Draft Final Report

Non-Aqueous Phase Liquid Focused Feasibility Study for the Soil and Groundwater Operable Units (OU2/OU4) Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, WA

Prepared for

U.S Environmental Protection Agency Region 10

April 2016

CH2MHILL®

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Executive Summary

This report presents a focused feasibility study (FFS) conducted for the Wyckoff/Eagle Harbor Superfund Site (Wyckoff Site, or Site) Soil and Groundwater Operable Units (OUs). As described in the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (United States Environmental Protection Agency [EPA], 1988), the feasibility study (FS) consists of three phases: screening remedial technologies, developing remedial action alternatives, and conducting a detailed analysis of the alternatives. The scope of the FFS is similar to the FS; however, the FFS addresses a specific problem or portion of a contaminated site. For the Wyckoff Soil and Groundwater OUs, this FFS specifically targets non-aqueous phase liquid (NAPL) present in soil and groundwater underlying the Former Process Area (FPA).

Focused Feasibility Study Approach

Remedial action alternatives were developed for detailed evaluation in this FFS by combining various technologies, and the media to which they are applied, into alternatives that address NAPL source material. The overall FFS approach included the following steps:

- <u>Step 1—Develop remedial action objectives (RAO)</u> specifying the contaminants of concern (COCs) and their corresponding clean-up levels, the environmental media, and the exposure pathways to be addressed. Most information associated with this step, which is discussed in Section 2 of this FFS, was obtained from *Wyckoff Eagle Harbor Superfund Site – OUs 2 and 4 Draft Remedial Action Objective Meeting Minutes* (Snider, 2013) and the *Draft Wyckoff Soil and Groundwater OUs RAOs* (EPA, 2014).
- <u>Step 2—Identify the areas and volumes</u> (e.g., remedial action target area or target zones) of contaminated media to be addressed. This is a key element that is summarized in Section 2 of this FFS. The remedial action target area was identified as described in the *Groundwater Conceptual Site Model Update Report for the Former Process Area, Wyckoff/Eagle Harbor Superfund Site, Soil and Groundwater Operable Units* (Draft CSM Update Report; CH2M HILL, 2013a).
- <u>Step 3—Identify general response actions (GRA)</u> for environmental media to be addressed, individually or in combination, which may be taken to achieve the RAOs. GRA categories applicable to NAPL present in the FPA include no action, access controls, containment, removal and disposal, ex situ treatment, and in situ treatment.
- <u>Step 4—Identify and screen the technologies and their associated process options</u> applicable to each GRA to eliminate those that are not viable for NAPL and the subsurface conditions present in the FPA. The screening process includes an evaluation of each technology based on considerations of effectiveness, implementability, and relative cost. The technology screening, which is presented in Section 2 of this FFS, was performed as generally described in *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, Interim Final* (EPA, 1988).
- <u>Step 5—Assemble the retained technologies into a range of source control alternatives</u> in accordance with the National Contingency Plan (NCP; Code of Federal Regulations [CFR], Title 40, Section 300.430[e][3]). When assembling alternatives containing multiple technologies, consideration was given to those that are compatible and complementary. The results from this step are presented in Section 3 of this FFS.

- Step 6—Conduct a detailed and comparative analysis of the alternatives individually, and relative to one another, against the evaluation criteria specified in the NCP, 40 CFR 300.430(e)(9). The detailed evaluation of the alternatives against the criteria of state acceptance and community acceptance was not performed in this FFS but will be conducted as described in the NCP, 40 CFR 300.430(e)(9)(iii)(H) and (I). The results from this step are presented in Section 4 of this FFS.
- Step 7—Identify a recommended alternative. Based on the results of the detailed and comparative evaluation and discussions between EPA, Washington State Department of Ecology (Ecology) and community representatives, a recommended alternative was identified as summarized in Section 5 of this FFS. The recommended alternative will be identified as the Preferred Alternative in the Proposed Plan.

As shown on **Figure ES-1**[1], The FFS/FS represents Step 2 of the decision process that leads to selecting a remedy for a Superfund site. Following EPA and Ecology review of the FFS, EPA, as the lead regulatory agency, will prepare and issue a Proposed Plan that will undergo public review and participation in accordance with 40 CFR 300.430(f). Following receipt of public comments and preparation of a Responsiveness Summary that address public comments, EPA will issue a Comprehensive Environmental Response Compensation and Liability Act (CERCLA) decision document that selects a remedial action alternative to address NAPL source material present in the Wyckoff Soil and Groundwater OUs.

Remedial Action Target Area

The area and volume of NAPL-contaminated source material to be addressed in the FFS was defined using information obtained from a Tar-specific Green Optical Scanning Tool (TarGOST®) field investigation conducted in 2013. The objective for the TarGOST® investigation was to define the distribution of NAPL within the Upper Aquifer underlying the FPA. Based on evaluation of the field investigation results (*2014 Conceptual Site Model Update for the OU2 and OU4 Former Process Area*, CH2M HILL, 2014) a TarGOST® response of 10 percent reference emitter (%RE) was identified as signifying the presence of NAPL. Because the TarGOST® measurements do not specifically indicate the presence of mobile or immobile (residual) NAPL, all locations and depths with a TarGOST® response of 10 %RE or greater were identified as NAPL source material. The volume of NAPL contaminated aquifer material (in cubic yards), and the volume of NAPL present (in gallons), lying within the 10% RE TarGOST® footprint were estimated using information obtained from each of the 141 TarGOST® borings drilled in the FPA and by converting the TarGOST® measurements into a NAPL concentration.

The TarGOST® results were used to define the following five remedial action target zones that are described in this FFS: (1) the Core Area and an Expanded Core Area, (2) North Shallow (Light NAPL [LNAPL]) area, (3) East Shallow (LNAPL) area, (4) North Deep (Dense NAPL [DNAPL]) area, and (5) the Other Periphery area.

Remedial Action Alternatives

The technologies retained from the screening performed in Step 4 were assembled into a range of source control alternatives in accordance with the NCP under 40 CFR 300.430(e)(3). Technology and technology combinations identified for each target zone included the following:

- **Core Area/Expanded Core Area:** Containment, In Situ Solidification/Stabilization (ISS), Excavation and Thermal Desorption, Thermal Enhanced Extraction, and Enhanced Aerobic Biodegradation (EAB)

[1] All figures referenced in the Executive Summary are presented at the end of Executive Summary section.

- **North Shallow (LNAPL):** Containment, ISS, Excavation and Thermal Desorption, Thermal Enhanced Extraction, Thermal Enhanced Recovery, and EAB
- **East Shallow (LNAPL):** Containment, ISS, Excavation and Thermal Desorption, Thermal Enhanced Extraction, Thermal Enhanced Recovery, NAPL Recovery, and EAB
- **North Deep (DNAPL):** Containment, ISS, Thermal Enhanced Extraction, Thermal Enhanced Recovery, NAPL Recovery, and EAB
- **Other Periphery:** Containment, ISS, Thermal Enhanced Extraction, Thermal Enhanced Recovery, and EAB

NAPL Recovery was often paired with Thermal Enhanced Recovery and Thermal Enhanced Extraction because it is a complimentary technology that can increase the effectiveness and shorten the treatment timeframe required for enhanced methods. EAB is used as a "polishing" technology for deployment in areas with sparse NAPL occurrences and/or for implementation in target zones following completion of more aggressive remedial action.

Based on CERCLA program expectations, a range of seven source control alternatives were assembled. In addition to the technologies named in each alternative title, an array of common elements is also required to fully implement each alternative. The seven alternatives include the following:

- **Alternative 1: No Action—**The No Action Alternative was developed per NCP requirements.
- **Alternative 2: Containment—**This is the current remedy implemented under the existing Soil and Groundwater OUs Record of Decision (EPA, 2000a).
- **Alternative 3: Excavation, Thermal Desorption, and ISS—**The excavation and thermal desorption components of this alternative would be implemented in the Core Area, North Shallow (LNAPL), East Shallow (LNAPL), and Other Periphery target zones, and ISS in the North Deep (DNAPL) target zone.
- **Alternative 4: ISS—**This technology would be implemented in each target zone.
- **Alternative 5: Thermal Enhanced Extraction and ISS—**Thermal enhanced extraction would be implemented in the Core Area, North Shallow (LNAPL), and East Shallow (LNAPL), with ISS implemented in the North Deep (DNAPL) and EAB in the Other Periphery target zones.
- **Alternative 6: Excavation, Thermal Desorption, and Thermal Enhanced Extraction—**The excavation and thermal desorption components of this alternative would be implemented in the Upper Core Area with thermal enhanced extraction implemented in the Lower Core Area, North Deep (DNAPL), North Shallow (LNAPL), and East Shallow (LNAPL) areas, and EAB in the Other Periphery target zone.
- **Alternative 7: ISS of Expanded Core Area and Thermal Enhanced Recovery—**ISS would be implemented in an expanded Core Area during the initial remedy implementation phase (Phase 1) with thermal enhanced recovery implemented in the remaining target zones outside the ISS footprint during a subsequent phase (Phase 2). This alternative also includes NAPL recovery in the North Deep (DNAPL) and East Shallow (LNAPL) target areas, and EAB in the Other Periphery area.

The estimated implementation timeframe and duration for each of the remedial action alternative technology and technology pairing is presented in **Figure ES-2**.

Following development, the seven alternatives identified above were screened against the NCP criteria of effectiveness, implementability, and cost as described in 40 CFR 300.430(e)(7). Based on the results of this screening, Alternative 3 – Excavation, Thermal Desorption, and Thermal Enhanced Extraction was eliminated based on implementability considerations. The shoring and dewatering necessary to implement the deep excavation technology at the Site under Alternative 3 was determined to pose significant geotechnical risk.

Detailed Evaluation of Alternatives

The six remedial action alternatives (e.g. Alternatives 1, 2, and 4 through 7) retained following the initial screening were carried forward for more detailed engineering development and evaluation against the CERCLA threshold and balancing criteria described in the NCP under 40 CFR 300.430(e)(9). The alternatives will be evaluated against the modifying criteria during the CERCLA public participation process that occurs following issuance of the Proposed Plan.

In addition to the individual evaluation of each alternative against the CERCLA criteria, which is presented in Section 4 of this FFS, the alternatives were evaluated relative to one another to identify key trades-offs. The comparative evaluation (see **Table ES-1**) was used to facilitate a ranking of the alternatives and identification of a recommended alternative. During preparation of the Proposed Plan, EPA will identify a preferred alternative that may differ from the recommended alternative identified in this FFS.

Recommended Alternative

Based on the results of the detailed and comparative evaluation, Alternatives 4 and 7 were ranked comparable relative to the CERCLA balancing criteria with Alternative 7 having a lower total present worth cost of $82.4 million versus $88.6 million for Alternative 4 based on a 7 percent discount factor.

Both alternatives use the ISS technology to treat NAPL source material. Alternative 4 implements ISS across the entire NAPL source area footprint to treat 93 percent of the material while Alternative 7 implements ISS across a smaller footprint to treat 65 percent of the NAPL source material. Because the ISS technology converts the soil/NAPL/cement into a hard, low-permeability monolith, it will be very difficult, potentially impossible, to implement additional remedial actions in the FPA if Alternative 4 performance monitoring indicates that remedial action objectives were not achieved. Alternative 7 uses ISS to treat a majority of the NAPL source material with performance monitoring conducted to confirm treatment effectiveness and to inform decisions on the need for additional treatment. The performance monitoring results would also be used to guide technology screening and identification of areas where further treatment is needed. The adaptive management logic employed by Alternative 7 is an important differentiator that supports identification of Alternative 7 as the recommended alternative.

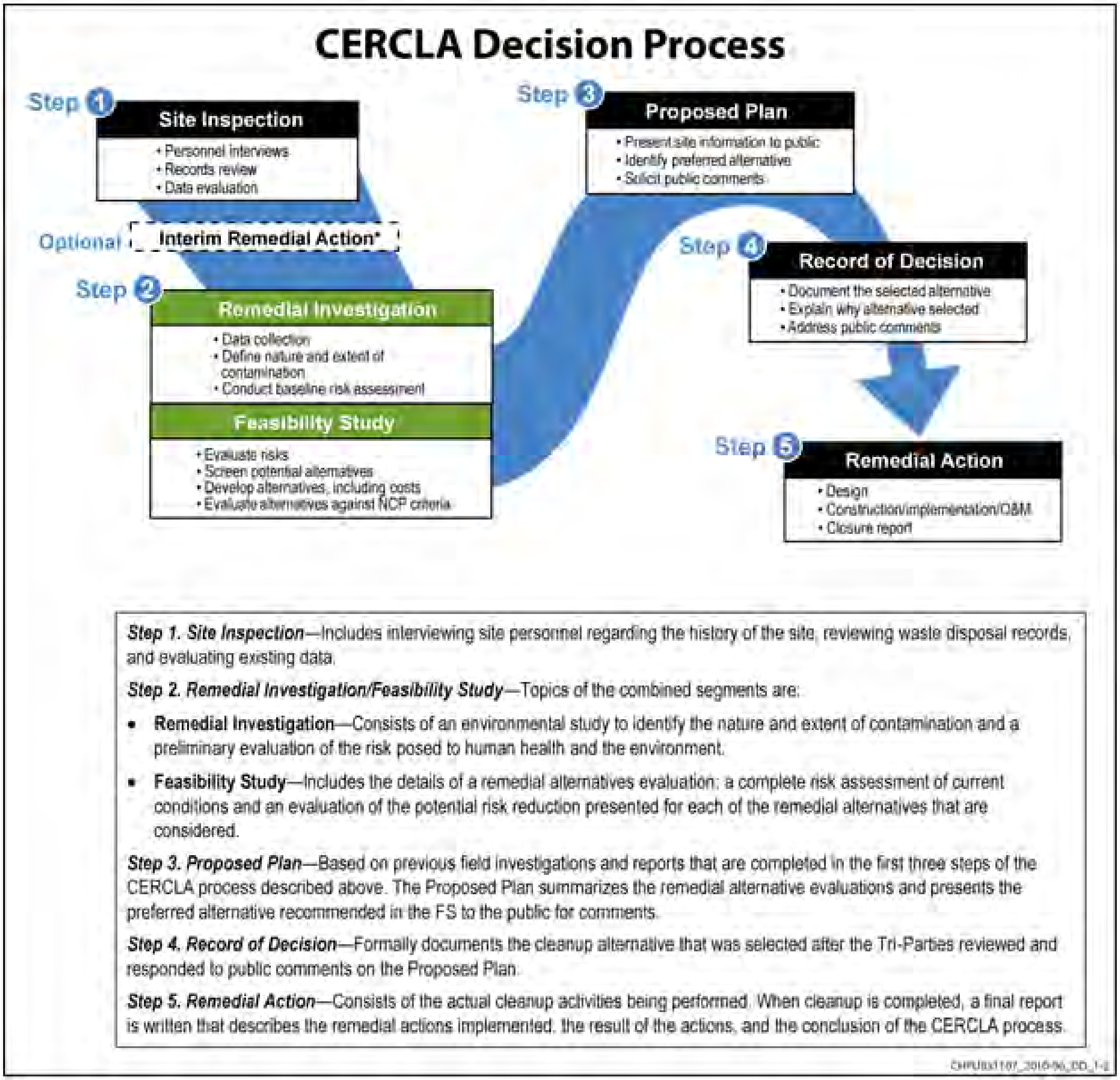
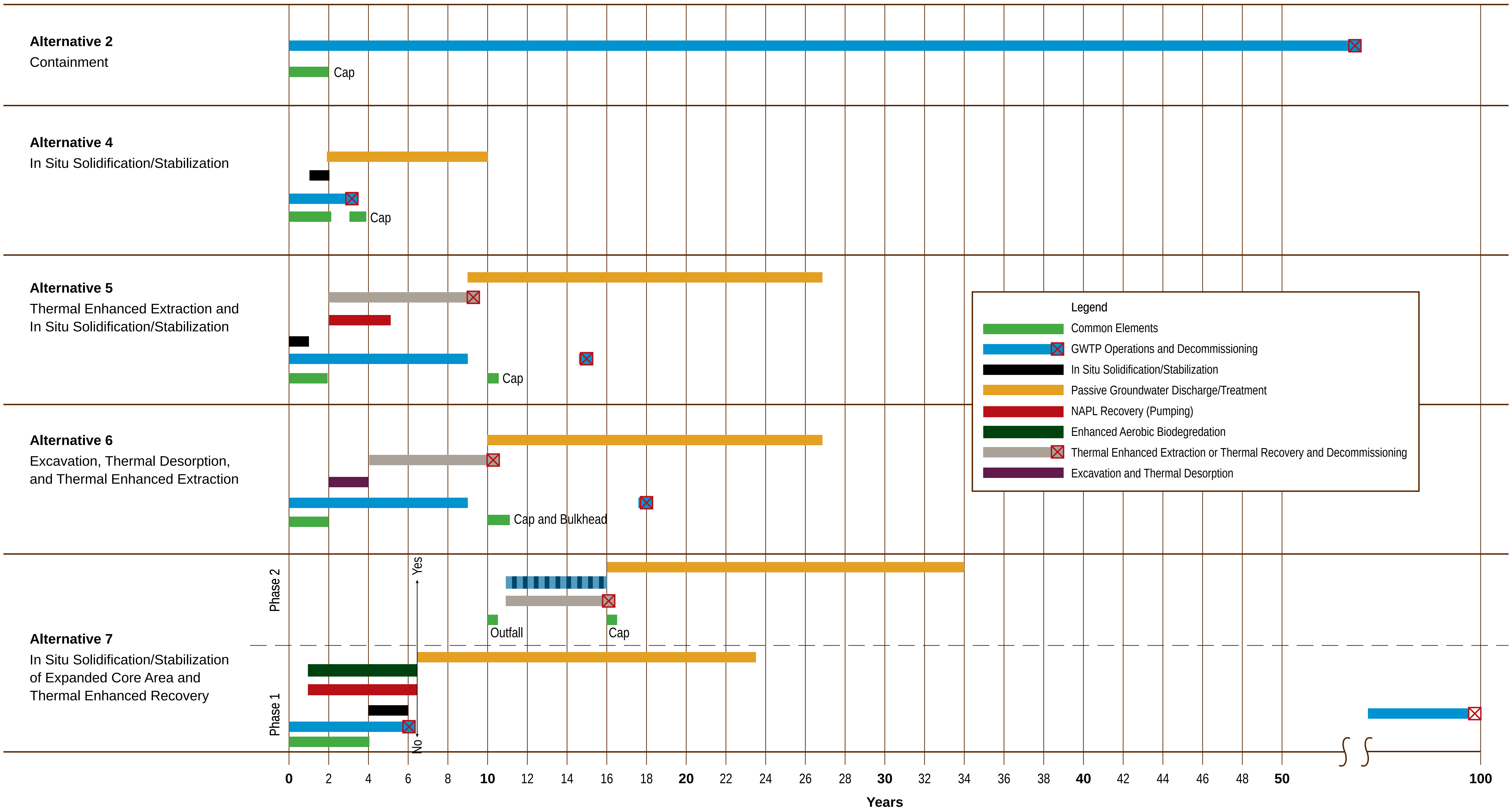


FIGURE ES-1

Comprehensive Environmental Response Compensation and Liability Act Decision Process
Soil and Groundwater OUs (OU2/OU4) FFS
Wyckoff/Eagle Harbor Superfund Site
Bainbridge Island, WA



Notes:

Alternative 1 – No Action

Alternative 3 – Excavation, Thermal Desorption, and ISCO were screened out and not carried forward for evaluation.

Figure ES-2
Remedial Action Alternative Technology Durations
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site
Bainbridge Island, WA

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Table ES-1
Comparative Evaluation of Alternatives
Soil and Groundwater OUs – Former Process Area, Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

<table>
<tr><th>Criterion</th><th>Alternative 1 – No Action</th><th>Alternative 2 - Containment</th><th>Alternative 4 - ISS</th><th>Alternative 5 – Thermal Enhanced Extraction and ISS</th><th>Alternative 6 – Excavation, Thermal Desorption, and Thermal Enhanced Extraction</th><th>Alternative 7 – ISS of Expanded Core Area and Thermal Enhanced Recovery</th></tr>
<tr><td colspan="7">Key Treatment Technologies</td></tr>
<tr><td>Core Area</td><td rowspan="5">Natural attenuation</td><td rowspan="5">Soil cap, hydraulic containment, and ICs</td><td rowspan="5">ISS, soil cap</td><td rowspan="3">Enhanced NAPL recovery, thermal enhanced extraction, EAB</td><td>Upper Core - Excavation, thermal desorption
Lower Core – Enhanced NAPL recovery, thermal enhanced extraction, EAB</td><td>ISS</td></tr>
<tr><td>East Shallow (LNAPL)</td><td rowspan="3">Enhanced NAPL recovery, thermal enhanced extraction, EAB</td><td rowspan="3">NAPL recovery, thermal enhanced recovery, EAB</td></tr>
<tr><td>North Shallow (LNAPL)</td></tr>
<tr><td>North Deep (DNAPL)</td><td>ISS</td></tr>
<tr><td>Other Periphery</td><td>EAB</td><td>EAB</td><td>EAB</td></tr>
<tr><td colspan="7">Percent of NAPL Treated using Key Technologies or Technology Pairs</td></tr>
<tr><td>Natural Attenuation</td><td>100</td><td>--</td><td>--</td><td>--</td><td>--</td><td>--</td></tr>
<tr><td>Passive Treatment/Natural Attenuation</td><td>--</td><td>70</td><td>7</td><td>16</td><td>15</td><td>15</td></tr>
<tr><td>Hydraulic Containment</td><td>--</td><td>30</td><td>--</td><td>--</td><td>--</td><td>--</td></tr>
<tr><td>ISS</td><td>--</td><td>--</td><td>93</td><td>--</td><td>--</td><td>--</td></tr>
<tr><td>Thermal Enhanced Extraction/ISS</td><td>--</td><td>--</td><td>--</td><td>84</td><td>--</td><td>--</td></tr>
<tr><td>Excavation/Thermal Desorption/ Thermal Enhanced Extraction</td><td>--</td><td>--</td><td>--</td><td>--</td><td>85</td><td>--</td></tr>
<tr><td>ISS/Thermal Enhanced Recovery</td><td></td><td></td><td></td><td></td><td></td><td>85</td></tr>
</table>

Table ES-1
Comparative Evaluation of Alternatives
Soil and Groundwater OUs – Former Process Area, Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Criterion	Alternative 1 – No Action	Alternative 2 - Containment	Alternative 4 - ISS	Alternative 5 – Thermal Enhanced Extraction and ISS	Alternative 6 – Excavation, Thermal Desorption, and Thermal Enhanced Extraction	Alternative 7 – ISS of Expanded Core Area and Thermal Enhanced Recovery
Threshold Criteria						
Protects HHE	No	Yes	Yes	Yes	Yes	Yes
Complies with ARARs	No	Yes	Yes	Yes	Yes	Yes
Balancing Criteria						
Long-term Effectiveness and Permanence	Not evaluated	★☆☆	★★★	★★★	★★★	★★★
Reduction of TMV through Treatment	Not evaluated	★☆☆	★★★	★★★	★★★	★★★
Short-term Effectiveness		★★☆ O&M limited to 100 years	★★☆	★★☆	★★☆	★★☆
Implementability		★★☆	★★☆	★☆☆	★☆☆	★★☆
Cost (millions) Total Present Worth Cost: 7.0% discount Total Present Worth Cost: 1.4% discount Total Non-discounted Cost	 $0 $0 $0	 $52.0 $79.8 $111.0	 $88.6 $93.7 $95.4	 $120.1 $142.1 $149.6	 $161.5 $197.7 $210.0	 $82.4 $113.0 $124.6
Modifying Criteria						
State Acceptance	Not evaluated in this FFS					
Community Acceptance						

★★★ = The alternative performs very well against the CERCLA balancing criterion with minimal disadvantages or uncertainties

★★☆ = The alternative performs moderately well against the CERCLA balancing criterion but with some disadvantages or uncertainties

★☆☆ = The alternative performs less well against the CERCLA balancing criterion with more disadvantages or uncertainty

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Acronyms and Abbreviations

°C	degrees Celsius
°F	degrees Fahrenheit
%RE	percentage of reference emitter
amsl	above mean sea level
ARARs	applicable or relevant and appropriate requirements
AST	aboveground storage tank
bgs	below ground surface
BTEX	benzene, toluene, ethylbezene, xylenes
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm/s	centimeters per second
COC	contaminant of concern
CSM	conceptual site model
CUL	clean-up level
CY	cubic yard
DAF	dissolved air flotation
DF	dilution factor
DNAPL	dense non-aqueous-phase liquid
DPT	direct push boring
EAB	enhanced aerobic biodegradation
Ecology	Washington State Department of Ecology
ELCR	excess lifetime cancer risk
EC	engineering control
EPA	United States Environmental Protection Agency
FFS	focused feasibility study
FPA	Former Process Area
FS	feasibility study
ft-MLLW	feet mean low-low water
ft^2	square feet
g/cc	grams per cubic centimeter
g/mL	grams per milliliter
GAC	granular activated carbon
gpm	gallons per minute
GRA	general response action
GSI	groundwater – surface water interaction
GWTP	groundwater treatment plant
HDPE	high-density polyethylene
HPAH	high-molecular weight PAH
IC	institutional control
ISCO	in situ chemical oxidation
ISS	in situ solidification/stabilization

LIF	laser-induced fluorescence
LNAPL	light non-aqueous -phase liquid
LPAH	low-molecular weight PAH
MCL	maximum contaminant level
mg/L	milligrams per liter
MLLW	mean low low water
mm	millimeters
MNA	monitored natural attenuation
MTCA	Model Toxics Control Act
MTTD	medium-temperature thermal desorption
MVS	Mining Visualization Software
NAPL	non-aqueous-phase liquid
NCY	NAPL contaminated soil cubic yards
NPDES	National Pollutant Discharge Elimination System
OU	operable unit
O&M	operations and maintenance
PAH	polycyclic aromatic hydrocarbons
psi	pounds per square inch
PCP	pentachlorophenol
PO	performance objective
ppm	parts per million
PRG	preliminary remediation goal
QAPP	quality assurance project plan
RAO	remedial action objective
RCRA	Resource Conservation Recovery Act
RI	remedial investigation
ROD	Record of Decision
SVE	soil vapor extraction
SVOC	semivolatile organic compound
TarGOST®	Tar-specific Green Optical Scanning Tool
TPH	total petroleum hydrocarbons
TPH-Dx	TPH-diesel
USACE	United States Army Corps of Engineers
USCS	Unified Soil Classification System
WAC	Washington Administrative Code

SECTION 1
Introduction

This report presents the draft Focused Feasibility Study (FFS) conducted for the Wyckoff/Eagle Harbor Superfund Site (Wyckoff Site, or Site) Soil and Groundwater Operable Unit (OU) located on Bainbridge Island, Washington. The FFS describes the process by which remedial action alternatives were developed and evaluated to assist in identifying a recommended alternative to address non-aqueous-phase liquid (NAPL) source material underlying the Site's Former Process Area (FPA). This FFS was prepared as one of the work scope items included under Task Order 079-RI-FS-10S1 of the U.S. Environmental Protection Agency (EPA) Region 10 and CH2M HILL Architecture and Engineering Services Contract No. 68-S7-04-01.

1.1 Purpose and Report Organization

A feasibility study (FS) ensures that appropriate remedial action alternatives are developed and evaluated so that relevant information concerning the remedial action options can be presented and an appropriate remedy selected. This document is referred to as an FFS, rather than an FS, because it addresses a specific problem within the Soil and Groundwater OUs; that is NAPL source material.

As described in *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA, 1988a), the FFS/FS consists of three phases:

- Screening remedial technologies
- Developing remedial action alternatives
- Conducting a detailed analysis of the alternatives

The results of the first two phases were presented in the *Wyckoff/Eagle Harbor Soil and Groundwater Operable Units Focused Feasibility Study - Remedial Technology Screening and Preliminary Remedial Action Alternatives* (CH2M HILL, 2014a). Much of the information presented in the February 2014 Technical Memorandum is included herein for completeness to support the identification of a recommended alternative in this draft FFS report.

The content and format of this document is based on the suggested FS report format described in *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA, 1988a) as follows:

- Section 1 – Introduction
- Section 2 – Identification and Screening of Technologies
- Section 3 – Development and Screening of Alternatives
- Section 4 – Detailed Analysis of Alternatives
- Section 5 – Recommended Alternative
- Section 6 - References

The tables and figures called out in this document are presented in separate sections that follow Section 6. This FFS report also contains several key appendices that provide important contributing information as follows:

- **Appendix A, Soil and Groundwater Operable Unit Applicable or Relevant and Appropriate Requirements,** contains an evaluation of applicable or relevant an appropriate requirements (ARARs) that specify federal and state of Washington regulations that govern the soil and groundwater clean-up levels that need to be achieved by the NAPL source area remedial action, and the manner in which the remedial action alternatives are to be implemented.

- **Appendix B, Remedial Action Alternative Drawings,** contains the engineering drawings that illustrate conceptual level design information for the common elements and remedial action alternatives described in Section 3.
- **Appendix C, Remedial Action Alternative Cost Estimate,** contains a -30/+50 percent cost estimate for each remedial action alternative carried forward for the detailed analysis of alternatives presented in Section 4.
- **Appendix D, Wyckoff NAPL Composition**, presents laboratory analysis results from testing of NAPL samples collected at the Site.

1.2 Background Information

This section summarizes background information for the Wyckoff/Eagle Harbor Superfund Site Soil and Groundwater OUs, including the Site description, Site history investigation chronology, nature, and extent of NAPL contamination, baseline risk, and status of the ongoing containment remedy. Most information was adapted from the following:

- *EPA Superfund Record of Decision: Wyckoff Co./Eagle Harbor, EPA ID: WAD009248295, OU 02, 04, Bainbridge Island, WA* (2000 ROD; EPA, 2000a)
- *Groundwater Conceptual Site Model Update Report for the Former Process Area Wyckoff/Eagle Harbor Superfund Site, Soil and Groundwater Operable Units* (CH2M HILL, 2013a)

1.2.1 Site Description

The Wyckoff/Eagle Harbor Superfund Site is located on the east side of Bainbridge Island, Kitsap County, Washington (**Figure 1-1**). The Site was divided into the following four OUs based on environmental media, contaminant sources, and environmental risks:

- **OU1** or the **East Harbor OU** (subtidal/intertidal sediments in Eagle Harbor contaminated by polycyclic aromatic hydrocarbons [PAHs])
- **OU2** or the **Wyckoff Soil OU** (unsaturated soil contaminated with PAHs and pentachlorophenol [PCP])
- **OU3** or the **West Harbor OU** (subtidal/intertidal sediments in Eagle Harbor contaminated by metals, primarily mercury, and upland sources)
- **OU4** or the **Wyckoff Groundwater OU** (the saturated soil and groundwater beneath OU2)

The Wyckoff Site spans approximately 57 acres of which OU2 and OU4 occupy about 18 acres. OU2/OU4 comprises the following three geographic areas: FPA, Former Log Storage/Peeler Area, and the Well CW01 Area. This FFS only addresses those portions of OU2/OU4 lying beneath the approximate 8-acre FPA, where most NAPL occurs. The Log Storage/Peeler Area and the Well CW01 Area are not discussed is this FFS report; additionally, OU1 and OU3 are also not discussed. OU1 is addressed in a separate FFS, while OU3 was addressed in a previous Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) decision document, *Record of Decision Amendment, Wyckoff/Eagle Harbor Superfund Site, Operable Unit 3, Bainbridge Island, Washington* (EPA, 1996).

1.2.1.1 Hydrogeology

This section summarizes the hydrogeology underlying the FPA. This includes information on the key hydrostratigraphic units, groundwater flow patterns, and groundwater/surface water interaction (GSI). This hydrogeologic understanding is based on the cumulative findings of numerous investigations (**Table 1-1**) that included drilling soil borings (geotechnical, direct push, probes, and/or cone penetrometer) and installing monitoring wells, piezometers, and/or extraction wells. Currently, there are 77 wells present in the FPA (**Figure 1-2**).

Based on geologic logging of the soil and well boreholes, the deepest of which is 127 feet below ground surface (bgs), there are four primary hydrostratigraphic units: Vadose Zone, Upper Aquifer, Aquitard, and the Lower Aquifer. A conceptual hydrogeologic cross-section showing the key hydrostratigraphic units, historical NAPL sources, and NAPL migration pathways is shown on **Figure 1-3.**

Vadose Zone

The vadose zone, or unsaturated zone above the water table, generally consists of fill material that extends from ground surface to depths ranging from 6 feet in the west portion of the FPA to 13 feet in the northeast portion. The vadose zone thickness varies with seasonal and tidally influenced groundwater elevations. Within the vadose zone, buried infrastructure, debris, and building foundations occurs within the footprint of the FPA (**Figure 1-4**). Some of these features are exposed at the ground surface, whereas others have been covered during filling and regrading activities. Buried debris is an important consideration for the FFS, because unless removed, it may affect NAPL source area remedy implementation.

Direct contact with the NAPL-contaminated soil present in the vadose zone, and associated with buried debris, represents the primary human health exposure pathway in the Soil and Groundwater OUs. Leaching of contaminants from NAPL present in vadose zone soil or associated with buried debris also represents a groundwater contaminant source.

Upper Aquifer

The Upper Aquifer consists primarily of sand and gravel with groundwater occurring under unconfined or water table conditions. Groundwater elevations range from about 7.5 to 10 feet mean lower low water (MLLW) under nonpumping, seasonal low conditions (based on September 2012 data). Daily tidal fluctuations have significantly influenced Upper Aquifer groundwater elevations, especially along the shoreline. These variations can result in water table fluctuations ranging from 1 to 10 feet. After the perimeter sheet pile wall was installed in 2001, tidal influence has diminished, and most wells now show a tidal influence ranging from 0.1 to 4 feet.

The perimeter or outer sheet pile wall bounding the north and east ends of the FPA is an important feature, because it represents an Upper Aquifer groundwater flow barrier. The sheet pile wall influences the Upper Aquifer's hydraulic response to seasonal water level changes and daily Puget Sound-Eagle Harbor tidal cycles. The sheet pile wall also controls NAPL and dissolved-phase contaminant transport from the Soil and Groundwater OUs to the East Harbor (OU1) and West Harbor (OU3) OUs.

As shown on **Figure 1-3**, groundwater flow in the Upper Aquifer before the sheet pile wall was installed (original conditions) was from the inland area towards Eagle Harbor and Puget Sound, where it discharged to the intertidal and subtidal zones. Groundwater flow patterns in the Upper Aquifer are currently influenced by the perimeter sheet pile wall and hydraulic containment pumping, which generally promote an inward groundwater flow pattern.

Per the 2000 ROD (EPA, 2000a), due to elevated salinity, Upper Aquifer groundwater beneath the FPA is not currently extracted, nor is it expected to be extracted in the future, for potable, agricultural, or industrial purposes. Elevated salinity is a natural condition that results from saltwater intrusion attributed to tidal cycles and the Site's proximity to Puget Sound/Eagle Harbor. The EPA and Washington State Department of Ecology (Ecology) have determined that Upper Aquifer groundwater in the FPA is nonpotable because it is affected by salinity. The assignment of a nonpotable, Class III groundwater beneficial use designation (total dissolved solids greater than 10,000 milligrams per liter [mg/L]) to Upper Aquifer groundwater present beneath the FPA is consistent with EPA's *Guidelines for Groundwater Classification under the EPA Groundwater Protection Strategy* (EPA, 1986) and Washington Administrative Code (WAC) 173-340-720(2)(a)(ii).

Aquitard

The Aquitard is a dense layer of marine silt, glacial deposits, and nonmarine clay material that separates the Upper Aquifer from the Lower Aquifer. The top of the Aquitard, which dips northeast, extends from near ground surface in the south-central portion of the Wyckoff Site to approximately 90 feet bgs along the northern portion. Based on numerous field explorations conducted during the Soil and Groundwater OUs remedial investigation (CH2M HILL, 1997), and various United States Army Corps of Engineers (USACE) exploratory drilling events (USACE, 1998a, 1998b, 2000, and 2006), the Aquitard appears continuous throughout most of the FPA.

