisson distribution, the number of fatal injuries predicted by the overall fatality rate is equal to the mean of the Poisson distribution (Hoskin et al. 1994):

- Expected number of fatalities (μ) = (worker-years of exposure) (weighted fatality rate), where the total worker-years of exposure is equal to the total estimated time (person-years) for implementing a specific remedy.

- Then the probability of exactly one fatality occurring during a remediation project is estimated based on the Poisson function as follows,

  Probability of exactly one fatality, $f(x) = (e^{-\mu} \bullet \mu^{x})/x!$, where $x = 1$

- The probability or risk of experiencing at least one fatality is then,

  $$f(x \geq 1) = 1 - f(0)$$

Based on this methodology, using manpower requirements developed in Attachment E-A and accident rates taken from the literature (Leigh and Hoskin, 1999) and Bureau of Labor Statistics (BBLS, 1994-1997, 1999), weighted fatality rates were calculated for each labor category involved and summed to predict an overall weighted fatality rate for each remediation alternative. The calculated fatality estimates for each remediation alternative are presented in Tables E-C.1, E-C-2, and E-C.3 for Alternatives 3, 7 and 8, respectively.

E-C.2 Estimation of Off-Site Transportation-Related Fatalities

The potential number of fatalities involving vehicles (truck, trains, barges) transporting Site-related materials (e.g., demolition debris, excavated soil, clean fill material or cover materials) on a particular route (F_s) is calculated by multiplying the vehicle-miles traveled (VMT) by the vehicle transporting Site-related materials on that particular route (referred to hereinafter as "the designated route") by the overall fatal accident frequency on the designated route:

$$F_s = VMT_s \; x \; AF_t$$

where:

- F_s = Number of fatalities involving vehicles carrying Site-related materials (fatalities/remedy alternative)
- VMT_s = Vehicle-miles traveled on the designated route by vehicles carrying Site-related materials (vehicle-miles/remedy period), and
- AF_t = Overall fatal accident frequency on the designated route (fatal accidents/vehicle-miles).

The VMT_s is equal to the length of the designated route (D) multiplied by the number of vehicle trips on the designated route (N_s):

$$VMT_s = D \; x \; N_s$$

where:

- D = Length of the designated route (vehicle miles/trip); and
- N_s = Number of vehicle trips on the designated route (vehicle trips/remedy period).

The overall vehicle accident frequency on the designated route (AF_t) were taken from the following sources for each mode of transport:

Truck A fatality rate of 4×10^{-9} fatalities per truck-mile was used in this analysis based on the average fatality rates for large trucks between 1990 and 1997 based on national transportation statistics for these years (USDOT 1997, 1999).

Train An average fatality rate of 1.5×10^{-6} fatalities per train mile was used in this analysis, based on Federal Railroad Administration accident statistics from 1996 to 1999 on Burlington Northern Sante Fe, Union Pacific, Norfolk Southern and CSX train lines (FRA 1999). For comparison purposes, the average fatality rates for trains between 1990 and 1998 is 9.3×10^{-7} fatalities per train mile based on national transportation statistics for these years (USDOT 1997, 1999). In addition, PBQ&D (1999) provided a fatality rate of 2.3×10^{-8} fatalities per train-car mile.

Barge A fatality rate of 6.7×10^{-6} fatalities per barge-mile was used in this analysis based on information provided by PBQ&D (1999).

The lengths of the designated routes are described in Attachment E-B. The calculation of the number of transportation-related fatalities by each mode of transport is presented in Tables E-C-4, E-C-5 and E-C-6 for Alternatives 3, 7 and 8, respectively.

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TABLE E-C-1
Weighted Fatality Rates
for Alternative 3, Excavation Remedy
Harbor-at-Hastings Site, Hastings-On-Hudson, NY

On-site Remediation Crew	Labor Category	Fatal Accident Rate (per person-year)	Reference/ Source	Estimated Time, adjusted for PPE (person years)	% of Total Remediation Time	Weighted Fatality Rate (no. fatalities per person-year)
Regulatory oversight/inspector	Construction inspector	8.90E-05	Leigh, 1999	21.29	9%	7.73E-06
Health and safety monitor	Construction inspector	8.90E-05	Leigh, 1999	27.47	11%	9.97E-06
Manager/site engineer	Manager	3.20E-05	Leigh, 1999	27.47	11%	3.58E-06
Foreman	Supervisors, construction occupations	1.08E-04	BLS 97,99	24.79	10%	1.09E-05
Excavator/loader operators	Excavating and Loading Machine Operators	2.57E-04	BLS 94,96	23.20	9%	2.43E-05
Dozer operator	Grader, Dozer and Scraper Operators	2.85E-04	BLS 94-95	16.92	7%	1.97E-05
On-site truck drivers	Truck drivers	2.67E-04	BLS 94-97	33.94	14%	3.70E-05
Laborers	Laborers, Construction	3.72E-04	BLS 94-97	51.39	21%	7.79E-05
Crane/shovel operator	Excavating and Loading Machine Operators	2.57E-04	BLS 94,96	5.02	2%	5.24E-06
Equipment operator	Material Moving Equipment Operators	1.56E-04	BLS 94-97	6.28	3%	3.98E-06
Pile drivers	Structural metal workers	8.13E-04	BLS 94,96,99	7.50	3%	2.49E-05
Carpenter	Laborers, Construction	3.72E-04	BLS 94-97	0.02	0%	2.28E-08
			Totals	**245.30**	**100.00%**	**2.25E-04**
			Fatality Estimates			
			Predicted Incidence of fatalities		**5.52E-02**	
			Risk of at least one fatality		**5.37E-02**	**or 1 in 18.6**

TAB. E-C-2
Weighted Fatality Rates
for Alternative 7, Shallow Excavation Remedy
Harbor-at-Hastings Site, Hastings-On-Hudson, NY

On-site Remediation Crew	Labor Category	Fatality Rate (no. fatalities per person-year)	Reference/ Source	Estimated Time, adjusted for PPE (person years)	% of Total Remediation Time	Weighted Fatality Rate (no. fatalities per person-year)
Regulatory oversight/inspector	Construction inspector	8.90E-05	Leigh, 1999	**8.19**	8%	6.99E-06
Health and safety monitor	Construction inspector	8.90E-05	Leigh, 1999	14.37	14%	1.23E-05
Manager/site engineer	Manager	3.20E-05	Leigh, 1999	14.37	14%	4.41E-06
Foreman	Supervisors, construction occupations	1.08E-04	BLS 97,99	13.22	13%	1.37E-05
Excavator/loader operators	Excavating and Loading Machine Operators	2.57E-04	BLS 94,96	7.15	7%	1.76E-05
Dozer operator	Grader, Dozer and Scraper Operators	2.85E-04	BLS 94-95	0.92	1%	2.53E-06
On-site truck drivers	Truck drivers	2.67E-04	BLS 94-97	1.16	1%	2.96E-06
Laborers	Laborers, Construction	3.72E-04	BLS 94-97	33.49	32%	1.19E-04
Crane/shovel operator	Excavating and Loading Machine Operators	2.57E-04	BLS 94,96	1.86	2%	4.59E-06
Equipment operator	Material Moving Equipment Operators	1.56E-04	BLS 94-97	6.77	6%	1.01E-05
Pile drivers	Structural metal workers	8.13E-04	BLS 94,96,99	2.79	3%	2.17E-05
Carpenter	Laborers, Construction	3.72E-04	BLS 94-97	0.00	0.00%	1.34E-08
			Totals	**104.28**	**100.00%**	**2.16E-04**
			Fatality Estimates			
			Predicted Incidence of fatalities		**2.26E-02**	
			Risk of at least one fatality		**2.23E-02**	**or 1 in 44.8**

TAB.. E-C-3
Weighted Fatality Rates
for Alternative 8, Containment Remedy
Harbor-at-Hastings Site, Hastings-On-Hudson, NY

On-site Remediation Crew	Labor Category	Fatality Rate (no. fatalities per person-year)	Reference/ Source	Estimated Time, adjusted for PPE (person years)	% of Total Remediation Time	Weighted Fatality Rate (no. fatalities per person-year)
Regulatory oversight/inspector	Construction inspector	8.90E-05	Leigh, 1999	7.66	8%	6.90E-06
Health and safety monitor	Construction inspector	8.90E-05	Leigh, 1999	13.84	14%	1.25E-05
Manager/site engineer	Manager	3.20E-05	Leigh, 1999	13.84	14%	4.48E-06
Foreman	Supervisors, construction occupations	1.08E-04	BLS 97,99	12.70	13%	1.39E-05
Excavator/loader operators	Excavating and Loading Machine Operators	2.57E-04	BLS 94,96	6.36	6%	1.65E-05
Dozer operator	Grader, Dozer and Scraper Operators	2.85E-04	BLS 94-95	0.14	0%	3.92E-07
On-site truck drivers	Truck drivers	2.67E-04	BLS 94-97	0.20	0%	5.46E-07
Laborers	Laborers, Construction	3.72E-04	BLS 94-97	32.71	33%	1.23E-04
Crane/shovel operator	Excavating and Loading Machine Operators	2.57E-04	BLS 94,96	1.86	2%	4.84E-06
Equipment operator	Material Moving Equipment Operators	1.56E-04	BLS 94-97	6.77	7%	1.06E-05
Pile drivers	Structural metal workers	8.13E-04	BLS 94,96,99	2.79	3%	2.29E-05
Carpenter	Laborers, Construction	3.72E-04	BLS 94-97	0.00	0.00%	1.41E-08
			Totals	**98.86**	**100.00%**	**2.17E-04**
			Fatality Estimates			
			Predicted Incidence of fatalities		**2.14E-02**	
			Risk of at least one fatality		**2.12E-02**	**or 1 in 47.2**

TABLE E-C-4
Predicted Incidence of Transportation-Related Fatalities Under Alternative 3, Excavation
Harbor-at-Hastings Site, Hastings-On-Hudson, NY

			Disposal of General Demolition Debris by Truck from Site to Green Tree Landfill in Kersey, PA				Disposal of Steel Demolition Debris by Truck from Site to Pascap Co. in Bronx, NY				Disposal of Wood Demolition Debris by Truck from Site to Pioneer Mill Works in Farmington, NY				Disposal of Excavated Soils by Train From Site to Clive, Utah		Disposal of Excavated Soils by Truck from Site to Holesopple, PA				Transport of Backfill by Barge from Hudson River to Site		Totals				
Symbol	Parameter	Units	Local Hastings-on-Hudson Roads	Rest of Route	Total Route	Basis	Local Hastings-on-Hudson Roads	Rest of Route	Total Route	Basis	Local Hastings-on-Hudson Roads	Rest of Route	Total Route	Basis	Total Route	Basis	Local Hastings-on-Hudson Roads	Rest of Route	Total Route	Basis	Total Route	Basis	Truck on Local Hastings-on-Hudson Roads	Truck on Rest of Route	Train	Barge	All Modes of Transportation
Volm	Volume of Material to be Transported	cubic yards	20,905.05	20,905.05	20,905.05	IT (equivalent to 62% of 570,200 sq feet)	11,126.88	11,126.88	11,126.88	IT (equivalent to 33% of 570,200 sq feet)	1,685.89	1,685.89	1,685.89	IT (equivalent to 5% of 570,200 sq feet)	126,136.00	IT (TSCA regulated material)	182,680	182,680.00	182,680.00	IT	308,816	IT					
Volc	Capacity of Container	cubic yards	15	15	15	PBQ&D 1999 (assumes 0.6875 cy per ton)	15	15	15	PBQ&D 1999 (assumes 0.6875 cy per ton)	15	15	15	PBQ&D 1999 (assumes 0.6875 cy per ton)	15	PBQ&D 1999 (assumes 0.6875 cy per ton)	15	15	15	PBQ&D 1999 (assumes 0.6875 cy per ton)	15	PBQ&D 1999 (assumes 0.6875 cy per ton)					
C	Containers per Vehicle	No. Containers per Vehicle	1	1	1	PBQ&D 1999	1	1	1	PBQ&D 1999	1	1	1	PBQ&D 1999	140	PBQ&D 1999	1	1	1	PBQ&D 1999	40	PBQ&D 1999					
Nv (Nv=Volm x 1/Volc x 1/C)	Number of Vehicles Required	No. Vehicles One-Way	1,394.0	1,394.0	1,394.0	Calculated	742.0	742.0	742.0	Calculated	112.0	112.0	112.0	Calculated	60.0	Calculated	12,179.0	12,179.0	12,179.0	Calculated	515.0	Calculated					
Ns	Number of One Way Trips on the Designated Route During Round Trip Travel	No. Vehicles Round Trip	2,788	2,788	2,788	Calculated	1,484	1,484	1,484	Calculated	224	224	224	Calculated	120	Calculated	24,358	24,358	24,358	Calculated	1,030	Calculated					
D,	Length of Designated Route (one-way)	Miles One-Way	2.0	315.0	317	Expedia.com	2.0	10.3	12.3	Expedia.com	2.0	312.0	314	Expedia.com	2,525	Rail miles from CSX and BNS	2.0	327.0	329	Expedia.com	75	IT		8,986,167			9,366,417
VMTs (VMTs = Ns x D)	Vehicle Miles Traveled on Designated Route	Vehicle-Miles	5,576	878,220	883,796	Calculated	2,968	15,285	18,253	Calculated	448	69,888	70,336	Calculated	303,000	Calculated	48,716	7,965,066	8,013,782	Calculated	77,250	Calculated	67708.0	8928459.2	303,000	77,250	9,366,417
Aft	Average Fatality rate per mile	Fatalities/Vehicle-Mile	4.00E-09	4.00E-09	4.00E-09	Large Truck (USDOT 1997,1999)	4.00E-09	4.00E-09	4.00E-09	Large Truck (USDOT 1997,1999)	4.00E-09	4.00E-09	4.00E-09	Large Truck (USDOT 1997,1999)	1.48E-06	Train (FRA 1999)	4.00E-09	4.00E-09	4.00E-09	Large Truck (USDOT 1997,1999)	6.7E-06	Barge (PBQ&D 1999)					1.0
Fs (Fs = AFt x VMTs)	Predicted Incidence of Transportation-Related Fatalities	Fatalities	0.00002	0.0035	0.0035	Calculated	0.00001	0.0001	0.0001	Calculated	0.000002	0.0003	0.0003	Calculated	0.4487	Calculated	0.0002	0.0318	0.0321	Calculated	0.5176	Calculated	0.0002	0.0357	0.45	0.52	1.0
Fs)	Risk of Transportation-Related Fatality	Fatalities per Scenario	1 in 44835	1 in 285	1 in 283	Calculated	1 in 84232	1 in 16366	1 in 13696	Calculated	1 in 558036	1 in 3577	1 in 3554	Calculated	1 in 2	Calculated	1 in 5132	1 in 31	1 in 31	Calculated	1 in 2	Calculated	1 in 4332	1 in 28	1 in 2	1 in 2	1 in 1