The Aquitard's thickness ranges from 10 to 40 feet, with the thinnest areas located near the northeast corner and central portion of the FPA. Borings drilled along the south hillside in 2004 to characterize the area for an upgradient cutoff wall (CH2M HILL, 2004) identified localized areas where the Aquitard was not visibly evident in the far southwest and southeast corners of the Site.

Lower Aquifer

The Lower Aquifer consists primarily of sand, with small amounts of silt, clay, and gravel. While the thickness and depth to the bottom of the Lower Aquifer have not been determined at the Site, it is believed that it extends to a depth of approximately 200 or 250 feet bgs. This estimate is based on the regional work of Frans et al. (2011) and the logs recorded for two deep, onsite water supply wells that were decommissioned in 1997 and for a new water supply well that was completed in January 2002.

The direction of groundwater flow in the Lower Aquifer is also from the inland area towards Eagle Harbor and Puget Sound, which is a regional groundwater discharge zone, a condition that promotes an upward vertical hydraulic gradient from the Lower Aquifer to the Upper Aquifer. The sheet pile wall and Upper Aquifer hydraulic containment pumping do not influence horizontal groundwater flow patterns in the Lower Aquifer.

Per the 2000 ROD, groundwater in the Lower Aquifer (approximately 80 to 200 feet bgs) is considered potable (Class II B, Groundwater Not a Current Source but Potential Future Source), although this aquifer has never been used for drinking water at the Site. Routine groundwater monitoring performed in the Lower Aquifer has measured salinity levels that exceed the upper-bound potable water total dissolved solids concentration of 10,000 mg/L (EPA, 1986; WAC 173-340-720[2]) at locations up to 200 feet inland of the outer sheet pile wall (**Figure 1-5**). If a water supply well were installed in the Lower Aquifer within the FPA and routinely pumped, then the saltwater-freshwater interface would shift further inland. Rising sea levels would also push the freshwater-saltwater interface further inland. Therefore, for this FFS, all Lower Aquifer groundwater within 200 feet of the outer sheet pile wall is deemed Class III due to existing or future levels of elevated salinity.

1.2.2 Site History

From the early 1900s through 1988, a succession of companies treated wood at the Wyckoff property for use as railroad ties and trestles, telephone poles, pilings, docks, and piers. The wood-preserving plant was one of largest in the United States, and its products were sold throughout the nation and the rest of the world. Wood-preserving operations included the following activities: (1) using and storing creosote, pentachlorophenol (PCP), solvents, gasoline, antifreeze, fuel and waste oil, and lubricants; (2) managing process wastes; (3) treating and discharging wastewater; and (4) storing treated wood and wood products.

The main features of the wood-treating operation included a process area that included numerous storage tanks and process vessels such as retorts; a log storage and log peeler area; and a treated log storage area.

There is little historical information about the waste management practices at the Wyckoff facility. Before the Wyckoff facility was reconstructed in the 1920s, logs were reportedly floated in and out of a lagoon that once existed at the Site; the lagoon has since been filled. Treated logs were also transported to and from the facility at the former West Dock via a transfer table pit, and the chemical solution that drained from the retorts after a treating cycle went directly on the ground and seeped into the soil and groundwater below the surface. This practice began around the mid-1940s until operations ceased in 1988. Wastewater was also discharged into Eagle Harbor for many years, and the practice of storing treated pilings and timber in the water continued until the late 1940s. The log storage area was primarily used to store untreated wood. **Table 1-1** summarizes a chronology of key investigation, enforcement, and clean-up activities conducted for the Soil and Groundwater OUs.

1.2.3 Nature and Extent of Contamination

This section summarizes NAPL distribution in the Soil and Groundwater OUs underlying the FPA. The three-dimensional NAPL contamination footprint defines the area where remedial action is proposed in this FFS.

1.2.3.1 Upper Aquifer

The distribution of NAPL in the Upper Aquifer was defined using the results of Tar-specific Green Optical Scanning Technology (TarGOST®) investigations conducted in 2012 and 2013 as described in the *2013 Wyckoff Upland NAPL Field Investigation Technical Memorandum Field Summary Report* (CH2M HILL, 2013b). During the 2013 upland NAPL field investigation, 141 primary and 7 replicate TarGOST® borings (**Figure 1-6**) and 20 confirmation direct-push technology (DPT) soil borings were advanced to characterize the horizontal and vertical distribution of NAPL in the Upper Aquifer.

The TarGOST® technology does not explicitly measure an absolute NAPL saturation; instead, it measures the “optically available” NAPL that passes against the small window in the probe as it advances downward in the subsurface. A laser is emitted through the window, and the florescent response of the NAPL is captured and transmitted by fiber optics to a detector on the surface. A standard “reference emitter” (e.g., an oil with a known florescent response) is used to calibrate the instrument daily, and the individual readings are given as a percentage of the reference emitter (%RE).

The results were interpreted to select a TarGOST® response factor that marks the transition from NAPL absent to NAPL present. Based on evaluation of the TarGOST® data (CH2M HILL, 2013b) a TarGOST® response factor of between 5%RE and 10%RE was selected as signifying NAPL presence. Therefore, for this FFS, a TarGOST® response of 10%RE and greater was inferred to indicate that NAPL is present. The area enclosed by the 10% RE is shown on **Figure 1-6**.

The findings of the TarGOST® investigation revealed the following:

- In general, the aggregate NAPL thickness (e.g., the summed or total thickness of all discrete NAPL layers) is greatest in the center portion of the FPA (the core area) where the highest TarGOST®

responses were observed. Extending outward from this core area, the aggregate NAPL thickness and inferred NAPL saturations decrease.

- Outside of the core area, discrete NAPL lenses are vertically distributed but not in an obvious pattern. This distribution likely results from multiple sources, preferential NAPL transport pathways associated with interbedded geologic materials, interaction with variable fluid densities resulting from the Upper Aquifer's transition from freshwater to saltwater, and operation of the Upper Aquifer containment remedy.
- TarGOST® responses greater than 10%RE appear to terminate at or above the boring refusal depth, which generally occurs at the top of the Aquitard. In general, where collocated geologic information is available, the TarGOST® boring refusal depth is coincident with or slightly below the transition from the Upper Aquifer to the Aquitard's glacial till layer. This indicates that the glacial till is restricting, but not necessarily preventing, NAPL migration to lower depths.
- Along the FPA's east and north sides, elevated TarGOST® readings were observed next to the outer sheet pile wall at depths above the Aquitard's glacial till layer. In these areas, the sheet pile wall driven depths are greater than the deepest elevated TarGOST® responses.

Because the TarGOST® technology provides a relative indicator of NAPL saturation, confirmation soil borings were drilled and visually logged for soil type and NAPL absence and/or presence. The resulting field logs were compiled to evaluate NAPL association with soil type (**Figure 1-7**). Of the nearly 600 feet of soil core recovered, NAPL was observed in 119 feet, or 20 percent of the sampled material. When comparing NAPL occurrences by geologic material, NAPL tends to inhabit coarser-grained soil preferentially. Eighty-two percent of the NAPL present in the soil cores was detected in coarser-grained material consisting of marine sand or marine sand and gravel, and 15.5 percent of NAPL was observed in finer-grained material consisting of marine silt or marine sediment.

To estimate the total volume of NAPL-contaminated material underlying the FPA, TarGOST® response data were coupled with a Thiessen polygon analysis where each boring was assigned a representative area based on proximity to adjacent borings and the FPA boundary. Detailed information on the overall approach used to estimate the volume of NAPL-contaminated material is presented in *Groundwater Conceptual Site Model Update Report for the Former Process Area Wyckoff/Eagle Harbor Superfund Site, Soil and Groundwater Operable Units* (CH2M HILL, 2013a).

Based on interpretation of the TarGOST® results and knowledge of wood-treating formulations, there are distinct hydrogeologic intervals where NAPL occurs as the following:

- LNAPL that has spread horizontally and smeared across a tidal and seasonally variable water table surface
- DNAPL that has migrated vertically downward and spread laterally across lenses of fine-grained sediment present within the Upper Aquifer and across the Aquitard's upper boundary

Based on this distribution, the Upper Aquifer was segregated into three vertical compartments (**Figure 1-8**) as follows:

- Compartment 1 – The top of this compartment lies at an elevation of +20 feet mean low-low water (ft-MLLW) and the bottom at an elevation of -5 ft-MLLW. The bottom of Compartment 1 corresponds to an elevation of 5 feet below the water table. A majority of the LNAPL occurs in Compartment 1.
- Compartment 2 – The top of this compartment is at an elevation of -5 ft-MLLW with the bottom elevation ranging from -5 ft-MLLW at the south end of the FPA to about -40 ft-MLLW on the north

side of the FPA. The bottom elevation of Compartment 2 lies about 10 feet above the top of the Aquitard. The variable depth and thickness of Compartment 2 reflects the Aquitard's northeast dip.

- Compartment 3 – This compartment defines a 10-foot thick interval above the Upper Aquifer and Aquitard boundary. Like Compartment 2, the variable depth of Compartment 3 reflects the Aquitard's northeast dip.

The total volume of NAPL-contaminated material present in the Upper Aquifer is estimated at 109,000 cubic yards (CY), or 14 percent of the total soil volume; this translates into a NAPL volume of 679,000 gallons with 302,000 gallons (44 percent) estimated to be present in Compartment 1, 128,000 gallons (19 percent) present in Compartment 2, and 249,000 gallons (37 percent) present in Compartment 3.

Based on the observed geographic distribution of NAPL, the Upper Aquifer remedial action target area was partitioned into a Core Area, where thick sequences of NAPL occur, and a Periphery Area, where thinner lenses of NAPL are present. While evaluating TarGOST® information for the Periphery Area, it became apparent that NAPL occurrences in the Periphery Area warranted further subdivision based on considerations of NAPL architecture, geology, depth, and potential remedial technology application. Therefore, the Periphery Area was further partitioned into the following four different target zones: East Shallow (Light NAPL [LNAPL]), North Deep (Dense NAPL [DNAPL]), North Shallow (LNAPL), and Other Periphery. The locations of the five NAPL remedial action target zones are shown on **Figure 1-9,** and the volume of NAPL-contaminated material and estimated volume of NAPL present shown in each shown in **Table 1-2** and **Figure 1-10**.

The five remedial action target zones are described as follows:

- The **Core Area** is characterized by thick lenses of NAPL that in aggregate account for 44 percent of the NAPL quantity present in the Upper Aquifer. The volume of NAPL-contaminated soil is estimated at 39,000 CY, and this volume is estimated to contain 302,000 gallons of NAPL.
- The **East Shallow (LNAPL) Periphery** target zone is located along the east side of the FPA and is characterized by LNAPL present in Compartment 1 and sporadic DNAPL present in Compartments 2 and 3 that in aggregate account for 30 percent of the NAPL quantity present in the Upper Aquifer. The volume of NAPL-contaminated soil is estimated at 43,000 CY and this volume is estimated to contain 207,000 gallons of NAPL.
- The **North Deep (DNAPL) Periphery** target zone is located on the north end of the FPA. This zone is characterized by DNAPL present in Compartment 3, but also contains significant NAPL in Compartments 1 and 2. This area contains 13 percent of the NAPL quantity present in the Upper Aquifer. The volume of NAPL-contaminated soil is estimated at 14,000 CY and this volume is estimated to contain 86,000 gallons of NAPL.
- The **Other Periphery** target zone represents areas with discontinuous NAPL that are located near the south and southwest portions of the FPA. This target zone is characterized by NAPL present in isolated pockets. The quantity of NAPL present in this area is estimated at 33,000 gallons, which represents about 5 percent of the NAPL present in the Upper Aquifer.
- The **North Shallow (LNAPL) Periphery** target zone is located on the north end of the FPA and is characterized by LNAPL present in Compartment 1 (capillary fringe). It is estimated this area contains 4 percent of the NAPL present in the Upper Aquifer or 30,000 gallons.

The target zones also include **North Shallow and Deep** area, which is an overlap of the North Shallow (LNAPL) Periphery and North Deep (DNAPL) Periphery target zones located on the north end of the FPA.

This zone is characterized by NAPL present in Compartment 2. The quantity of NAPL present in this area is estimated at 18,000 gallons of NAPL or 3 percent of the NAPL present in the Upper Aquifer. Areas not specifically targeted for treatment because of sporadic NAPL occurrences total about 350 CY; the areas contain an estimated 1,000 gallons of NAPL. Although not targeted for treatment, they will be treated incidentally because of their proximity to areas where treatment will occur.

1.2.3.2 Aquitard

There are no monitoring wells or piezometers within the Aquitard, and only limited borings have been advanced through it. Consequently, creosote as NAPL or as dissolved constituents in Aquitard pore water cannot be directly measured. Instead, indirect observations and estimates must be relied on to evaluate the extent of NAPL contamination in the Aquitard. The following observations are informative in evaluating NAPL extent in the Aquitard:

- NAPL is present at the base of the Upper Aquifer at varying thicknesses and volumes in certain areas of the FPA. This indicates there is potential for downward NAPL migration into the Aquitard. However, penetrating the Aquitard is likely limited due to the heights (e.g., thickness) that NAPL must pool to overcome the entry pressures present in the Aquitard. The critical pool height for NAPL to penetrate the Aquitard is estimated at 9.4 feet.[2] Once exceeded, the NAPL head increases with penetration into the Aquitard, and unless the pool height decreases, NAPL migration will continue through the Aquitard.
- NAPL is present in the Lower Aquifer in an area to the north of Lower Aquifer wells (VG-2L, P-3L, and CW15). NAPL has migrated to this area from the Upper Aquifer, but the migration pathway is unclear.
- Lower Aquifer groundwater quality monitoring has identified two areas with PAH constituent concentrations greater than clean-up levels specified in the 2000 ROD: one to the north encompassing monitoring wells CW05, CW15, P-3L, and VG-2L and the other to the southwest surrounding piezometer PZ-11.
- The Aquitard is thin to absent near PZ-11. Consequently, the potential migration of dissolved-phase constituents from surface contamination to the Lower Aquifer is not inhibited in this area. It is unclear whether NAPL is present in the Lower Aquifer in this area.
- The Aquitard thickness varies over portions of the Site where NAPL is present at the base of the Upper Aquifer. The Aquitard’s slope and thickness, capillary forces, and NAPL pool height control the potential for NAPL penetration and migration through the Aquitard to the Lower Aquifer.

Interpreting these lines of evidence on **Figure 1-11** suggests the presence of NAPL and dissolved constituents in the Aquitard likely occurs in the northern portion of the FPA and possible in the center of the FPA. At the north end of the FPA, the presence of PAH constituents in Lower Aquifer groundwater reflects NAPL occurrences in Lower Aquifer monitoring wells, NAPL thicknesses observed in the Upper Aquifer that exceed the required height for NAPL entry into the Aquitard (as observed at TarGOST® location 2013T-043), and areas of decreased Aquifer Thickness. Furthermore, the Aquitard’s top surface is thought to have several depressions where NAPL could pool.

[2] The critical NAPL pool height was estimated as described in Appendix A, *2013 Conceptual Site Model Update for the OU2 and OU4 Former Process Area* (CH2M HILL, 2013a).

1.2.3.3 Lower Aquifer

The distribution of NAPL in the Lower Aquifer was estimated from NAPL thickness measurements made at Lower Aquifer monitoring wells during the June 2012 groundwater sampling event (CH2M HILL, 2013c). These measurements, as indicated by creosote staining on the measuring tape - although no defined oil-water interface was detected by the interface probe, indicate the presence of NAPL in four Lower Aquifer wells (CW15, P-3L, VG-2L, and VG-5L) in the northern portion of the FPA. This corresponds with an area where acenaphthene (**Figure 1-12**) and other PAH constituents are consistently detected near or above the 2000 ROD groundwater clean-up levels.

1.2.4 Contaminant Fate and Transport

The coal-tar creosote used at the Wyckoff Site was a complex mixture of chemicals, containing many different compounds. Approximately 85 percent of these compounds are classified as PAHs and 2 to 17 percent as phenols (Bedient et al., 1984). Historical laboratory analysis of creosote samples collected from the Site shows that naphthalene accounts for most of the overall PAH composition (**Figure 1-13**). To improve penetration during the wood-treatment process, creosote and PCP were mixed with a carrier oil, which is presumed to have been diesel. The carrier oil is often indicated by the presence of benzene, toluene, ethylbenzene, and xylenes (BTEX) and total petroleum hydrocarbon (TPH) – diesel (TPH-Dx) concentrations in NAPL samples.

Wood-treating NAPL is subject to naturally occurring physical-chemical processes that, over time, result in transfer of contaminant mass from the NAPL to the vapor, aqueous, and solid-sorbed phases. Collectively, these processes reduce the mass of the NAPL source. Contaminants that partition from the NAPL to the vapor phase, and from the NAPL to the aqueous phase, may undergo further biologically mediated degradation and non-biologically mediated degradation reactions that reduce their concentrations in environmental media.

Volatilization is a process by which chemical compounds partition from the NAPL to a vapor and, hence, is an important process for NAPL present above the water table. The compounds present in NAPL at the Wyckoff Site that likely exhibit some volatilization behavior include naphthalene and benzene. Volatilization depends on soil temperatures with higher temperatures promoting higher rates of volatilization. The composition of NAPL present above the water table at the Site is expected to have been significantly affected by the loss of benzene and naphthalene.

Solubilization, or dissolution, is a process by which chemical compounds partition from the NAPL present above the water table to infiltrating rainfall or to groundwater for NAPL present below the water table. For multicomponent NAPLs, the solubilization process is governed by the compound's fractional concentration in the NAPL mixture and the water flux that moves across the NAPL zone. The chemical compounds present in NAPL at the Site have a wide range of aqueous solubilities with BTEX and low-molecular weight PAHs (LPAHs), such as naphthalene, acenaphthylene, and acenaphthane, most likely to be removed from the NAPL through solubilization.

Chemical compounds removed from the NAPL through solubilization can undergo non-biologically mediated and biologically mediated degradation in groundwater under aerobic and anaerobic conditions. Biodegradation is an important process at the Site for many of the BTEX compounds and for the LPAHs, such as naphthalene. To assess potential rates of NAPL depletion resulting from dissolution and biodegradation, the mass of naphthalene present in the 679,000 gallons of NAPL was calculated. Naphthalene was used as an indicator because it accounts for 35 to 55 percent of the NAPL mass fraction (**Figure 1-13**) based on laboratory analysis of NAPL samples collected in 1999 and 2014. The amount of naphthalene present in the NAPL phase was estimated at 1.15 million kilograms[3]. The amount of naphthalene present in the NAPL phase was estimated based on the assumption that: 1) 85 percent of the NAPL mixture is comprised of LPAH compounds, and 2) naphthalene comprises 50 percent of the LPAH mass in the NAPL phase. This is equivalent to naphthalene accounting for 43 percent of the total PAH mass. This fractional composition is also consistent with more recent laboratory analysis of NAPL samples, which showed that naphthalene accounts for approximately 40 to 50 percent of the total SVOC mass in the LNAPL samples and 30 to 40 percent of the total SVOC mass present in the DNAPL samples.

To estimate PAH concentration half-life, two sets of historical NAPL composition data were evaluated. The first sample was collected in 1999 and the second in 2014. The changes in PAH concentration between these two NAPL samples were used to calculate an effective groundwater concentration for each major PAH constituent. The effective concentrations were then used to calculate a half-life for several PAH constituents. The calculated half-life for naphthalene was estimated at 30.4 years while PCP was estimated at 15.7 years. The half-life estimates are comparable to those reported for other creosote sites, although values for naphthalene vary widely. The estimated half-life value incorporates NAPL dissolution, biodegradation, and other weathering and mass transfer limitation effects.

The naphthalene half-life yields mass removal rates that approach about 22,000 kilograms per year initially eventually declining to less than 1,000 kilograms per year in about 140 years (**Figure 1-14**). Assuming that the naphthalene dissolution is not rate controlled, and there are no other biodegradation rate limitations (e.g., nutrients, salinity, or microorganism availability), it takes approximately 400 years for the initial naphthalene mass of 1.15 million kg to decrease to less than 100 kg. This estimate assumes ideal conditions. In reality, as the NAPL composition changes with time, some other form of rate controls will begin to influence the rate of naphthalene dissolution resulting in a much longer timeframe.

Other key NAPL fate and transport behavior at the Site includes the following:

- As the spills and leaks occurred, the contaminants moved as mobile NAPL into the vadose zone, adsorbing onto soil, volatilizing into soil gas, and dissolving into pore water.
- Mobile NAPL migrated downward through the vadose zone until it reached the water table and separated into light and dense phases:
  - The LNAPL spread out along the water table surface and migrated laterally with the groundwater.
  - Downward migration of DNAPL was slowed or halted as it encountered higher-density saline groundwater and lower-permeability zones within the Upper Aquifer. Some DNAPL continued migrating downward until it reached the Aquitard.
  - Lateral movement of DNAPL has occurred through high-permeability gravel and cobble zones or through spreading when the DNAPL reached low-permeability zones within the Upper Aquifer or at the top of the Aquitard.
  - NAPL undergoes dissolution as it encountered groundwater in the Upper Aquifer, resulting in formation of a multicomponent dissolved-phase plume characterized primarily by the presence

[3] 679,000 gallons of NAPL × 3,785 milliliters/gallon × 1.021 grams/milliliter (NAPL density) × 0.001 kilograms/gram × 0.85 × 0.5 = 1,150,000 kilograms of naphthalene.

of LPAH compounds. The aqueous-phase contaminants were then transported with the groundwater flow, laterally toward Eagle Harbor and Puget Sound.

Following are potential mechanisms for transport of contaminants to the Lower Aquifer:

- Leakage of DNAPL or dissolved contaminants through “holes” and sand zones in the Aquitard. Downward advective transport of dissolved contaminants through the Aquitard is considered unlikely under natural conditions or containment pumping, because the hydraulic head is higher in the Lower Aquifer than in the Upper Aquifer creating a net upward flow potential.
- Transport of DNAPL across the Aquitard by water displacement or “wicking” mechanisms.
- Leakage of DNAPL or dissolved contamination as a result of early drilling activities on the Site, which may have provided conduits through the Aquitard. In 1995, EPA decommissioned 12 old wells. These were industrial water supply wells, monitoring wells, groundwater/contaminant extraction wells, and two deep drinking water supply wells.
- Transport of dissolved contaminants by molecular diffusion across the Aquitard from DNAPL on top of the Aquitard.

Any dissolved contaminants reaching the Lower Aquifer may be carried by regional groundwater flow toward discharge areas deep in Eagle Harbor and Puget Sound. However, because of the long transport distances involved, and assuming the groundwater is not extracted for beneficial use, any contaminants reaching the Lower Aquifer would likely be removed by sorption and decay before discharge to surface water.

1.2.5 Baseline Risk Assessment

No new Soil and Groundwater OUs risk assessment evaluation has been performed since the 2000 ROD was issued (EPA, 2000a). Therefore, risks posed to human health and the environment by current conditions are expected to be comparable with those described in Section 7 of the 2000 ROD. Risk assessment to specifically characterize the threat to human health and the environment by NAPL has not been performed, but direct exposure to NAPL is generally recognized to likely pose human health risk exceeding the upper bound of the CERCLA 1 x10^{-4} to 1 x 10^{-6} excess lifetime cancer risk range.

1.2.6 Status of Current Containment Remedy

In February 2000, EPA issued the 2000 ROD for the upland portion of the Wyckoff Site addressing contaminated soil (OU2) and groundwater (OU4). The selected remedy, thermal remediation, included a number of components designed to achieve substantial risk reduction by cutting off subsurface contaminant migration pathways with a sheet pile wall and treating the principal threat at the Site using thermal technology. A thermal remediation pilot study was conducted between October 2002 and April 2003. Numerous technical difficulties were encountered and it was determined that cleanup objectives could not be met using this technology.

The 2000 ROD identified a contingent remedy to be implemented should the thermal remediation pilot test not achieve its performance objectives. The contingent remedy – containment – is still in operation today and consists of the following components:

- Groundwater Extraction and Treatment. This includes eight recovery wells (**Figure 1-15**) screened in the Upper Aquifer. Pumps installed in these wells draw groundwater and NAPL away from the site perimeter and in toward the extraction wells. The groundwater and NAPL recovered from the extraction wells are treated in the onsite GWTP.

- Sheet-pile Wall – the 1,870-foot long steel sheet pile wall was constructed around the shoreline of the FPA to prevent potential flow of contaminants to Eagle Harbor.
- Long-Term Monitoring – provides data on water levels in both the Upper and Lower Aquifers beneath the FPA (for confirming hydraulic containment), and on contaminant distribution and movement in the subsurface. Monitoring is ongoing.
- Institutional and Engineering Controls – prevent access to contaminated areas. Engineering controls (e.g., fencing) have been implemented to prevent contact with contaminated soil while institutional controls (ICs) prevent groundwater withdrawals except for monitoring and remediation purposes.

Ecology assumed operation of the groundwater extraction and treatment system in 2012, pursuant to a State Superfund Contract (SSC). The original SSC expired in April 2014, so it has been extended to June 2016. The system is effective in preventing further degradation of the Lower Aquifer. However, it is expensive to operate. Annual operation and maintenance costs are about $800,000 per year. At the current rate of PAH extraction and degradation, more than 300 years of additional pump and treat operations would be required to meet cleanup goals.

Based on recent performance, the groundwater extraction system removed about 22 million gallons from April 2012 through March 2013. The monthly groundwater extraction rate for all nine extraction wells varied from 0 gallons per month in August 2012 to 3,381,757 gallons per month (77.2 gpm) in December 2012. Groundwater pumping rates generally follow a seasonal pattern that correlates with monthly rainfall. Average pumping rates were 1.6 gpm to 9.5 gpm at individual wells. Approximately 72 percent of the groundwater currently extracted comes from four wells (RPW1, RPW2, RPW5, and RPW6).

From March 2012 through March 2013, approximately 1,300 gallons of NAPL (120 gallons LNAPL and 1,180 gallons DNAPL) were removed from seven recovery wells (RPW1, RPW2, RPW4, RPW5, RPW6, RPW8, and RPW9). Approximately 90 percent of the NAPL recovered during this period was from four wells (RPW1, RPW2, RPW5, and RPW8). In addition to the NAPL pumped directly from the extraction wells, an estimated 2,900 gallons of NAPL was removed from the GWTP tanks during the same period for a total of 4,200 gallons of NAPL recovered between March 2012 and March 2013.

The hydraulic containment system also removes dissolved-phase contaminant mass through the GWTP. Based on the average influent flow rate and average influent total PAH concentration, about 3,600 pounds of dissolved-phase contaminant mass was removed between March 2012 and March 2013.

The containment remedy is effective at maintaining an upward vertical gradient from the Lower Aquifer to the Upper Aquifer. The upward gradient is evaluated quarterly by downloading water level data from pressure transducers installed in 10 Upper and Lower Aquifer monitoring well pairs, calculating average groundwater elevations for defined measurement periods, and comparing the Upper and Lower Aquifer groundwater elevations for each period. If the Lower Aquifer groundwater elevation is higher than the Upper Aquifer groundwater elevation, then an upward vertical gradient is present. When the containment system is operating, it protects marine water quality by reducing or eliminating the discharge of dissolved-phase contaminants to Eagle Harbor and Puget Sound.

SECTION 2

Identification and Screening of Technologies

As described in Section 1.1, the FFS consists of three phases:

- Screening remedial technologies
- Developing remedial action alternatives
- Conducting a detailed analysis of the alternatives

This section presents the approach and results of the remedial technology screening phase. The technologies retained from the screening described in this section are assembled into a range of source area remedial action alternatives that are described in Section 3 and evaluated in Section 4 to assist in identifying a recommended alternative that is presented in Section 5. The remedial technology screening phase is preceded by the development of RAOs and preliminary remediation goals (PRGs) that define the clean-up levels that need to be achieved to protect human health and the environment.

2.1 Remedial Action Objectives

RAOs are narrative statements that describe what the remedial action is intended to accomplish. The RAOs may identify the contaminants of concern (COCs) and environmental media of concern, the exposure pathways to be protected, and the levels of cleanup that need to be achieved.

The RAOs developed by EPA and Ecology for the Wyckoff Soil and Groundwater OUs are provided in Table 2-1 and are described as follows:

- **RAO 1—Reduce human health risks associated with direct contact, ingestion, or inhalation of contaminated soil to levels that allow unrestricted outdoor recreational use.**

  The designated future use of the Site is a public park. By cleaning up contaminated soil to a depth of 15 feet, the designated point of compliance under WAC 173-340-740 (6), or placing a barrier with ICs to prevent direct contact with surface soils, future recreational users will be protected from exposure to contaminants.

- **RAO 2—Prevent use of Upper Aquifer groundwater for irrigation or industrial purposes that would result in unacceptable risks to human health.**

  Due to elevated salinity, Upper Aquifer groundwater is designated as Class III, which makes it nonpotable and most likely unusable for most industrial or irrigation uses. However, the concentration of COCs present in Upper Aquifer groundwater would pose a threat to human health should long-term exposure occur. Therefore, this RAO was established to prevent the withdrawal of Upper Aquifer groundwater for drinking, irrigation, or industrial purposes. Groundwater withdrawal for monitoring and remediation is allowable and noncontact industrial uses may also be allowable as approved by EPA and Ecology on a case-by-case basis.

- **RAO 3—Reduce risks associated with discharge of contaminated Upper Aquifer groundwater to Eagle Harbor and Puget Sound to levels that protect aquatic life and human consumption of resident fish and shellfish.**

  Under natural groundwater flow conditions, Upper Aquifer groundwater flows toward Eagle Harbor and Puget Sound upwelling into the water column through seeps and diffuse flow across the intertidal and subtidal sediments. After the outer sheet pile wall was installed in February 2001, the groundwater flow path was altered reducing the natural flux to Eagle Harbor and Puget Sound. However, small amounts of leakage through the sheet pile wall joints do occur. This RAO was established to prevent contaminated Upper Aquifer groundwater from discharging to surface water at concentrations that would result in unacceptable risks to recreational users (fishers, shellfish gathers, or beach play), consumers of resident fish and shellfish, and Eagle Harbor or Puget Sound aquatic life.

- **RAO 4—Prevent further degradation of the Lower Aquifer, and prevent use of Lower Aquifer groundwater that would result in unacceptable risk to human health.**

  As described in Section 1.2, Lower Aquifer groundwater is designated as Class IIB (future drinking water source) except for those portions lying within 200 feet of the outer sheet pile wall where elevated salinity would likely preclude most uses. Human exposure is currently prevented with access controls and ICs. Lower Aquifer groundwater within 200 feet of the outer sheet pile wall is not potable, but it discharges to Eagle Harbor, so protection of aquatic organisms is an important consideration. EPA is not selecting a remedy for the Lower Aquifer at this time. Through cleanup actions in the Upper Aquifer, EPA expects to prevent further degradation of the Lower Aquifer. EPA will monitor contaminant concentrations during and after cleanup actions in the Upper Aquifer and collect data needed to determine whether monitored natural attenuation might be an effective remedy for the Lower Aquifer. A cleanup decision will be made for the Lower Aquifer in a future CERCLA decision document.

2.1.1 Performance Objectives

In addition to the four RAOs described above, the following two performance objectives (POs) were also established by EPA and Ecology:

- **PO 1—**Remove or treat mobile NAPL in the Upper Aquifer to the maximum extent practicable such that migration and leaching of contaminants is significantly reduced. This will remove principal threat materials, which allows for considering monitored natural attenuation (MNA) as a remedial action technology for residual concentrations, and allows for implementing PO 2.

- **PO 2—**Implement a remedial action that does not require active hydraulic control as a long-term component of operations and maintenance (O&M) following completion of source removal action.

These objectives were used to guide the development of the remedial action alternatives presented in Section 3 of this FFS. Relative to PO 2, hydraulic control may be used during the active remediation phase, but not for the long term. A 10-year period of hydraulic control following completion of all source removal activities is assumed as the maximum allowable duration for active hydraulic control in this FFS.

2.1.2 Contaminants of Concern

Following are the soil and groundwater COCs identified in the 2000 ROD:

- PAHs also present in the NAPL
- PCP also present in the NAPL
- Dioxins/Furans (soil only) are typically associated with PCP and, therefore, are inferred to be present in NAPL

Each of the above represent a specific contaminant or group of contaminants that are known through laboratory analysis or process knowledge to be associated with historical wood-treating activities conducted in the FPA. No additional NAPL related COCs have been identified.

For this FFS, other contaminants—such as BTEX, which is associated with the carrier oil that is blended with creosote and PCP-based wood-treating oils, and heterocyclic aromatic compounds (e.g., 2-methylnaphthelene, carbazole, and dibenzofuran)—are assumed to be co-located with the PAHs and PCPs and will be remediated along with these primary COCs.

2.1.3 Preliminary Remediation Goals

PRGs represent the allowable concentration of COCs in environmental media that are protective of human health and the environment. Therefore, they define the level of cleanup to be achieved at the completion of a remedial action. PRGs are defined based on expectations for land, groundwater, and interconnected surface water beneficial uses. PRGs are also used to identify the area and/or volume of contaminated media to be addressed by a soil and/or groundwater remedial action.

This FFS develops and evaluates remedial action alternatives designed to address NAPL source material. Therefore, the area/volume of contaminated material is not defined by a soil or groundwater PRG but by areas where NAPL occurs. EPA and Ecology agreed to use a TarGOST® 10%RE measurement value as an indication of NAPL presence. Areas with a TarGOST® response of 10%RE or greater are presumed to contain NAPL and areas with a TarGOST® response of less than 10%RE are presumed to not contain NAPL.

The RAOs presented in Section 2.1 are expected to require a level of NAPL remediation or exposure control that accomplishes the following:

- Protects human health from exposure to NAPL-contaminated material present within the ground surface to 15-foot depth interval.
- Restores Upper Aquifer groundwater quality to a level that protects marine surface water quality and aquatic receptors.
- Protects Lower Aquifer groundwater that is suitable as a drinking water source from further degradation. Groundwater within the potable portions of the Lower Aquifer underlying the FPA does not currently contain COCs at concentrations above EPA maximum contaminant levels (MCL).

Owing to the technical challenge associated with remediating sites with large areas/volumes of NAPL contamination, it is not known what fraction of the NAPL present within the area enclosed by the TarGOST® 10% RE isopach must be remediated to achieve the RAOs. For the purposes of this FFS and remedial action alternative development, it is presumed that a much of the NAPL contaminated material lying within the Upper Aquifer beneath the FPA will have to be treated.

The following subsections summarize the regulatory and technical approach used to develop soil and groundwater PRGs. These PRGs are preliminary and will be finalized in the CERCLA decision document.

2.1.3.1 PRG Development Approach

PRGs for contaminants present in soil and groundwater are generally defined by state and federal regulations. These regulations are identified through a comprehensive review of ARARs. The Soil and Groundwater OUs ARARs review (**Appendix A**) was conducted in accordance with the following guidance:

- “Cleanup Standards,” “Degree of Cleanup” (CERCLA [Section 121(d)]
- CERCLA RI/FS Guidance (EPA/540/G-89/004; EPA, 1991a)
- *CERCLA Compliance with Other Laws Manual: Interim Final* (EPA/540/G-89/006; EPA, 1988b)
- *CERCLA Compliance with Other Laws Manual: Part II, Clean Air Act and Other Environmental Statutes and State Requirements* (EPA/540/G-89/009; EPA, 1989a)

Section 121(d) of the CERCLA statute, requires, with exceptions, that any promulgated substantive ARAR standard, requirement, criterion, or limitation under any federal environmental law, or any more stringent state requirement pursuant to a state environmental statute, or facility siting law be met (or a waiver justified) for any hazardous substance, pollutant, or contaminant that will remain on Site after the remedial action has concluded. The NCP ("Remedial Design/Remedial Action, Operation and Maintenance," 40 CFR 300.435[b][2]) requires that ARARs be attained (unless waived) during the remedial action.

Potential ARARs for the Soil and Groundwater OUs were identified and reviewed to group them into one of three categories as follows:

- **Chemical-specific ARARs—**These include health- or risk-based numerical values or methodologies that, when applied to site-specific conditions, establish public and worker clean-up levels (e.g., PRGs).
- **Location-specific ARARs—**These include restrictions placed on the concentration of dangerous substances or the conduct of activities solely because they occur in special geographic areas.
- **Action-specific ARARs—**These are technology- or activity-based requirements or limitations triggered by remedial actions performed at a site.

The chemical-specific ARARs applicable to the Wyckoff Soil and Groundwater OUs remedial actions are the elements of the WAC that implement the Model Toxics Control Action (MTCA) regulations. Within WAC 173-340, Cleanup, there are detailed regulations specifying soil ("Unrestricted Land Use Soil Cleanup Standards" [WAC 173-340-740]) and groundwater ("Groundwater Cleanup Standards" [WAC 173-340-720]) clean-up standards. These standards are in the form of risk-based concentrations that define soil, groundwater, and air clean-up standards for chemical contaminants. Following is a list of other chemical-specific ARARs:

- Substantive portions of MTCA, including "Selection of Cleanup Actions" (WAC 173-340-360) and "Overview of Cleanup Standards" (WAC 173-340-700) through "Priority Contaminants of Ecological Concern" (WAC 173-340-7494) that also includes "Cleanup Standards to Protect Air Quality" (WAC 173-340-750), "Sediment Cleanup Standards" (WAC 173-340-760), and "Sediment Management Standards" (WAC 173-204)
- Nonzero MCL goals and MCLs promulgated under the Safe Drinking Water Act (SDWA), "National Primary Drinking Water Regulations" (40 CFR 141) and/or by the State of Washington ("Group A Public Water Supplies" [WAC 246-290]) as they apply to primary MCL constituents
- Ambient water quality criteria (AWQC) and state water quality standards at the groundwater/surface water interface developed under the CWA (Section 304) and/or promulgated by the state of Washington ("Water Quality Standards for Groundwaters of the State of Washington" [WAC 173-200] and "Water Quality Standards for Surface Waters of the State of Washington" [WAC 173-201A]), "National Pollutant Discharge Elimination System [NPDES] Permit Program" [WAC 173-220], and "Wastewater Discharge Standards and Effluent Limitations" [WAC 173-221A].

2.1.3.2 Soil

The State of Washington MTCA regulation is the principal ARAR governing the development of PRGs for environmental clean-up actions. As set forth in WAC 173-340-700(2), remedial actions shall attain the following:

- Numeric clean-up levels for all COCs
- Clean-up levels at defined locations termed the points of compliance

Cleanup levels for soil are not specifically proposed for this NAPL source control action because a surface soil cover, which represents a direct contact barrier between human and terrestrial receptors and contaminated soil, will be included in each of the remedial action alternatives developed in this FFS except the no action alternative. If any imported fill material is required for construction of the surface cover, it will be sampled to confirm that it meets MTCA cleanup levels for residential exposure assumptions.

2.1.3.3 Upper Aquifer Groundwater

Upper Aquifer groundwater PRGs must protect marine surface water quality. The approach used to develop PRGs for each COC consists of multiplying the lowest applicable marine AWQC by a dilution-factor (DF). The DF reflects the concentration reduction that occurs during COC transport along a flow path that extends from the Upper Aquifer to the surface water column. As shown on **Figure 2-1**, the flow path length can vary considerably. The shortest flow path, which has the lowest DF and will be the basis for development of the Upper Aquifer groundwater PRGs, is the flow path that extends from the Upper Aquifer through the sheet pile wall and discharges to the surface water column through the intertidal sediments.

Currently, no information exists to estimate this DF. Therefore, during implementation of the selected remedy, the remedial design will include a modeling or field investigation activity to define the DF. Once a DF is defined, it will be multiplied by the values shown in **Table 2-3** to establish PRGs for the COCs present in Upper Aquifer groundwater. The methods used to define the DF may need to account for the presence of NAPL outside the sheet pile wall, which will be addressed by the East Harbor OU1 remedy.

2.1.3.4 Lower Aquifer Groundwater

As indicated previously, a remedy for the Lower Aquifer will be identified in a future CERCLA decision document. PRGs for Lower Aquifer groundwater will be identified in the Proposed Plan and technical documents used to support that decision.

2.2 General Response Actions

General response actions (GRAs) are typically media-specific actions that are appropriate for the site conditions, COCs, and RAOs. GRAs may include either individual or combinations of the following:

- No action
- Access restrictions, including ICs and engineering controls (ECs)
- Containment
- Removal and disposal (onsite and offsite)
- Ex situ treatment (onsite and offsite)
- In situ treatment

Because this FFS focuses on NAPL source material, the GRAs were not segregated by soil and groundwater. Sections 2.2.1 through 2.2.5 provide a general description of each GRA.

2.2.1 No Action

This GRA is required as a baseline for comparison against other technologies as specified under the NCP (40 CFR 300.430[e][6]). Under this GRA, no further action is taken at a site. If interim or final actions have been completed or are underway at the time of remedy selection, they are terminated following ROD or ROD amendment signature.

2.2.2 Access Restrictions

This GRA includes ICs and ECs. ICs are administrative controls or legal restrictions placed on land and groundwater use to protect the public against inadvertent exposure to hazardous constituents and/or to protect the integrity of a functioning or completed remedy. ICs may include land use restrictions, natural resource use restrictions, groundwater use restrictions or management areas, property deed notices, declaration of environmental restrictions, access controls (digging and/or drilling permits), surveillance, information posting or distribution, restrictive covenants, and federal, state, county, and/or local registries.

ECs generally include fences or manned security to protect against trespasser exposure to contaminated soils or groundwater (seeps and/or springs) until RAOs are achieved. For groundwater, ECs may include providing an alternate water supply for current or future users when contaminated groundwater is identified as a current drinking water source.

The existing containment remedy for the Site uses access restrictions to reduce the potential for human exposure to contaminated media present in the Former Process Area.

2.2.3 Removal and Disposal

These GRAs include excavation to remove contaminated media with long-term containment and management provided by disposing of the material at a secure onsite or a permitted offsite Resource Conservation and Recovery Act (RCRA) Subtitle D or Subtitle C facility. Depending on the concentration of contaminants present, disposal may be combined with ex situ treatment to comply with RCRA land disposal restrictions.

2.2.4 Ex Situ Treatment

This GRA includes technologies employed at an onsite or offsite treatment facility that treat contaminated media in aboveground treatment units. The current containment remedy uses ex situ physical treatment technologies (NAPL separation and granular activated carbon filtration) to treat NAPL, PAH, and PCP contamination in groundwater.

2.2.5 In Situ Treatment

This GRA includes various technologies (biological, chemical, thermal, physical) to treat contaminated media below the ground surface or in situ. MNA is also included within the scope of this GRA.

2.2.6 Area and Volume of NAPL Source Material Addressed

As described previously, EPA and Ecology agreed to use the TarGOST® 10%RE measurement value as an indicator of NAPL presence. Additional information on the rationale used for selecting the 10%RE value is presented in the *Wyckoff Upland NAPL Field Investigation Technical Memorandum Field Summary Report* (CH2M HILL, 2013b). The area enclosed by the 10%RE TarGOST® response was subdivided into five different geographic areas based on differences in NAPL volumes and NAPL architecture (e.g., LNAPL versus DNAPL). The location of these areas was described previously in Section 1.2.3 and shown on **Figure 1-9**.

The NCP establishes an expectation that EPA will use treatment to address the principal threats posed by a site wherever practicable (NCP CFR 300.430[a][l][iii][A]). Identifying principal threat wastes combines concepts of both hazard and risk. The manner in which principal threats are addressed generally determines whether the statutory preference for treatment as a principal element of the remedial alternative is satisfied in a CERCLA decision document.

Principal threat wastes are those source materials considered to be highly toxic or highly mobile that generally cannot be reliably contained or would present a significant risk to public health or the environment should exposure occur. The decision to treat these wastes is made on a site-specific basis through a detailed analysis of remedial alternatives, using the remedy selection criteria specified in the NCP. This analysis provides the basis for making a statutory finding that the selected remedy uses a proven treatment technology as a principal element. For this Wyckoff Soil and Groundwater OUs FFS, NAPL source material meets the definition of a principal threat waste. Contaminated groundwater is not considered a principal threat or low-level threat waste because it is not source material (EPA, 1991b).

2.3 Identification and Screening Technologies and Process Options

This section identifies remedial technologies, and their associated process options, that are applicable to NAPL source material present in the Soil and Groundwater OUs. The remedial technologies were screened for their ability to achieve the RAOs and POs described in Section 2.1 based on the CERCLA criteria of effectiveness; implementability; and relative cost. The technologies retained from the screening are combined into a range of remedial action alternatives in Section 3 of this FFS report.

The technology screening step included a broad range of technologies applicable to wood-treating sites with an emphasis on treatment technologies that address NAPL source material. Additionally, because the remedial action timeframe is expected to span several to tens of years, technologies that protect human health and the environment during the remedial action were also emphasized. Factors considered in this evaluation include the state of technology development, site conditions, NAPL characteristics and distribution, and specific COCs that could limit a technology's effectiveness or implementability.

Sources of information considered for the technology screening included the following:

- *Presumptive Remedies for Soils, Sediment, and Sludges at Wood Treater Sites* (EPA, 1995)
- 1997 OU2/OU4 FS Report (CH2M HILL, 1997)
- Previous bench-scale and field-scale pilot studies
- CH2M HILL project experience on other wood-treating sites
- *Federal Remediation Technologies Roundtable* (FRTR; 2010)
- Interstate Technology and Regulatory Council (ITRC; 2009)
- Vendor information, case studies, and technical journal articles
- Information presented in the Wyckoff *Generational Remedy Evaluation Report* (Ecology, 2010)

The technology screening includes many of the technologies retained in the OU2/OU4 FS Report (CH2M HILL, 1997) and technologies used under the current containment remedy.

2.3.1 Technology Screening Criteria and Methodology

The technology screening qualitatively assesses each technology's ability to achieve the RAOs and POs using the CERCLA criteria of effectiveness, implementability, and relative cost as defined in the NCP (40 CFR 300.430[e][7]). Technologies that are not viable based on these considerations were eliminated from further consideration.

2.3.1.1 Effectiveness

Effectiveness refers to a technology's ability and its associated process option(s) to perform as a stand-alone or component of a broader alternative to meet RAOs under the conditions and limitations present at a site. Additionally, the NCP (40 CFR 300) defines effectiveness as follows: "…degree to which an alternative reduces toxicity, mobility, or volume through treatment; minimizes residual risk; affords long-term protection; complies with Applicable or Relevant and Appropriate Requirements (ARARs); minimizes short-term effects; and how quickly it achieves protection." Section 4.2.5 of CERCLA RI/FS Guidance (EPA, 1988a) states that the evaluation of remedial technologies and process options with respect to effectiveness should focus on the following:

1. the potential effectiveness of process options in handling the estimated areas or volumes of media and meeting the remediation goals identified in the RAOs;
2. the potential impacts to human health and the environment (HHE) during the construction and implementation phase; and
3. how proven and reliable the process is with respect to the contaminants and conditions at the site.

2.3.1.2 Implementability

Implementability refers to the relative degree of difficulty anticipated in implementing a particular remedial technology and process option under technical, regulatory, and schedule (administrative) constraints posed by a site. As suggested by CERCLA RI/FS Guidance (EPA, 1988a), process options and entire technology types can be eliminated from further consideration if a technology or process option cannot be effectively implemented at a site. As discussed in Section 4.2.5 of CERCLA RI/FS Guidance (EPA/540/G-89/004), "technical implementability is used as an initial screening of technology types and process options to eliminate those that are clearly ineffective or unworkable at a site." Administrative implementability, which includes "the ability to obtain necessary permits for off-site actions, the availability of treatment, storage, and disposal services (including capacity), and the availability of necessary equipment and skilled workers to implement the technology," is also considered in the initial screening.

2.3.1.3 Relative Cost

For the initial screening of technology types and process options, the cost criterion is relative, meaning quantitative cost estimates are not prepared. Rather it compares remedial technology and process option costs using narrative terms. Section 4.2.5 of CERCLA RI/FS Guidance (EPA, 1988a) states that "cost plays a limited role in the screening of process options. Relative capital and O&M costs are used rather than detailed estimates. At this stage in the process, the cost analysis is made on the basis of engineering judgment, and each process is evaluated as to whether costs are high, low, or medium relative to other process options in the same technology type." For this evaluation, relative cost is used to screen out process options that have a high capital cost if there are other choices that perform similar functions with similar effectiveness. Technology screening based on relative O&M costs was not specifically performed but was considered as part of the overall cost evaluation.

2.3.1.4 Assessment Methodology

The assessment of individual technologies and their associated process options was performed based on the criteria described above using a relative grading scale employing a "good," "moderate," or "poor" rating. To create greater separation, or where a technology's performance could vary within the different target zones at the Site, a blended rating such as poor to moderate or moderate to good was used. Once the assessment against each of the three criteria was completed, a "retained" or "not retained" determination was made.

2.3.2 Retained Technologies

Individual remedial technologies and their associated process options were screened based on considerations of effectiveness, implementability, and relative cost. The screening step is designed to narrow the list of remedial technologies to identify the most viable candidates for use in assembling remedial action alternatives. The technology screening and screening results are summarized in **Table 2-3**. Where appropriate, the technology screening also provides the justification for retaining or not retaining a technology for further consideration. The overall goal is to retain representative process options within the GRA categories to form remedial alternatives. The remedial technologies and process options retained from the screening are summarized in **Table 2-4**. Individual technology and technology pairings assigned to each target zone are presented in **Table 2-5**.

SECTION 3

Development and Screening of Alternatives

This section assembles the technologies retained from the screening performed in Section 2.3 into an array of NAPL source remedial action alternatives, presents a conceptual design for each alternative based on the representative process options, and then screens the alternatives to determine which ones should be carried forward for detailed evaluation in Section 4.

3.1 Development of Alternatives

The NCP ("Remedial Investigation/Feasibility Study and Selection of Remedy," 40 CFR 300.430[e][3]) sets forth the following expectations for development of source control alternatives:

- *"A range of alternatives in which treatment that reduces the toxicity, mobility, or volume of the hazardous substances, pollutants, or contaminants is a principal element. As appropriate, this range shall include an alternative that removes or destroys hazardous substances, pollutants, or contaminants to the maximum extent feasible, eliminating or minimizing, to the degree possible, the need for long-term management.*
- *Alternatives, as appropriate, which, at a minimum, treat the principal threats posed by the site but vary in the degree of treatment employed and the quantities and characteristics of the treatment residuals and untreated waste that must be managed.*
- *One or more alternatives that involve little or no treatment, but provide protection of human health and the environment primarily by preventing or controlling exposure to hazardous substances, pollutants, or contaminants, through engineering controls, for example, containment, and, as necessary, institutional controls to protect human health and the environment and to assure continued effectiveness of the response action."*

In accordance with the above NCP expectations and the technologies retained from the screening performed in Section 2.3, a range of source control alternatives were assembled. While other technology and process option combinations are possible, technology combinations that are most viable based on the RAOs, POs, and subsurface conditions present in each of the target zones were considered.

The proposed alternatives include the following (**Table 3-1**):

- Alternative 1—No Action (required per the NCP)
- Alternative 2—Containment (the current remedy)
- Alternative 3—Excavation, Thermal Desorption, and In Situ Chemical Oxidation (ISCO)
- Alternative 4—In Situ Solidification/Stabilization (ISS)
- Alternative 5—Thermal Enhanced Extraction and ISS
- Alternative 6—Excavation, Thermal Desorption, and Thermal Enhanced Extraction
- Alternative 7—ISS of Expanded Core Area and Thermal Enhanced Recovery

The alternatives listed above are identified by their primary technologies. However, exclusive of Alternative 1—No Action, each alternative requires supporting technologies to allow for full and successful implementation. Section 3.2 describes these supporting technologies, which are identified as common elements, and Section 3.3 describes in detail the remedial action alternatives.

3.1.1 Preliminary Screening

After the technologies were assembled into a range of alternatives, preliminary engineering was performed to develop a design concept to identify technical and overall implementation considerations. Following this step, the alternatives were screened (see Section 2.3.1 for the definition of the screening criteria) per *The Feasibility Study: Development and Screening of Remedial Action Alternatives* (EPA, 1989b). The purpose of the screening step is to determine whether any alternatives should be eliminated from further consideration based on effectiveness, implementability, or relative cost considerations. The alternatives retained from the screening step were carried forward for more detailed engineering and cost estimate development.

3.1.2 Conceptual Design

The level of engineering performed for the alternatives presented in Section 3.3 varies and is estimated to range from 3 to 15 percent of that required to prepare a fully biddable and constructible remedial design.

The conceptual design for each alternative is based on the volume of NAPL contaminated soil present in each of the remedial action target zones listed in Table 1-2, and the characteristics of the NAPL present in the various Upper Aquifer Compartments (e.g. Compartment 1: LNAPL, and Compartments 2 and 3: DNAPL). During the conceptual design process, the areas and volumes of NAPL contaminated material treated by each alternative may have changed from that shown in Table 1-2. These changes are attributed to the logistics and performance expectations that are unique to each alternative's treatment technology.

The actual areas and volumes of NAPL contaminated media addressed by the selected alternative will be refined during the remedial design using new information obtained from predesign investigations and more detailed evaluation of existing information. Additionally, the actual volumes of NAPL contaminated media treated or volumes of NAPL recovered by the selected alternative will also likely differ from that estimated in this FFS. This difference is attributed to subsurface heterogeneity and estimated versus observed performance of each remedial technology.

3.1.3 Cost Estimating

The cost estimates prepared for each retained remedial action alternative were developed per *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* (EPA, 2000b). The cost estimates are intended for comparison purposes and were prepared to meet the -30 to +50 percent range of accuracy recommended in the CERCLA RI/FS Guidance (EPA, 1988a). Actual costs will depend on the final scope and design of the selected remedial action alternative, implementation schedule, competitive market conditions, and other variables. However, these factors are applicable to all alternatives and not expected to affect the relative cost differences between them. The cost estimates include allowances for the following items:

- Remedial design costs, including preparation of design drawings and specifications and construction bid documents, which were calculated as a percentage of the construction cost.
- Remedial alternative construction costs, including construction management, capital equipment, general and administrative costs, and construction subcontract costs and fees, which are based on engineering judgment, cost estimating references, actual costs for similar work performed at other sites, and vendor quotes.
- Annual short-term O&M including remedy performance monitoring and reporting costs for the estimated duration of the remedial action until RAOs are achieved. The term short-term O&M, as

used in this FFS, refers to recurring costs associated with implementation of remedial action technologies over a multi-year period until RAOs are achieved. Long-term O&M costs associated with maintaining the remedy after RAOs have been achieved are not included in the cost estimate. Examples of long-term O&M costs include maintenance of a final site cap and maintenance of water balance (stormwater and groundwater elevation) control measures.

- Equipment or remedy component replacement costs.
- Project management, oversight costs, and preparation of CERCLA five-year reviews until RAOs are achieved.

The total remedial action alternative life-cycle costs (see Appendix C) are presented as non-discounted (base year of 2016) and present worth values. The present worth cost-estimating method establishes a common baseline for evaluating costs that occur during different periods, thus allowing for direct cost comparisons between different alternatives. The present worth cost represents the dollars that would need to be set aside during the base year, which for this FFS is assumed to occur in 2016, at the defined interest rate, to ensure that funds would be available in the future, as they are needed to implement the remedial action alternative. Present worth costs were estimated using the 1.4 percent real discount rate published in *Appendix C - Discount Rates for Cost Effectiveness, Lease Purchase, and Related Analyses*, *Guidelines and Discount Rates for Benefit Cost Analysis of Federal Programs* (OMB Circular A-94), effective June 2016 and the 7 percent discount rate cited in *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* (EPA, 2000b). Present worth costs calculated using the 7 percent discount rate are intended to show the sensitivity of each alternative's total present value cost to the discount rate.

3.2 Common Elements

The following subsections briefly summarize each common element. **Table 3-2** shows which common elements are associated with each alternative, while **Figure 3-1** shows the total common element cost for each alternative. Several common element descriptions include a reference to engineering drawings, which are provided in **Appendix B**.

3.2.1 Pre-Construction Activities

This common element is associated with Alternatives 2 through 7 and includes the following activities:

- Obtaining local and State permits as applicable
- Preparing subcontractor work plans, health and safety plans, activity hazard analysis, and project schedule
- Mobilizing/demobilizing subcontractor general equipment
- Conducting community relations
- Preparing the Site and conducting a property survey
- Developing prorated remedial design, construction management, and project management costs.

The total estimated cost for this common element is $879,000.

3.2.2 Access Road

Most equipment needed to implement the remedial action alternatives is large and will require delivery to the Site via trailer. The existing road has curves that are too sharp for large semitrailer trucks to navigate, and the 15 percent grade is too steep for trucks to maintain traction. This common element, which is required for Alternatives 2 through 7, includes realigning, regrading, and resurfacing the existing asphalt road (1,500 lineal feet) at an estimated cost of $306,000 as shown on **Appendix B**, **Drawings 101-CE-100 and 101-CE-101**.

3.2.3 Concrete Demolition, Decontamination, and Reuse

Previous demolition conducted at the Wyckoff Site has primarily included aboveground equipment and facilities. Most of the equipment and building foundations, and other below ground concrete structures (primarily sumps), have not been removed. This common element removes buried concrete (**Appendix B**, **Drawing 101-CE-102**) that could prevent or significantly impede implementation of the subsurface components of Alternatives 3 through 7. The estimated cost for this common element is $2.3 million.

The work associated with this element would occur before the remedial action alternative is implemented. All concrete would be removed and/or demolished, pressure-washed to capture creosote for offsite disposal, and then crushed to segregate rebar and size the material for subsequent onsite reuse. Recycling the rebar provides an estimated credit of $189,000. The area of concrete foundations and structures requiring demolition is estimated at 1.5 acres (7,200 square yards). The thickness of each foundation was conservatively estimated to be 2 to 3 feet based on the known previous use of the foundations. The total estimated volume of concrete is 8,000 CY.

3.2.4 Sitewide Debris Removal

Other buried utilities and debris (e.g., process pipes, storm drains, electrical conduit, and the wing wall) are also known to exist given the Site's long history. Under this common element, sitewide subsurface debris would be removed (**Appendix B**, **Drawing 101-CE-102**) to allow the subsurface work required in Alternatives 3 through 7 to be implemented. The estimated cost for this common element in Alternatives 3 through 7 is $3.2 million. This work would include excavating an estimated 66,600 CY of material and disposing of 670 CY (300 tons) of hazardous debris at an offsite RCRA Subtitle C facility.

3.2.5 Bulkhead Debris Removal

The area between the original Site bulkhead and the current outer sheet pile wall was filled with rock and concrete debris that must be removed (**Appendix B Drawing 101-CE-102**) to permit access for remediation of subsurface material up to the edge of the sheet pile wall under Alternatives 2 through 7. Under this common element, an estimated 17,000 CY of rock, 30,000 CY of other material, and 2,700 CY of bulkhead would be removed. Approximately 2,000 tons of this material would be transported and disposed at a RCRA Subtitle C facility and a similar amount disposed at a Subtitle D facility. The area would then be backfilled with 45,000 CY of clean soil and rock. The estimated cost for this common element is $8.8 million.

3.2.6 Other Miscellaneous Demolition

This common element allows for decommissioning and disposing of the steam pilot plant area, equipment, and its associated infrastructure, and removal of an estimated 100 CY of PAH contaminated soil present near PZ-11. Under Alternatives 3 through 7, all pilot plant components would be demolished and disposed at an estimated cost of $2.8 million. Under Alternative 2, all pilot plant components except the northwest beach sheet pile wall would be removed at an estimated cost of $1.3 million. It is assumed the equipment and contaminated soil will be disposed at a Subtitle D landfill.

3.2.7 Stormwater Infiltration Trench

This common element involves installing a stormwater infiltration trench along the southern boundary of the FPA to intercept and divert run-off away from the Alternatives 4 through 7 work area during construction of the alternatives before the final cap is placed. The estimated cost for the trench is $214,000.

3.2.8 Replacement Sheet Pile Wall

This common element includes replacing the outer sheet pile wall, which due to corrosion at and above the mud line (approximate elevation 5 feet), could fail within 10 to 20 years. The replacement sheet pile is required for installing the concrete perimeter bulkhead wall described in Section 3.2.9. Replacement includes installing 1,900 lineal feet of wall to an elevation of -52.5 feet (142,200 square feet total). The sheet pile wall would be replaced under Alternatives 2, 5, 6, and 7 at an estimated cost of $13.4 million.

3.2.9 Concrete Perimeter Bulkhead Wall

Under this common element, a new reinforced concrete wall would be constructed on the inside of the existing outer sheet pile wall (see **Appendix B, Drawing 101-CE-300**). The purpose of the wall is to provide geotechnical support to accommodate additional soil loading associated with reuse of remediation material and to promote post-remediation stability of the shoreline.

There are two designs for the wall (**Appendix B**, **Drawing 101-CE-300**). The design under Alternatives 2, 5, 6, and 7, which is estimated to cost $11.4 million, involves installing a 1,900-foot-long wall to a depth of 38 feet. The design for Alternative 4 is estimated to cost $8.0 million and involves constructing a 1,900-foot-long wall to a depth of approximately 30 feet.

3.2.10 New Outfall

The existing GWTP outfall pipe is 8 inches in diameter and used only for effluent discharge. Once the final Site cap (a separate common element described further below) is constructed, stormwater that previously infiltrated into the ground will have to be collected and discharged. Based on a 100-year storm event, the peak stormwater discharge rate was estimated at 11 cubic feet per second or 4,900 gpm. Under this common element, a new 20-inch-diameter outfall (**Appendix B, Drawings 101-CE-103 and 101-CE-104**) would be installed under Alternatives 2 through 7 to provide for stormwater discharge to Puget Sound, using horizontal directional drilling methods, at an estimated cost of $3.3 million.

3.2.11 Passive Groundwater Discharge/Treatment

This common element provides technology for long-term management of the Upper Aquifer groundwater elevation. Under current conditions, Upper Aquifer water levels are controlled by operation of the hydraulic containment wells. If these wells are turned off, the water level will rise, potentially flooding portions of the FPA, most likely during the winter and springs months when rainfall is highest. Flooding would likely hinder future site use.

The passive discharge/treatment system would consist of a series of drain systems that would maintain the Upper Aquifer groundwater level at an elevation of approximately -1 foot MLLW. Each drain system includes three main components: a collection system, a treatment media such as granular-activated carbon (GAC) housed in a manhole-accessible vessel to remove dissolved-phase COCs, and a pipe that conveys the treated water through the sheet pile wall and the new concrete bulkhead (**Appendix B Drawings 101-CE-105 and 101-CE-301**) to a discharge point below the mudline.

The design concept utilizes the hydraulic head difference present during the outgoing tide to move the water through the GAC to the discharge point. It is estimated each system would treat about 360,000 gallons of groundwater per year (3.6 million gallons total, assuming 10 systems) recovering 570 kilograms of dissolved-phase contaminant mass. The groundwater treatment volume was estimated from a tidal flux analysis that estimates an average discharge rate of about 0.7 gpm.

The drain systems would be located around the perimeter of the FPA in areas where NAPL is absent and dissolved phase COC concentrations are expected to be lower. This approach may eliminate the need for treatment at some locations while reducing GAC usage at locations where treatment is required.

For the purposes of this FFS, 10 independent systems would be installed using vertical wells under Alternative 4 at an estimated cost of $1.3 million. Under Alternatives 3, 5, 6, and 7, short horizontal drains would be used at an estimated cost of $1.1 million. Annual O&M costs under Alternative 4 are estimated at $333,000 and $284,000 for Alternatives, 3, 5, 6, and 7. A quarterly GAC media change-out frequency was assumed for cost estimating purposes.

During remedial design, and the initial phase of remedy implementation, additional information will be collected to determine where treatment is required and to size the GAC vessels. This information may justify the need for fewer systems or combining each collection drain to a centralized treatment system with a single discharge outfall.

3.2.12 Final Site Cap

The planned final end use of the Wyckoff Site is a park with open areas. To reduce surface water infiltration at the Site and prevent exposure to potential, low-level residual contaminants, a permanent surface cap with a low-permeability geomembrane layer is included as a common element for all alternatives.

The conceptual design assumed for this FFS (**Appendix B, Drawings 200-CE-101 and 200-CE-301**) is based on a 60-mil high-density polyethylene (HDPE) geomembrane overlain by 12 inches of drainage material and 12 inches of topsoil. A 12-ounce-per-square-yard cushion geotextile would be placed over the geomembrane to provide drainage layer puncture protection. The total covered area is 8.1 acres. The drainage material and topsoil will be imported to the Site and will have a total volume of 13,050 CY each. During remedial design, the cap design could be modified to support an alternate topographic profile if desired. The estimated cost for this common element is $4.1 million.

3.2.13 Long-term Monitoring

Under this common element, a network of existing or new monitoring wells would be sampled quarterly to track Upper Aquifer remediation accomplishments, while Lower Aquifer wells would be sampled annually to confirm that no further degradation is occurring per RAO 4. This common element is a recurring item at annual O&M cost under Alternatives 2 through 7 of approximately $90,000 per year.

3.2.14 Access Controls

For all remedial alternatives (except Alternative 1—No Action), Site fencing would remain until the Site could be converted to a public area. ICs to ensure that the Upper Aquifer groundwater within the FPA remains unused would be maintained. ICs restricting Site use to reduce direct exposure to soil would also be maintained. No capital or annual O&M cost has been assumed for this common element.

3.2.15 5-Year Reviews

The NCP, under 40 CFR 300.430(f)(4) (ii), requires that periodic reviews be conducted if a remedial action is selected that results in hazardous substances, pollutants, or contaminants remaining at the Site above levels that allow for unlimited use and unrestricted exposure. These reviews are conducted no less often than every 5 years after the selected remedial action is initiated. Three 5-year reviews have been performed to date, with the third 5-year review completed in 2012. This common element provides for continuing the 5-year reviews until the contaminants are no longer present at unrestricted use and/or unrestricted exposure levels. For this FFS, a 5 year, $20,000 periodic cost was included for each alternative.

3.3 Description and Screening of Remedial Alternatives

This section describes the seven NAPL source area remedial action alternatives listed in Section 3.1. Each description includes a narrative summary of the key components, a table listing the primary components, and engineering drawings showing equipment layout, treatment diagrams, and implementation logic. All drawings referenced in this section are provided in **Appendix B** and the cost estimates presented in **Appendix C**.

3.3.1 Alternative 1—No Action

Section 300.430(e)(6) of the NCP requires that a No Action Alternative be included in the FFS to use as a baseline for comparison to other alternatives. Under Alternative 1—No Action, no additional actions would be taken for the Wyckoff Soil and Groundwater OUs. The existing groundwater extraction wells and GWTP would be shutdown (if operating), and this equipment would not be decommissioned. The outer sheet pile wall would be left in place, and over time, it would be expected to fail near the mudline due to corrosion. The sections of wall present below the mudline may still provide some partial containment of NAPL and dissolved-phase contaminants.

3.3.1.1 Screening Evaluation

Per the NCP (40 CFR 300.430) requirement to develop the No Action Alternative and carry it through the detailed analysis of alternatives, Alternative 1—No Action was not screened and will be retained.

3.3.1.2 Cost Estimate

Alternative 1 has no components, and therefore, the net present value cost is $0.

3.3.2 Alternative 2—Containment

Alternative 2 is the contingent remedy implemented under the 2000 ROD. Including this alternative in the FFS satisfies the NCP requirement to develop an alternative that involves little or no treatment and protects human health and the environment by preventing or controlling exposure to contaminants through engineering controls and, as necessary, ICs.

Under this alternative, constructing the remaining containment components specified in the 2000 ROD would be completed, and the remedy operated for 100 years. The key components of Alternative 2 include the following (**Table 3-3**):

- The applicable common elements listed in **Table 3-2**.
- The existing sheet pile wall is 1,870 feet long, bounding the north and east sides of the FPA. This remedy component was installed in 2001. It is assumed that the wall would be replaced once during the 100-year O&M timeframe.
- Installation of four new recovery wells and rehabilitation of the nine existing recovery wells (**Appendix B Drawing 200-C-100**). All wells would be completed with flush-mounted vaults and buried HDPE piping. The total system pumping rate with all 13 wells in operation would vary seasonally from 80 to 140 gpm. The wells would operate 24 hours a day, 7 days a week, except for maintenance and repair and during electrical service disruptions.
- Upgrades to the existing GWTP electrical and instrumentation and control systems to provide greater remote/offsite wellfield and GWTP operations control and improved reliability.
- One hundred years of O&M. The recovery wells and some GWTP mechanical equipment are assumed to require replacement approximately every 30 years. GWTP tanks and piping constructed of fiberglass reinforced plastic would not need replacement due the integrity of this material.

- Periodic sampling and analysis to accomplish the following: 1) confirm GWTP treatment effectiveness, assess the need for treatment media change-out, and compliance with outfall discharge criteria; 2) assess COC concentration changes in Upper and Lower Aquifer groundwater; and 3) verify hydraulic containment of the dissolved-phase plume.
- Existing engineering - access controls (GWTP and recovery well fencing and signage) and ICs would be maintained to prevent unauthorized land and groundwater use and to protect the integrity of the soil cover.
- Documentation of remedy performance and protectiveness in 5-year reviews.

The location of the four new and nine existing recovery wells is shown on **Appendix B, Drawing 200-C-100**. A process flow diagram showing the various treatment steps in the existing GWTP is shown on **Appendix B, Drawing 200-CE-302**.

Under this alternative, hydraulic containment pumping would remove an estimated 737 kilograms of dissolved-phase COCs per year. Pumping the hydraulic containment wells would also remove DNAPL with recovery rates steadily declining from an estimated 4,000 gallons per year in 2016 to 100 gallons per year by 2116. Based on the 100-year O&M timeframe established for this alternative, it is estimated that 30 percent of the NAPL present in the Upper Aquifer would be removed.

Alternative 2 addresses RAO 1 by installing a final Site cap across the FPA to prevent direct contact with contaminated soil and maintaining ICs to protect cap integrity and to prevent inadvertent intrusion through the cap to the underlying contaminated soil. RAO 2 is addressed by implementing and maintaining ICs that prevent Upper Aquifer groundwater withdrawals except for remediation purposes. Access controls (fencing and signage) would also be maintained around the GWTP and extraction well vaults to prevent potential contact with contaminated groundwater pumping equipment. RAO 3 is addressed by operating the recovery wells to hydraulically contain the dissolved-phase plume, thereby preventing migration to Eagle Harbor and Puget Sound, and treating Upper Aquifer groundwater in the GWTP prior to Eagle Harbor outfall discharge. RAO 4 is addressed by operating the Upper Aquifer hydraulic containment system to maintain an upward vertical gradient, thereby preventing dissolved phase COC transport from the Upper Aquifer to the Lower Aquifer.

3.3.2.1 Implementation and Sequencing

The general sequence and duration of key activities under Alternative 2, assuming all elements of the alternative were fully implemented, would include the following:

Year 0 - 1	Year 2	Year 3- 100	Year 100
• Construct common elements • GWTP O&M	• Complete common elements construction (final cap) • New recovery well installation and rehab of existing wells • GWTP O&M • GWTP upgrades • GWTP O&M	• GWTP O&M	• GWTP decommissioning

3.3.2.2 Screening Evaluation

Screening of Alternative 2—Containment against the criteria of effectiveness, implementability, and cost indicates that this alternative should be retained. This alternative would be effective because it reduces or eliminates contaminant migration through treatment and over the long term also reduces toxicity and volume. This alternative would be readily implemented because most components have already been constructed. Although long-term O&M costs are expected to be high, some of this cost would be offset by low capital costs.

3.3.2.3 Cost Estimate

The total present worth cost for Alternative 2, based on a 7 percent discount rate, is $52.0 million with a -30/+50 percent cost range of $36.4 million to $78.0 million. A breakout of total life cycle costs is provided in **Table 3-3**.