TABLE E-C-6

Predicted Incidence of Transportation-Related Fatalities Under Alternative 7, Shallow Excavation

Harbor-at-Hastings Site, Hastings-On-Hudson, NY

			Disposal of General Demolition Debris by Truck from Site to Green Tree Landfill in Kersey, PA				Disposal of Steel Demolition Debris by Truck from Site to Pascap Co. in Bronx, NY				Disposal of Wood Demolition Debris by Truck from Site to Pioneer Mill Works in Farmington, NY				Disposal of Excavated Soils by Train from Site to Utah		Transport of Backfill and Cover Materials by Barge from Hudson River to Site		Totals				
Symbol	Parameter	Units	Local Hastings on-Hudson Roads	Rest of Route	Total Route	Basis	Local Hastings-on-Hudson Roads	Rest of Route	Total Route	Basis	Local Hastings-on-Hudson Roads	Rest of Route	Total Route	Basis	Total Route	Basis	Total Route	Basis	Truck on Local Hastings-on-Hudson Roads	Truck on Rest of Route	Train	Barge	All Modes of Transportation
Volm	Volume of Material to be Transported	cubic yards	20905.05	20905.05	20905.05	IT (equivalent to 62% of 570,200 sq feet)	11126.88	11126.88	11126.88	IT (equivalent to 33% of 570,200 sq feet)	1685.89	1685.89	1685.89	IT (equivalent to 5% of 570,200 sq feet)	18170.00	IT	62480.33	IT*					
Volc	Capacity of Container	cubic yards	15	15	15	PBQ&D 1999 (assumes 0.6875 cy per ton)	15	15	15	PBQ&D 1999 (assumes 0.6875 cy per ton)	15	15	15	PBQ&D 1999 (assumes 0.6875 cy per ton)	15	PBQ&D 1999 (assumes 0.6875 cy per ton)	15	PBQ&D 1999 (assumes 0.6875 cy per ton)					
C	Containers per Vehicle	No. Containers per Vehicle	1	1	1	PBQ&D 1999	1	1	1	PBQ&D 1999	1	1	1	PBQ&D 1999	140	PBQ&D 1999	40	PBQ&D 1999					
Nv (Nv=Volm x 1/Volc x 1/C)	Number of Vehicles Required	No. Vehicles Round Trip	1394	1394	1394	Calculated	742	742	742	Calculated	112	112	112	Calculated	9.0	Calculated	104.0	Calculated					
Ns	Number of One Way Trips on the Designated Route During Round Trip Travel	No. Vehicles One-way	2788	2788	2788	Calculated	1484	1484	1484	Calculated	224	224	224	Calculated	18	Calculated	208	Calculated					
D,	Length of Designated Route one-way	Miles One-Way	2	315	317	Expedia.com	2	10.3	12.3	Expedia.com	2	312	314	Expedia.com	2,525	Rail miles from CSX and BNS	75	IT		972,385			1,033,435
VMTs (VMTs = Ns x D)	Miles Traveled Transporting Site-Related Material	Vehicle-Miles	5576	878220	883796	Calculated	2968	15285.2	18253.2	Calculated	448	69888	70336	Calculated	45,450	Calculated	15,600	Calculated	8992	963393	45450	15,600	1,033,436
Aft	Average Fatality rate per mile	Fatalities/ Vehicle-Mile	4.0E-09	4.0E-09	4.0E-09	Large Truck (USDOT 1997,1999)	4.0E-09	4.0E-09	4.0E-09	Large Truck (USDOT 1997,1999)	4.0E-09	4.0E-09	4.0E-09	Large Truck (USDOT 1997,1999)	1.5E-06	Train (FRA 1999)	6.7E-06	Barge (PBQ&D 1999)					1.8E-01
Fs (Fs = AFt x VMTs)	Expected Number of Fatalities Related to Transporting Site-Related Material	Fatalities	0.00002	0.00351	0.00354	Calculated	0.00001	0.00006	0.00007	Calculated	0.000002	0.00028	0.00028	Calculated	0.0673	Calculated	0.1045	Calculated	0.000036	0.0039	0.0673	0.105	0.18
R (R=1/Fs)	Risk of Fatality	Fatalites per Scenario	1 in 44835	1 in 285	1 in 283	Calculated	1 in 84232	1 in 16356	1 in 13696	Calculated	1 in 558036	1 in 3577	1 in 3554	Calculated	1 in 15	Calculated	1 in 10	Calculated	1 in 27802	1 in 259	1 in 15	1 in 10	1 in 6

This volume includes the assumption that 6 square yards of a 6 inch layer of asphalt or soil is equivalent to one cubic yard of material

TABLE E-C-6
Predicted Incidence of Transportation-Related Fatalities Under Alternative 8, Containment
Harbor-at-Hastings Site, Hastings-On-Hudson, NY

			Disposal of General Demolition Debris by Truck from Site to Green Tree Landfill in Kersey, PA				Disposal of Steel Demolition Debris by Truck from Site to Pascap Co. in Bronx, NY				Disposal of Wood Demolition Debris by Truck from Site to Pioneer Mill Works in Farmington, NY				Disposal of Excavated Soils by Truck from Site to Model City, NY				Transport of Backfill and Cover Materials by Barge from Hudson River to Site		Totals			
Symbol	Parameter	Units	Local Hastings-on-Hudson Roads	Rest of Route	Total Route	Basis	Local Hastings-on-Hudson Roads	Rest of Route	Total Route	Basis	Local Hastings-on-Hudson Roads	Rest of Route	Total Route	Basis	Local Hastings-on-Hudson Roads	Rest of Route	Total Route	Basis	Total Route	Basis	Truck on Local Hastings-on-Hudson Roads	Truck on Rest of Route	Barge	All Modes of Transportation
Volm	Volume of Material to be Transported	cubic yards	20905.05	20905.05	20905.05	IT (equivalent to 62% of 570,200 sq feet)	11126.88	11126.88	11126.88	IT (equivalent to 33% of 570,200 sq feet)	1685.89	1685.89	1685.89	IT (equivalent to 5% of 570,200 sq feet)	658.00	658.00	658.00	IT	44968.33	IT*				
Volc	Capacity of Container	cubic yards	15	15	15	PBQ&D 1999 (assumes 0.6875 cy per ton)	15	15	15	PBQ&D 1999 (assumes 0.6875 cy per ton)	15	15	15	PBQ&D 1999 (assumes 0.6875 cy per ton)	15	15	15	PBQ&D 1999 (assumes 0.6875 cy per ton)	15	PBQ&D 1999 (assumes 0.6875 cy per ton)				
C	Containers per Vehicle	No. Containers per Vehicle	1	1	1	PBQ&D 1999	1	1	1	PBQ&D 1999	1	1	1	PBQ&D 1999	1	1	1	PBQ&D 1999	40	PBQ&D 1999				
Nv (Nv=Volm x 1/Volc x 1/C)	Number of Vehicles Required	No. Vehicles Round Trip	1394	1394	1394	Calculated	742	742	742	Calculated	112	112	112	Calculated	44.0	44.0	44.0	Calculated	75.0	Calculated				
Na	Number of One Way Trips on the Designated Route During Round Trip Travel	No. Vehicles One-way	2788	2788	2788	Calculated	1484	1484	1484	Calculated	224	224	224	Calculated	88	88	88	Calculated	150	Calculated				
D,	Length of Designated Route one-way	Miles One-Way	2	315	317	Expedia.com	2	10.3	12.3	Expedia.com	2	312	314	Expedia.com	2.0	412	414	Expedia.com	75	IT		1,008,817		1,020,067
VMTs (VMTs = Na x D)	Miles Traveled Transporting Site-Related Material	Vehicle-Miles	5576	878220	883796	Calculated	2968	15285.2	18253.2	Calculated	448	69888	70336	Calculated	176	36,256	36,432	Calculated	11,250	Calculated	9168	999649	11,250	1,020,067
Aft	Average Fatality rate per mile	Fatalities/ Vehicle-Mile	4.0E-09	4.0E-09	4.0E-09	Large Truck (USDOT 1997,1999)	4.0E-09	4.0E-09	4.0E-09	Large Truck (USDOT 1997,1999)	4.0E-09	4.0E-09	4.0E-09	Large Truck (USDOT 1997,1999)	4.0E-09	4.0E-09	4.0E-09	Large Truck (USDOT 1997,1999)	6.7E-06	Barge (PBQ&D 1999)				7.9E-0
Fs (Fs = AFt x VMTs)	Expected Number of Fatalities Related to Transporting Site-Related Material	Fatalities	0.00002	0.00351	0.00354	Calculated	0.00001	0.00006	0.00007	Calculated	0.000002	0.00028	0.00028	Calculated	0.000001	0.0001	0.0001	Calculated	0.0754	Calculated	0.000037	0.0040	0.076	0.07
R ([illegible]Fs)	Risk of Fatality	Fatalites per Scenario	1 in 44836	1 in 285	1 in 283	Calculated	1 in 84232	1 in 16356	1 in 13696	Calculated	1 in 558036	1 in 3577	1 in 3554	Calculated	1 in 1420455	1 in 6895	1 in 6862	Calculated	1 in 13	Calculated	1 in 27269	1 in 250	1 in 13	1 in 1