3.3.3 Alternative 3—Excavation, Thermal Desorption, and In Situ Chemical Oxidation

Alternative 3 addresses the NCP requirement to develop an alternative that removes contaminants to the maximum extent practicable minimizing the need for long-term management. This alternative includes the following components:

- The applicable common elements listed in **Table 3-2**.
- Excavation and thermal desorption treatment of contaminated soil present in the Core Area, North Shallow (LNAPL), and East Shallow (LNAPL) target zones. The design basis for this alternative assumes a medium temperature thermal desorption (MTTD) unit operating at a rate of 20 tons per hour. Assuming soil excavation is conducted 50 hours per week, and the MTTD unit operates 100 hours per week, 1,500 CY of contaminated soil would be treated per week.
- ISCO-permanganate treatment of NAPL-contaminated material present in the North Deep (DNAPL) target zone. Three separate injection events would be performed with groundwater monitoring conducted following each injection event. The monitoring results would be used to confirm treatment effectiveness and to optimize the scope of subsequent injection events.
- ISCO-hydrogen peroxide treatment of small amounts of NAPL-contaminated material present in the Other Periphery target zone. ISCO-hydrogen peroxide treatment would be applied in a manner similar to that described above for ISCO-permanganate treatment.
- Enhanced aerobic biodegradation (EAB) following completion of Core Area, North Shallow (LNAPL), and East Shallow (LNAPL) treatment using an array of biosparge wells that would inject air into the Upper Aquifer.

The excavation, MTTD, and ISCO treatment steps would be performed simultaneously. EAB would be implemented after the excavation, MTTD, and ISCO treatment steps. Additional information on the primary alternative components of excavation, MTTD, and ISCO is provided in the subsections below.

This alternative addresses RAOs 1 through 3 by excavating and thermally treating NAPL-contaminated soil to destroy COCs and installing a final cap to serve as a barrier to direct contact. The ISCO treatment program, is designed to achieve a high level of treatment but it’s uncertain that ISCO treatment alone would achieve the soil and Upper Aquifer groundwater PRGs; therefore, EAB would be implemented to complete any remaining treatment necessary to achieve Upper Aquifer groundwater PRGs. RAO 4 is addressed through treatment of Upper Aquifer NAPL source material, thereby preventing the formation and transport of dissolved phase contaminants to the Lower Aquifer.

3.3.3.1 Excavation Methods

In the Core Area, the target depth interval for excavation and thermal desorption would include the ground surface down to the top of the Aquitard (e.g., Compartments 1, 2, and 3). In the North Shallow (LNAPL) and East Shallow (LNAPL) target zones, excavation would extend to an estimated depth of

35 feet bgs. The footprint for each target zone would be subdivided into an array of excavation cells, and each cell geotechnically and hydraulically isolated by internal and external braced sheet pile walls. After the sheet pile walls are installed, the excavation cell would be dewatered using two dewatering wells and the water pumped to the existing GWTP for treatment. Excavation would proceed downward in vertical lifts until the target depth is reached. As each excavation cell is completed, treated soil would be returned to the excavation and used for backfilling. Once the Core Area excavation cells are completed, the work would proceed to the North Shallow (LNAPL) and East Shallow (LNAPL) target zones.

Excavation of the North Shallow (LNAPL) and East Shallow (LNAPL) target zones would be performed in a similar manner but would not requiring lowering of the water table to the same degree as the Core Area due to the shallower excavation depths.

3.3.3.2 Thermal Desorption Treatment

Excavated soil would be treated through a direct-fired thermal desorption unit that includes a rotary desorber for soil treatment, a baghouse for dust collection, and a thermal oxidizer to destroy organic vapors. Excavated material would be segregated in stockpiles for air drying and subsequent loading into the thermal desorber unit. A burner located at the discharge end of the desorber unit would provide the energy to heat the soil, causing organic compounds to volatilize into an air stream and be carried out of the unit. Material processing temperatures would be adjusted during the treatment process based upon COC concentrations present in the feed stockpile and soil PRGs. For this FFS, a soil temperature of 1,100 degrees Fahrenheit (°F) is assumed. Field-scale trials would be conducted to establish optimum treatment temperatures and contact times. After treatment, the soils would exit the kiln at temperatures of 400 to 900 °F and be staged for cooling and confirmation testing prior to placement as backfill in the excavation cells.

Air containing water, organic vapors, and particulate matter would exit the desorber unit to the baghouse, where particulates would be removed. The resulting air flow would be routed to the thermal oxidizer and heated to between 1,400 and 1,800 °F, at which point the organics would be combusted to carbon dioxide and water vapor. The creosote NAPL present at the Wyckoff Site contains PCP, which would generate hydrochloric acid in the thermal oxidizer unit. Therefore, the offgas would undergo additional treatment in an acid scrubber or thermal oxidizer unit operations limited per hydrochloric acid atmospheric discharge regulatory limits. Air monitoring of the thermal oxidation unit would be performed to confirm that the stack offgas complies with discharge limits.

3.3.3.3 In Situ Chemical Oxidation Treatment

The North Deep (DNAPL) target zone would be treated using ISCO-permanganate with treatment occurring in Compartment 3. Permanganate was selected because of the depth of DNAPL contamination lying below the water table, its effectiveness for PAH treatment, the persistence of its oxidizing power, and its relative ease of injection through temporary or fixed wells. The primary disadvantage of permanganate is its potential negative impact on groundwater quality (e.g., increased manganese concentrations and discoloration) and the conditions required to apply EAB polishing. A lag period would exist before suitable conditions for EAB are reestablished.

To reduce the overall oxidant demand and increase ISCO treatment effectiveness, a program of enhanced NAPL recovery from existing and newly installed recovery wells would precede ISCO injection. Once the enhanced NAPL recovery step is completed, oxidant injection would be performed through the same wells used for enhanced NAPL recovery. Following completion of the initial (Phase 1) permanganate injections, which are expected to require about 6 months, changes in PAH concentration, redox conditions, and other groundwater quality parameters would be monitored for 6 to 12 months. Reductions in hydraulic conductivity from precipitated manganese dioxide, which could decrease future injection rates, would also be assessed. Following the Phase 1 injection and monitoring period, Phase 2 injections would occur. The Phase 2 injections are assumed to require approximately 50 percent of the permanganate mass injected during Phase 1. After the Phase 2 monitoring period is completed, Phase 3 permanganate injection would occur. Phase 3 injections are assumed to require approximately 25 percent of the permanganate mass injected during Phase 1.

In the Other Periphery target zone, ISCO would be implemented with catalyzed hydrogen peroxide injected through direct-push technology to provide more focused treatment. Up to three ISCO injections, performed in a phased manner, are assumed to be required in a similar manner as described above for the permanganate injection in the North Deep (DNAPL) target zone.

For both oxidant types, Site-specific, bench-scale testing of oxidant dosage in both Upper Aquifer and Aquitard material would be performed along with field-scale pilot tests during remedial design to confirm treatment effectiveness prior to full-scale field deployment.

3.3.3.4 Screening Evaluation

Screening of Alternative 3—Excavation MTTD and ISCO against the criteria of effectiveness, implementability, and cost indicates that this alternative should be eliminated based on implementation considerations. During preliminary engineering, the degree of shoring and dewatering necessary to excavate Upper Aquifer soil to depths up to 55 feet bgs was determined to not be technically practicable without incurring significant geotechnical risk. Additionally, due to these considerations, it was apparent that the cost of this alternative would be grossly excessive relative to its effectiveness.

3.3.3.5 Cost Estimate

Because this alternative was eliminated at the screening step, a cost estimate was not prepared.

3.3.4 Alternative 4—In Situ Stabilization/Solidification

Alternative 4 addresses the NCP requirement to develop and alternative that treats the principal threat posed by the Site but varies in the degree of treatment and the characteristics of the treatment residuals. Under Alternative 4, all NAPL-contaminated material greater than the TarGOST® 10%RE would be treated in situ by immobilizing the NAPL in a cement -type matrix. This approach is expected to greatly reduce the need for long-term management. Alternative 4 includes the following components (**Table 3-4**):

- Each of the applicable common elements listed in **Table 3-2**.
- ISS of NAPL-contaminated material using a combination of auger mixing and jet grout techniques in each of the five remedial action target zones as follows:
  - **Core Zone—**85,300 CY of contaminated material would be treated to a depth of about 50 feet.
  - **North Shallow (LNAPL)—**17,700 CY of contaminated material would be treated to a depths ranging from 25 to 45 feet
  - **North Deep (DNAPL)—**About 59,200 CY of contaminated material would be treated to depths up to 76 feet (treatment in this area includes auger mixing of more shallow impacts and jet grout mixing of discreet deeper zones of impacts)
  - **East Shallow (LNAPL)—**120,000 CY of contaminated material would be treated to depths ranging from 25 to 45 feet
  - **Other Periphery—**43,100 CY of contaminated material would be treated to a depth ranging from 10 to 45 feet

- The overall approach as presented in the following subsections assumes that ISS would be performed 10 hours per day, 7 days per week, requiring approximately 2 years. ISS is assumed to have a 95 percent treatment efficiency, because the technology promotes excellent contact between the reagent and the NAPL-contaminated material.
- An additional 2,700 CY of soil would receive ISS treatment along the bulkhead to solidify soil to a minimum elevation of -15 MLLW to facilitate repairs and new wall construction
- Excavating and removing 7 feet (86,000 CY) of overburden material to offset the swell that occurs during ISS treatment. Excavated material would be staged and treated in an aboveground treatment cell using ISS reagent and the material reused for final Site grading and contouring. Groundwater and stormwater that accumulates in the excavation would be pumped to the GWTP for treatment and outfall discharge. Berms and trenches would also be used to minimize stormwater entry into the excavation footprint.

Under Alternative 4, an estimated 93 percent of 678,000 gallons of the NAPL present in the FPA would be immobilized. The remaining 7 percent would be addressed through natural attenuation and passive groundwater treatment.

This alternative addresses RAOs 1 through 3 by altering NAPL characteristics to reduce toxicity, mobility, and leachability, thereby protecting human health from unacceptable risk due to direct contact and protecting the environment by eliminating a dissolved-phase contaminant source. RAO 4 is addressed through solidification and stabilization of Upper Aquifer NAPL source material, thereby significantly reducing the leaching of COCs at levels that would degrade Lower Aquifer potable groundwater.

3.3.4.1 In Situ Stabilization/Solidification Description

Auger mix ISS would be performed using a crane mounted auger or hydraulic drill rig. For deep soil application (60 to 75 feet bgs) in the North Deep (DNAPL) zone, small diameter, jet grout injection equipment would be used. One ISS auger rig would operate at the Site full-time. **Appendix B, Drawing 300-C-100** shows the ISS Site layout and where ex situ ISS treatment would be performed while **Drawings 300-C-101** and **300-C-102** show the footprints where auger ISS and jet grout ISS would be implemented, respectively.

In the Core Area, North Shallow (LNAPL), East Shallow (LNAPL), and Other Periphery target zones, the ISS auger rigs would mechanically mix reagent and NAPL-contaminated soil, creating an array of overlapping, cement-like columns extending from the surface to the bottom of the target zone. Reagent for the ISS would be delivered to the Site by truck and mixed on Site in a batch plant.

In the North Deep (DNAPL) target zone, jet grouting equipment would be used to mix the reagent and NAPL-contaminated soil. Due to the high pressures employed for jet grouting, the reagent and NAPL-contaminated soil are fluidized rather than mechanically mixed. Jet grouting ISS would also create an array of overlapping, cement-like columns, but the columns would be smaller in diameter than those created with vertical augers.

Along the perimeter of the ISS treatment zone, the mix design would be enriched to create a “rind” or ”crust” to form a contiguous ring of overlapping columns with increased durability and leaching resistance achieved from a higher unconfined compressive strength performance requirement. This crust is shown on **Drawing 300-C-101**.

Prior to commencing ISS, the treatment area would be excavated to a depth of 7 feet to create a sump to contain the swell volume that accompanies ISS. This volume expansion is estimated to range from 20 to 25 percent of the treatment volume. The excavated material would be treated in an aboveground cell (**Drawing 300-C-100**) using the ISS reagent and stockpiled for future Site grading and contouring reuse.

3.3.4.2 Design Criteria and Basis for Approach

Following are the primary ISS design criteria:

- Identify the compressive strength for the stabilized material that supports future Site reuse.
- Determine the leaching reduction needed to achieve Upper Aquifer groundwater PRGs.
- Develop mix design for inner and perimeter columns. The mix design for the perimeter columns is expected to contain a higher concentration of reagent relative to the inner columns to improve durability characteristics.
- Conduct Upper Aquifer groundwater flow modeling to evaluate: 1) altered groundwater flow patterns around and beneath the ISS monolith; 2) groundwater elevation mounding south of the ISS treatment zone that could result in increased potential for groundwater seeps; and 3) post ISS groundwater quality conditions.

Bench-scale testing would be performed during remedial design to determine the optimum reagents, mix ratios, and reagent addition rates for the inner and perimeter columns. The mix design would be evaluated by measuring the maximum hydraulic conductivity, minimum unconfined compressive strength, and overall leaching reduction in a series of tests prepared using NAPL-contaminated soil obtained from the Site. The bench-scale testing would also include optimization testing to refine the reagent mix design, establish ranges for reagent and water addition ratios, and evaluate reagent enhancements that can be added to improve performance (e.g., decrease leachability) or lower costs. For the purposes of this FFS, and based on experience at other wood-treating Superfund sites (e.g., Mountain Pine, North Cavalcade, Texarkana, and American Creosote Works), the mix design for Alternative 4 may include up to 10 percent Portland cement and 1 percent bentonite. A typical compressive strength of 50 pounds per square inch (psi) with no single point less than 40 psi is assumed for this FFS. Compressive strength is an indirect indicator of durability as materials with higher initial compressive strength are typically considered more resistant to aging (ITRC, 2011). For the perimeter crust, the target compressive strength would be double the requirement of the interior columns or a minimum of 100 psi.

A field demonstration test would also be performed to verify the bench-scale results, evaluate full-scale equipment options, establish productivity rates, and identify Sitewide implementation considerations. Due to logistical limitations associated with mobilizing ISS equipment to the Site for a field scale pilot test, a demonstration test would occur at the start of full-scale remediation.

Contaminant leaching is reduced by a reduction either in hydraulic conductivity or by using amendments to absorb organic constituents. The lower hydraulic conductivity of the ISS monolith relative to the surrounding soils forces groundwater around it, thereby reducing the potential for groundwater to come into direct contact with entombed COCs. Absorbents (activated carbon or oleophilic clay) can reduce leaching by increasing the ability to absorb contaminants over native soils. Based on testing conducted for other CERCLA NAPL-contaminated sites, the increased cost of absorbent may not warrant the nominal decrease in leachability that is typically observed. For this FFS, an absorbent material is assumed to not be necessary.

Leaching reduction would be evaluated through treatability testing conducted during remedial design to aide in selecting the most effective reagent mix design. Leachability testing would be conducted on both the untreated NAPL-contaminated soil and the NAPL-contaminated soil treated with various mix designs after a 28-day cure period. The test would be conducted in accordance with the approaches presented in the *Development of Performance Specifications for Solidification/Stabilization* (ITRC, 2011) using EPA pre-methods known as Leaching Environmental Assessment Framework. The leaching characteristics of the untreated material would be evaluated using Pre-method 1314 or 1316, while the treated material would be evaluated using Pre-method 1315 to assess the reduction in leaching after treatment. These tests are not intended as a measure of performance during full-scale ISS, but rather as a tool to identify the most effective mix design and to provide data to model post-ISS groundwater quality conditions outside the target zones.

3.3.4.3 Implementation and Sequencing

Given the Site's size and volume of material to be treated, several operations would be performed concurrently. Field activities would generally be sequenced as shown on **Appendix B, Drawing 300-C-301 and 300-C-600,** as follows:

1. The ISS auger rig and reagent batch plant would first be mobilized and set up. Large items such as silos and the ISS auger rig would be transported to the Site by barge and offloaded with a crane over the existing sheet pile wall. Smaller items that can be transported without oversize load restrictions would be delivered to the Site via truck. The batch plant would be set up in a central location to allow for delivery of reagent to the entire treatment area. In general, the batch plant must be located within 1,000 feet of the target zones. Additional grading surface stabilization may be required within the batch plant and bulk material storage area. The batch plant includes pumps, mixers, silos, mixed reagent storage, tool shed, and laydown areas. ISS operation likely would be performed year-round; as such, adequate winterizing of the batch plant would be required.
2. Site controls, erosion and sediment controls, stormwater controls and collection systems, odor and vapor controls systems, temporary facilities, and temporary utilities would be installed. Perimeter air monitoring systems would be set up prior to the start of subsurface intrusion activities.
3. As the swell sump excavation progresses from north to south across the Site, jet grouting would be initiated in the North Deep (DNAPL) target zone. Prior to full-scale jet grout treatment, a jet grout field demonstration test would be performed to evaluate jet grout characteristics and expected jet grout column size based on the Site-specific conditions. Several columns would be created using varying injection pressures, drill stem revolutions per minute, and drill stem withdrawal rate. The columns would be created at a depth that allows for excavation and observation after curing. Jet grouting would occur prior to auger mix ISS in areas that are treated using both techniques to avoid drilling through previously solidified soils.
4. As the swell sump excavation and jet grout ISS operations proceed south across the Site, ISS auger mixing would begin. Mixing would be accomplished with 6-foot- and 8-foot-diameter augers, depending on required depth of treatment and mixing difficulty. While auger diameter up to 10 or 12 feet are often used for large ISS projects, smaller diameter augers may be required to penetrate and mix "hard" soil layers. A review of the existing boring logs in the FPA indicates the presence of varying thickness of poorly and well-graded sand and gravel. Standard penetration test "blow counts" ranged from 35 to 55 blows per foot using a 300-pound hammer. This soil density would slow auger advancement requiring more mix time and potentially the addition of more reagent. Using smaller-diameter augers would improve mixing conditions and minimize auger refusal. ISS columns would be overlapped to treat 100 percent of the NAPL-contaminated soil within the target zone. The first several days would be used to demonstrate that the treatability results are verified and to establish the effectiveness of the selected equipment to mix sufficiently to the target depths.

Visual observations, field tests, and quick turnaround laboratory testing would be used to demonstrate achievement of performance requirements.

5. Quality control during full-scale ISS includes the following:
    a. Verifying contractor calculations for reagent slurry mixture and for volume of reagents to be added for each ISS column.
    b. Requiring the contractor to complete at least three mixing strokes (a stroke is from top to bottom to top again).
    c. Discrete sampling at different depth intervals to check for consistency of mixing, using color charts, pH, and slump. No unmixed soil should be observed in the sample. This sampling would be done at no less than one time per shift.
    d. Collection of samples for laboratory testing at a frequency of once every 500 CY or once per shift, whichever is less. This frequency would be reduced once data shows that the contractor can consistently meet performance requirements after the completion of 10,000 CY or 20 days of mixing.
6. Stockpiled soil removed during the sump excavation step would be treated using ex situ solidification/stabilization. A treatment cell(s) would be created using a lined and bermed area. Measured quantities of soil would be transferred from the soil stockpile to the treatment cell and mixed with reagents. The same reagent mix design used for ISS is assumed to be appropriate to treat the preexcavation soils, although the water ratio may be adjusted for ex situ conditions. This would be evaluated during the initial demonstration period. The soil and reagent mixture would be mixed using a hydraulic excavator and/or excavator equipped with a horizontal blending attachment. When the soil is adequately mixed, it would then be transferred on Site and allowed to cure in place for final Site grading and contouring, consistent with planned future Site use, to create landscape features.
7. At completion of ISS, the contractor would decontaminate equipment, dismantle the ISS auger and jet grout rig and batch plant, and demobilize.
8. The passive groundwater treatment system and final soil cap would be installed after ISS demobilization.

Groundwater monitoring performed following completion of ISS treatment would be used to confirm groundwater flow patterns and assess the need for the passive groundwater treatment common element.

The general sequence and duration of key Alternative 4 elements, assuming all elements of Alternative 4 were fully implemented, would include:

Year 0	Year 1	Year 2	Year 3 - 10
• Construct common elements • GWTP O&M	• Construct common elements • Plug and abandon recovery or monitor wells within the ISS footprint • Complete auger and jet grout ISS	• Passive groundwater discharge/treatment system construction • GWTP O&M	• Passive groundwater discharge/treatment O&M • Final site cap construction • GWTP decommissioning

3.3.4.4 Screening Evaluation

Screening of Alternative 4—ISS against the criteria of effectiveness, implementability, and cost indicates that this alternative should be retained. This alternative would be effective because it would reduce NAPL toxicity and mobility through treatment, achieve protection in a relatively short timeframe, and minimize the need for long-term management. ISS treatment of NAPL-contaminated material will significantly alter the Upper Aquifer's hydrogeologic characteristics. The reduction in hydraulic conductivity within the ISS monolith will change groundwater flow patterns diverting flow from the upgradient portion of the FPA around or beneath the ISS monolith. With the perimeter sheet pile wall blocking natural groundwater discharge to Eagle Harbor and Puget Sound, the passive groundwater discharge/treatment systems will be an important long-term water balance management tool.

This alternative would be readily implemented using technology and equipment proven at other NAPL-contaminated sites, although some implementation elements would need to be refined during the field demonstration. ISS deployment using auger mixing has been successfully implemented at a number of hazardous waste sites; however, the depth and volume of material to be treated at this site would make this one of the largest ISS projects implemented. Jet grouting technology to improve soil geotechnical properties is also a mature technology. The deployment of ISS technology at the Site may pose some implementation challenges because of the depth of treatment, dense nature of aquifer materials, and potential presence of subsurface fill debris placed during site development. Jet grouting has been successfully used at the U.S. Department of Energy's Hanford Site to distribute pre-formed apatite in the Hanford formation, which is comprised of a dense mixture of cobbles, gravel, and sand. Although this use occurred at shallow depths (25 feet), it demonstrates that the technology can successfully fluidize large coarse-grained material.

While the cost would be high, due the volume and depth of NAPL-contaminated material requiring treatment, this cost is not disproportionate to overall effectiveness.

3.3.4.5 Cost Estimate

The total present worth cost for Alternative 4, based on a 7.0 percent discount rate, is $88.6 million with a -30/+50 percent cost range of $62.0 million to $132.9 million. A breakout of total life cycle costs is provided in **Table 3-4**.

3.3.5 Alternative 5—Thermal Enhanced Extraction and In Situ Stabilization/Solidification

Alternative 5 addresses the NCP requirement to treat the principal threats posed by the Site using thermal enhanced extraction to draw NAPL from the subsurface in the Core, North Shallow (LNAPL), and East Shallow (LNAPL) zones and destroying the NAPL in an aboveground thermal oxidation unit. In the North Deep (DNAPL) zone, NAPL is immobilized using ISS. Alternative 5 includes the following components (**Table 3-5a**):

- Each of the applicable common elements listed in **Table 3-2**.
- Enhanced NAPL recovery using an array of multipurpose wells and the GWTP for approximately 3 years. Mobile NAPL removal prior would shorten the duration of the thermal treatment period thereby reducing cost.
- Thermal steam-enhanced extraction and thermal destruction of NAPL as follows:
  - **Core Zone—**186,000 CY of contaminated material would be treated to a depth of about 55 feet.
  - **North Shallow (LNAPL) zone—**18,600 CY of contaminated material would be treated to depths ranging from 25 to 45 feet.

— **East Shallow (LNAPL) zone—**143,000 CY of contaminated material would be treated to depths ranging from 25 to 45 feet.

- ISS of the North Deep (DNAPL) zone. 29,400 CY of contaminated material would be treated to depths up to 76 feet using the jet-grout mixing as described for Alternative 4.
- EAB[4] of the Other Periphery zone. 327,000 CY of low-level NAPL-contaminated material present at depths from 10 to 45 feet would be treated.
- EAB polishing of thermally treated zones. After thermal treatment is completed, EAB would be implemented in each zone as a polishing step to promote aerobic biodegradation of residual NAPL and dissolved/sorbed-phase COCs. Residual heat from the thermal treatment step would accelerate aerobic biodegradation promoting a higher degree of treatment.

Under this alternative, it is estimated that 84 percent of the NAPL would be would be removed and treated. The remaining 16 percent would be treated through passive groundwater treatment and natural attenuation processes.

This alternative addresses RAOs 1 through 3 using multiple technologies to extract, destroy, and immobilize NAPL source material thereby reducing COC concentrations in Upper Aquifer soil and groundwater to levels that would allow for further concentration reductions to PRGs through EAB treatment. RAO 4 is addressed through treatment of Upper Aquifer NAPL source material to reduce COC concentrations to levels that prevent further degradation of Lower Aquifer potable groundwater.

3.3.5.1 Enhanced NAPL Recovery Description

Thermal treatment would be preceded by a period of enhanced NAPL recovery from an array of 147 extraction wells (**Appendix B, Drawing 400 C-100**). NAPL and groundwater would be extracted using pneumatically driven pumps. The wells and pumps are both compatible with thermal-steam injection operations. Enhanced NAPL recovery reduces the duration and cost of the steam-injection phase. During the initial phases of recovery, NAPL and groundwater would be pumped directly from the wells. As NAPL recovery volumes diminish, NAPL recovery would be enhanced by increasing the gradient through injection of treated water from the GWTP. During the NAPL recovery phase, the Upper Aquifer recovery wells would continue to maintain hydraulic containment of the dissolved-phase plume.

Extracted NAPL and groundwater would be pumped to the GWTP where the NAPL would be separated in a newly installed oil-water separator and the groundwater treated in the existing GWTP. Recovered NAPL would be transported and disposed of (incinerated) off Site. The total volume of NAPL recovered during the 3-year enhanced recovery program is estimated at 134,000 gallons.

3.3.5.2 Thermal Treatment Description

Thermal enhanced extraction would be performed using steam injected into an array of multi-purpose wells. The Core Area (three cells identified as Core A, Core B, and Core C) and East Shallow (LNAPL) (two cells identified as North and South) target zones would be divided into smaller treatment cells using sheet pile walls that extend from the ground surface to the top of the Aquitard so that hydraulic containment can be maintained during the thermal treatment step. To maintain hydraulic containment, the steam injection rate must be offset by a groundwater extraction rate that is equal or greater. The sheet pile walls would reduce groundwater intrusion and allow the water table to be lowered close to the bottom of the NAPL treatment zone. The total volume of NAPL-contaminated material that is thermally treated would be larger than described for Alternatives 3 and 4 to allow for “squaring off” the

[4] EAB may also be referred to as biosparging in the text and Appendix B drawings.

individual treatment cells. For example, the Core Area was extended northward in "Core C" to capture additional highly NAPL-impacted soil.

After isolating each treatment cell with the vertical sheet pile walls, a vapor barrier would be constructed over the treatment area. The vapor barrier would span 6 acres extending approximately 20 feet beyond the edges of the thermal treatment footprint (**Appendix B Drawing 400-C-101**).

After installing the vapor barrier, all remaining wells would be installed, including 27 dewatering wells, 172 multipurpose steam injection/EAB wells, 201 temperature monitoring wells, and 31 EAB wells. The 147 wells previously installed for NAPL recovery would be re-purposed as steam extraction wells. Installation of piping, fittings, instrumentation, and surface process systems would be performed sequentially and precede initiation of thermal operations in each treatment cell. After all the wells are installed, and during enhanced NAPL recovery operations, the surface process components necessary for vapor and liquid treatment would be constructed.

Core Area, East Shallow (LNAPL), and North Shallow (LNAPL)

Thermal enhanced extraction in these three areas utilizes the enhanced NAPL recovery wells for fluid/vapor extraction and injects steam through a network of injection wells installed in a repeated 7-spot configuration with a 30-foot spacing between injection and extraction wells. The layout of the 172 steam injection wells is shown on **Appendix B, Drawing 400-C-101**. The 7-spot well pattern was modified based on the placement of the sheet pile walls and identified areas of NAPL accumulation. **Drawing 400-C-101** also shows the approximate location of 201 temperature monitoring wells. The thermal treatment areas are overlain by a temporary vapor barrier to prevent steam and contaminant vapor escape and heat losses to the atmosphere during operations. This vapor barrier is augmented by active extraction of vapors through perforated piping installed under a geomembrane and/or injection of air through other piping installed under the geomembrane. Injected air is intended for extraction by the deeper, vertical steam extraction wells. The extent of the vapor barrier cap across the Core, East Shallow (LNAPL), and North Shallow (LNAPL) areas, and the placement of shallow, horizontal piping beneath the vapor barrier is shown on **Appendix B, Drawing 400-C-102**.

As NAPL recovery in the Core Area diminishes or ceases, sequential application of thermal enhanced extraction is initiated with Core A treated first, followed by Core B, and Core C. Upon completion of all thermal treatment in the Core Area, the process is moved to the East Shallow (LNAPL) South and then the East Shallow (LNAPL) North treatment cells. The North Shallow (LNAPL) target zone would be treated last.

3.3.5.3 EAB Description

After thermal operations are completed, EAB would be implemented across the thermally treated areas for approximately 1 year accompanied by hydraulic containment to promote mixing and oxygen distribution. **Appendix B, Drawing 400-C-103,** presents the biosparging well layout. EAB has synergy with the thermal treatment. Air injection for aerobic biodegradation promotes mixing dissolved contaminant mass with oxygen, while the residual heat from thermal operations promotes increased dissolution of residual NAPL and increased biological degradation rates. During EAB operations, the infrastructure for thermal operations is dismantled and removed from the Site.

The passive groundwater treatment system, as described in Section 3.2, Common Elements, and deemed necessary from performance monitoring, would be installed during the final stages of EAB. When EAB is terminated, hydraulic containment also would be terminated, and passive treatment operations begin. The passive treatment system would operate for approximately 20 years, after which all wells would be are abandoned, save a few monitoring wells, the GWTP is demolished, and the final Site cap is constructed, as described in Section 3.2, Common Elements.

In the Other Periphery target zone, EAB would be applied using an array of air and amendment injection points and wells. Supplemental biosparging points and wells for amendment injection and monitoring are installed as illustrated in **Appendix B, Drawing 400-C-103** to provide injection points for air and nutrients to enhance aerobic biodegradation of contaminants.

3.3.5.4 Design Criteria and Basis for Approach

The following subsections present the design criteria and design basis for the key Alternative 5 treatment technologies.

ISS -Jet Grouting

The design criteria and basis for ISS-jet grouting of the North Deep (DNAPL) target zone is the same as described for Alternative 4 in Section 3.3.4.2.

Enhanced NAPL Recovery

Enhanced NAPL recovery rates were estimated using a decline curve analysis (American Petroleum Institute Publication 4711, 2011) along with Site-specific parameters for the recovery well spacing (approximately 55 feet), fraction of NAPL volume characterized as mobile (0.34), and the NAPL and soil physical properties. Based on the analysis, 3 years of operation would recover approximately 35 percent of the mobile NAPL. The 55-foot spacing between recovery wells was optimized with the design basis for the steam injection well spacing.

Thermal Treatment

Thermal enhanced extraction utilizes the enhanced NAPL recovery wells and injects steam through a network of injection wells installed amongst the extraction wells in a repeated seven-spot configuration with a 30-foot spacing between steam injection and extraction wells. This pattern overlays with the 55-foot spacing between NAPL recovery (steam extraction) wells.

The primary design criteria for thermal enhanced extraction is the GWTP's 80-gpm available hydraulic capacity, which controls dewatering and vapor/fluid extraction rates, and hence the size of each treatment cell. Per this criteria, the Core, East Shallow (LNAPL), and North Shallow (LNAPL) target zones were divided into six treatment volumes (cells) ranging in size from 31,000 CY to 78,000 CY. The cells would be segregated by internal sheet pile walls as shown on **Appendix B, Drawing 400-C-100**.

The design basis for Alternative 5 accounts for high naphthalene mass extraction rates. Naphthalene crystallization considerations start in the treatment train and within the extraction wells. Wellhead details are shown on **Appendix B, Drawing 400-C-500** and include multipurpose drop tubes that allow measurements of water level, soil temperature at the bottom of the well, and access for steam cleaning of the well screen should naphthalene fouling degrade recovery rates. Steam can also be supplied through this location to clean the vapor instrumentation and piping at the wellhead.

The conveyance piping includes heat tracing to maintain high temperatures that minimize crystallization while providing access ports for periodic steam cleaning as a routine maintenance procedure. As shown on **Appendix B, Drawing 400-C-600**, all extracted liquids and vapors are routed through a direct contact condenser specifically designed to remove NAPL sludge, solid-phase PAH, and any solids extracted from the subsurface. Steam condensation is expected to generate PAH solids that would be handled as shown on **Drawing 400-C-600**. This process flow diagram illustrates the primary treatment equipment required for the thermal component of Alternative 5 including vapor treatment in a thermal oxidizer.

The water from the thermal treatment is near ambient temperature, has a low NAPL content, and is routed to the GWTP for final treatment. The existing GWTP process flow diagram is shown on **Appendix B, Drawing 400-C-601** with the proposed upgrades to increase its capacity to 140 gpm and handle higher temperature water shown on **Drawing 400-C-602**. The thermal treatment system layout is shown on **Drawing 400-M-101**.

Dewatering and Soil Vapor Extraction

Each of the three Core Area treatment cells includes six dewatering wells with the objective of lowering the water table as close to the Aquitard as practical. The total pumping rate is estimated to range from 60 to 80 gpm. The East Shallow (LNAPL) South, East Shallow (LNAPL) North, and North Shallow (LNAPL) treatment cells each have three dewatering wells. The objective for pumping in these cells is to lower the average water table elevation by 10 to 15 feet to expose the majority of the NAPL. The total pumping rate is estimated to range from 30 to 45 gpm. After lowering the water table, soil vapor extraction (SVE) is initiated using the NAPL extraction wells at a total rate up to 600 scfm.

Soil Heating and Mobile NAPL Recovery during Steam Injection

Once most of the mobile NAPL is recovered, thermal treatment would be used to recover additional NAPL through the steam enhanced recovery and distillation recovery steps (**Table 3-5b**). Steam injection is not expected to result in complete recovery of all NAPL due to subsurface heterogeneities. Under Alternative 5, the design assumption is for 35 percent recovery achieved through a longer period of enhanced NAPL recovery preceding steam injection and more uniform heating during steam operations in each treatment cell. The estimated NAPL volumes characterized as residual, that require recovery or treatment through the distillation, dissolution, and EAB steps account for about 65 percent of the original NAPL volume present in each treatment cell.

Of the 582,000 gallons of NAPL initially present in the “squared off” treatment cells, it is estimated that 208,000 gallons are recovered using enhanced pumping and steam enhanced recovery methods. The remaining 374,000 gallons of immobile NAPL are thermally recovered through volatilization into the extracted vapor phase, dissolution into extracted water, or EAB. Some COC mass is adsorbed by aquifer solids. Desorption of this mass is enhanced by steam injection, but this fraction is not considered further because the mass is very small relative to the total NAPL mass.

Residual NAPL Distillation during Steam Injection

The duration of steam distillation to achieve the NAPL mass reduction is calculated from the rate of steam injection and the total mass of steam required. A practical steam injection rate during NAPL distillation was determined from the surface treatment capacity for condensing extracted steam and for handling PAH solids. Based on practical mass and energy balances, the assumed steam injection rate during distillation is 6,500 pph. For this steam injection rate, initial production of solid PAHs in the treatment system for the Core treatment cells is about 6,000 pounds per day. The total mass of steam required for the NAPL mass reduction would be more than the mass calculated from the ideal distillation model. Overall, the steam requirement averaged 1,000 lbs/CY and required a total injection of about 277 million pounds of steam. The thermal component in the six treatment cells requires about 5 years to complete based on the proposed approach.

EAB following Steam Injection

Soil temperatures remain elevated for a long period following the end of steam injection and afford the opportunity for continued volatilization and recovery of NAPL components. When steam injection is terminated, air injection is continued through the same system of wells. The vapor and groundwater extraction systems continue operating to maintain a depressed water table and recover the injected air.

For design, the air injection rate is assumed to sweep the vapor pore volume within the treatment target once per day. A daily pore volume sweep corresponds to an air injection rate of 200 scfm. Air injection and extraction operates for 30 days following the end of steam injection while the water table is lowered in the next treatment target.

As subsurface temperatures decay further and after 30 days of operation, liquid and vapor extraction cease in the extraction wells, allowing the water table to rise. Biosparging is then initiated into the warm saturated zone to enhance the aerobic degradation of remaining dissolved-phase and desorbing contaminants. Biosparging is implemented by pulsing air injection into rotating sets of wells at an average rate of 100 scfm and extracting from the vapor barrier at a similar rate. Biological degradation parameters (e.g., dissolved oxygen [DO] and oxidation-reduction potential [ORP] in groundwater and carbon dioxide in vapor barrier extraction) and groundwater PAH concentrations are monitored. This operation continues for six to nine months during steam injection in the next treatment volume.

The design basis for EAB is described further in the following subsection.

EAB of Other Periphery Target Zone

The Other Periphery target zone lies outside and partially within the footprint of the thermal enhanced extraction and the ISS treatment zones. The design basis for implementing EAB in this target zone and as a thermal treatment polishing step varies and depends on the following Site-specific factors:

- Oxygen requirement for aerobic biodegradation based on contaminant mass estimates (assume 1,000 standard cubic feet of air per kilogram of contaminant mass degraded)
- Air injection well radius of influence (assume 25 feet)
- Anticipated average air injection rate for soil properties, air distribution patterns, NAPL dissolution rates, and aerobic biodegradation rates of individual creosote components (assume 8 scfm per well).

NAPL dissolution, oxygen distribution and diffusion, and reaction rates combine to slow the process and reduce the efficiency of oxygen utilization, thereby requiring the injection of an excess of oxygen into the subsurface. The air injection rate in the EAB system would be estimated from the anticipated half-lives of contaminants in the groundwater at the Wyckoff Site and the partitioning of oxygen from air into groundwater during design. For naphthalene in groundwater, typical half-lives under ambient anaerobic conditions have been observed from 110 to 462 days with a recommended value of 258 days (Aronson et al., 1997). For aerobic conditions, such as those created during EAB, the half-life of naphthalene in groundwater at ambient temperatures is typically about 30 days (Aronson et al., 1999).

3.3.5.5 Implementation and Sequencing

The implementation of thermal treatment under this alternative[5] would typically consist of the following steps:

1. Install all process piping, including heat tracing or equivalent, to maintain vapors at an elevated temperature up to the point of ex situ treatment.
2. Initiate dewatering from the six dewatering wells and pump water to the GWTP.
3. Reroute groundwater extraction piping from the enhanced NAPL recovery wells to the thermal pretreatment system, and increase the extraction rate to recover as much remaining mobile NAPL as practical.

[5] The steps described are based on conditions present in Core A; steps would likely vary for other treatment cells.

4. Initiate SVE in the extraction wells and beneath the vapor barrier.
5. Initiate steam injection and use performance observations to optimize flow and withdrawal rates.
6. Cease steam injection after 270 days, and continue liquid and vapor extraction at decreased rates.
7. With elevated soil temperatures still present, initiate EAB through multipurpose wells.
8. As subsurface temperatures decrease, cease liquid and SVE allowing the water table to rise. Continue SVE beneath vapor barrier at a rate matching the EAB injection rate. Continue EAB and monitor biological degradation parameters and COC concentrations for six months. Introduce amendments, as necessary, to optimize aerobic biodegradation of residual COCs by adjusting redox conditions and adding electron donors, acceptors, and nutrients as needed.
9. Remove and inspect extraction wellhead assemblies and downhole pumps, remove steam injection wellhead assemblies, disassemble piping (excluding air lines to injection wells) and manifolds, and refurbish all for reuse in subsequent treatment cells. Move to the next treatment cell in the sequence and proceed with constructing the piping system for injection and extraction.
10. The leapfrogging construction and operations sequence continues across the FPA proceeding from Core A to Core B, Core C, East Shallow (LNAPL) South, East Shallow (LNAPL) North, and last the North Shallow (LNAPL) target zone.

Implementing Alternative 5 would span approximately 9 years of sustained Site activity from initial design to the initiation of the passive groundwater discharge/treatment.

Assuming 2016 as the base year, the implementation sequence, assuming all elements of the alternative were fully implemented, would consist of the following activities:

Year 0	Year 1	Year 2	Year 3-4	Year 4 - 8	Year 9
• Construct common elements • GWTP O&M • Jet grout ISS North Deep (DNAPL)	• Construct common elements • GWTP O&M	• NAPL recovery O&M • GWTP O&M	• NAPL recovery O&M • GWTP O&M • Thermal construction	• Thermal O&M • GWTP O&M • EAB	• Thermal well decommissioning • Construct passive groundwater discharge/treatment

Year 10	Year 11 - 27
• Passive groundwater discharge/ treatment O&M • Install final site cap	• Passive groundwater discharge/ treatment • GWTP demolition

3.3.5.6 Screening Evaluation

Screening of Alternative 5 – Thermal Enhanced Extraction and ISS against the criteria of effectiveness, implementability, and cost indicates that this alternative should be retained. This alternative would be effective because it would reduce toxicity, mobility, and volume through treatment, achieve protection in a reasonable timeframe, and reduce the need for long-term management. This alternative would use advanced treatment technology that requires an extensive network of injection and recovery wells that utilize the GTWP to recover NAPL and thermal oxidation to destroy vapor-phase contaminants. Thermal enhanced extraction has been deployed successfully at other sites. While the cost is high, due the volume of NAPL-contaminated material requiring treatment, this cost is not disproportionate to overall effectiveness.

3.3.5.7 Cost Estimate

The total present worth cost for Alternative 5, based on a 7.0 percent discount rate, is $120.1 million with a -30/+50 percent cost range of $84.1 million to $180.2 million. A breakout of total life cycle costs is provided in **Table 3-5a**.

3.3.6 Alternative 6—Excavation, Thermal Desorption, and Thermal Enhanced Extraction

Alternative 6 combines the excavation and MTTD technologies to treat NAPL source material present in the upper portion of the Core Area to a depth of 20 feet. Alternative 6, like Alternative 5, addresses the NCP requirement to develop an alternative that removes or destroys contaminants to the maximum extent feasible, eliminating or minimizing, to the degree possible, the need for long-term management.

This alternative includes the following components (**Table 3-6**):

- The applicable common elements listed in **Table 3-2**.
- Excavation and MTTD treatment of an estimated 81,300 CY of NAPL source material present within the top 20 feet of the Core Area. Before backfilling treated soil, a geosynthetic clay liner would be placed on the bottom of the excavation to create a vapor barrier to support subsequent thermal treatment operations.
- Thermal enhanced extraction in the Lower Core Area, between depths of 20 feet and the top of the Aquitard, and the East Shallow (LNAPL), North Shallow (LNAPL), and North Deep (DNAPL) target zones. Following completion of thermal treatment, EAB would be implemented as a polishing step to promote aerobic biodegradation of residual NAPL and dissolved/sorbed-phase COCs. Residual heat from the thermal treatment step would accelerate aerobic biodegradation promoting a higher degree of treatment.
- EAB in the Other Periphery target zone.

Under this alternative, an estimated 85 percent of the NAPL present in the FPA would be treated using the primary technologies of excavation, thermal desorption, thermal enhanced extraction, and EAB, with the remaining 15 percent addressed through passive groundwater treatment and natural attenuation.

This alternative addresses RAOs 1 through 3 by excavating and/or thermally treating NAPL-contaminated soil to reduce COC concentrations to the defined PRGs. EAB would be implemented to complete any remaining treatment necessary to achieve Upper Aquifer soil and groundwater PRGs. RAO 4 is addressed through treatment of Upper Aquifer NAPL source material and MNA within the Lower Aquifer to reduce COC concentrations to the Lower Aquifer groundwater PRGs.

3.3.6.1 Excavation Methods – Description

To facilitate dewatering and soil excavations, the Core Area would be divided into nine sheet pile cells (**Drawing 500-C-100**) with surface areas ranging from 10,000 to 16,000 ft^2. The sheet pile walls extend from the ground surface to the Aquitard. Sheet pile wall bracing would be accomplished using welded whalers and struts, which would be left in place for backfilling. Within each of the cells, two dewatering wells would be installed to lower the water table below a depth of 20 feet. Each dewatering well is estimated to yield 10 to 20 gpm. The dewatering wells would be left in place to assist with the thermal treatment portion of the remedy or used as monitoring wells.

3.3.6.2 Thermal Desorption Treatment – Description

MTTD would generally be performed as described for Alternative 3.

Additional infrastructure to support MTTD operations includes the following:

- **Sheet Pile Cells and Dewatering Wells** – would be installed to form the nine cells in the Core Area and would be installed into the top of the Aquitard.
- **Soil Blending and Handling Building** – this is a metal building or fabric structure used for staging the soil in order to improve its uniformity prior to feeding into the MTTD. The building is constructed on an asphalt concrete pavement (ACP) pad with a concrete berm. The building atmosphere is ventilated through a vapor-phase GAC system to control odor and emissions. Trucks would dump over a ramp near the eastern building entrance. The feeder to the MTTD system would be placed in the building thus allowing for interior loading to reduce noise during night and weekend periods.
- **MTTD Pad** – an ACP lined pad for the MTTD equipment as well as the genset and fractionation tanks for quenching of treated soils. The pad is sloped for stormwater collection and to support treatment.
- **Soils Awaiting Analysis Pad** – ACP lined holding area divided into cells to stage soil while it is tested to support blending, re-treatment, and backfill determinations. The cells are constructed of ecology blocks stacked three high. A turn-around-time for PAH and PCP soil analysis of 3 days is planned.
- **Treated Soils Stockpile Area**- ACP lined pad holding up to 16,000 CY of soil awaiting confirmation that soil PRGs have been achieved prior to backfill placement.
- **Propane Storage Tank** – a 30,000-gallon storage tank placed on a concrete pad with cradles enclosed by ecology blocks. The tank also includes a vaporizer.
- **MTTD Genset** – a containment pad for the genset as well as fuel cell. The fuel cell would have a capacity of about 16,000 gallons and provide for an estimated 12 days of operation.
- **Existing GWTP** – the water from the dewatering wells would be treated through the GWTP.
- **Storm Water Infiltration Trench** – would handle stormwater from the Site as well as the Treated Soil Stockpile Area if it is contaminated and cannot be direct discharged. Prior to construction of the trench, the soils in this area would be excavated to a depth of 7 feet and treated using MTTD.
- **Decontamination Pad** – including a fractionation tank, genset, and a powered wheel wash. The fractionation tank would also support dust control. This pad would be located along the main access road between the Treated Soils Stockpile and the Soil Blending and Handling Building. The road would be constructed with 12 inches of crushed rock over a geotextile fabric.
- **Existing Well** – the well would be used for process and dust control water supply.
- **Underground Piping and Cables**. The following would be run underground; dewatering well pipe to GWTP; propane service to the primary and secondary chambers; stormwater conveyance to the infiltration trench; power to MTTD control trailer and the Soils Blending and Handling Building. The dewatering well piping would be buried HDPE with stub ups at each of the cells. The discharge header from the dewatering wells would be connected to the transfer piping using fire hoses. The wells would be powered by genset.

3.3.6.3 Thermal Enhanced Extraction and EAB

The thermal enhanced extraction and EAB components of Alternative 6 are similar to that described for Alternative 5. The layout of these components is shown on **Drawing 500-C-101** (Enhanced NAPL

Recovery Wells and Thermal Wells), **Drawing 500-C-102** (Vapor Cover), **Drawing 500-C-102 and 500-C-103** (Piping), and **Drawing 500-C-104** (EAB Wells).

3.3.6.4 Design Criteria and Design Basis

Propane consumption for the MTTD unit is estimated at 23 gallons per ton of soil treated or 3 million gallons total. Electrical power would also be required and would be obtained from a 750 kilowatt (kW) TIER IV genset (480-volt three-phase) with an estimated fuel consumption at 100 percent operations of 55 gallons/hour or 450,120 gallons of diesel total.

The treatment rate through the MTTD system is estimated at 20 tons per hour with an estimated maximum treatment rate of 480 tons/day. The system would operate 24 hours/day for 7 days/week, and with an 80 percent availability, the daily treatment rate is about 16 tons/hour or 380 tons/day for 11 months.

The design criteria and design basis for the thermal enhanced extraction and EAB components are the same as described for Alternative 5.

3.3.6.5 Implementation and Sequencing Schedule

The general sequence of events for excavation and MTTD operations in each treatment cell would include the following steps:

1. During weekdays, excavation would be conducted in parallel with MTTD treatment.
2. During the weekday night shift, and on weekends, soil would not be excavated but MTTD treatment would continue using stockpiled material loaded from the Soil Blending and Handling Building interior into the MTTD feeder to minimize noise levels. For extended weekends, excavation may be required or additional soil may need to be staged within the cells.
3. Excavation would begin in the first cell using a combination of long reach excavator and a drag line. Foam would be used to control odors during excavation. Soils with excess moisture may be staged in an adjoining contaminated cell for drying prior to transport to the Soils Blending and Handling Building.
4. As the excavation within a cell proceeds to the design depth, the whalers and struts would be installed using a crane and man lift to provide lateral support for the sheet pile walls.
5. As the excavation progresses a track mounted dozer would be lowered into the cell to support the staging of soils for removal by long reach excavator or clamshell.
6. Excavated soil would be transported in 20-ton off-road trucks to the Soil Blending and Handling Building where it would be staged for further dewatering (using a tiller) as well as blending and/or addition of admixtures. Soils would be end dumped over a dump ramp.
7. Soils in the Soil Blending and Handling Building would be windrowed for tilling or mixing to support dewatering and homogenization as well as adding reagents (such as lime) to support dewatering. The building would be designed to hold a 3- to 4-day supply of soil for MTTD treatment.
8. Soils within the Soil Blending and Handling Building would be loaded into the feeder of the MTTD unit, which is located within the building. This approach minimizes odors and dust, as well as reducing noise levels during nighttime and weekend operations.
9. Treated soil is staged by conveyor in day piles on the MTTD pad, where it is subsequently hauled to the Soils Awaiting Analysis pad where it is held in cells (one day's treatment per cell) until it has been demonstrated, through analytical testing, that the soil meets the treatment objectives.

10. Soil that does not meet the treatment objectives would be staged for re-treatment. Soil meeting the treatment objectives would be staged in the Treated Soils Stockpile area and/or staged for direct backfill adjacent to an excavation.
11. Prior to backfilling, sump pumps would be used for any further dewatering prior to the placement of the geosynthetic clay liner vapor barrier.
12. When two cells are open, the backfilling operation would be conducted. Backfill would be placed in lifts and compacted. A crane would be used to lower equipment into each cell as required to support geosynthetic clay liner placement, spreading of backfill, and compaction. As indicated above the whalers would be left in place. As conditions dictate, the struts may be removed to support backfilling.

Once MTTD is completed, the unit would be decontaminated and removed along with other surface and below ground (piling) features. ACP would be removed and recycled to the degree feasible. Subgrade gravel for base material would be removed from the Treated Soil Stockpile area and used along with other base materials for backfill within the cell or general Site.

The general duration of key excavation, MTTD, and thermal enhanced extraction treatment activities would include the following:

Year 0	**Year 1**	**Year 2 - 3**	**Year 4**
• Construct common elements • GWTP O&M	• Construct common elements • GWTP O&M	• Soil excavation and MTTD • GWTP O&M	• NAPL recovery O&M • GWTP O&M • Begin thermal system construction
Year 5-6	**Year 7 -9**	**Year 10 -12**	**Year 13-27**
• Complete thermal extraction system construction • Thermal extraction and NAPL recovery O&M • GWTP O&M	• Thermal extraction O&M • GWTP O&M	• Passive groundwater discharge/treatment O&M • Thermal decommissioning • Construct final site cap	• Passive groundwater discharge/treatment O&M • GWTP decommissioning (year 18)

Following completed of excavation and MTTD treatment, thermal enhanced extraction and EAB would be implemented as described for Alternative 5.

3.3.6.6 Screening Evaluation

Screening of Alternative 6 – Excavation, MTTD and Thermal Enhanced Extraction against the criteria of effectiveness, implementability, and cost indicates that this alternative should be retained.

Alternative 6 is effective because it utilizes multiple treatment technologies, employing excavation and MTTD to address high concentration NAPL source material and thermal enhanced extraction to address areas where lower concentrations of NAPL source material occur. Although this alternative faces some implementation challenges, the design concept has developed approaches to address each condition. As described in the following subsection, the estimated cost for this alternative is higher relative to the other alternatives but provides important information that shows what is required to implement this technology combination at the Site.

3.3.6.7 Cost Estimate

The total present worth cost for Alternative 6, based on a 7.0 percent discount rate, is $161.5 million with a -30/+50 percent cost range of $113.1 million to $242.3 million. A breakout of total life cycle costs is provided in **Table 3-6**.

3.3.7 Alternative 7—ISS of Expanded Core Area and Thermal Enhanced Recovery

This alternative employs an adaptive management or iterative approach that provides the opportunity to respond to new information and changing site conditions observed over the remedy implementation lifecycle. Under this alternative, remedial action target areas and technology selection would be refined based on the results of remedial design data collection, performance monitoring, and field observations made during a Phases 1 and 2 implementation schedule. Remedial design data collection would be used to define the treatment area where Phase 1 remedial actions would be implemented, while Phase 1 performance monitoring data would be used to determine the need for Phase 2 remedial action, and if so, which technologies should be used and where they would be implemented.

The primary components of this alternative (**Table 3-7a**) that would be implemented during Phase 1 include:

- The Common Elements listed in **Table 3-2**.
- ISS of an expanded Core Area (**Figure 3-2**).
- NAPL recovery at targeted locations in the North Deep and East Shallow areas where ISS is not performed with continued operation of the GWTP. Several existing groundwater extraction wells lying within the ISS footprint would be plugged and abandoned and replacement wells installed. For the purposes of this FFS, it is assumed that six wells would be replaced. The exact number of recovery wells necessary to maintain hydraulic containment will be determined during remedial design.
- EAB along the inside of the existing sheet pile wall using a network of vertical air sparge wells that inject atmospheric air in the upper portion (e.g. Compartment 1) of the Upper Aquifer and trace nutrients (if necessary), to stimulate in situ biodegradation of dissolved phase COCs. The EAB system would create a treated groundwater shell along the downgradient margins of the FPA, with low or non-detect COC concentrations, to allow for passive groundwater discharge or cost efficient operation of a passive groundwater treatment system as a long-term Upper Aquifer water balance control measure.
- A 5-year performance monitoring period to assess Phase 1 treatment effectiveness. Data generated from the performance monitoring program would be compared to the defined Upper Aquifer and Lower Aquifer trigger criteria to determine the need for Phase 2 remedial action.
- Transition to passive groundwater discharge or passive groundwater treatment, at the end of the 5-year performance monitoring period, based on comparison of the performance results to the passive discharge and passive treatment trigger criteria as follows:
  - If the passive discharge (e.g. no treatment required) criteria are met, no further action would be performed.
  - If the passive treatment criteria are met, the performance monitoring data would be used to design the system and to prepare an O&M cost estimate. If the cost estimate indicates that O&M costs are substantially lower than operation of the GWTP, the passive treatment system

would be constructed as described in Section 3.1 – Common Elements. If passive treatment costs are not substantially lower, then targeted Phase 2 remedial action would be implemented to treat additional NAPL source material such that the desired passive treatment cost threshold is achieved.

If Phase 1 performance monitoring reveals conditions that exceed the Phase 2 remedial action trigger criteria, then Phase 2 remedial actions would be implemented. These may include:

- Targeted treatment, where a decision on which treatment technology or technologies to use, and the areas to be targeted, would be based on Phase 1 performance monitoring results. Candidate technologies include ISS, thermal enhanced NAPL recovery, and in situ chemical oxidation. For the purposes of scoping and cost estimating in this FFS, thermal enhanced recovery across the Phase 2 treatment area shown on **Figure 3-2** is assumed.
- Continued operation of the GWTP to provide hydraulic containment and protection of the Lower Aquifer.
- Performance monitoring to assess Phases 1 and 2 treatment effectiveness.
- Transition from active to passive groundwater discharge or passive groundwater treatment, as described for Phase 1.

The estimated soil and NAPL volumes present in the Phases 1 and 2 treatment zones are shown in **Table 3-7b**.

3.3.7.1 Adaptive Management and Trigger Criteria

A guiding principle for the adaptive management approach is to treat the most contaminated area first and expand treatment to other areas, as determined by performance monitoring data, to achieve the performance objectives[6] (POs) and RAOs efficiently. Initial ISS activities and NAPL recovery are expected to achieve PO 1 and the RAOs, leaving PO 2 and confirmation that RAO 3 has been achieved as the focus for adaptive management decisions. PO 2 is interpreted as transitioning site remedial activities to maintenance of the site cap and operation of the passive groundwater discharge/treatment system to maintain achievement of the RAOs.

Key site conditions and elements of the Phase 1 remedial action that warrant an adaptive management approach for NAPL treatment within the FPA include the following:

- Installation of a new sheet pile wall inside the existing perimeter sheet pile wall, and a reinforced concrete bulkhead constructed between the two sheet pile walls, will physically contain contaminated soil while providing a significant physical barrier to future NAPL and dissolved phase contaminant transport from the upland to the beach. This is expected to result in lower PAH concentrations in the groundwater that upwells within the intertidal area.
- Phase 1 actions will result in a significant reduction in the contaminant mass flux that is generated from Upper Aquifer groundwater contact with pooled and residual NAPL. ISS of the expanded Core Area will also alter Upper Aquifer groundwater flow patterns, and potentially Lower Aquifer

[6] PO 1 is to remove or treat mobile NAPL in the Upper Aquifer to the maximum extent practicable such that migration and leaching of contaminants is significantly reduced.

PO 2 is to implement a remedial action that does not require active hydraulic control as a long-term component of O&M following completion of source removal action.

groundwater recharge of the Upper Aquifer. A clear understanding of these changes is needed to inform the need for and scope of Phase 2 remedial actions.

- Remedial action planned for the East Beach and North Shoal areas within OU1 will reduce NAPL concentrations in the top 30 inches of sediment, where recreational and ecological exposure can potentially occur, by removing contaminated sediment and placing sorbent caps over NAPL transport pathways.

The components of the OU2/OU4 and OU1 remedial actions described above will result in significant risk reductions at the Site, and collectively, may achieve the POs and RAOs without the need for treatment of the entire 10%RE NAPL footprint.

To guide decisions on the need for Phase 2 remedial action, a set of Upper Aquifer (**Figure 3-3a**) and Lower Aquifer (**Figure 3-3b**) trigger criteria were developed as components of Alternative 7.

A key element of the trigger criteria is a Phase 1 performance monitoring program that includes baseline (pre-treatment) and post-treatment Upper Aquifer and Lower Aquifer NAPL and groundwater monitoring with the monitoring results compiled and compared to the trigger criteria to determine the need for Phase 2 remedial action.

An additional element of the Alternative 7 trigger criteria is a decision point for transitioning from active groundwater treatment to passive groundwater discharge/treatment. Passive groundwater discharge consists of maintaining the Upper Aquifer groundwater elevation, at a level to be determined during remedial design, by draining the overflow to Puget Sound without treatment.

Passive treatment is similar except the overflow would be treated as described in Section 3.1 – Common Elements prior to discharge. Because passive treatment will incur routine O&M costs; associated with periodic inspections, sampling to confirm treatment effectiveness, and replacement of spent media, for an extended period it is important the cost not exceed a reasonable level. Passive treatment O&M costs are largely controlled by the volume of treatment media required and the frequency of spent media change-out with both of these factors defined by the passive groundwater flow rate and the COC concentrations present in Upper Aquifer groundwater at the time treatment occurs. To ensure that O&M costs are reasonable, should passive treatment be required, an additional trigger has been included that would require Phase 2 remedial action.

3.3.7.2 Phase 1 Predesign Investigation

To support remedial design of the ISS, NAPL recovery, and EAB remedy components, a predesign investigation would be conducted. The predesign investigation would include the following activities:

- TarGOST® Investigation – to refine the footprint where Phase 1 ISS would be deployed, a series of TarGOST® borings would be drilled around the perimeter of the Expanded Core Area.

- Groundwater Sampling – to establish baseline groundwater quality conditions, two rounds of groundwater monitoring would be conducted. The first event would be performed under high groundwater elevation conditions similar to passive discharge elevations, and the second prior to Phase 1 implementation. It is assumed that 20 existing wells will be sampled. Lower Aquifer groundwater sampling is being performed as part of the current remedy. These data will be compiled for use as part of the predesign investigation data evaluation.

- GWTP Data Compilation – existing GWTP influent SVOC results for a 2-year period will be compiled for use in defining a mass flux baseline to support implementation of the Phase 2 trigger criteria. This information will be obtained from process control monitoring performed under the current remedy.

- Air Sparge Pilot Test – to develop performance information (flow rate and radius of influence) to support design of the Phase 1 EAB system, a pilot test will be conducted. This will consist of installing two typical air sparge wells screened in the Upper Aquifer, injecting compressed air spiked with a tracer for up to 24 hours to span a full tidal cycle, and measuring water levels and collecting groundwater samples from adjacent monitor wells for tracer analysis.
- Surface Geophysical Investigation – to confirm the extent of buried debris within the expanded Core Area, a surface geophysics survey will be conducted. This survey will also include excavation of three to five deep test pits to confirm the geophysical survey results and to assess the presence of buried debris.
- ISS Mix Design – laboratory bench-scale testing will be performed using creosote-contaminated material obtained from the TarGOST® or geophysical survey test pit work to refine the design for the ISS stabilization agent. The testing includes blending a series of creosote-contaminated samples with varying reagent concentrations and evaluating performance using unconfined compressive strength, hydraulic conductivity, and leachability analysis.

3.3.7.3 Phase 1 ISS Treatment

The primary component in Alternative 7 is ISS treatment in the Expanded Core Area to treat NAPL-contaminated material down to the depth of the contamination, which varies across the treatment footprint area. If the remedial design investigation determines that ISS treatment in additional areas may be warranted or treatment of previously identified areas may no longer contribute towards achievement of the POs and RAOs, the ISS treatment area can be readily modified per the adaptive management approach.

Deployment of the ISS technology in the expanded Core Area would be similar as described under Alternative 4, treating approximately 65 percent of the NAPL source material present in the FPA. Four existing hydraulic containment wells, lying within the ISS treatment footprint, would be plugged and abandoned beforehand.

The ISS footprint for Alternative 7 is shown in **Appendix B Drawing 700-C-100**, with details for the assumed depth of treatment illustrated in **Appendix B Drawings 700-C-101 through 700-C-105**. As shown in **Drawing 700-C-105**, ISS treatment creates a substantial cut-off wall between the southern and northern areas of the FPA, but leaves a gap between the bottom of the ISS treatment zone and the Aquitard in the eastern portion of the FPA. Hence, Upper Aquifer groundwater flow paths will be altered. The impact of these changes on groundwater flow can only be assessed with modeling performed during remedial design and Phase 1 performance monitoring.

3.3.7.4 Phase 1 NAPL Recovery and Hydraulic Containment

Preceding ISS deployment, NAPL recovery would be implemented using an array of new or existing recovery wells installed at targeted locations in the North Deep and East Shallow areas (**Appendix B Drawing 700-C-107**). Where NAPL is pooled along the water table (LNAPL) or on low permeability layers (DNAPL) within the Upper Aquifer, inducing NAPL to flow to recovery wells is an effective means of achieving significant contaminant mass reduction, which in turn may increase the effectiveness of other treatment technologies (e.g. EAB). NAPL recovery would be performed by increasing the horizontal hydraulic gradient across the area where mobile NAPL occurs using direct NAPL pumping in the East Shallow area and total fluids extraction coupled with NAPL separation and water re-injection in the North Deep area.

The NAPL recovery system for the North Deep area is designed to remove both LNAPL and DNAPL in the area by screening the recovery wells across the entire saturated zone. Groundwater is extracted to reduce the hydraulic head at the recovery well. Extracted groundwater is treated in an oil water separator to separate oil from groundwater and then the water is reinjected upgradient of the recovery wells through screens at the top of the Aquitard, targeting DNAPL for recovery. This “water flooding” system steepens the hydraulic gradient near the recovery well, increasing NAPL recovery effectiveness.

The NAPL recovery system in the East Shallow area is designed to remove LNAPL. The system includes skimming pumps with sensors that detect when the pump is in LNAPL; thereby, it only pumps LNAPL and not LNAPL and groundwater. The pump and transfer piping are suspended on a reel that automatically lowers and raises the pump within the well to keep the pump intake in the NAPL. This is important with the fluctuating water levels attributed to tidal and seasonal water level conditions. Recovered LNAPL will be collected in a satellite tank for periodic transfer to the GWTP NAPL storage tank.

The estimated layout of the Phase 1 NAPL recovery wells is illustrated in **Appendix B Drawing 700-C-106** and **Drawing 700-C-107**. The exact number and optimum placement of the recovery wells may change during remedial design based on evaluation of updated information. NAPL recovery infrastructure in the North Deep area includes a line of seven extraction wells aligned with the sheet pile wall accompanied by surface separation equipment and an upgradient line of seven water re-injection wells. In the East Shallow area, there are 23 recovery wells fitted with skimming pumps and a single injection well for discharge of any co-extracted groundwater.

Concurrent with NAPL recovery, the balance of the wellfield will be operated to maintain hydraulic containment. This will consist of operating the system at a total flow rate of 35 to 40 gpm, and adjusting individual well flows as needed. Because several existing hydraulic containment wells will have to plugged and abandoned to allow for ISS, groundwater pumping from the new recovery wells will be used to supplement hydraulic containment pumping. **Drawing 700-C-106** shows the location of existing hydraulic containment recovery wells and the proposed locations for six new groundwater extraction wells to replace those abandoned for ISS. Water level measurement data from the in well transducers will be downloaded every three months and the data evaluated in accordance with the current protocol to assess hydraulic containment effectiveness.

Recovered groundwater would be treated at the existing GWTP as described for Alternative 2. NAPL recovery volumes measured at the GWTP and NAPL thickness measurements in recovery wells and adjacent monitoring wells would be compiled and the data used to optimize recovery operations. Periodic NAPL transmissivity tests would be performed to measure the ability of the formation to provide NAPL to the recovery wells. Optimization may include increased or decreased groundwater pumping rates, shifting NAPL recovery equipment to other existing well locations or converting recovery/monitoring wells into treated water injection wells to enhance gradient induced recovery.

3.3.7.5 Phase 1 - Enhanced Aerobic Biodegradation

The EAB element consists of a linear array of vertical biosparge wells installed parallel to and offset 15 to 30 feet inland from the sheet pile wall. The biosparge wells inject atmospheric air, containing 21 percent oxygen and trace nutrients (if necessary), into the Upper Aquifer to accelerate in situ biodegradation of residual NAPL and dissolved phase COCs. For this FFS, the biosparge wells are installed on 50-foot centers (30-foot radius of influence for each well) along an approximate 1,500-foot section of the sheet pile wall (27 biosparge wells total) as illustrated in **Appendix B Drawing 700-C-106**. Each well would receive an airflow rate of 11 scfm (300 scfm total) from a compressor installed in the GWTP building. The EAB system would be installed during the initial Phase 1 construction efforts so that operations can be optimized to achieve the highest levels of treatment.

The EAB system would create a shell of aerobic groundwater just inside the sheet pile wall, with dissolved phase COCs present at non-detect to low concentrations, from which the passive discharge/treatment system would draw water. If the EAB system is highly effective, then the passive system could discharge groundwater directly to the intertidal area below the mudline without treatment. If the system is marginally effective, then passive treatment would occur before discharge.

Because air injection creates a groundwater elevation mound around the injection point, biosparging would be performed while the tide is rising with the system turned off during the outgoing tide to promote Upper Aquifer groundwater flow into the passive system. The GWTP - PLC would be programmed to turn the compressor on and off based on the tide schedule or with a water level sensor installed below the low point of the water table.

Sampling and analysis of the passive system influent and selected monitoring wells located along the sheet pile wall perimeter would be used to assess EAB effectiveness and to optimize biosparge operations.

3.3.7.5 Phase 1 Performance Monitoring

To assess the effectiveness of Phase 1 ISS, NAPL recovery, and EAB for comparison to the Phase 2 trigger criteria and to assess achievement of POs and RAOs, an upper and Lower Aquifer performance monitoring program will be implemented. This program would include the following:

1. **In-well NAPL Thickness.** Measurements would be performed at a subset of Upper Aquifer and Lower Aquifer monitoring wells. For the purposes of this FFS, it is assumed that NAPL measurements will be performed monthly at 20 Upper Aquifer wells and 10 Lower Aquifer wells during the first year, quarterly in years 2 and 3, and semiannually in years 4 and 5.
2. **NAPL Transmissivity Tests.** NAPL recovery is effective for as long as the formation can effectively transmit NAPL to the wells. At some point, pooled NAPL is separated into smaller pockets and the NAPL transmissivity decreases. Therefore, periodic measurements of NAPL transmissivity will be performed. Standard ASTM International procedures will be used.
3. **Water Level Measurements.** Upper Aquifer groundwater elevations are influenced by hydraulic containment pumping, tidal fluctuations, and seasonal rainfall variations. The effect of these events will continue during Phase 1 remedial action with additional effects arising from installation of the new sheet pile wall and perimeter bulkhead and ISS of a large block of Upper Aquifer material within the central portion of the FPA. To assess the effects of these events on Upper Aquifer groundwater flow patterns and contaminant transport, water level measurements will be performed at most of the existing Upper Aquifer and Lower Aquifer monitoring well locations. For the purposes of this FFS, it is assumed the measurements will be performed monthly for year 1 and semiannually for years 2 through 5. This dataset will be supplemented with continuous water level monitoring data obtained from transducers installed in the hydraulic containment network. Tidal stage information from the Eagle Harbor gaging station will also be downloaded from the National Oceanic and Atmospheric Administration (NOAA) website to supplement the upland water level data.
4. **Groundwater Sampling and Analysis.** As shown on **Figures 3-3a and 3-3b**, COC concentrations present in Upper and Lower Aquifer groundwater are a key data input to the Phase 2 remedial action trigger criteria evaluation. ISS treatment will result in a new COC concentration distribution and new groundwater flow patterns within the area bounded by the expanded Core Area footprint and the perimeter sheet pile wall. It may take several years before an equilibrium is achieved. To assess the effectiveness of ISS treatment, groundwater samples will be collected from a subset of

Upper Aquifer and Lower Aquifer monitoring wells. For the purposes of this FFS, it is assumed that samples will be collected from 10 Upper Aquifer wells quarterly for year 1, and semiannually for years 2 through 5. In the Lower Aquifer, groundwater samples will be collected from 10 wells semiannually for years 1 through 5.

5. **Dilution Factor (DF) Determination.** COCs present in Upper Aquifer groundwater that lies below the passive discharge/treatment system invert elevation would eventually discharge to the intertidal area after the hydraulic containment/GWTP system is turned off. The length of this flow path and the magnitude of the COC concentration reduction that occurs through dilution and attenuation is expected to vary both spatially and temporally. The presence of the sheet pile wall, and the tidally induced gradient reversals that occur across the Aquitard, likely result in a very tortuous flow path. As shown on **Figure 2-1**, the magnitude of the medium – deep flow path DF is estimated to be 20. The magnitude of the shallow flow path will be determined during remedial design using a groundwater flow and transport model or through a field tracer test.

   The shallow flow path DF will be used to establish COC discharge limits for the passive discharge/treatment system. The outfalls for this system would terminate below the mudline, thus allowing the effluent to mix with groundwater and sediment pore water upwelling through the sediment column.

6. **Data Evaluation and Reporting.** Phase 1 performance monitoring data will be compiled periodically and an annual report issued. Reports for years 1, 2, and 3 will focus on remediation accomplishments while those prepared for years 4 and 5 will focus on evaluating the data relative to the Phase 2 triggers. The data compiled for these reports will also be used to support the 5-year reviews.