*This volume includes the assumption that 6 square yards of a 6 inch layer of asphalt or soil is equivalent to one cubic yard of material

Figure E-C-1: Contribution of Each Task to Predicted Incidence of On-Site Worker Fatalities During Remedy Implementation
Alt. 3 - Excavation
Harbor-at-Hastings Site, Hastings-On-Hudson, NY

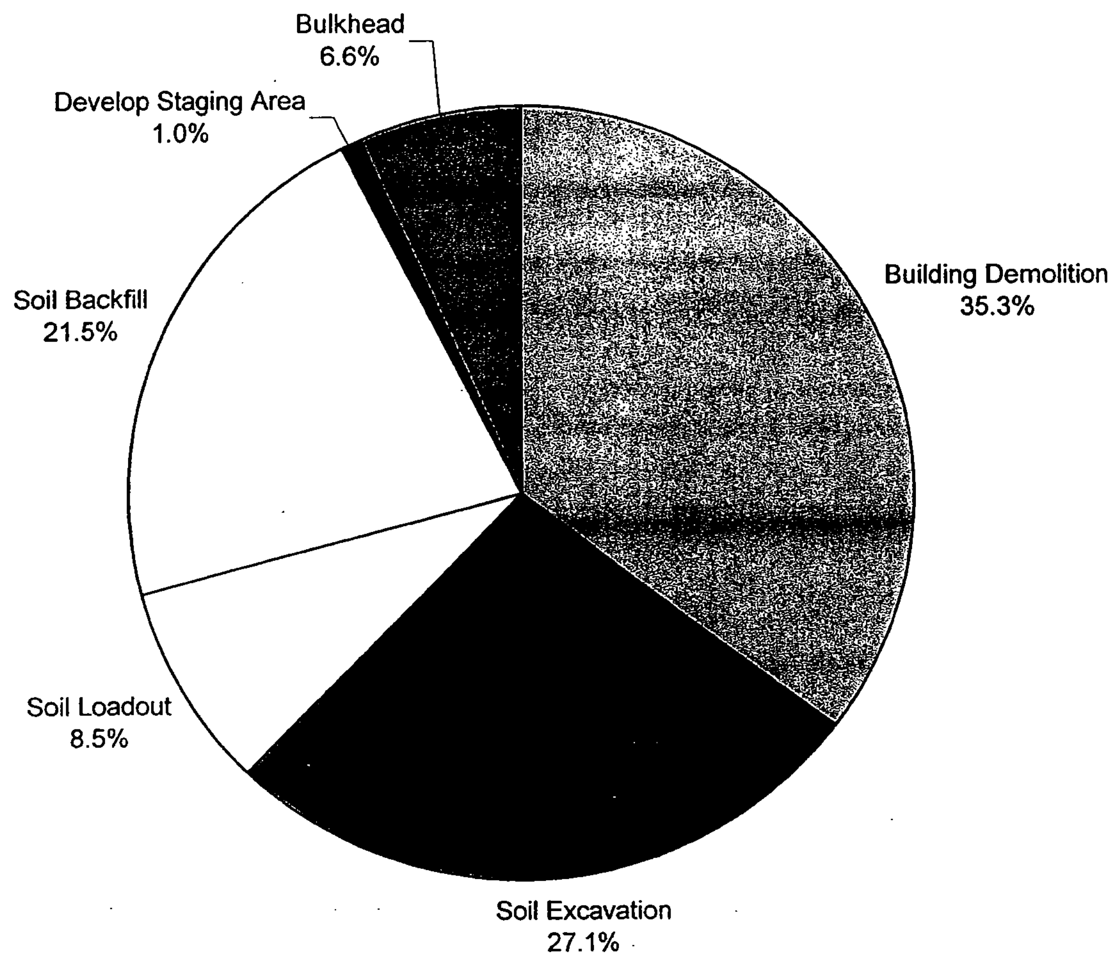


Figure E-C-2: Contribution of Each Task to Predicted Incidence of On-Site Worker Fatalities During Remedy Implementation
Alt. 7 - Shallow Excavation
Harbor-at-Hastings Site, Hastings-On-Hudston, NY