3.3.7.6 Phase 1 Passive Groundwater Discharge or Passive Groundwater Treatment

Because of natural recharge sources (e.g. rainfall, upgradient inflow, and Lower Aquifer groundwater upflow), it is expected that Upper Aquifer water level control will be needed for long-term site management. To maintain the Upper Aquifer groundwater level at a not-to-exceed elevation estimated at -1.0 ft-MLLW, a passive drainage system will be installed as described in Section 3.1, Common Elements, at locations illustrated in **Appendix B Drawing 700-C-108**. Phase 1 performance monitoring data will provide the input required for the design of this system, such as the groundwater elevation and dissolved phase COC concentrations. It is expected that after 3 to 4 years of Phase 1 treatment performance monitoring data have been compiled, and the effectiveness of the EAB system is well defined, a determination will be made on whether a passive discharge system or a passive treatment system is required. If a passive treatment system is needed, a preliminary design and O&M cost estimate will be prepared to determine if the system meets the O&M cost trigger (**Figure 3-3a**). If the O&M cost trigger is met, and other performance monitoring data indicate that Phase 2 remedial action is not required, the system would be constructed near the end of the 5-year Phase 1 performance monitoring period.

3.3.7.7 Phase 2 – Thermal Enhanced NAPL Recovery

If Phase 1 performance monitoring data indicate that Phase 2 remedial action is required, the data would be evaluated to determine which technology is best suited to address the conditions that prevent achievement of PO 2 and the RAOs. Candidate technologies include ISS, ISCO, and thermal-enhanced NAPL recovery. Localized areas with high levels of NAPL contamination would favor the use of ISS and ISCO; whereas, larger areas with more disperse contamination might favor thermal-enhanced recovery. For the purposes of this FFS, it is assumed that thermal-enhanced recovery would be implemented within the Phase 2 area shown on **Figure 3-2**. Thermal-enhanced NAPL recovery would be implemented using ”wet” steam injection.

Wet steam injection employs a mix of liquid and vapor at steam temperature to provide substantial energy injection rates without creating a continuous steam vapor zone. The approach promotes NAPL mobilization for recovery by reducing NAPL viscosity, increasing the solubility of NAPL components, thereby increasing residual NAPL dissolution rates while providing a hydraulic gradient exceeding that of liquid water injection alone. In addition, there is no continuous steam zone or multi-phase (vapor and liquid) waste stream, thereby simplifying above ground treatment. However, because the groundwater temperature and throughput rates would increase, the GWTP would be upgraded to accommodate throughput rates up to 140 gpm with provisions for an influent temperature estimated at 95 to 105 °F. Introduction of thermal enhancements would proceed across the Phase 2 footprint to mobilize and recover NAPL and increase both dissolution rates from immobile NAPL and in situ biological degradation rates. It is estimated that Phase 2 target soil volumes could be moderately heated to an optimal average temperature of about 140 °F in about one year.

After initial heating of the treatment area, NAPL recovery, dissolved-phase extraction, and hydraulic containment would continue as needed along with operation of the GWTP. The hot groundwater extracted from the subsurface would pass through heat exchangers to transfer the extracted energy to treated water piped for re-injection. This would significantly decrease the energy required to maintain an elevated subsurface temperature. Periodic addition of heat through wet steam injection would be performed in areas where temperatures are low or subject to encroachment of ambient groundwater from outside the target soil volumes. Operation of the thermal enhanced NAPL recovery is anticipated to occur for up to 4 years beyond the initial 1-year heating period. Per the adaptive management approach, annual evaluations of contaminant mass recovery rates would be performed and appropriate optimization steps implemented, such as intensifying treatment or terminating treatment in areas where NAPL recovery rates have diminished and dissolved phase COC concentrations have stabilized. Portions of the Site could also transition to other technologies such as ISCO or EAB as conditions dictate.

Table 3-7c lists the estimate for the initial NAPL volume in each target soil volume, including the ISS volume for reference. The Phase 2 estimates include the Phase 1 targets because these are included in the Phase 2 operations. The third column provides the estimated duration of wet steam injection required for the initial heating of the volume from ambient temperature to the target average temperature of 140 °F. If the soil volumes are heated sequentially, the total estimated time required is 216 days of continuous injection. The estimates for NAPL recovery from direct pumping enhanced by thermal heating within each target treatment volume (or sequestered by ISS) are listed in the fourth column. Under ambient conditions, the percentage of NAPL deemed mobile based on TarGOST® results is 34 percent. From literature reviews, heating and the consequent reduction in creosote viscosity and reduction in residual saturation provides a 50 percent increase in the percentage of NAPL that is mobile (i.e., 1.5 x 34 percent = 51 percent). It is reasonable to assume 75 percent recovery of the mobile NAPL over the full term of the Phase 2 effort (5 years). Based on these assumptions, approximately 70,000 gallons of NAPL is recovered during Phase 2, and when combined with ISS, represents an overall reduction in NAPL of 77 percent. The residual NAPL left for treatment by dissolution and degradation at elevated temperature is about 113,000 gallons. Based on the soil volume in each target (or pore volume) and estimated residual NAPL, the flushing rate to achieve an exchange of 10 pore volumes in 4 years is provided in the final column. The total flushing rate is coincident with the anticipated capacity of the GWTP available for the thermal operations. A flush of 10 pore volumes at elevated temperature is consistent with efforts at other creosote sites and dissolution modeling accompanied by biological degradation. In addition, it indicates that 10 pore volumes are sufficient to achieve a reduction in equilibrium groundwater naphthalene concentration of over 90 percent. Such a reduction is expected to make passive discharge or passive treatment viable at the end of the thermal operations.

The wells installed for Phase 1 NAPL recovery would be included in the well field for Phase 2 thermal enhanced recovery, as illustrated in **Appendix B Drawing 700-C-109** and in more detail on **Drawings 700-C-110 and 700-C-111**. As shown, Phase 2 necessitates the additional installation of 67 extraction wells and 39 injection wells, both assumed to have 4-inch diameters, as well as 97 temperature-monitoring wells located among the injection and extraction wells. Pneumatically driven pumps are assumed suitable for the total liquids pumping from the wells.

Following well installation, other infrastructure includes piping, fittings, instrumentation, and surface process systems. Wellhead designs for extraction, injection, and biosparging are provided in **Drawing 700-C-112**. New surface process components are limited to liquid treatment that includes:

1. Place process equipment for pre-treatment of extracted liquids ahead of the existing GWTP (e.g., accumulation tank, heat exchangers, NAPL separators, NAPL storage tank, and connecting pipes).
2. Place a propane storage tank (30,000 gallons).
3. Place a propane-fired steam generation system capable of producing 10 million British thermal units per hour and connect to propane tank.

The process flow diagram of surface equipment preceding the existing GWTP is shown in **Drawing 700-C113**. The process includes a 20,000-gallon accumulation tank into which all extracted liquids are pumped. This tank acts as the first oil separator because of its slow velocity. Skimmed LNAPL and DNAPL are pumped directly to the existing oily waste storage tank. From the accumulation tank, the liquid is directed through a 150 gpm oil water separator for additional NAPL recovery. From the oil water separator, the hot water is routed through heat exchangers to transfer energy to treated water for re-injection and then through a second set of heat exchangers to reduce the temperature to an acceptable level for entry to the existing GWTP for treatment prior to discharge or re-injection. The equipment site plan for the Phase 2 surface system is illustrated in **Drawing 700-C-114**.

Enhanced Biological Degradation

Following completion of thermal enhanced NAPL recovery, EAB would be performed using existing Phase 2 injection and recovery wells to compliment the continuing EAB along the entire site perimeter. Because subsurface temperatures will be elevated, EAB will be an effective polishing step that would provide added assurance that PO 2 and RAOs will be fully achieved. Installation of the surface components for the EAB system consist of placing two air compressors, installing pipe and instrumentation between the compressors and air sparge wells, and a control system to regulate air injection. The duration of Phase 2 EAB operations is assumed to be 2 years for the purposes of this FFS but it may be extended or shortened depending on thermal enhanced recovery and EAB performance monitoring results.

The calculated NAPL volumes characterized as residual and requiring dissolution and degradation or extraction are summarized in **Table 3-7c** for each target volume. Aerobic biodegradation can be more effective in larger volumes because more volume is available for microbes to inhabit. The primary variables governing degradation, beyond oxygen availability, are temperature and dissolution rates from residual NAPL. In general, the higher the NAPL saturation, the higher the dissolution rate because of larger contact area between water and NAPL. Equilibrium between the groundwater and NAPL cannot be assumed if degradation is relatively rapid.

A common assumption for the bulk mass transfer at hydrocarbon NAPL sites under ambient conditions is 0.05 day^{-1}. With the agitation provided by hydraulic containment pumping and air injection, this value is assumed double for the purposes of this FFS. Under ambient conditions and temperatures, if sufficient oxygen is provided, the half-life of dissolved naphthalene in groundwater is typically about 30 days (Aronson et al., 1999). This value is assumed for the Wyckoff Site at a system temperature of 12 degrees Celsius (°C). Heating the subsurface to 40 °C is expected to reduce the half-life by a factor of 4 in the presence of abundant oxygen. For periphery area, outside the air sparge zone, an aerobic naphthalene half-life of 7.5 days is assumed.

3.3.7.7 Phase 2 - Passive Groundwater Discharge or Passive Groundwater Treatment

At the conclusion of Phase 2 thermal enhanced recovery, a passive groundwater discharge or passive groundwater treatment system would be designed and constructed as described for Phase 1.

3.3.7.8 Implementation Sequence and Schedule

The sequence and duration of key Alternative 7 Phase 1 and Phase 2 activities, assuming all elements of the alternative are fully implemented, includes the following:

Year 0: Phase 1	Year 1: Phase 1	Year 2: Phase 1	Year 3: Phase 1	Year 4 – 5: Phase 1	Year 6 – 10: Phase 1
• Project planning • GWTP O&M (State lead)	• Construct common elements • Construct NAPL recovery and EAB wells • NAPL recovery, EAB, and GWTP O&M • GWTP O&M	• Construct common elements • NAPL recovery, EAB, and GWTP O&M	• Construct common elements • NAPL recovery, EAB, and GWTP O&M	• ISS of Expanded Core Area • NAPL recovery, EAB, and GWTP O&M	• Design, construct, operate, passive groundwater discharge/treatment (if applicable) • Phase 1 performance monitoring • Phase 2 determination (year 10)

Year 11: Phase 2 (if necessary)	Year 12 – 15: Phase 2	Year 16: Phase 2	Year 17-34: Phase 2
• Construct thermal enhanced recovery • Construct common elements (outfall) • EAB O&M	• Thermal enhanced recovery O&M • EAB O&M	• Thermal decommissioning • Passive groundwater discharge/treatment construction • Construct common element (final cap)	• Passive groundwater discharge/treatment O&M

3.3.7.5 Cost Estimate

The total present worth cost for Alternative 7, based on a 7.0 percent discount rate, is $82.4 million with a -30/+50 percent cost range of $57.7 million to $123.6 million. A breakout of total life cycle costs is provided in **Table 3-7a**.

SECTION 4

Detailed Analysis of Alternatives

This section presents the detailed analysis of remedial action alternatives described in Section 3.3 for the Wyckoff Soil and Groundwater OUs. The remedial action alternatives were evaluated against seven of the nine CERCLA criteria described in the NCP ("Remedial Investigation/Feasibility Study and Selection of Remedy," 40 CFR 300.430€[9]). The CERCLA evaluation criteria are described in **Table 4-1**, and each of the remedial action alternatives evaluated individually and comparatively against these criteria in Sections 4.2 and 4.3, respectively. The remaining two criteria, which are identified as modifying criteria, are formally assessed during preparation of the Proposed Plan (State Acceptance) and following review of public and stakeholder comments (Community Acceptance) on the Proposed Plan.

The detailed and comparative analysis of alternatives helps to develop the information necessary to recommend an alternative in this FFS and assist in identifying a preferred alternative in the Proposed Plan. Following public and stakeholder review of the Proposed Plan, EPA and Ecology would select a final remedial action alternative for the Soil and Groundwater OUs and identify the selected alternative in a CERCLA decision document.

4.1 Description of CERCLA Evaluation Criteria

The nine CERCLA evaluation criteria upon which the detailed and comparative evaluations are based are designed to enable the analysis of each alternative to address the statutory, technical, and policy considerations necessary for selecting a final remedial alternative. These evaluation criteria (**Table 4-1**) provide the framework for conducting the detailed analysis of alternatives and selecting an appropriate remedial action. The performance or acceptability of each alternative is first evaluated individually, so relative strengths and weaknesses may be identified (Section 4.2), and then comparatively (Section 4.3) to assess trade-offs and to aid in an alternative ranking.

The evaluation criteria are divided into three categories (threshold, balancing, and modifying) based on the function of each category in the remedy selection process. The NCP ("Remedial Investigation/ Feasibility Study and Selection of Remedy," 40 CFR 300.430[f]) states that the first two criteria—protection of human health and the environment (HHE) and compliance with ARARs—are "threshold criteria" that must be met by the selected remedial action unless a waiver can be granted under CERCLA ("Cleanup Standards," Section 121[d][4]).

The five "balancing criteria" represent technical considerations, upon which the detailed analysis is primarily based and include long-term effectiveness and permanence; reduction of toxicity, mobility, or volume (TMV) through treatment; short-term effectiveness; implementability; and cost. The cost estimate details and supporting information are included in Appendix C. In assessing how well each alternative performs relative to the balancing criteria, the fraction of NAPL mass that is treated by each alternative is a key subfactor.

The final two criteria—State and Community Acceptance—are "modifying criteria." State Acceptance is formally assessed during preparation of the Proposed Plan, and Community Acceptance is formally assessed following review of Tribal Nations, public, and stakeholder comments on the Proposed Plan. Community and State Acceptance are not addressed in this FFS. Based on information from public participation, EPA and Ecology may modify some aspects of the preferred alternative or decide that another alternative is more appropriate.

4.2 Individual Analysis of Alternatives

This section evaluates each of the remedial action alternatives retained from the screening presented in Section 3.3 against the CERCLA threshold and balancing criteria described in **Table 4-1**. The evaluation results are presented in a narrative and tabular form. The tabular format also provides a pass (yes)/fail (no) determination for each threshold criteria and a rating for each of the balancing criteria. The rating is designed to assist with the comparative evaluation of alternates presented in Section 4.3 and identification of a recommended alternative in Section 5. The three rating factors used include the following:

★★★ = Alternative expected to perform very well against the CERCLA balancing criterion with minimal disadvantages or uncertainties

★★☆ = Alternative expected to perform moderately well against the CERCLA balancing criterion but with some disadvantages or uncertainties

★☆☆ = Alternative expected to perform less well against the CERCLA balancing criterion with more disadvantages or uncertainty

4.2.1 Alternative 1—No Action

This alternative was developed per NCP requirements ("Remedial Investigation/Feasibility Study and Selection of Remedy," 40 CFR 300.430[e][6]) to provide a baseline for comparison to other alternatives. Alternative 1 – No Action represents a scenario where no access restrictions, ICs, or active remedial actions would be taken. Under this alternative, hydraulic containment pumping would cease in year 2015, and no further maintenance of access restrictions (fencing) or ICs would be performed. Absent hydraulic containment pumping, NAPL and dissolved-phase contaminants would migrate towards Eagle Harbor and Puget Sound resulting in potential for greater human and ecological receptor exposure to contaminants within the intertidal area.

Evaluation of Alternative 1 against the CERCLA threshold criteria (**Table 4-2**) indicates this alternative would not protect HHE nor would it comply with chemical-specific ARARS for protection of marine surface water quality. Because this alternative would not protect HHE nor comply with chemical-specific ARARS, it cannot be selected under CERCLA. Therefore, an evaluation against the CERCLA balancing criteria was not performed.

4.2.2 Alternative 2—Containment

Alternative 2 is the contingent remedy implemented under the 2000 ROD. This alternative is included in this FFS to satisfy the NCP requirement to develop a source control alternative that involves little or no treatment and protects HHE by preventing or controlling exposure to contaminants through engineering controls, and as necessary, ICs.

Evaluation of Alternative 2 against the CERCLA threshold criteria (**Table 4-3**) indicates this alternative would protect current and future human health by restricting land use and Upper Aquifer and Lower Aquifer groundwater use. Protection of HHE also would be achieved by operating the hydraulic containment system to reduce or prevent NAPL and dissolved-phase contaminant migration to Eagle Harbor and Puget Sound. Installing the soil cap and replacement sheet pile wall (common elements) would provide additional protection for HHE by placing barriers that protect against direct contact exposure and reduce contaminant flux to Eagle Harbor and Puget Sound. This alternative would comply with action and location-specific ARARs. Alternative 2 is expected to comply with chemical-specific ARARs, defined by groundwater PRGs, at the point of compliance.

Relative to the CERCLA balancing criteria (**Table 4-3**), this alternative would perform less well for long-term effectiveness and permanence because 70 percent of the NAPL mass[7] is estimated to remain at the end of the 100-year O&M period. Additionally, while the adequacy and reliability of the containment measures would be good during the 100-year O&M period, this maintenance would be discontinued after 100 years; therefore, the reliability of these controls would decrease over time. Alternative 2 also would perform less well relative to the TMV reduction through treatment criteria due to the large mass of the NAPL source material that would remain at the end of the 100-year O&M period.

With respect to short-term effectiveness and implementability, Alternative 2 would perform moderately well because risks to the remedial action workers and community are low and the technologies associated with this alternative have been in use at the Site for 20 years. Because this alternative would maintain compliance with chemical-specific ARARs and RAOs only while the hydraulic containment system is in operation during the 100-year O&M timeframe it was rated lower for short-term effectiveness.

The total present worth cost of Alternative 2, based on a 7.0 percent discount rate, is $52.0 million. Further cost information is shown in **Table 4-3**.

4.2.3 Alternative 3—Excavation, Thermal Desorption, and In Situ Chemical Oxidation

This alternative was screened out in Section 3.3 and not carried forward in the FFS. Therefore, a detailed evaluation of this alternative against the CERCLA criteria was not performed.

4.2.4 Alternative 4—In Situ Solidification/Stabilization

Alternative 4 addresses the NCP requirement to develop an alternative that treats the principal threat posed by the Site but varies in the degree of treatment and the characteristics of the treatment residuals. Under Alternative 4, NAPL present within all remedial action target zones (e.g., entire area enclosed by the TarGOST® 10% RE) would be immobilized in situ within a cement – soil solid matrix. The cement concentration used to treat the perimeter of the NAPL source zone would be higher than used to treat the interior portion to create a hardened shell that would have a higher durability to reduce leaching potential further around the perimeter where greater contact with flowing groundwater would occur. Passive groundwater discharge treatment is also a component of this alternative that would be implemented following ISS treatment to provide for long-term Upper Aquifer water level control.

Evaluation of Alternative 4 against the CERCLA threshold criteria (**Table 4-4**) indicates this alternative would protect current human health by restricting land use and Upper Aquifer and Lower Aquifer groundwater use until RAOs are achieved. Protecting HHE in the future also would be achieved by immobilizing the NAPL, which reduces or eliminates its toxicity and mobility. The hardened shell would provide additional protection for the environment by entombing the NAPL in a leaching resistant matrix. Chemical-specific ARARs in marine surface water would be achieved by immobilizing the NAPL, which reduces COC concentrations in FPA soil and groundwater.

Relative to the CERCLA balancing criteria (**Table 4-4**), this alternative is expected to perform very well for long-term effectiveness and permanence because 93 percent of the NAPL source material would be treated using the ISS technology. The NAPL-soil-cement monolith would have high durability and low leachability, thus minimizing the need for long-term maintenance. Because contaminants are not destroyed or removed, long-term stewardship of the ISS treatment zone would be required. The key elements of this stewardship include the soil cap and bulkhead common elements to provide protection

[7] All references to fraction of NAPL mass remaining or mass of NAPL treated are based on the use of naphthalene as a NAPL indicator.

against erosion that could expose the ISS treatment zone with ICs protecting against inadvertent intrusion into the ISS monolith. This alternative also performs very well for TMV reduction because ISS treatment encapsulates NAPL to form a solid material, with significantly lower toxicity, while reducing contaminant mobility by decreasing the leachability of the NAPL and surface area exposed to leaching processes (e.g. infiltration and groundwater flow). ISS does not decrease the volume of NAPL source material.

Because RAOs would be achieved in an estimated timeframe of 10 years, with low risk to workers and the community, Alternative 4 would perform moderately well relative to the short-term effectiveness criteria. This alternative also performs moderately well for the implementability criterion because of size (approximately 5 acres) and depth (55 feet) of the ISS treatment zone and the auger-drilling challenges associated with difficult subsurface conditions (gravel and debris) that may slow remediation progress.

The total present worth cost of this alternative, based on a discount rate of 7.0 percent, is $88.6 million. A detailed breakdown of costs is provided in **Table 4-4**.

4.2.5 Alternative 5—Thermal Enhanced Extraction and In Situ Solidification/Stabilization

This alternative addresses the NCP requirement to develop an alternative that removes or destroys contaminants to the maximum extent feasible, eliminating or minimizing, to the degree possible, the need for long-term management. Alternative 5 addresses the principal threat using thermal enhanced extraction to draw NAPL from the subsurface in the Core, North Shallow (LNAPL), and East Shallow (LNAPL) zones. Thermal enhanced extraction would be preceded by up to 3 years of enhanced NAPL recovery to shorten the thermal treatment period. EAB would be used as a polishing technology in the thermally treated zones to biodegrade residual NAPL that may remain and in the Other Periphery target zone where NAPL is more disperse and present at lower concentrations. In the North Deep (DNAPL) zone, NAPL would be immobilized using ISS. Passive groundwater treatment also would be a component of this alternative that may be implemented if post-EAB performance monitoring indicates it is necessary.

Evaluating Alternative 5 against the CERCLA threshold criteria (**Table 4-5**) indicates that this alternative would protect current human health by restricting land use and Upper Aquifer and Lower Aquifer groundwater use. Protecting HHE in the future would be achieved by removing NAPL and treating the soil and groundwater to the PRGs that protect HHE. Chemical-specific ARARs in marine surface water would be achieved by reducing COC concentrations in FPA soil and groundwater to PRGs.

Relative to the CERCLA balancing criteria (**Table 4-5**), this alternative would perform very well for long-term effectiveness and permanence and TMV reduction through treatment because 84 percent of the NAPL source material would be treated using enhanced NAPL recovery/thermal enhanced extraction and EAB. By removing, immobilizing, and biodegrading NAPL, soil and groundwater PRGs would be achieved, eliminating the need for long-term Site management controls.

Alternative 5 would achieve RAOs within an estimated timeframe of approximately 27 years. During this period, there would be a significant level of daily activity associated with thermal treatment operations. This activity would pose increased risk to the workers and would be visible to the community. Therefore, Alternative 5 would perform only moderately well relative to the short-term effectiveness criteria. This alternative also performs moderately well for implementability because of scale of thermal treatment operations, which requires a significant level of infrastructure and O&M resources and skilled operators.

The total present worth cost of this alternative, based on a discount rate of 7.0 percent, is $120.1 million. A detailed breakdown of costs is provided in **Table 4-5**.

4.2.6 Alternative 6—Excavation/Thermal Desorption and Thermal Enhanced Extraction

Alternative 6, like Alternative 5, addresses the NCP requirement to develop an alternative that removes or destroys contaminants to the maximum extent feasible, eliminating or minimizing, to the degree possible, the need for long-term management. However, Alternative 6 would utilize excavation and thermal desorption in lieu of thermal enhanced extraction to address the NAPL-contaminated material present in the Upper (e.g., top 20 feet) Core Area. By using sheet pile wall to subdivide the Upper Core Area into three smaller cells, and dewatering each cell to dry the material before excavation, Alternative 6 would be expected to achieve a higher level of treatment in the Upper Core Area than the other alternatives. Unfortunately, the full benefit of the excavation and thermal desorption technology would not be realized under this alternative because most NAPL present in the Core Area lies at depths below 20 feet. As discussed previously in Section 3.3, excavation at depths greater than 20 feet is not technically practicable given Site conditions.

Like Alternative 5, Alternative 6 would use thermal enhanced extraction, preceded by up to 3 years of enhanced NAPL recovery, to draw NAPL from the Lower Core Area, and the North Shallow (LNAPL) and East Shallow (LNAPL) zones; destroying the NAPL in an aboveground thermal oxidation unit. Alternative 6 also would use thermal enhanced extraction to remove NAPL from the North Deep (DNAPL) zone. EAB would be used as a polishing technology, following thermal treatment, to biodegrade residual NAPL that may remain and in the Other Periphery target zone where NAPL is more disperse and present at lower concentrations. Passive groundwater treatment also would be a component of this alternative that may be implemented if post-EAB performance monitoring indicates it is necessary.

Evaluation of Alternative 6 against the CERCLA threshold criteria (**Table 4-6**) indicates this alternative would protect current human health by restricting land use and Upper Aquifer and Lower Aquifer groundwater use. Protecting HHE in the future would be achieved by removing NAPL and treating the soil and groundwater to reduce COC concentrations to PRGs that are protective of HHE. Chemical-specific ARARs in marine surface water would be achieved by reducing COC concentrations in FPA soil and groundwater to PRGs.

Relative to the CERCLA balancing criteria (**Table 4-6**), Alternative 6 performs moderately well for long-term effectiveness and permanence and reduction of TMV because 85 percent of the NAPL source material would be treated. The remaining fraction would be treated using EAB and natural attenuation processes, which may place more dependence on long-term Site controls if EAB treatment rates are lower than estimated. Relative to short-term effectiveness, Alternative 6 would perform moderately well. Although excavation and thermal desorption activities unlikely would pose a risk to the community, the remedial action would create noise, light, and atmospheric discharges that would be visible to the community. Additionally, the thermal desorption equipment would be housed in an enclosed building resulting in a temporary visible impact. Excavation to depths of 20 feet and handling of high temperature steam, vapor, and fluids may also pose increased risk to workers. The time required to achieve RAOs of 28 years would be greater than Alternatives 4 and 5, which justifies a moderately well rating for the short-term effectiveness criteria.

Alternative 6 would perform moderately well for implementability because of its overall technical complexity and the magnitude of resources needed for full implementation.

The total present worth cost of this alternative, based on a discount rate of 7.0 percent, is $161.5 million. A detailed breakdown of costs is provided in **Table 4-5**.

4.2.7 Alternative 7— ISS of Expanded Core Area and Thermal Enhanced Recovery

Alternative 7 merges the key technologies of ISS and thermal enhanced recovery into a phased implementation approach. Under this alternative, ISS would be implemented in Phase 1 to treat an Expanded Core Area where 65 percent of the NAPL mass occurs. If Phase 1 performance monitoring indicates additional treatment is necessary, using the Phase 2 trigger criteria, thermal enhanced recovery would be implemented in the remaining areas. If it is shown that the RAOs and POs could be met with only ISS, then the thermal enhanced recovery would not be implemented.

Evaluation of Alternative 7 against the CERCLA threshold criteria (**Table 4-7**) indicates this alternative would protect current human health by restricting land use and Upper Aquifer and Lower Aquifer groundwater use until RAOs are achieved. Protecting HHE in the future would be achieved by immobilizing NAPL present in the Expanded Core Area and thermally destroying (e.g., offsite incineration) NAPL recovered from the East Shallow (LNAPL), North Shallow (LNAPL), and North Deep (DNAPL) zones. Chemical-specific ARARs in marine surface water would be achieved by immobilizing and removing NAPL to reduce COC concentrations in FPA groundwater to PRGs.

Relative to the CERCLA balancing criteria (**Table 4-7**), this alternative would performs very well for long-term effectiveness and permanence and TMV reduction through treatment because 65 percent of the NAPL source material is treated using ISS and 20 percent treated using thermal enhanced recovery. Within the Expanded Core Area the NAPL-soil-cement monolith would have durability and low leachability, thus minimizing the need for long-term maintenance. The soil cap would provide protection against surface erosion that could potentially expose the ISS treated zone. Using the adaptive management approach in the remaining target zones, thermal enhanced recovery and thermal destruction of the NAPL, coupled with EAB, would remove the remaining NAPL minimizing or eliminating the need for long-term Site controls if needed to meet the RAOs.

Relative to the CERCLA balancing criteria of short-term effectiveness and implementability, Alternative 7 would perform moderately well for the reasons similar to those described for Alternatives 4 and 5. One notable distinction for Alternative 7 is its ability to achieve RAOs with less reliance on the need for passive groundwater treatment.

The total present worth cost of this alternative, based on a 7.0 percent discount rate, is $82.4 million. A detailed breakdown of costs is provided in **Table 4-7**.

4.3 Comparative Analysis of Remedial Alternatives

This section summarizes the comparative analysis of alternatives, which is designed to assess the advantages and disadvantages of each alternative relative to one another to identify key tradeoffs that should be noted during remedy selection. The comparative evaluation is summarized in **Table 4-8**.

4.3.1 Overall Protection of Human Health and the Environment

All of the alternatives, except Alternative 1 – No Action, would protect current human health by restricting land and groundwater use.

Alternatives 4 through 7 would protect HHE in the future by treating NAPL source material to reduce COC concentrations to groundwater PRGs and placing a soil cap over the FPA to prevent direct contact with contaminated soil. Alternative 2 would protect HHE in the future by reducing or eliminating NAPL and dissolved-phase plume migration, reducing COC concentrations in groundwater, and installing a soil cap across the FPA to provide a barrier against direct contact with contaminated soil.

4.3.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternatives 4 through 7 would achieve Upper Aquifer groundwater PRGs, and chemical-specific ARARs for groundwater discharged to the intertidal area from the passive discharge/treatment systems, within timeframes that are estimated at 10 years for Alternative 4, 24 years for Alternative 7, and 27 years for Alternatives 5 and 6.

Alternative 2 would comply with chemical-specific ARARs while the hydraulic containment system remains in operation, but there is uncertainty on whether compliance would be maintained if the system is turned off after 100 years.

All alternatives except Alternative 1 – No Action would be designed and operated to comply with action and location-specific ARARs.

4.3.3 Long-Term Effectiveness and Permanence

The balancing criterion of long-term effectiveness and permanence considers the following: (1) magnitude of residual risk from untreated waste or treatment residuals remaining at the conclusion of the remedial activities, and the (2) adequacy and reliability of controls such as containment systems and ICs that are necessary to manage treatment residuals and untreated waste. With respect to this criterion, Alternatives 4, 5, 6, and 7 were rated as performing very well, while Alternative 2 was rated as performing less well.

The percentage of NAPL source material treated by each of the alternatives varies with Alternative 2 estimated to treat 30 percent and Alternatives 4, 5, 6, and 7 treating from 93 to 84 percent (**Figure 4-2**). The balance of the NAPL source material treatment would be accomplished using passive treatment and natural attenuation processes. With respect to this criterion, the magnitude of residual risk present at the conclusion of remedial action would be greatest under Alternative 2 because it is estimated that 70 percent of the NAPL source material would remain untreated at the end of the 100-year O&M timeframe. Alternatives 5, 6, and 7 would have a comparable level of the level of residual risk with Alternative 4, which is expected to have the least amount of risk due to the high level of treatment that occurs by applying the ISS technology across the NAPL treatment zone.

Under Alternatives 4 and 7, the ISS technology uses vertical augers and jet-grouting (Alternative 4 only) equipment to homogenize the NAPL and the cement-based reagent, resulting in a high level of direct contact and overall treatment that significantly lessens the potential for untreated material. Alternatives 5 and 6 rely on thermal-enhanced extraction to remove the NAPL and EAB to biodegrade any residual NAPL, as does Alternative 7, Phase 2. The performance of thermal-based technologies can be influenced by the presence of subsurface heterogeneities that may influence heat distribution and NAPL recovery, which could result in partially treated zones. Therefore, while Alternatives 4, 5, 6, and 7 were all rated as performing very well, the ISS components under Alternatives 4 and 7 are expected to perform superior relative to this criterion because subsurface heterogeneity effects are eliminated by auger mixing.

The performance of the EAB technology in this FFS is judged based on its ability to biodegrade naphthalene. The other LPAHs, and high-molecular weight PAHs (HPAHs), do not biodegrade as easily as naphthalene; therefore, other PAHs could persist, even though most of the naphthalene has been degraded.

4.3.4 Reduction of Toxicity, Mobility, or Volume through Treatment

This balancing criterion assesses the degree to which an alternative employs recycling or treatment to reduce TMV, specifically the following:

- The treatment or recycling processes used and materials they would treat
- The amount of hazardous substances that would be destroyed, treated, or recycled
- The degree of expected reduction in TMV of the waste due to treatment or recycling and the specification of which reduction(s) are occurring
- The degree to which the treatment is irreversible
- The type and quantity of residuals that would remain following treatment, considering the persistence, toxicity, mobility, and propensity to bioaccumulate of such hazardous substances and their constituents
- The degree to which treatment reduces the inherent hazards posed by principal threats at the Site.

With respect to this criterion, Alternatives 4, 5, 6, and 7 were rated as performing very well, while Alternative 2 was rated as performing less well.

Alternatives 5, 6, and 7 were rated similar because each of these alternatives includes a thermal-based technology component that results in a high level of NAPL TMV reduction, including thermal destruction of NAPL brought to the surface. While Alternative 4 was rated equal to Alternatives 5, 6, and 7, it should be noted that the ISS technology reduces NAPL toxicity and mobility; it does not reduce the volume of contaminants contained in NAPL impacted soil. Additionally, although ISS treatment is considered irreversible, there is no performance data to show that the ISS columns can hold up for multigenerational timeframes.

Alternative 2 was rated lowest because of the large volume of NAPL that would remain at the end of the 100-year O&M period.

4.3.5 Short-Term Effectiveness

This balancing criterion considers the following subfactors:

- Short-term risks that might be posed to the community during implementation of an alternative
- Potential impacts on workers during remedial action and the effectiveness/reliability of protective measures
- Potential environmental impacts of the remedial action and the effectiveness/reliability of mitigation measures during implementation
- Time until protection is achieved

With respect to this criterion, each of the alternatives was rated similarly as performing moderately well. The remedial design for each alternative would include measures to minimize affects to workers, the community, and the environment during the implementation phase. Therefore, the primary differentiator is the time until protection is achieved. Relative to this subfactor, Alternative 4 achieves protection in the shortest timeframe (8 years) with Alternatives 5, 6, and 7 achieving protection in a timeframe estimated at 24 to 27 years. Alternative 2 maintains protection for up to 100 years, while it is operation, but protectiveness may be lost at the end of the 100-year operations period.

4.3.6 Implementability

This balancing criterion considers the ease or difficulty of implementing an alternative including the following as appropriate:

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

With respect to this criterion, Alternatives 2, 4, and 7 were rated as performing moderately well with Alternatives 5 and 6 rated as performing less well. All of the alternatives pose technical challenges. For Alternative 2, the primary implementation challenge would be the overall O&M timeframe of 100 years, which would require replacing extraction wells and portions of the GWTP every 30 years, and long-term staffing, offsite NAPL disposal, and offsite GAC media change-out commitments.

For Alternative 4 and 7, the primary implementation challenge would be the scale of ISS treatment, which would be one of the largest ISS treatment projects to date. Vertical auger mixing to depths of 55 feet and jet injection to depths of approximately 70 feet represent the upper limit for this type of equipment, therefore, treatment rates could be slower than initially estimated.

For Alternatives 5, 6, and 7, the complexity of implementing a thermal-based remedy in terms of the number of wells, piping, treatment equipment, and sequencing of the treatment across the Site would pose unique implementation and logistical challenges.

4.3.7 Cost

As described previously in Table 4-1, the remedial action alternative cost estimates include allowances for the following:

- Common elements, including the items listed in **Table 3-2**
- Capital costs, including costs for construction of the key technology components
- Annual remedial action O&M costs, including costs for operation of the key technology components
- Periodic costs, including costs for nonrecurring items like equipment replacement

The total present worth cost (**Table 4-8**), based on a 7.0 percent discount rate, for the alternatives ranges from $52.0 million for Alternative 2 to $161.5 million for Alternative 6.

Remedial action alternative costs were also compared by developing a 25-year cash-flow projection for each alternative; although some alternatives incur costs for more than 25 years (Alternative 2 at 100 years, Alternative 5 at 29 years, Alternative 5a at 32 years, and Alternative 6 at 29 years) and others incur costs for less than 25 years (Alternative 4 at 12 years, Alternative 4a at 15 years, and Alternative 7 at 22 years). The cost flow projections are presented on **Figure 4-3**.

SECTION 5

Recommended Alternative

Based on the results of the detailed and comparative evaluation, Alternatives 4 and 7 were ranked comparable relative to the CERCLA balancing criteria, with Alternative 7 having a lower total present worth cost of $82.4 million versus $88.6 million for Alternative 4 based on a 7 percent discount factor.

Both alternatives use the ISS technology to treat NAPL source material. Alternative 4 implements ISS across the entire NAPL source area footprint to treat 93 percent of the material while Alternative 7 implements ISS across a smaller footprint to treat 65 percent of the NAPL source material. Because the ISS technology converts the soil, NAPL, and cement into a hard, low-permeability monolith, it will be very difficult, potentially impossible, to implement additional remedial actions in the FPA if Alternative 4 performance monitoring indicates that RAOs were not achieved. Alternative 7 uses ISS to treat most of the NAPL source material with performance monitoring conducted to confirm treatment effectiveness and to inform decisions on the need for additional treatment. The performance monitoring results would also be used to guide technology screening and identification of areas where further treatment is needed. The adaptive management logic employed by Alternative 7 is an important differentiator that supports selection of Alternative 7 as the recommended alternative.

SECTION 6
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Tables

TABLE 1-1

Chronology of Soil and Groundwater OUs Investigation and Remediation Activities

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Approximate Date	Activity
1971	Environmental investigation begins at the Site in response to report of oil observed on the beach.
August 1984	EPA issues a Consent Order requiring Wyckoff Company (renamed Pacific Sound Resources) to conduct environmental investigations.
July 1987	Wyckoff site listed on Superfund NPL.
July 1988	Wyckoff Company ordered by EPA to install groundwater pump-and-treat system to halt continuing release of wood treatment contaminants to Eagle Harbor.
December 1988	Wyckoff Company ceases wood-preserving operations.
January 1990	Groundwater pump-and-treat system begins operation.
June 1992 - April 1994	EPA conducts time-critical removal action that removed approximately 29,000 tons of creosote sludges; disposed of 100,000 gallons of contaminated material; disposed of 430 cubic yards of asbestos; installed 300 feet of sheet piling; repaired and constructed 150 feet of bulkhead; and recycled 660 long tons of steel from onsite structures.
1993	EPA assumes control of the Site and the pump-and-treat system. Inspection reveals the system is in state of disrepair.
1994	Consent Decree creates PSR Environmental Trust to partially fund investigation and cleanup costs.
July 1994	Focused RI/FS completed for the Groundwater OU (OU4).
September 1994	EPA issued an Interim ROD for the Groundwater OU that included the following elements: 1) replacing the existing groundwater treatment plant, 2) evaluate, maintain, and upgrade the existing extraction system 3) installation of a physical barrier (i.e. slurry wall) to prevent further releases of contaminants to Eagle Harbor and Puget Sound, and 4) plugging and abandonment of onsite water supply wells.
November 1994	EPA and Ecology sign the SSC for the interim groundwater remedy.
January - June 1995	EPA sealed and abandoned 12 on-site production wells.
June - December 1995	The seven original extraction wells were replaced by eight new extraction wells. Other plant upgrades were also made.
January - June 1996	A non-time-critical removal action was conducted in the FPA. Site structures were demolished, and debris was removed and disposed of offsite.
November 1997	Removal of some upland subsurface structures, such as process piping, utility lines, foundations, concrete pads, and asphaltic concrete completed.
November 1997	Soil and Groundwater OU Proposed Plan issued. Containment identified as the preferred cleanup strategy for soil and groundwater.
July 1998	EPA completed the design for the replacement groundwater treatment plant but it was not constructed pending a final decision on the groundwater remedy. EPA presented the results of the thermal technologies evaluation activities and proposed a new remedy for the removal of contaminants in soil and groundwater at the Wyckoff Site to the NRRB.

TABLE 1-1
Chronology of Soil and Groundwater OUs Investigation and Remediation Activities
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Approximate Date	Activity
1998-1999	Long-term O&M associated with the containment strategy were of concern to Ecology. Therefore, EPA evaluated thermal technologies for possible application at the Wyckoff Site, conducting laboratory studies, meeting several times with the ITTAP, and evaluating the results of various other thermal technologies studies and site demonstrations.
April 1999	Focused Feasibility Study Comparative Analysis of Containment and Thermal Technologies completed.
September 1999	Conceptual design for thermal remediation of Soil and Groundwater OU completed. Second Proposed Plan issued for Soil and Groundwater OUs.
January 2000	Approximately 88,700 gallons of NAPL recovered and 316 million gallons of contaminated groundwater treated to date.
February 2000	EPA issued the ROD for the Wyckoff Soil and Groundwater OUs, conditionally selecting steam injection as the cleanup remedy. Components of this remedy included: 1) constructing a sheet pile wall around the highly contaminated zone of the FPA; 2) conducting a pilot study to test the applicability and effectiveness of steam injection; 3) consolidating hotspots from the Former Log Storage/Peeler Area to the FPA; 4) monitoring the lower-aquifer groundwater; and 5) implementing institutional controls.
May 2000	EPA and Ecology sign SSC for the Soil and Groundwater OUs.
February 2001	Over 1,800 lineal feet of sheet pile installed around the FPA (two acres of beach were created to mitigate habitat loss) and over 530 lineal feet of sheet pile was installed within a one-acre area of the site for the steam injection pilot.
February 2002	In the stem injection pilot area, a vapor cap, 16 injection wells, and seven extraction wells were installed. Approximately 600 thermal monitoring devices, a boiler building, and production well were also installed. Soil cleanup of the Former Log Storage/Peeler Area was completed.
September 2002	Modifications of the treatment system were made and the boiler system was installed, including water softeners, heat exchangers, a thermal oxidizer, compressors, pumps, and balance of plant equipment.
October 2002 – April 2003	Steam pilot conducted. Operation reached approximately 25 percent capacity with approximately 50 percent up-time. Groundwater extraction in the FPA continued during the steam pilot.
April 2004	Soils and Groundwater OU Contingent Containment Remedy implemented.
September 2004	An upgradient cutoff wall soil and groundwater investigation was completed.
February 2006	Soil and Groundwater OU property sold to the City of Bainbridge.
October 2006	Thermal Remediation Pilot Study Summary Report completed.
March 2007	Construction contract for the replacement groundwater treatment plant awarded.
April 2010	Replacement GWTP construction complete and online.
Summer 2011	Old GWTP demolished.
April 2012	SSC signed with Ecology. Ecology takes over operation and maintenance of groundwater treatment plant until April 2014. EPA agrees to conduct FFS to evaluate additional source removal options for the Soils and Groundwater OUs.

TABLE 1-1

Chronology of Soil and Groundwater OUs Investigation and Remediation Activities

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Approximate Date	Activity
May 2012	Soil and Groundwater OU FFS begins. The FFS was preceded by a comprehensive investigation using the TarGOST technology to delineate NAPL distribution within the FPA. The TarGOST investigation results were used to define the areas to be addressed in the FFS.

Notes:

Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FFS	focused feasibility study
FPA	Former Process Area
FS	feasibility study
GWTP	groundwater treatment plant
IITTAP	In-situ Thermal Technologies Advisory Panel
NAPL	non-aqueous phase liquid
NPL	National Priority List
NRRB	National Remedy Review Board
O&M	operations and maintenance
OU	operable unit
RI	remedial investigation
ROD	Record of Decision
SSC	State Superfund Contract
TarGOST	Tar-specific green optical screening tool

TABLE 1-2

Volume Estimates of NAPL-Contaminated Soil and NAPL Present in the Upper Aquifer

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Compartments and Remedial Action Target Zones	Total Soil Volume (CY)	NAPL-Contaminated Soil Volume (NCY)	Volume Estimate of NAPL Present (gallons)
Upper Aquifer	**755,000**	**109,000**	**679,000**
- Compartment 1	383,000	56,600	302,000
- Compartment 2	199,000	24,800	128,000
- Compartment 3	173,000	27,700	249,000
Core Area	106,000	39,000	302,000
East Shallow (LNAPL)	278,000	43,000	207,000
North Deep (DNAPL)	109,000	14,000	86,000
Other Periphery	44,000	4,000	33,000
North Shallow (LNAPL)	49,000	4,300	30,000
North Shallow and North Deep (Overlap of LNAPL and DNAPL Areas)[a]	46,000	2,700	18,000
Not Targeted for Treatment[b]	125,000	350	1,000

Notes:

[a] North Shallow and Deep is an overlap area encompassing zones from the LNAPL and DNAPL Areas, and is not called out as a separate target zone except in this table. For the purposes of remedial action alternative development and the detailed evaluation of alternatives, 50 percent of this volume (9,200 gallons) was allocated to the North Shallow (LNAPL) and 50 percent (9,200) to the North Deep (DNAPL) remedial action target zones.

[b] Although not specifically targeted for treatment, it is expected that treatment will occur in this area incidentally through treatment of adjacent areas.

CY cubic yards
DNAPL dense non-aqueous phase liquid
FFS focused feasibility study
LNAPL light non-aqueous phase liquid
NAPL non-aqueous phase liquid
NCY NAPL cubic yards
OU operable unit

TABLE 2-1
Wyckoff Soil and Groundwater OUs Remedial Action Objectives
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Narrative Objective	PRGs
1. RAO 1—Reduce human health risks associated with direct contact, ingestion, or inhalation of contaminated soil to levels that allow unrestricted outdoor recreational use.	Not specifically applicable. A surface cap will be used to provide a direct contact barrier. Any imported fill material required for cap construction will be tested to confirm it meets MTCA cleanup levels for residential soil.
2. RAO 2—Prevent use of Upper Aquifer groundwater for irrigation or industrial purposes that would result in unacceptable risks to human health.	Not applicable [1, 2]
3. RAO 3—Reduce risks associated with discharge of contaminated Upper Aquifer groundwater to Eagle Harbor and Puget Sound to levels that protect aquatic life and human consumption of resident fish and shellfish.	Marine AWQC adjusted upward at points of discharge to the intertidal area to account for dilution – attenuation between the point of discharge and the point of compliance (see Table 2-2).
4. RAO 4—Prevent further degradation of the Lower Aquifer, and prevent use of Lower Aquifer groundwater that would result in unacceptable risk to human health.	Not applicable

Notes:

[1] Institutional controls will remain in effect to prohibit withdrawal of upper aquifer groundwater for irrigation or other beneficial use.

[2] A remedy for the Lower Aquifer will be selected in a future CERCLA decision document.

AWQC ambient water quality control
FFS focused feasibility statement
NAPL non-aqueous phase liquid
OU operable unit
PRG preliminary remediation goal

TABLE 2-2

Upper Aquifer Groundwater Preliminary Remediation Goals - Protection of Human Health and the Marine Environment

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

COC	Surface Water Aquatic Life Marine/ Chronic 173-201A WAC (µg/L)	Surface Water Aquatic Life Marine/ Chronic CWA §304 (µg/L)	Surface Water Aquatic Life Marine/ Chronic NTR 40 CFR 131 (µg/L)	Surface Water Human Health Marine Waters CWA §304 (µg/L)	Surface Water Human Health Marine Waters NTR 40 CFR 131 (µg/L)	Freshwater Single Component Aqueous Solubility (µg/L)	Lowest Criteria Value (µg/L)	Upper Aquifer Groundwater PRG (µg/L)
Naphthalene	--	--	--	--	--	31,000	--	Not applicable
Acenaphthylene	--	--	--	--	--	--	--	Not applicable
Acenaphthene	--	--	--	990	--	4,240	990	TBD[1]
Fluorene	--	--	--	5,300	14,000	1,980	1,980	TBD[1]
Phenanthrene	--	--	--	--	--	--	--	Not applicable
Anthracene	--	--	--	40,000	110,000	43.4	43.4	TBD[1]
Fluoranthene	--	--	--	140	370	260	140	TBD[1]
Pyrene	--	--	--	4,000	11, 000	135	135	TBD[1]
Benz(a)anthracene	--	--	--	0.018	0.0311	9.4	0.018	TBD[1]
Chrysene	--	--	--	--	--	1.6	1.6	Not applicable
Benzo(b)fluoranthene				0.018	0.0311	1.5	0.018	TBD[1]
Benzo(k)fluoranthene	--	--	--	0.018	0.0311	0.8	0.018	TBD[1]
Benzo(a)pyrene	--	--	--	0.018	0.0311	1.62	0.018	TBD[1]
Indeno(1,2,3 c,d) Pyrene	--	--	--	0.018	0.0311	0.22	0.018	TBD[1]
Dibenzo (a,h) Anthracene	--	--	--	0.018	0.0311	2.49	0.018	TBD[1]
Benzo(g,h,i)perylene	--	--	--	--	--	--	0.018	Not applicable
Pentachlorophenol	7.9 (d)	7.9	7.9	3.0	8.2	1,950,000	3.0	TBD[1]

Notes:

--: no value specified

[1] The PRG will be determined by multiplying the Lowest Criteria Value by the dilution factor (DF) to be determined during remedial design. The DF reflects the tidal mixing that occurs in the sediment column prior to surface water discharge.

µg/L	micrograms per liter	NAPL	non-aqueous phase liquid
CFR	Code of Federal Regulations	NTR	National Toxics Rule
COC	contaminant of concern	OU	operable unit
CWA	Clean Water Act	PRG	preliminary remediation goal
FFS	focused feasibility study	WAC	Washington Administrative Code

TABLE 2-3
Soil and Groundwater OU Remedial Technology Screening
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

General Response Actions	Remedial Technology	Target Zone, Media, and COCs	Process Options	Description	Effectiveness (Target Zone and RAOs, Impacts to HHE during Construction, Reliability)	Implementability (Technical and Administrative)	Relative Cost	Screening Comment
No Action	No Action	Not Applicable	No action	NAPL in soil and groundwater is left untreated.	**Poor.** Not effective, because no active measures are taken to remove, treat, and/or immobilize NAPL.	**Poor.** While technically implementable, no action does not address CERCLA threshold criteria and principal threats.	**None.**	**Retained** per the NCP.
Access Restrictions	Fencing	All Zones Soil/Groundwater NAPL/All COCs	Cyclone perimeter fence	Exposure pathway controlled with engineering measures.	**Poor to Moderate.** Generally effective for protecting human health, but must be maintained over time. May not eliminate entry (trespass) or remedial action worker exposure. Does not contribute to NAPL source zone treatment.	**Good.** A fence currently encloses the Former Process Area.	**Low.**	**Retained.** Fencing is a component of the current remedy and is needed, as a component of a broader alternative, until RAOs achieved.
	ICs		Land use zoning, deed restrictions, restrictive covenants	Exposure pathway controlled with administrative measures.	**Poor to Moderate.** Relies on administrative measures to limit exposure to contaminated soil and groundwater. ICs expected to be effective short term, but uncertainty on long-term effectiveness over periods of 100 years or more exists. Does not contribute to NAPL source zone treatment.	**Moderate.** Readily implemented using existing EPA (EPA 540-F-00-005) guidance, however, requires land-owner concurrence. Some uncertainty on enforcement tools and responsibility over long term.	**Low.**	**Retained.** ICs are a component of the current remedy and are needed, as a component of a broader alternative, until RAOs achieved.
Containment	Surface Barrier	All Zones Soil NAPL/All COCs	Low permeability asphalt barrier (MATCON)	An impermeable cover (asphalt) is placed over ground surface to provide a direct contact barrier and to deter surface water infiltration away from contaminated soil. Typical asphalt mix is modified to use smaller aggregate, higher binder content, and/or proprietary binder additives.	**Moderate.** Low permeability asphalt covers are effective at reducing direct contact with contaminants and reducing infiltration ($1x10^{-8}$ cm/sec permeability), but require routine inspection, maintenance (crack repair and sealing), and periodic replacement to maintain long-term effectiveness. Not effective in eliminating lateral COC migration unless coupled with vertical barrier. Does not reduce NAPL source zone. Reduces mobility in vadose zone by minimizing infiltration. Does not reduce mobility in Upper Aquifer.	**Good.** Readily implemented. Low permeability asphalt requires special asphalt mix designs (generally proprietary) and high levels of QA/QC to demonstrate impermeability of the barrier. Asphalt barrier can be a benefit or detriment to future site development depending on intended use. Future use would need to be known and accounted for in remedial design.	**High.** Moderate to high capital and periodic cost with low initial O&M cost. O&M cost rises as asphalt ages, eventually requiring replacement. O&M and periodic costs incurred for an indefinite period of time.	**Not Retained** due to long-term site use considerations, and high O&M and periodic costs.
			Multi-layer impermeable barrier	Contaminated surface soil graded and capped with low permeability materials that may include flexible membrane liner, drainage (gravel), sand/silt/clay, and vegetation or combination thereof.	**Moderate.** Mature technology with demonstrated ability to limit infiltration and direct contact with contaminants. Would need to be coupled with other process options (for example, sheet pile wall) to address groundwater contamination, and ICs to protect against intrusion. Reduces mobility in vadose zone by minimizing infiltration. Does not reduce overall source zone.	**Moderate.** Readily implemented using standard construction practices. Requires long-term inspection and maintenance (mowing, erosion repair). Future site use may be restricted to ensure barrier integrity is maintained.	**Moderate.** Moderate capital cost, with low annual O&M and periodic costs for an indefinite duration.	**Retained.** Is a component of the current remedy. Also expected to be a component of a broader alternative to support long-term reuse.
			ET barrier	An engineered soil and native vegetation cover placed over contaminated soil to increase ET rates, and decrease surface water infiltration.	**Moderate.** Most effective in arid climates, but with appropriate design and vegetation selection, can be applied in wetter climates. Barrier layer thickness, soil gradation, vegetation, grading, and drainage, if carefully designed, can effectively limit infiltration beneath the cap. Not effective in eliminating horizontal migration of contaminants unless implemented in conjunction with vertical barrier (for	**Moderate to Good.** Easily implementable with standard construction equipment and materials. May not require mowing (depending on vegetation type), but would still require periodic inspection and repair of any erosion. Long-term maintenance required and future site uses are limited by need to protect barrier integrity.	**Low to Moderate.** Very low capital and inspection and maintenance costs (does not require mowing). O&M costs incurred for an extended period of time.	**Retained** as a component of a broader alternative.

TABLE 2-3
Soil and Groundwater OU Remedial Technology Screening
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

General Response Actions	Remedial Technology	Target Zone, Media, and COCs	Process Options	Description	Effectiveness (Target Zone and RAOs, Impacts to HHE during Construction, Reliability)	Implementability (Technical and Administrative)	Relative Cost	Screening Comment
					example, slurry wall). Differential settlement can compromise barrier effectiveness. Reduces mobility in vadose zone by minimizing infiltration. Does not reduce overall source zone	Administrative acceptance may be a barrier to implementation.		
	Subsurface Barrier	All Zones Groundwater NAPL/All COCs	Physical containment wall (for example, sheet pile, slurry wall) with interior fluids pumping	Vertical wall generally keyed into low permeability natural geologic unit to fully or partially enclose an NAPL source area. Often coupled with fluid pumping inside the containment wall to maintain an inward/upward hydraulic gradient.	**Moderate.** Well suited to site conditions. Effective at minimizing horizontal NAPL and dissolved-phase contaminant migration. Low level pumping necessary to maintain inward/upward hydraulic gradient to offset surface, upland, and Lower Aquifer recharge. Does not provide timely reductions in NAPL source zone. Reduces horizontal mobility in the Upper Aquifer, but less effective at reducing vertical mobility.	**Good.** Readily implemented with conventional construction equipment. Higher level of QA/QC required to confirm that a contiguous barrier is achieved and joint sealer is properly installed. Requires shoreline protection system to guard against corrosion. Effectiveness may decrease over time without this system. Requires periodic replacement (est. at 50 years).	**Moderate to High.** Moderate capital cost due to barrier length. High annual O&M cost for interior fluids pumping, treatment, and discharge. High periodic costs for replacement of various components.	**Retained.** Component of the current remedy. However, must be coupled with other technologies, as a component of a broader alternative, to achieve Performance Objectives and RAOs. Not retained as a stand-alone technology.
	Hydraulic Containment	All Zones Groundwater NAPL/PAHs/PCP	Groundwater extraction, treatment, and discharge	Vertical extraction wells placed throughout the Wyckoff Site to control dissolved-phase plume migration and discharge to surface water.	**Poor to Moderate.** Effective for minimizing dissolved-phase contaminant migration; however, tidal influences and Lower Aquifer hydraulic communication and routine/non-routine O&M downtime may allow some contaminant discharge to Lower Aquifer and surface water. Unlikely to contain vertical and horizontal NAPL migration. Does not provide timely reductions in NAPL source zone.	**Moderate.** All of the process options for this technology are already in place. Requires ongoing O&M operator presence, resource commitment, and vendor support network for transportation and residuals disposal. Dioxin and sulfide in recovered NAPL pose additional implementation challenges.	**Moderate to High.** Low capital cost because infrastructure already in place. High annual O&M and periodic costs based on current information.	**Retained.** Is a component of the current remedy, and expected to be short-term component of a broader alternative. Not retained as a stand-alone alternative.
Removal	Shallow Excavation (less than 15 feet)	All Zones Debris/Soil/Upper Aquifer Solids NAPL/All COCs	Standard excavation equipment/methods Benching/sloping/ shoring Dewatering Stockpiles/Run-off and Run-on controls Air monitoring	Excavation using trackhoe(s). Excavated soil direct loaded for offsite treatment and disposal or stockpiled for onsite treatment and reuse. Shoring potentially needed for depths below 4 feet. Dewatering for excavation below the water table (5 to 7 feet) also requires treatment, and offsite discharge. Air monitoring (worker and perimeter) for fugitive emissions associated with large excavation footprints or excavations in highly concentrated areas.	**Good.** Highly effective because contaminants are permanently removed from excavation zone. Reduces NAPL source zone.	**Moderate to Good.** Readily implemented to depths of 5 to 7 feet using conventional equipment with limited benching/sloping required. At depths greater than 5 to 7 feet (below water table), implementation challenges grow due to shoring and dewatering additions.	**Moderate** (not including ex situ treatment or disposal costs).	**Retained.**
	Deep Excavation (more than 15 feet)	All Zones Soil/Upper Aquifer Solids NAPL/All COCs	Long-reach excavation equipment/methods Benching/sloping/ shoring Dewatering Stockpiles/Run-off and Run-on controls Air monitoring		**Poor to Moderate.** Effectiveness decreases at greater depths because there is increased potential for residual contamination to be left behind due to inaccessibility (material against sheet pile wall or material in shoring setback-non excavation zone). Reduces NAPL source zone. However, due to depth of contamination present at the Wyckoff Site, unlikely that all NAPL down to top of Aquitard can be removed.	**Poor to Moderate.** Shoring and dewatering complexity increases with depth. May have to be implemented using grid approach to better manage shoring and dewatering volumes. Poses significant hazards to remedial action workers.	**Moderate to High.** Costs increase in proportion to excavation depth.	**Retained.** Although no complete direct contact exposure pathway for contaminated media present at depths below 15 feet exists, this material poses a sediment and surface water quality threat through the leaching and transport pathway.

TABLE 2-3
Soil and Groundwater OU Remedial Technology Screening
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

General Response Actions	Remedial Technology	Target Zone, Media, and COCs	Process Options	Description	Effectiveness (Target Zone and RAOs, Impacts to HHE during Construction, Reliability)	Implementability (Technical and Administrative)	Relative Cost	Screening Comment
	Extraction	All Zones Groundwater NAPL/All COCs	Fluids pumping from horizontal and vertical wells. Can be coupled with treated water injection, and injection amendments.	Similar to the current groundwater extraction and treatment system. Includes aggressive optimization and potential enhancements to accelerate NAPL and dissolved-phase mass removal.	**Poor to Moderate.** NAPL characteristics are less favorable for recovery via direct pumping, but mass reductions can be achieved over extended time periods. Decreases NAPL source zone.	**Moderate.** All of the process options for this technology are already in place. Requires ongoing O&M operator presence, resource commitment, and vendor support network for transportation and residuals disposal. Dioxin and sulfide in recovered NAPL pose additional implementation challenges.	**High.** Low capital cost because infrastructure already in place. High annual O&M and high periodic costs based on current information.	**Retained.** Experience with this technology at other wood treating sites indicates this technology, as a stand-alone alternative, would be unable to achieve the Performance Objectives and RAOs established for the Wyckoff Site in reasonable timeframe. However, this technology will likely be needed to support targeted DNAPL recovery, dewatering, and as a polishing step.
			Enhanced Mobilization/Solubilization (water flood)	Treated water, potentially heated, injected to enhance transport of mobile NAPL and solubilization of residual NAPL from the Upper Aquifer for extraction and ex situ treatment.	**Moderate.** Direct contact required. Heterogeneity controls injected water flow in the subsurface and can lessen effectiveness if significant heterogeneity exists. Poor injection control can mobilize NAPL to less accessible areas. More effective for LPAHs and less effective for HPAHs. Temporary short-term increase in NAPL mobility provides long-term reductions in NAPL source zone.	**Moderate.** Can be implemented using existing site infrastructure supplemented with additional injection wells or infiltration trenches.	**Low to Moderate.** Injection wells and trenches have low capital and O&M costs. If enhanced with heat, costs will rise. Majority of treatment can be performed in existing GWTP with minor modifications (if heating used).	**Retained.** Water flooding and gradient induced recovery used at other wood-treating sites to recovery mobile NAPL. This technology retained as a component of a larger alternative or potential standalone alternative.
			Enhanced Mobilization/Solubilization (surfactant)	Potable/treated water amended with agent and injected to enhance flushing of mobile and residual NAPL and sorbed PAHs from the Upper Aquifer for extraction and ex situ treatment.	**Poor to Moderate.** Direct contact required. Heterogeneity controls distribution in the subsurface, and can lessen effectiveness. Poor injection control can also mobilize NAPL to less accessible areas. More effective for LPAHs and less effective for HPAHs. Temporary short-term increase in NAPL mobility provides long-term reductions in NAPL source zone.	**Moderate.** Can be implemented using existing site infrastructure supplemented with additional wells or infiltration trenches. Modifications to GWTP potentially required depending on surfactant used.	**Moderate.** Injection wells and trenches have low capital and O&M costs. Chemical costs will be high due to volume and duration of injection required.	**Not Retained** no experience with surfactants and injection enhanced recovery at this site results in significant uncertainty on this technology's effectiveness and overall implementability.
Disposal	Onsite RCRA Landfill	All Zones Debris/Soil/Upper Aquifer Solids NAPL/All COCs	Standard transportation methods Clean offsite backfill material required	Waste materials are excavated and placed in an onsite landfill constructed with liner, leachate collection, and impermeable cap per regulatory standards.	**Good.** Effective because contaminants are contained in a landfill designed to RCRA standards. Requires long-term monitoring and maintenance to ensure effectiveness.	**Poor.** Site conditions within Former Process Area not compatible with RCRA TSD requirements. Would require identification of location further inland. May limit future site use but design work-arounds possible. Technology used at several Region 6 wood-treating sites (Bayou Bonfouca, Conroe Creosote, Hart Creosote, Jasper Creosote Superfund sites). CERCLA AOC policy allows waste materials exceeding LDRs to be disposed onsite.	**Moderate to High.** High capital cost; low O&M cost.	**Not Retained** due to current site conditions and future land use considerations.

TABLE 2-3
Soil and Groundwater OU Remedial Technology Screening
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

General Response Actions	Remedial Technology	Target Zone, Media, and COCs	Process Options	Description	Effectiveness (Target Zone and RAOs, Impacts to HHE during Construction, Reliability)	Implementability (Technical and Administrative)	Relative Cost	Screening Comment
	Offsite RCRA TSD	All Zones Debris/Soil/Upper Aquifer Solids NAPL/All COCs	Transport and dispose of waste at offsite RCRA TSD Pretreatment to meet LDRs Clean offsite backfill material required	Waste materials are excavated and transported offsite to a permitted disposal facility. Offsite disposal may require treatment of some or all waste material if subject to LDR.	**Good.** Effective because contaminants are contained in a permitted facility with a high level of monitoring and controls. Pretreatment to meet LDRs required.	**Moderate.** May require pretreatment prior to disposal or obtaining an LDR variance. Obtaining an LDR variance would require a mobility determination. Uncertainty exists on whether such waivers have been granted in Region 10. Potentially requires segregation of dioxin- and non-dioxin-bearing waste.	**High.** Transportation and treatment costs high given the Wyckoff Site's remote location. Rail may be lower cost option. Dioxin-bearing waste may further increase cost. Facility must be in compliance with CERCLA offsite rule.	**Retained** due to limited alternative offsite options.
	Offsite Subtitle D	All Zones Debris/Soil/Upper Aquifer Solids NAPL/All COCs	Transport and dispose of waste at offsite Subtitle D subject to waste acceptance criteria Clean backfill material required	Waste materials are excavated and transported offsite to a permitted disposal facility. Waste subject to receiving facility's acceptance criteria.	**Good.** Effective because contaminants are contained in a permitted facility with a high level of monitoring and controls.	**Moderate.** Applicable for characteristic non-hazardous materials exceeding cleanup levels and listed wastes that have received a no-longer-contained-in determination and require disposal for other technical reasons.	**Moderate to High.** Transportation and treatment costs contingent on facility approved to accept waste. Facility must be in compliance with CERCLA offsite rule.	**Retained** for non-hazardous debris and non-hazardous via characteristic rule material**.**
Ex Situ Treatment (assume soil excavated)	Biological Treatment	All Zones Soil/Upper Aquifer Solids NAPL/All COCs	Biopiles/Landfarming	Excavated waste materials are mixed with amendments and placed in a treatment cell with aeration and leachate collection systems. Temperature, moisture, nutrients, oxygen, and pH are controlled to enhance biodegradation of contaminants. Soil is periodically remixed/tilled to promote aeration and stimulate further treatment.	**Poor.** Not effective for HPAHs and dioxin. High concentration wastes may be toxic to microbes, thus limiting effectiveness. Field scale pilot ex situ biological treatment has performed poorly at other wood-treating sites (for example, Hart Creosote and North Cavalcade Superfund sites).	**Poor to Moderate.** Readily implementable using conventional equipment, but may be difficult to implement for very large volumes of contaminated materials due to space limitations. High rainfall amounts at the site will require extensive run-on and run-off controls.	**Moderate.** Moderate capital cost and O&M cost.	**Not Retained** due to ineffectiveness for HPAHs and past performance at other wood-treating sites.
			Slurry phase biological	Contaminated materials are mixed with water to form aqueous slurry that is aerated and amended with nutrients, microbes, and pH adjustment. The slurry is mixed to keep solids in suspension and to promote contact between microbes and contaminants. Following treatment, the slurry is dewatered and the treated solids disposed. Water generated from the dewatering and treatment process is recycled into existing treatment process.	**Poor.** More effective for LPAHs and PCP, and less effective for HPAHs and dioxin. Slurry-phase bioremediation of PAHs is generally more effective than solid-phase biological treatment due to more direct contact between contaminants and microbes and ability to control environmental factors (pH, temperature, nutrients).	**Poor to Moderate.** Generally requires less land area than biopiles, but requires more infrastructure. Implementation on a large scale would require treatment of contaminated soil in batches. Large volumes of soil requiring treatment may require long-term operation of a bioreactor to treat all contaminated materials due to time requirement to degrade HPAHs. Also requires screening step to remove debris, gravel, and to break up clayey soils. Soil particles greater than 2 millimeters are not recommended for slurry phase bioreactors (Sopanaro et al., 2001).	**Moderate.**	**Not retained** due to ineffectiveness for HPAHs and dioxin. Subsurface soil contains fill and marine gravel that would have to be removed through screening. This material would have to be handled using another technology.