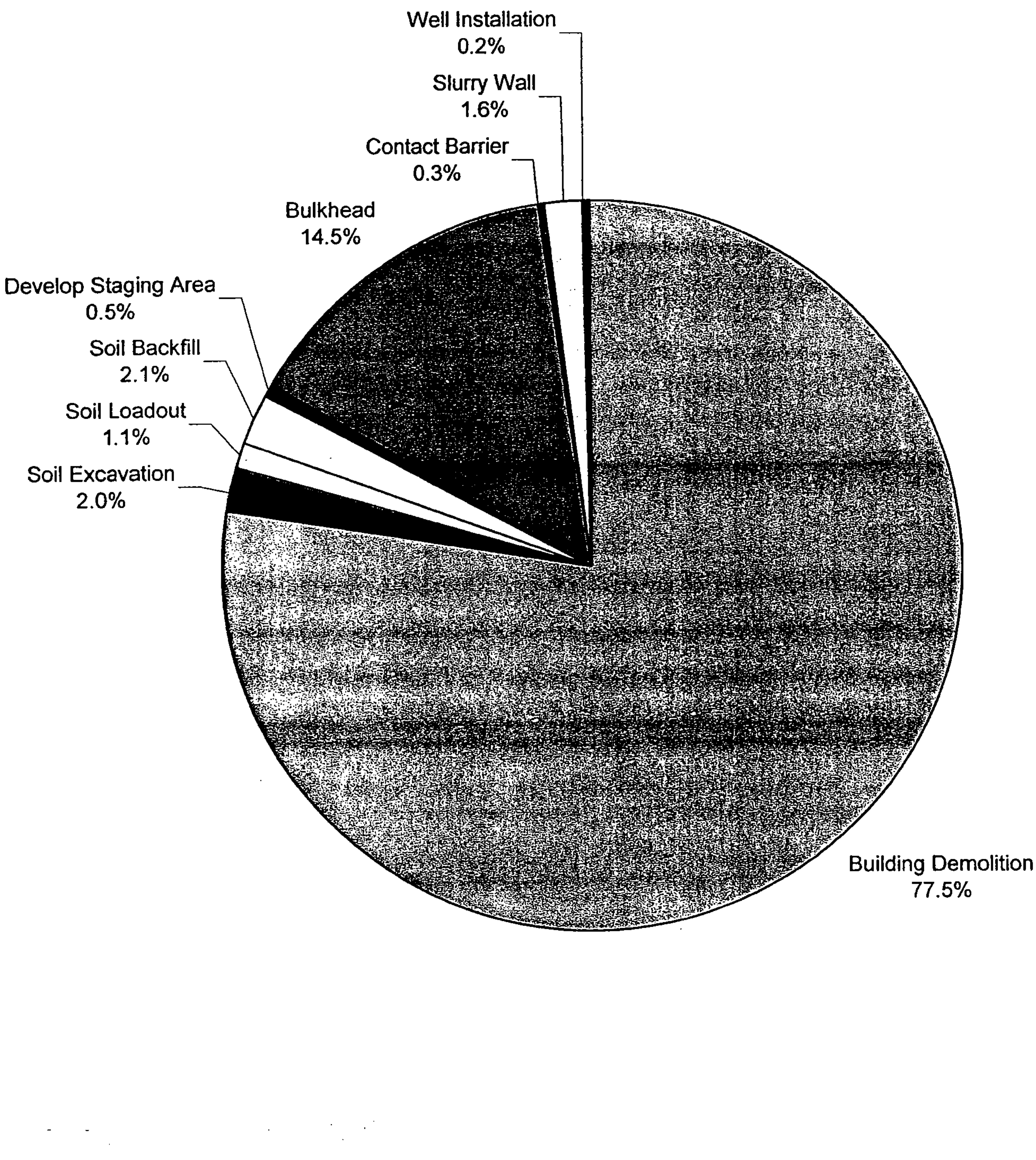
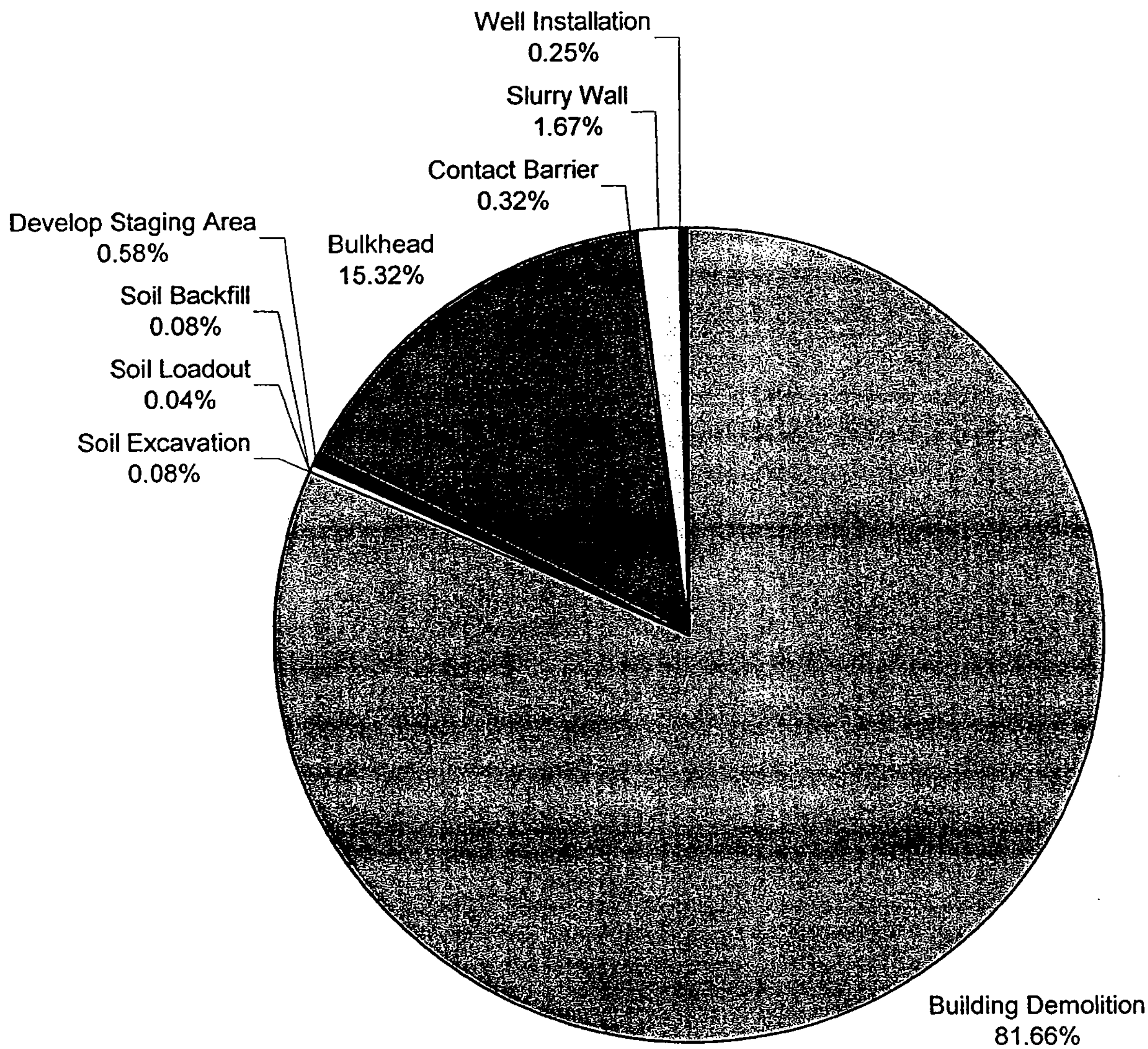


Figure E-C-3: Contribution of Each Task to Predicted Incidence of On-Site Worker Fatalities During Remedy Implementation
Alt. 8 - Containment
Harbor-at-Hastings Site, Hastings-On-Hudston, NY



ATTACHMENT E-D

References

ATTACHMENT E-D

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Atlantic Richfield Company

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January 21, 2003

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New York State Department of
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Division of Environmental Remediation
Bureau of Eastern Remedial Action
625 Broadway, Albany, New York 12233-7010

Subject: Response to Comments to the Feasibility Study
Harbor At Hastings Site, Hastings On Hudson, New York
NYSDEC Site No. 360022

Dear Mr. Heitzman,

Atlantic Richfield Company (Atlantic Richfield) has reviewed the New York State Department of Environmental Conservation (NYSDEC) comments dated December 11, 2002 to the *Feasibility Study Report, Harbor At Hastings Site, Shaw Environmental & Infrastructure, Inc. & Haley & Aldrich, September 18, 2002* (FS). Atlantic Richfield has prepared this letter to respond to the NYSDEC's comments. The NYSDEC Comments are listed below in bold font as presented within the department's December 11, 2002 correspondence. Each of the NYSDEC comments is followed by Atlantic Richfield's response. As discussed with the NYSDEC on January 10, 2003, this letter will serve as an addendum to the FS. Accordingly, a reissue or revision of the FS will not be required.

Additional Excavation Alternatives

In addition to the remedial alternatives developed and evaluated in ARCO's FS, the DEC is considering other alternatives for evaluation in the upcoming PRAP. Additional information is requested to enable these alternatives to be properly evaluated. While ARCO asserts that the feasible limit of dry excavation is 12 feet below grade, the DEC believes that this limit can be safely extended. To fully evaluate the technical data and balancing criteria for deeper excavation, the following information is requested for dry excavation depths of both 15 and 20 feet:

- **Excavation Volumes and costs associated with removal of PCBs >10 ppm,**
- **Percentage of PCBs that would be removed by this excavation,**
- **Acreage of PCB-contaminated soil remaining**

This information may be provided in a letter response, and need not be developed and evaluated as a new alternative in a revised FS

Response: Atlantic Richfield's consultants have thoroughly analyzed the data related to advancement of dry excavations at the Site. Based on sound engineering analysis it has been concluded that excavation below a depth of 12 feet will present significant risk to public health and the environment and may result in catastrophic excavation failure and/or remobilization of contaminants. However, as requested by the NYSDEC, the excavation volumes and costs associated with removal of PCBs >10 ppm, the percentage of PCBs removed, and the acreage of PCB-contaminated soils remaining on-site after the removal were calculated for excavation depths of 15 and 20 feet **(Attachment 1)**. For the purpose of completing the calculations, factors limiting the implementability of excavations to depths of 15 and 20 feet, such as shoring instability, bottom heave, and cross contamination issues, were disregarded. Atlantic Richfield remains concerned that the benefits of removing PCBs below a depth of 12 feet are outweighed by the risk of such action to site workers, public health, and the environment.

Asphalt Contact Barrier

The DEC is concerned with the potential hydraulic impacts of using asphalt as the contact barrier in a multi-layer cover system. A low permeability asphalt layer would require careful grading and installation of a drainage layer above it to prevent ponding of water within the cap system. If this water is not drained, the overlying soils would become saturated, and site vegetation could be limited to wetland species. New buildings constructed at the site could require careful design of the drainage system around their foundations to accept roof runoff. Surface grades would be dictated to a large degree by the asphalt configuration, and the flexibility in the final site-grading plan could be reduced. In addition, asphalt may not be a reliable demarcation boundary because it is commonly found beneath the surface of historically filled sites.

The DEC believes that a synthetic material such as geonetting or geotextile could serve as an effective barrier and warning layer without the negative hydraulic effects of an asphalt layer. The DEC may use a general term "penetration barrier", in the PRAP rather than specifying asphalt. Because the ambient water table is close to the site surface and most of the fill unit is saturated, a hydraulic barrier would provide little environmental benefit. DEC may also adjust the capital and post-closure costs of the cover system to reflect a more efficient design.

Response: Each of the 12 Remedial Alternatives outlined within the FS specifies the installation of a watertight bulkhead along the shoreline of the Site to protect the Site's shoreline and prevent the migration of fill particulate to the river. The water tight bulkhead structure will require hydraulic relief structures within its design to prevent fill water from mounding behind the wall. It is important that the multi-layer cover system include a low permeability layer (asphalt or geosynthetic) to inhibit rainwater infiltration to the fill water system that would cause unnecessary stresses on the hydraulic relief structures and the wall itself.

Although a detailed design has not been completed, the design will likely include a multi-layer cover system with an impermeable layer overlain by a demarcation layer, a high permeability drainage layer and clean cover soils. As discussed above, the low permeability layer will prevent rainwater infiltration to the fill. The demarcation layer will provide a high visibility subsurface layer defining the maximum excavation depth to utility workers. The high permeability layer will facilitate rainwater drainage to the river. The detailed design will also likely include final surface grading of clean cover soils and incorporate other drainage structures to reduce the potential for surface water ponding.

Based on the presence of the existing asphalt / concrete layer across a majority of the site, it is possible that the final design will incorporate the use of many existing surfaces as part of the low permeability layer. It is anticipated that some areas of the site would require the installation of an asphalt or geosynthetics where currently none exist. Atlantic Richfield intends to use existing surfaces to the extent that they would effectively meet design criteria (rainwater infiltration prevention, demarcation of native fill materials, and surface cover system).

Institutional Controls

For areas where PCBs would remain at concentrations greater than 10 ppm, the installation of piles through the Fill Unit and into the Basal Sand would likely be prohibited. This would essentially prevent the construction of pile-supported structures in areas where PCBs will be managed in the long term. In the description of most of the alternatives, the FS concludes that all 28 acres of the site would be restored to productive use with institutional controls, even though PCBs would remain. The FS should be revised to reflect that buildings would be prohibited in areas where PCBs remain. The acreage of these building restricted areas should be identified for each alternative, so that the true productive potential for the site can be evaluated.

Response: Atlantic Richfield considers potential future uses of the property, including park and recreation use / open space, as a productive use of the Site. However, as requested, Attachment 1 provides the acreage of the Site considered restricted based on the area of the

Site where PCBs >10 ppm will remain and pilings will not be permitted to be driven from the Fill Unit through the Marine Grey Silt Unit into the Basal Sands Unit.

<u>No Action</u>

The No Action Alternative described in the FS includes a substantial amount of remedial work, at a total cost of $16.7 million. The DEC may develop a true No Action Alternative for the PRAP, and present FS Alternative 1 as a shoreline Containment alternative

Response: The No Action Alternative cost estimate in the FS was developed to provide a realistic cost estimate and cost contingency for completing and maintaining shoreline restoration as well as costs for site maintenance activities over a 30 year post closure period.

<u>Minor and Editorial Comments</u>

Section 1.3.2, page 11 – The NYSDEC's decision to separate the site into two operable units was not based on the "presence of other contributing upgradient sources" in the Hudson River. It was primarily to propose a remedy for OU#1 while the OU#2 investigation proceeded.

Response: The NYSDEC comment has been reviewed and noted.

Section 1.3.3.1, page 13, first full bullet – It is unlikely that migration of the PCB/solvent mixture halted at the Fill/Marine Silt interface due to the high hydraulic head in the underlying Basal Sand Unit. The artesian pressure of the Basal Sand Unit dissipates across the thickness of the Marine silt confining unit, and is not present at the Marine Silt/Fill Unit interface. Due to the relatively high conductivity of the Fill Unit, the hydraulic head in the Fill Unit is expected to be nearly equal at the top and bottom, which would also preclude the presence of a high hydraulic head at the interface. The migration of the mixture was likely halted by pore size and density effects alone. This concept should also be corrected at the top of page 18.

Response: As noted in the RI Report, historically a less viscous, free-phase PCB/solvent mixture likely moved downward in the Northwest Corner, gradually hardening due to the physical properties of the mixture. As noted on Figure 1-6 of the FS, PCB containing materials were observed several feet into the Marine Silt at some locations. Further vertical migration appears to be halted at/near the top of the Marine Silt as a result of the upward groundwater flow at the Site and the pore properties of the Marine Grey Silt Unit.

In accordance with Darcy's Law, under steady state conditions the hydraulics between the Fill Unit and the Basal Sands Unit are controlled by pressure differential, represented by hydraulic gradient through the Marine Grey Silt Unit. This hydraulic gradient must be present throughout the Marine Grey Silt Unit in order for the steady-state groundwater flow system to be maintained. In other words, groundwater that flows vertically from the Basal Sand Unit through the Marine Grey Silt Unit must discharge into the Fill. The gradient must be maintained throughout the Marine Grey Silt Unit or the Marine Grey Silt would infinitely receive but not discharge groundwater, which is not possible.

The downward DNAPL movement at the site is controlled by resisting forces (upward gradient and pore entry resistance) being greater than or equal to the driving forces (downward weight of the DNAPL and capillary forces) as shown in the following mathematical solution:

$$i\rho_w g + \frac{P_d}{L} \geq \frac{P_{c0}}{L} + (\rho_{DNAPL} - \rho_w)g$$ (adapted from Chown, Kueper, and McWhorter 1997)

(resisting) $\geq$(driving)

where:

i = gradient in the aquitard,

L = thickness of unit

r_w = unit weight of water, r_{DNAPL} = unit weight of the DNAPL

g = gravity

P_d = Pore Entry Resistance

P_{c0} = Capillary Forces

As identified in this equation, a decrease in the upward hydrauilic gradient (i) has the potential to decrease the resisting forces to less than the driving forces and thereby mobilize DNAPL. Therefore, it follows that a disturbance of the hydraulic gradient at the Site in the form of pumping the Basal Sands and/or increasing the water level in the Fill by flooding has the potential to mobilize currently stable DNAPL. Based on these physical principles it is incorrect to state that the migration of the DNAPL was likely halted by pore size and density effects alone.

In addition to hydraulic forces, other factors are likely to have limited vertical migration of the PCB solvent mixture. These factors include the volatilization of the volatile fraction of the mixture, the small pore size of the Marine Grey Silt Unit, surface features of the Marine Grey Silt Unit (such as depressions and obstructions), and the physical/chemical properties of the PCBs (adsorbed to particulate, low solubility in water, solid or other form).

Section 1.3.3.1, page 14, top – The DEC disagrees that a consistent correlation between concentrations of metal analytes at specific depths in the fill to potential source areas was not identified. All detections of lead greater than 10,000 ppm were in soils less than 2 feet deep in the southern area of the site. That area was historically used for lead scrap processing and reclamation.

Response: The NYSDEC comment has been reviewed and noted.

Section 1.4.1.1, page 17 – The PCB/solvent mixture accumulated in areas other than depressions at the fill/silt interface. It also collected on horizontal lenses of less permeable material throughout the soil column, which accounts for the maximum detection of 380,000 ppm at a depth of 13'. The mixture also migrated laterally along these lenses and the Marine Silt, which accounts for the presence of rubbery cement beneath the Hudson River.

Response: The NYSDEC comment has been reviewed and noted. Based on multiple historic site operations, the movement of a PCB/solvent mixture along permeable and less permeable materials in the Fill Unit and the Marine Grey Silt Unit is believed to have been one of many potential PCB transport mechanisms at the Site.

Section 1.6.1.5, page 24 – The rubbery matrix was found more than "occasionally" at shallower depths within the fill.

Response: The NYSDEC comment has been reviewed and noted.

Section 1.6.2.1, page 26 – The maintenance workers must follow the current Site Health and Safety Plan to prevent exposure is a defacto institutional control.

Response: The NYSDEC comment has been reviewed and noted.

Section 1.6.2.2, page 27 – In the last sentence of the "Residents" scenario, the homegrown consumption pathway cannot be entirely eliminated because it is not the dominant pathway for one contaminant of concern. As the NYSDEC found in the Risk Assessment for the Tappan Terminal site, the homegrown consumption pathway poses a significant risk due to non-PCB contaminants in the fill material.

Response: Risk assessments at some sites may include potential residential exposure to contaminants in soil via consumption of homegrown produce. However, such potential exposures, if they occur at a particular site, are usually less significant than potential exposure to the contaminants via direct ingestion of the contaminated soil, unless chemicals at the site bioconcentrate significantly in edible parts of homegrown produce. EPA guidance indicates that the consumption of homegrown produce is an exposure pathway that need not be evaluated at all sites, and that the pathway may be relevant for only certain contaminants (EPA 1991a). For PCBs, dioxins, and dioxin-like compounds in contaminated soil, EPA analysis shows that the homegrown produce consumption pathway is less significant than the soil ingestion pathway (EPA 1994). Since PCBs are the primary COPCs in fill at the Site, the EPA analysis suggests that the homegrown produce consumption pathway should be less significant than the direct contact pathways discussed above. Therefore, quantitative assessment of the homegrown produce consumption pathway is not necessary.

Section 2.2.5, page 34 – As discussed above, PCB-containing materials (the rubbery matrix) were not found exclusively at depths greater than 30 feet.

Response: The NYSDEC comment has been reviewed and noted.

Section 2.4, page 36 – The FS earlier asserted that PCBs at the site have limited mobility because they are sorbed onto particulate matter, have low solubility, and are solid and "immobile" in their highly concentrated (rubbery matrix) form. If they are immobile, it is inconsistent to claim in this section that "should PCBs be directly introduced in the Basal Sands Unit during remedial activities, significant lateral and potentially off-site migration of PCBs will occur." Further, the flow direction from the Basal Sand Unit is upward toward the fill unit, and outward through the Hudson River sediments. Both of these units are currently contaminated with PCBs from the site.

Response: The current immobility of PCB containing materials is dependent upon both their physical/chemical properties (adsorbed to particulate, low solubility in water, solid or other form) and the current equilibrium groundwater conditions. The current undisturbed subsurface conditions, including the upward hydraulic head exerted by the Basal Sands Unit on the Marine Grey Silt Unit, substantially reduce the risk of contaminant migration into the underlying Basal Sands Unit. If remedial activities substantially alter current equilibrium conditions by lowering of the head in the Basal Sands, increasing the head of the Fill Unit, or applying other forms of downward pressure on these materials, it is reasonable to conclude that PCB containing materials may re-mobilize and migrate into the underlying, non-contaminated, Basal Sands aquifer. Atlantic Richfield remains concerned that pumping of the Basal Sands and/or flooding the excavation could cause significant irreversible damage to the environment.

Section 2.5.2, page 38, third bullet – 6NYCRR Part 703 standards apply to all ambient groundwater in New York State. A separate standard under 10NYCRR Part 5 applies to drinking water supplies. The fact that groundwater beneath the site is non-potable does not exclude it from the ambient standards in Part 703 and guidelines in TOGS 1.1.1.

Response: The NYSDEC comment has been reviewed and noted.

Section 3.3.5.3, page 74 – In the penultimate sentence on the page, change "consolidated" to "unconsolidated".

Response: The NYSDEC comment has been reviewed, noted and the requested edit to the text is hereby changed by reference.

Section 3.3.5.3, page 75, second bullet – It is misleading to state that the silt "is very thin in some locations" in the context of excavation from the Northwest Corner. The November 30, 2001 Peer Review Summary Report concluded that the Marine Silt is generally thicker than was previously defined in these areas (page 5 bottom). While the silt is thinner in some areas of the site, these have not been considered for excavation.

Response: The NYSDEC comment has been reviewed and noted.

Section 4.1.2.3, page 86, top paragraph – Because groundwater in the Basal Sand is clean, it could be discharged untreated, and additional treatment infrastructure would not be required.

Response: In the event that groundwater pumping were required, groundwater sampling and analyses for multiple parameters including various metal analytes would likely be required under a SPDES Permit. Based on the permeability of the Basal Sands Unit it is anticipated that pumping from this formation would result in high groundwater yields. Due to the proximity of the Basal Sands to the Fill Unit on the east side of the Site as well as the fill materials composing the Metro North Commuter Rail Road, the potential exists for reversing the groundwater gradients and cross contamination of the Basal Sands during pumping. Therefore it is not unreasonable to anticipate and plan for additional treatment system capacity and costs during cost estimating procedures associated with this remedial alternative.

Section 5.3, page 156 – Much of this section is not a process description, but a reiteration of why ARCO believes that deep excavation is not feasible. This section should be an objective description of how the recommended alternative will be implemented, not further justification of it. This should include a detailed description of the remedy components, including building demolition as necessary, and a general sequence.

Response: The requested modification to the text is acceptable and revisions to the text are provided as Attachment 2 to this letter.

Section 5.4, page 157 – The basis for the Remedial Design will be the final remedy selected by the NYSDEC in the Record of Decision, after the public comments on the Proposed Remedial Action Plan (PRAP). Alternatively, this section may be eliminated.

Response: The NYSDEC comment has been reviewed and noted.

If you have any questions or comments regarding this submittal please contact me at 216-271-8037.

Sincerely,

Werner A. Sicvol
Sr. Project Manager

cc: S. Stash, Atlantic Richfield Company
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S. Meier, Shaw Environmental, Inc.
M. Gardner, Shaw Environmental, Inc.
D. Hagen, Haley & Aldrich

Attachment 1

Atlantic Richfield Company
Harbor at Hastings, New York
PCB Removal per Alternative

Alternative Number	Alternative Description	Alternative Cost ($)	PCB Excavation Volume (CY)	Mass PCBs Removed (lb)	% PCBs Removed	Mass PCBs Remaining (lb)	% PCBs Remaining	Acres of PCB Soils Remaining	Remaining PCBs Contained/ Capped?	Acres of Site Use: Unrestricted*	Acres of Site Use: Restricted*
1	No action	16,751,668	0	0	0	88,000	100	3.8	No	24.2	3.8
2	Full PCB removal	149,743,819	110,376	88,000	99	10	>1	0	No	28	0
3	Full PCB/ TAGM removal	224,629,986	110,376	88,000	99	10	>1	0	No	28	0
4	Full PCB/ TAGM removal, cap entire site	166,786,588	110,376	88,000	99	10	>1	0	Yes	28	0
5	Rubbery Matrix removal inside containment; PCB/ TAGM removal outside of containment	165,053,066	31,034	86,000	98	2,000	2	1.9	Yes	26.1	1.9
6	Rubbery Matrix removal inside containment	131,948,808	27,778	85,600	97	2,400	3	2	Yes	26.0	2
7	Removal of shallow PCBs across site	45,836,935	40,798	25,600	29	62,400	71	3.8	Yes	24.2	3.8
8	Removal of shallow PCBs outside containment	33,003,523	9,286	485	0.6	87,515	>99	3.8	Yes	24.2	3.8
9	Stabilization of PCBs within containment; removal of shallow PCBs outside containment	37,203,840	9,286	485	0.6	87,515	>99	3.8	Yes	24.2	3.8
10	Contact barrier & soil cover over site	17,624,135	0	0	0	88,000	100	3.8	Yes	24.2	3.8
11	PCB removal at 3, 9 & 12 ft depths within containment	52,471,940	47,320	13,000	15	75,000	85	1.3	Yes	26.7	1.3
12	PCB removal at 9 & 12 ft depths within containment	74,493,069	66,487	46,000	52	42,000	48	1.3	Yes	26.7	1.3
X-15ft	PCB removal to 15 ft maximum depth within containment	77,230,489	73,061	52,579	60	30,656	40	1.3	Yes	26.7	1.3
X-20ft	PCB removal to 20 ft maximum depth within containment	81,547,489	83,709	61,411	70	26,824	30	1.3	Yes	26.7	1.3

Note:
* = PCBs were COPC considered for restricted/unrestricted land use evaluation
unrestricted = areas where no PCB fill remains
restricted = areas where PCB fill remains

Attachment 2

5.3 *Process Components of Selected Alternative*

Major process components of the selected remedial alternative are described below, in the relative order of their implementation:

- *Building Demolition and Asphalt Removal:* To facilitate the implementation of the remedial alternative, the remaining site buildings will be demolished. In areas of the proposed excavation, building foundations and asphalt roadways will be removed. Building foundations and asphalt roadways that are located outside the proposed excavation areas will be left in place and may be incorporated in the contact barrier/cover system.

- *Reconstruction of Shoreline Bulkhead:* A water-tight steel bulkhead will be installed along the shoreline of the site to prevent erosion of fill material and the transport of fill particulate into the Hudson River. The proposed bulkhead will be installed to a depth of approximately 38 feet below grade and it will incorporate hydraulic relief structures within its design to prevent mounding of fill water behind the wall. The hydraulic relief structures will be designed to drain the fill water while retaining fill particulate. In certain areas of the Northwest Corner and the Water Tower Areas, the steel bulkhead will serve as part of the excavation support structures, in addition to reinforcing the shoreline of the site.

- *Engineered Containment System:* To fully contain PCBs remaining at depth after remedial excavations are performed, a slurry trench will be installed on the up-gradient side (east side) of the Northwest Corner and the Water Tower Area. The slurry trench will be comprised of a mixture of bentonite, water and soil, and will be installed to prevent fill water infiltration into areas where PCBs will remain on-site.

- *Excavation and Treatment of Soils Exceeding Risk-Based PRGs and NYS TAGM Guidelines for PCBs:* Approximately 2,400 cubic yards of PCB-contaminated fill material lies within 1 to 2 feet of the ground surface in the central and southern portions of the Site. This material may be readily excavated and sent off-site for disposal, leaving only concentrations of other industrial and municipal residuals (ash, coal, clinker, and other debris) that are characteristic of urban fill throughout the Hudson Valley and much of the Northeastern portion of the United States.

  In addition, an approximate 44,500 cubic yards of PCB-contaminated fill material are located within the Northwest Corner and Water Tower areas of the Site, at depths which are accessible to moderate depth excavations. Fill material will be excavated in the dry condition to depths of 3, 9 and 12-feet below grade, as illustrated in **Figure 4-11**. De-watering will be required for any excavation below the groundwater table, which is present at an average depth of 5 feet bgs across this portion of the site. The de-watering process water may require treatment prior to disposal. Grout stabilization will be required in the 12-foot depth excavation area for structural support of the sheet pile wall. The excavated material will be sent off-site for disposal, leaving contamination at depths that only deep construction excavations could reach.

- *Contact Barrier and Soil Cover System:* Throughout the Site, any PCB-impacted fill remaining on the Site and industrial and municipal residuals will be covered by a low permeability contact barrier consisting of a 6-inch layer of asphaltic cement (or equivelant). The contact barrier will be covered with a demarcation layer, a drainage layer, a 12-inch layer of clean soil, and a 6-inch layer of topsoil that will be seeded and fertilized. Depending on the future development plans for the Site, it is likely that as many as several feet of additional cover soil may be added to certain portions of the Site, however for the FS it was not included in the evaluation of this alternative. Utility conduits would be limited to the subsurface area above the asphaltic cement/demarcation layer. This action would provide a physically effective means of preventing potential future utility worker direct contact exposures to industrial and municipal residues in fill and fill water at the Site.

- *Institutional Controls:* Institutional controls would be included as part of this alternative, to ensure that the intent of the physical controls used in this alternative is communicated to potential future land use planners or maintenance and repair organizations. While the central and southern portions of the Site could be constructed (or modified later, as necessary) to incorporate such features as tree wells, utility conduits, footings, or pilings to accommodate a wide range of planned uses, access to the subsurface at the Water Tower and Northern Portions of the Site would need to be carefully controlled to prevent access by persons unaware or untrained in the specific requirements for work in this type of hazardous environment. Specific limitations on subsurface access or disturbance, redevelopment, or change-in-use of the Site must be placed on the deed and survey plan for this parcel prior to any potential transfer of its ownership, and must also transfer to all successors and assigns. Postings regarding appropriate activities or access to the Site would also be feasible and appropriate. The NYSDEC may be petitioned to reclassify the central and southern portions of the Site differently from the northern portion in the NYS Inactive Hazardous Registry. The reclassification would indicate the appropriate status and restrictions on change-in-use for each area after completion of the remedial action.