TABLE 2-3
Soil and Groundwater OU Remedial Technology Screening
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

General Response Actions	Remedial Technology	Target Zone, Media, and COCs	Process Options	Description	Effectiveness (Target Zone and RAOs, Impacts to HHE during Construction, Reliability)	Implementability (Technical and Administrative)	Relative Cost	Screening Comment
	Thermal Treatment	All Zones Soil/Upper Aquifer Solids NAPL/All COCs	Onsite incineration	Waste materials are excavated, and stockpiled onsite prior to treatment in a mobile incinerator unit, which uses high temperatures (typically greater than 1,400 ºF) to destroy organic contaminants. Offgas stream requires air pollution control equipment.	**Good.** Highly effective in destruction of organic contaminants. Requires additional offgas and scrubber water treatment for halogenated contaminants (PCP). Effectiveness is affected by need to do extensive pretreatment, including screening to adjust particle size, chemical treatment to adjust the pH, and dewatering to adjust moisture content (prior to incineration). Used at other wood-treating sites in the 1990s.	**Moderate.** Onsite incinerators are required to meet RCRA incinerator regulations (40 CFR Parts 264 and 265, Subpart O). Incinerator performance standards include 99.99% DRE for organic contaminants and 99.9999% DRE for dioxins and furans (EPA-542-R-97-012). Will likely face opposition from local community. Large ash volume would require onsite or offsite disposal. Very high energy (natural gas) operational requirements.	**High.** High capital cost for treatment equipment mobilization/demobilization and operations. Requires ash handling and disposal, which may incur additional capital and O&M costs if managed onsite.	**Not Retained** due to high cost and implementability (public acceptance) concerns.
			Offsite incineration	Waste materials are transported offsite to a permitted treatment facility for incineration prior to offsite landfill disposal.	**Good.** Treatment efficiencies must meet RCRA incinerator regulations (40 CFR Parts 264 and 265, Subpart O) performance standards of 99.99 percent DRE for organic contaminants and 99.9999 percent DRE for dioxins and furans (EPA-542-R-97-012). Requires additional offgas and scrubber water treatment for halogenated contaminants. Dedicated offsite treatment facilities can better handle varying waste materials by blending with other feed streams and utilization of pretreatment steps to maximize treatment efficiency.	**Good.** Readily implementable with conventional construction equipment and permitted incineration facilities. Very high energy requirements for treatment. This technology is containment remedy residuals (NAPL and spent GAC media).	**High.** High capital cost for transportation and incineration due to volume of material. No O&M and periodic costs because waste material is removed from the site.	**Retained** for dioxin-contaminated material exceeding land disposal restriction treatment standards.
	Thermal Treatment	All Zones Soil/Upper Aquifer Solids NAPL/All COCs	Onsite thermal desorption with onsite reuse	Soil excavated, stockpiled, and screened prior to treatment in a mobile treatment unit. Thermal desorption uses heat and mechanical agitation to volatilize contaminants from soils into a gas stream. The offgas stream is then treated to destroy or remove vapor-phase contaminants. Treated/sterile soil reused to backfill excavation footprints. Top soil cover required to promote future vegetation growth.	**Moderate.** Likely requires offgas treatment because desorption is not a 100 percent destructive process. Less effective for soils with high silt and clay content (EPA 542-F-96-005). Higher temperature is required for desorption of HPAHs. PCP can lead to formation of dioxins/furans in the stack or air pollution control devices (EPA, 1996). Dioxin treatment uncertain.	**Moderate.** More implementable with granular material; difficult in silt/clayey type soil. Uniform heating of cohesive soils is problematic, and fine particulates can disrupt air emissions equipment (EPA 542-F-96-005) leading to difficulty in meeting air permit requirements. High energy requirement, though lower than incineration. High moisture content increases reaction time and fuel requirements. Equipment poses hazards to remedial action workers. Community acceptance may be low, but not as poor as for onsite incineration. Has been used at other wood treating sites (Central Wood Superfund Site).	**Moderate to High.** Capital cost dependent on volume of material to be treated. No O&M or periodic costs expected.	**Retained**
			Offsite thermal desorption Clean backfill material placement	Soils are excavated and transported offsite for treatment (as described above) at a permitted treatment facility.	**Moderate to High.** Effectiveness is similar to onsite thermal desorption; however, improved treatment performance expected from a permitted/fixed commercial thermal desorption facility.	**Moderate.** Offsite treatment facilities are designed and permitted to handle offgas treatment. High energy requirement, though lower than incineration. Requires offsite transport, which adds transportation risks. Offsite thermal	**High.** Cost does not include offsite disposal of treated waste material. Offsite thermal desorption would typically be coupled with offsite disposal, which would	**Not Retained** due to high cost

TABLE 2-3
Soil and Groundwater OU Remedial Technology Screening
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

General Response Actions	Remedial Technology	Target Zone, Media, and COCs	Process Options	Description	Effectiveness (Target Zone and RAOs, Impacts to HHE during Construction, Reliability)	Implementability (Technical and Administrative)	Relative Cost	Screening Comment
						desorption would need to be implemented in conjunction with offsite disposal.	increase cost significantly over onsite treatment and disposal.	
In Situ Treatment	MNA	All Zones Soil/Groundwater NAPL less than 1-foot thickness/ PAHs/PCP	Non-degradation (dispersion, dilution, sorption) Degradation (abiotic and biotic)	Contaminants attenuate over time through natural physical, chemical, and biological processes.	**Poor to Moderate.** HPAHs are relatively stable and not amenable to degradation processes; however, these characteristics render them relatively immobile. LPAHs, and PCP are amenable to degradation through biotic processes under aerobic conditions. Provides nominal contribution to achievement of Performance Objectives and RAOs.	**Moderate.** Implementable using standard monitoring, testing, and data evaluation methods but may be more difficult to prove specific processes and attenuation rates, especially for HPAHs. Limited hazards to remedial action workers and community.	**Moderate.** Long attenuation timeframe will require extended monitoring duration.	**Not Retained.** Although aerobic and anaerobic biodegradation are likely occurring, no site-specific data has been collected to confirm degradation processes and rates.
		All Zones Soil – Dioxin Groundwater NAPL more than 1-foot thickness			**Poor.** Dioxin toxicity and volume not reduced; dioxin has low mobility under typical environmental conditions. Mobile NAPL toxicity, mobility, and volume not reduced. Does not contribute significantly to achievement of Performance Objectives and RAOs.	**Poor.** Not implementable due to poor effectiveness.	**Moderate High.** Undefined attenuation timeframe will likely require extended monitoring period.	**Not Retained** due to poor effectiveness.
	Thermal Treatment	All Zones Soil Upper Aquifer Solids Groundwater NAPL/All COCs	Electrical resistance heating	Electrical current is passed through electrodes spaced approximately 15 to 20 feet apart. The electrical resistance of the formation creates heat, which vaporizes water, creating steam and volatilizing VOC and SVOC contaminants. Volatilized contaminants captured by a vapor extraction system and treated ex situ.	**Moderate to High.** Effective for VOCs and LPAH in permeable soil. Less effective for HPAH/dioxin compounds. Requires capture and treatment of offgas/condensate containing contaminants for destruction or transfer to another medium for disposal. Reduces NAPL source zone.	**Poor to Moderate.** Removal of debris improves implementability. Typically, requires a minimum treatment thickness of 10 feet. Energy requirements greater for sites with higher fraction of HPAHs/dioxins. Complex energy, treatment, and supporting infrastructure requirements. Uncertainty on energy source and availability. Electrical generation and distribution equipment can pose hazards to remedial action workers.	**High.** DNAPL source zone treatment costs range from $32 to $300 per cubic yard (McDade et al., 2005).	**Not Retained.** Steam identified as preferred process option for thermal treatment.
			In situ Thermal Destruction (NAPL smoldering - STAR technology)	Contaminants are used as a fuel source for in situ combustion to destroy NAPL. A heating element is inserted into the treatment zone to heat the NAPL to between 200 and 400 °C, and then air is injected to ignite the NAPL. The heat released through combustion preheats NAPL in adjacent areas. With the continued injection of air, combustion may become self-sustaining and the heating element can be turned off.	**Unknown.** This is an emerging remediation technology with little field-scale data available to sufficiently evaluate the technology's effectiveness. Vendor information suggests treatment efficiencies in the range of 95 to 99 percent (http://star.siremlab.com/overview.php).	**Poor.** The implementability of this technology is difficult to assess. Based on vendor information, the technology has been demonstrated at the pilot-scale, but full-scale field implementation information is not yet available. Requires a bench-scale and pilot-scale test prior to implementation at estimated cost of $350,000 to $450,000.	**Moderate to High.** No definitive cost information due to lack of full-scale projects. Vendor reports that costs for full-scale implementation are projected to be around $80 per cubic yard.	**Not Retained.** Technology not proven at large enough scale for application at the Wyckoff Site.
			Steam generation and injection	Steam is injected into vadose zone and Upper Aquifer through injection wells to vaporize VOCs/SVOCs for recovery via vapor extraction and ex situ treatment.	**Moderate to High.** Effective for removal of VOCs and SVOCs. Used effectively at similar sites. Reduces NAPL source zone.	**Poor to Moderate.** High energy and complex infrastructure requirements. Uncertainty on energy source and availability.	**High.** Capital Cost range from $100 to $300 per cubic yard (Clu-in.org).	**Retained** due to effectiveness in reducing NAPL mobility and thickness.

TABLE 2-3
Soil and Groundwater OU Remedial Technology Screening
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

General Response Actions	Remedial Technology	Target Zone, Media, and COCs	Process Options	Description	Effectiveness (Target Zone and RAOs, Impacts to HHE during Construction, Reliability)	Implementability (Technical and Administrative)	Relative Cost	Screening Comment
						Steam generation and handling equipment can pose hazards to remedial action workers, while noise may be objectionable to community.		
	Physical Treatment	All Zones Soil Upper Aquifer Solids Groundwater NAPL/All COCs	Solidification/ stabilization	Injection and mixing of solidifying reagents with the soil to form a monolithic, low-permeability, solid mass with high structural integrity. The resulting matrix reduces the mobility and solubility of contaminants originally present in the soil. Reagents may include Portland cement, fly ash, blast furnace slag, and organic sorbents, such as GAC, Zeolite, and organophilic clay.	**Moderate to Good.** Effectiveness depends on stabilization reagent's ability to demonstrate reduction in leaching of organic contaminants. Sorbents can be added to enhance immobilization of organic contaminants. Process yields a solidified stable mass with high structural strength and low leaching potential. Also results in an increase in overall volume of contaminated media (swell). Increased pH from stabilization increases solubility of naphthalene, which can bleed from the monolith. Technology used at North Cavalcade and Texarkana Superfund (former creosote – wood treating) sites. Decreases NAPL source zone. NAPL in S/S areas no longer exists as a separate liquid phase.	**Moderate to Good.** Large mixing augers (5- to 10-foot diameter) or jet injection equipment used to blend and homogenize reagents with soil. Specialty mixing equipment (augers) can be impeded at sites with debris or coarse granular material (cobbles). Implementation difficulty increases with depth. Large equipment can pose hazards to remedial action workers, while noise may be objectionable to community.	**Moderate.** A majority of cost is capital cost; low O&M cost. Cost increases if swell material is disposed offsite, particularly if pre-treatment required to meet LDRs.	**Retained** based on ability to immobilize NAPL and experience at other sites.
		Periphery Areas Groundwater Dissolved COCs	Funnel and Gate	This is a passive treatment technology that would be deployed following active treatment phase. Consists of a perimeter collection system that routes contaminated groundwater through a treatment media. Depending on media selected and contaminant loading (flux), periodic rejuvenation or change out likely required. For Wyckoff site, may be able to use natural flow gradients and tidal action in lieu of pumps.	**Moderate.** Treatment portion of this technology highly effective, but will require O&M to maintain effectiveness. Some uncertainty on effectiveness of collection system due to unknown vertical contaminant distribution at end of active treatment phase.	**Poor to Moderate.** Technology not as well developed for thick aquifers. More difficult to implement if treatment across the Upper Aquifer's full saturated thickness required.	**Low to High.** Cost will vary depending on length, depth and system flow rate, and treatment media changeout and disposal requirements.	**Retained** in the event some localized groundwater treatment is required following active treatment phase.
	Chemical Treatment	All Zones Upper Aquifer Solids Groundwater Residual NAPL/All COCs	ISCO	Liquid reagents injected to form strong oxidants that chemically destroy contaminants. Generally requires multiple injections.	**Moderate to Good.** Proven technology at multiple sites. High oxidant demand for NAPL and PAHs. Less full-scale wood-treating sites.	**Poor to Moderate.** Implementable using array of injection points and trailer/skid-mounted equipment. Uniform distribution of reagents in heterogeneous soil is necessary and represents the primary challenge associated with this and other direct contact treatment technologies. Depending on reagent chosen, may pose increased hazard to remedial action workers.	**Moderate to High** capital cost due to extensive infrastructure and chemical volume requirements. Low O&M costs if treatment objectives are met quickly without need for repeat injections.	**Retained.** Will be incorporated as polishing step within a broader alternative for use in addressing immobile NAPL or areas with limited NAPL thickness.
	Biological Treatment	All Zones Groundwater	Biosparging Enhanced aerobic	Air injection into an array of horizontal or vertical wells to stimulate aerobic biodegradation and volatilization of residual NAPL and dissolved-phase contaminants.	**Moderate.** Technology more favorable for LPAHs.	**Good.** Technology design and equipment well developed; lots of experience.	**Low to Moderate** capital and O&M costs depending on size of injection array.	**Retained** as a polishing component within broader based alternative.

TABLE 2-3
Soil and Groundwater OU Remedial Technology Screening
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

General Response Actions	Remedial Technology	Target Zone, Media, and COCs	Process Options	Description	Effectiveness (Target Zone and RAOs, Impacts to HHE during Construction, Reliability)	Implementability (Technical and Administrative)	Relative Cost	Screening Comment

Sources: EPA, 1995, 1996; McDade et al., 2005.

ºC degrees Celsius
ºF degrees Fahrenheit
AOC Area of concern
CERCLA Comprehensive Environmental Response, Compensation, and Liability Act
CFR Code of Federal Regulations
cm/sec centimeter(s) per second
COC contaminant of concern
DNAPL dense non-aqueous phase liquid
DRE destruction and removal efficiency
EPA U.S. Environmental Protection Agency
ET evapotranspiration
FFS focused feasibility study
GAC granular-activated carbon
GWTP groundwater treatment plan
HHE human health and the environment
HPAH high molecular weight PAHs
IC institutional control
ISCO in situ chemical oxidation
LDR land disposal restrictions
LPAH low molecular weight PAHs
NAPL non-aqueous phase liquid
NCP National Contingency Plan
O&M operations and maintenance
OU operable unit
PAH polycyclic aromatic hydrocarbons
PCP pentachlorophenol
QA/QC quality assurance/quality control
RAO remedial action objective
RCRA Resource Conservation and Recovery Act
SVOC semivolatile organic compound
TSD treatment, storage, and disposal
VOC volatile organic compound

TABLE 2-4
Summary of Retained Remedial Technologies
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

General Response Action	Technology Type	Key Process Options	Target Zone, COCs
No Action	No Action	No Action	Not applicable
Access Restrictions	Fencing	Signs/cyclone fence	All Zones and COCs
	ICs	Land use zoning, deed restrictions, restrictive covenants	
Containment	Surface Barrier	Multi-layer impermeable barrier and ET barrier	All Zones and COCs
	Subsurface Barrier	Sheet pile wall	All Zones, NAPL, PAHs, PCP
	Hydraulic Containment	Groundwater extraction, treatment, and discharge	All Zones, NAPL, PAHs, PCP
Removal	Shallow Excavation (less than 15 feet)	Standard equipment, shoring, dewatering, stockpiles/run-on and run-off controls	All Zones and COCs
	Deep Excavation (more than 15 feet)	Standard equipment, shoring, dewatering, stockpiles/run-on and run-off controls	All Zones and COCs
	Extraction	NAPL and groundwater extraction, treatment, and discharge	All Zones, NAPL, PAHs, PCP
	Enhanced Extraction	NAPL and groundwater extraction, treatment, and discharge	All Zones, NAPL, PAHs, PCP
	- Thermal Extraction - Thermal Recovery	Steam – dry Steam - wet	All Zones, NAPL, PAHs, PCP
Disposal	Offsite RCRA Landfill/TSD Offsite Subtitle D landfill	Standard transportation methods (truck, rail), waste acceptance	Debris - All Zones and COCs
Ex situ Treatment	Thermal Treatment	Offsite incineration	Dioxin-contaminated soil
		Onsite thermal desorption	All Zones and COCs
	Ex Situ Stabilization	Backhoe mixing	All Zones (shallow soil) and COCs
	Physical	Existing GWTP - Gravity settling; Dissolved air floatation; Granular activated carbon filtration	Groundwater-All Zones, NAPL, PAHs, PCP
In Situ Treatment	In Situ Stabilization	Auger mixing, jet grouting	All Zones and COCs
	Physical	Granular activated carbon	
	Biological	Biosparging/EAB	

TABLE 2-4
Summary of Retained Remedial Technologies
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

General Response Action	Technology Type	Key Process Options	Target Zone, COCs

Notes:

COC	contaminant of concern
EAB	enhanced aerobic biodegradation
ET	evapotranspiration
FFS	focused feasibility study
GWTP	groundwater treatment plant
NAPL	non-aqueous phase liquid
OU	operable unit
PAH	polycyclic aromatic hydrocarbons
PCP	pentachlorophenol
RCRA	Resource Conservation and Recovery Act
TSD	treatment, storage, or disposal

TABLE 2-5
Remedial Technologies Applied to Each Target Zone
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

	Remedial Action Target Zone				
Technology and Technology Pairings	**Core Area**	**East Shallow (LNAPL)**	**North Shallow (LNAPL)**	**North Deep (DNAPL)**	**Other Periphery**
Soil Cap	X	X	X	X	X
Sheet Pile Wall	X	X	X	X	X
Hydraulic Containment/GWTP	X	X	X	X	X
In situ Solidification/Stabilization	X	X	X	X	X
Excavation/Thermal Desorption	X	X	X	X	NA
Extraction	NA	X	X	X	NA
Enhanced Extraction/Recovery	X	X	X	X	NA
Enhanced Aerobic Biodegradation	NA	X	X	NA	X
Passive Groundwater Treatment	X	X	X	X	X
Access Controls/Institutional Controls	X	X	X	X	X

Notes:

DNAPL dense non-aqueous phase liquid
FFS focused feasibility study
GWTP groundwater treatment plant
LNAPL Light non-aqueous phase liquid
NA not applicable
NAPL no-aqueous phase liquid
OU operable unit

TABLE 3-1

Remedial Action Alternative Technology Pairings

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

	Remedial Action Target Zone				
Remedial Action Alternative Key Technology Components	**Core Area**	**East Shallow (LNAPL)**	**North Shallow (LNAPL)**	**North Deep (DNAPL)**	**Other Periphery**
Alternative 1					
None	X	X	X	X	X
Alternative 2 - Containment					
Hydraulic Containment/GWTP	X	X	X	X	X
Alternative 3 – Excavation, Thermal Desorption, and ISCO					
Excavation/Thermal Desorption/EAB	X	X	X	NA	NA
ISCO	NA	NA	NA	X	X
Alternative 4 –ISS					
In situ Solidification/Stabilization	X	X	X	X	X
Alternative 5 – Thermal Enhanced Extraction and ISS					
Thermal Enhanced Extraction/EAB	X	X	X	NA	NA
In situ Solidification/Stabilization	NA	NA	NA	X	NA
EAB	NA	NA	NA	NA	X
Alternative 6 – Excavation, Thermal Desorption, and Thermal Enhanced Extraction					
Excavation/Thermal Desorption	X (upper)	NA	NA	NA	NA
Enhanced NAPL Recovery/Thermal Enhanced Extraction/EAB	X (Lower)	X	X	X	NA
EAB	NA	NA	NA	NA	X
Alternative 7 – ISS of Expanded Core Area and Thermal Enhanced Recovery					
ISS	X [1]	NA	NA	NA	NA
NAPL Recovery	NA	X	X	X	NA
Thermal Enhanced NAPL Recovery	NA	X	X	X	NA
EAB	NA	X	X	NA	X

Notes:

[1] The Expanded Core Area (202,000 cubic yards) is approximately two times larger than the Core Area (106,000 cubic yards) and contains an estimated 456,000 gallons of NAPL versus 302,000 gallons estimated to be present in the Core Area.

DNAPL dense non-aqueous phase liquid
EAB enhanced aerobic biodegradation
FFS focused feasibility study
GWTP groundwater treatment plant
ISCO In situ chemical oxidation
ISS In situ solidification/stabilization
LNAPL light non-aqueous phase liquid
NA not applicable
NAPL non-aqueous phase liquid
OU operable unit

TABLE 3-2
Remedial Action Alternative–Common Elements
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

		Alternatives						
Common Element	**Estimated Cost**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Preconstruction Activities	$879,000	NA	X	X	X	X	X	X
Access Roads	$306,000	NA	X	X	X	X	X	X
Concrete Demolition, Decontamination/Reuse	$2,324,000	NA	NA	X	X	X	X	X
Debris Removal	$3,195,000	NA	NA	X	X	X	X	
Bulkhead Debris Removal	$8,764,000	NA	X	X	X	X	X	X
Other Demolition	$1,276,000	NA	X	NA	NA	NA	NA	NA
	$2,832,000	NA	NA	X	X	X	X	X
Stormwater Infiltration Trench	$214,000	NA	NA	X	X	X	X	X
New Perimeter Sheet Pile Wall	$13,362,000	NA	X	X	NA	X	X	NA
Concrete Perimeter Wall	$11,363,000	NA	X	X	NA	X	X	X
	$8,029,000	NA	NA	NA	X	NA	NA	NA
New Outfall	$3,294,000	NA	X	X	X	X	X	X
Passive Groundwater Discharge/Treatment	$1,306,000	NA	NA	X	X	NA	NA	NA
	$1,149,000	NA	NA	NA	NA	X	X	X
Site Cap	$4,100,000	NA	X	X	X	X	X	X
Access Controls	Included in annual/periodic costs	NA	X	X	X	X	X	X
5-year reviews [a]		NA	X	X	X	X	X	X

[a] 5-year reviews provided here for completeness. For the purposes of this FFS, it is assumed that the cost of 5-year reviews is included within the scope of the remedial action alternative.

FFS focused feasibility study
NA not applicable
NAPL non-aqueous phase liquid
OU operable unit

TABLE 3-3
Components of Alternative 2 – Containment
Soil and Groundwater OUs (OU2/OU4) NAPL FFS,
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Remedial Action Target Zone	Component	Description		
Sitewide	Common Elements	Preconstruction activities Access roads Bulkhead removal Other demolition Perimeter sheet pile wall Concrete perimeter wall New outfall for GWTP and stormwater discharge Soil cap ICs, access controls, and 5 year reviews		
Sitewide	NAPL/Groundwater Extraction Wells	Install 4 new recovery wells. Redevelop 9 existing recovery wells. Install 2.100 feet of aboveground HDPE conveyance piping for new wells. Define new recovery well locations and pumping rates during remedial design. Assume recovery wells require replacement every 30 years.		
	Groundwater Treatment	Utilize existing GWTP. Upgrade electrical and I&C. Existing fiberglass tanks and piping don't require replacement within the 100-year operations period.		
	GWTP - Operations and Maintenance	O&M of the extraction well network, conveyance infrastructure, and GWTP and other remedy components would be performed for 100 years.		
	Groundwater Monitoring and Reporting	Groundwater monitoring consists of quarterly Upper Aquifer and annual Lower Aquifer sampling and preparation of an annual report. Hydraulic containment assessed quarterly using water level measurements in Upper and Lower Aquifer well pairs.		
	Remedial Action Timeframe	Operations limited to 100 years.		
	Cost	**Category**	**Discount Factor: 1.4%**	**Discount Factor: 7%**
		Capital - Common Elements	$43.3 million	
		Capital Remedial Technology (2016 base year)	$2.5 million	
		Short-term O&M (annual)	$515,000 - $535,000	
		Short-term O&M and Periodic (total, non-discounted)	$12.6 million	
		Total Present Worth (discounted)	$79.8 million	$52.0 million
		Total Non-discounted	$111.0 million	

Notes:

CY	cubic yard	HDPE	high-density polyethylene	MNA	monitored natural attenuation
DNAPL	dense non-aqueous phase liquid	I&C	instrumentation and control	NAPL	non-aqueous phase liquid
FFS	focused feasibility study	IC	institutional control	O&M	operations and maintenance
GWTP	groundwater treatment plant	LNAPL	light non-aqueous phase liquid	OU	operable unit

TABLE 3-4

Components of Alternative 4 – In situ Solidification/Stabilization

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Remedial Action Target Zone	Component	Description
Sitewide	Common Elements	Preconstruction activities Access roads Concrete demolition, decontamination/reuse Debris removal Bulkhead removal Other demolition Storm water infiltration trench Concrete perimeter wall New outfall for stormwater discharge Passive groundwater discharge/treatment Site cap ICs, 5 five-year reviews
Core Area North Shallow (LNAPL) East Shallow (LNAPL) Periphery	ISS - Auger	Core Area—Treat 85,300 CY of NAPL contaminated material to depths of 50 feet. North Shallow (LNAPL) Zone—Treat 17,700 CY of NAPL contaminated material present at depths of 25 to 45 feet. East Shallow (LNAPL) Zone—Treat 120,000 CY of NAPL contaminated material present at depths ranging from 25 to 45 feet. Periphery Zone—Treat 43,100 CY of NAPL contaminated material present at depths ranging from 10 to 45 feet. Excavated Soil—Treat 86,00 CY of material, removed to offset ISS swell, using ex situ ISS methods and reuse this material for grading – contouring. The perimeter of the NAPL contaminated zone would be treated using higher strength – low leachability reagent material to create a "rind" or hardened shell to provide increased durability.
North Deep (DNAPL)	ISS – Jet Grouting	North Deep (DNAPL)—About 59,200 CY of contaminated material would be treated to depths up to 76 feet (treatment in this area includes auger mixing of more shallow impacts and jet grout mixing of discreet deeper zones of impacts).
Sitewide	GWTP – Short-term Operations and Maintenance	Existing GWTP operated for 3 years. Passive groundwater treatment system operated for 8 years.
	Passive Groundwater Treatment	Estimate that each of the 10 systems would treat 357,000 gallons per year using tidal induced gradient to draw low-level contaminated groundwater through a granular activated carbon filter media housed in a manhole type station. Estimate four media changeouts per year for each of the 10 stations.
	Groundwater Monitoring and Reporting	Includes quarterly Upper Aquifer and annual Lower Aquifer sampling and analysis and preparation of an annual report.

TABLE 3-4

Components of Alternative 4 – In situ Solidification/Stabilization

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

<table>
<tr><th>Remedial Action Target Zone</th><th>Component</th><th colspan="3">Description</th></tr>
<tr><td></td><td>Remedial Action Timeframe</td><td colspan="3">Approximately 10 years.</td></tr>
<tr><td rowspan="7"></td><td rowspan="7">Cost</td><th>Category</th><th>Discount Factor: 1.4%</th><th>Discount Factor: 7%</th></tr>
<tr><td>Capital - Common Elements</td><td colspan="2">$35.2 million</td></tr>
<tr><td>Capital Remedial Technology (2016 base year)</td><td colspan="2">$57.3 million</td></tr>
<tr><td>Short-term O&M (annual)</td><td colspan="2">$788,000 for Years 0, 1 and 2.
$333,000 for Years 4 through 10.</td></tr>
<tr><td>Short-term O&M and Periodic (total - nondiscounted)</td><td colspan="2">$2.4 million</td></tr>
<tr><td>Total Present Worth (discounted)</td><td>$93.7 million</td><td>$88.6 million</td></tr>
<tr><td>Total Non-discounted</td><td colspan="2">$95.4 million</td></tr>
</table>

Notes:

CY	cubic yard
DNAPL	dense non-aqueous phase liquid
FFS	focused feasibility study
GWTP	groundwater treatment plant
HDPE	high-density polyethylene
I&C	instrumentation and control
IC	institutional control
ISS	In situ Solidification/Stabilization
LNAPL	light non-aqueous phase liquid
MNA	monitored natural attenuation
NAPL	non-aqueous phase liquid
O&M	operations and maintenance
OU	operable unit

TABLE 3-5a

Components of Alternative 5 – Thermal Enhanced Extraction and ISS

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Remedial Action Target Zone	Component	Description
Sitewide	Common Elements	Preconstruction activities Access Roads Concrete Demolition, Decontamination/Reuse Debris removal Bulkhead removal Other demolition Stormwater infiltration trench Perimeter sheet pile wall Concrete perimeter wall New outfall for GWTP and stormwater discharge Passive groundwater discharge/treatment Site cap MNA, ICs, and five-year reviews
Sitewide	Enhanced NAPL Recovery	Installation of 147 multi-purpose wells Pumping of NAPL and groundwater for 3 years NAPL and groundwater separation/treatment performed in GWTP equipped with new oil-water separator NAPL disposed offsite, groundwater discharged to harbor via new outfall
North Deep (DNAPL)	ISS – Jet Grouting	About 59,200 CY of contaminated material treated to depths up to 76 feet (treatment in this area includes auger mixing of more shallow impacts and jet grout mixing of discreet deeper zones of impacts).
Core Area East Shallow (LNAPL) North Shallow (LNAPL)	Thermal Enhanced Extraction	Core Area divided into three smaller cells (Core A, Core B, and Core C) using sheet pile to balance injection/extraction while maintaining hydraulic containment during treatment phase East Shallow (LNAPL) divided into two smaller cells (North and South) to allow for similar approach as Core Area; North Shallow (LNAPL) addressed as a single area. Installation of shallow vapor barrier Installation of 27 de-watering wells, 172 multi-purpose steam injection and EAB wells, 201 temperature monitoring wells, and 31 EAB wells. Extraction and injection wells installed in a 7-spot pattern with approximate 30-ft spacing between wells in individual cells. Re-purposing of 147 NAPL recovery wells as fluid/vapor extraction wells Installation of above ground vapor/condensate treatment system and steam generation equipment

TABLE 3-5a

Components of Alternative 5 – Thermal Enhanced Extraction and ISS

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

<table>
<tr><th>Remedial Action Target Zone</th><th>Component</th><th colspan="3">Description</th></tr>
<tr><td></td><td>Thermal Enhanced Extraction Operations and Maintenance</td><td colspan="3">Treatment sequence is as follows: Core A, followed by Core B, Core C, East Shallow (LNAPL) South, East Shallow (LNAPL) North, and North Shallow (LNAPL)
Treatment steps include: dewatering, steam injection, fluids/vapor extraction, and fluids/vapor treatment
Steam injected at higher rate, initially, over an estimated 18 day period to raise subsurface temperature and promote recovery of remaining mobile NAPL; rate then decreased with injection continuing for 255 days to complete balance of NAPL recovery
Performance monitoring during operations to optimize steam injection/fluid/vapor extraction rates
Initiate EAB after steam injection turned off
Disassemble aboveground components and move to next treatment cell in the sequence</td></tr>
<tr><td>Periphery</td><td>EAB</td><td colspan="3">Inject air through multi-purpose wells at rates varying from 100 to 200 scfm. Assume 8 scfm flow rate per well
In situ biodegradation performance enhanced by residual heat from thermal treatment operations</td></tr>
<tr><td rowspan="12">Sitewide</td><td>GWTP – Short-term Operations and Maintenance</td><td colspan="3">Utilizes existing GWTP to treat groundwater from dewatering operations, groundwater generated from hydraulic containment pumping, and water generated from thermal extraction operations
Operations continue for 9 years</td></tr>
<tr><td>Passive Groundwater Treatment</td><td colspan="3">Performed as described for Alternative 4
Performed for approximately 18 years</td></tr>
<tr><td>Groundwater Monitoring and Reporting</td><td colspan="3">Includes quarterly Upper Aquifer and annual Lower Aquifer sampling and analysis and preparation of an annual report.</td></tr>
<tr><td>Remedial Action Timeframe</td><td colspan="3">Estimate 27 years</td></tr>
<tr><td rowspan="8">Cost</td><th>Category</th><th>Discount Factor: 1.4%</th><th>Discount Factor: 7%</th></tr>
<tr><td>Capital - Common Elements</td><td colspan="2">$51.8 million</td></tr>
<tr><td>Capital Remedial Technology (2016 base year)</td><td colspan="2">$51.0 million</td></tr>
<tr><td>Short-term O&M (annual)</td><td colspan="2">Ranges from $284,000 to $9.3 million (during thermal treatment)</td></tr>
<tr><td>Short-term O&M and Periodic (total - nondiscounted)</td><td colspan="2">$46.3 million</td></tr>
<tr><td>Total Present Worth (discounted)</td><td>$142.1 million</td><td>$120.1 million</td></tr>
<tr><td>Total Non-discounted</td><td colspan="2">$149.6 million</td></tr>
</table>

TABLE 3-5a

Components of Alternative 5 – Thermal Enhanced Extraction and ISS

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Remedial Action Target Zone	Component	Description

Notes:

CY	cubic yard
DNAPL	dense non-aqueous phase liquid
EAB	enhanced aerobic biodegradation
FFS	focused feasibility study
GWTP	groundwater treatment plant
IC	institutional control
ISS	In situ Solidification/Stabilization
LNAPL	light non-aqueous phase liquid
MNA	monitored natural attenuation
NAPL	non-aqueous phase liquid
O&M	operations and maintenance
OU	operable unit
scfm	standard cubic foot per minute

TABLE 3-5b

Durations of Steam Injection in Treatment Volumes

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Remedial Target	Treated Soil Volume (CY)	Duration of Steam Pre-Heating (days)	Duration of Steam Distillation (days)	Total Steam Duration[a] (months)	Steam per Unit Soil Volume[b] (lbs/cy)
Core Area					
Core A	30,800	18	255	9.0	1,427
Core B	36,100	21	221	8.0	1,094
Core C	44,800	26	277	9.9	1,100
East Shallow (LNAPL)					
East South	65,000	38	323	11.9	913
East North	78,000	45	366	13.5	868
North Shallow (LNAPL)					
North Shallow	18,600	11	94	3.5	920
Total (All Zones)	**272,900**	**Not Applicable**	**1,536**	**56**	**1,013**

Notes

[a] This column includes the initial heating and presents the total duration of steam injection.

[b] This column presents the calculated mass of steam injected divided by the treated soil volume.

CY cubic yard
FFS focused feasibility study
Lbs/cy pounds per cubic yard
LNAPL light non-aqueous phase liquid
NAPL non-aqueous phase liquid
OU operable unit

TABLE 3-5c

Estimates of NAPL Recovery during Thermal Treatment

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

	NAPL Volumes (gallons)				
Remedial Target Zone	**Pre-Steam [a]**	**Steam Enhanced NAPL Recovery [b]**	**Post-Heating Residual NAPL[c]**	**Recovered via Distillation (76.6 percent efficiency)**	**Residual for EAB Treatment [d]**
Core Area					
Core A	100,600	16,600	84,000	64,300	19,600
Core B	87,500	14,500	73,000	56,000	17,000
Core C	108,000	17,900	90,100	69,100	21,100
East Shallow (LNAPL)					
East South	64,000	10,600	53,400	40,900	12,500
East North	70,800	11,700	59,100	45,300	13,800
North Shallow (LNAPL)					
North Shallow	17,500	2,900	14,600	11,200	13,800
Total (All Zones) [d]	**448,000**	**74,200**	**374,000**	**287,000**	**87,500**

Notes:

[a] This is the volume of NAPL present at the start of steam injection (e.g. following enhanced NAPL recovery).

[b] This is the volume of NAPL recovered during the initial steam injection or pre-heating phase (i.e., 75% of the remaining mobile NAPL after enhanced NAPL recovery and no immobile NAPL).

[c] This is the residual NAPL remaining after initial heating and is calculated by subtracting the steam enhanced NAPL recovery from the pre-steam NAPL volume.

[d] Due to significant figure and rounding carry over, Residual for EAB Treatment and Total (All Zones) volumes may not sum exactly.

EAB enhanced aerobic biodegradation
FFS focused feasibility study
LNAPL light non-aqueous phase liquid
NAPL non-aqueous phase liquid
OU operable unit

TABLE 3-6

Components of Alternative 6 – Excavation, Thermal Desorption, and Thermal Enhanced Extraction

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Remedial Action Target Zone	Component	Description
Not Applicable	Common Elements	Preconstruction activities Access Roads Concrete demolition, decontamination/reuse Debris removal Bulkhead removal Other demolition Stormwater infiltration trench Perimeter sheet pile wall Concrete perimeter wall Passive groundwater treatment Site cap MNA, access controls, and 5 year reviews
Upper Core Area	Soil Excavation and Thermal Desorption	Excavate an estimated 81,300 CY of NAPL contaminated soil to depth of 20 feet Excavation area divided into nine smaller cells using sheet pile to allow for dewatering and treatment of dewatering fluids in the GWTP Excavated soil transferred to staging area for drying and blending Thermal desorption treatment performed inside a new building. Exhaust gases discharged to the atmosphere. Treated soil staged, sampled to confirm treatment effectiveness, and used to backfill the excavation
Lower Core Area, East Shallow (LNAPL), North Shallow (LNAPL), North Deep (DNAPL)	Thermal Enhanced Extraction	Performed as described for Alternative 5
Periphery	EAB	Performed as described for Alternative 5
Sitewide	GWTP – Short-term Operations and Maintenance	Utilizes existing GWTP to treat groundwater from dewatering operations, groundwater generated from hydraulic containment pumping, and water generated from thermal extraction operations Operations continue for 10 years
	Passive Groundwater Treatment	Performed as described for Alternative 4 Performed for approximately 19 years
	Groundwater Monitoring and Reporting	Includes quarterly Upper Aquifer and annual Lower Aquifer sampling and analysis and preparation of an annual report.

TABLE 3-6

Components of Alternative 6 – Excavation, Thermal Desorption, and Thermal Enhanced Extraction

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Remedial Action Target Zone	Component	Description		
	Remedial Action Timeframe	Estimate 27 years		
	Cost	**Category**	**Discount Factor: 1.4%**	**Discount Factor: 7%**
		Capital - Common Elements	$51.8 million	
		Capital Remedial Technology (2016 base year)	$111.3 million	
		Short-term O&M (annual)	Ranges from $284,000 to $9.7 million (during thermal treatment)	
		Short-term O&M and Periodic (total, non-discounted)	$46.4 million	
		Total Present Worth (discounted)	$197.7 million	$161.5 million
		Total Non-discounted	$210.0 million	

Notes:

CY cubic yard
DNAPL dense non-aqueous phase liquid
EAB enhanced aerobic biodegradation
FFS focused feasibility study
GWTP groundwater treatment plant
LNAPL light non-aqueous phase liquid
MNA monitored natural attenuation
NAPL non-aqueous phase liquid
O&M operations and maintenance
OU operable unit
scfm standard cubic foot per minute

TABLE 3-7a

Components of Alternative 7 – ISS of Expanded Core Area and Thermal Enhanced Recovery

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Remedial Action Target Zone	Component	Description
Phase 1		
Sitewide	Common Elements	Preconstruction activities Access Roads Concrete Demolition, Decontamination/Reuse Debris removal Bulkhead removal Other demolition Stormwater infiltration trench Perimeter sheet pile wall Concrete perimeter wall New outfall for GWTP and stormwater discharge Passive groundwater treatment (passive drainage) Site cap MNA, ICs, and 5-year reviews
Expanded Core Area	ISS - Auger	Core Area. Treat of 202,000 CY of NAPL contaminated material to depths of 55 feet. Excavated Soil. Treat 20,600 CY of material, removed to offset ISS swell, using ex situ ISS methods and reuse this material for grading – contouring.
East Shallow (LNAPL) North Deep (DNAPL)	NAPL Recovery	Installation of 23 LNAPL skimming wells Pumping of LNAPL for up to 5 years Installation of seven DNAPL and groundwater extraction wells and five groundwater injection wells Pumping of DNAPL for up to 5 years LNAPL and DNAPL separation performed at wellhead or GWTP equipped with new oil-water separator LNAPL/DNAPL disposed offsite, groundwater treated in GWTP and discharged to Puget Sound through new outfall Installation of 27 EAB sparge wells inside existing sheet pile wall to stimulate in situ biodegradation. Assume 8 scfm flow rate per well or approximately 200 scfm total. Implementation of Upper Aquifer and Lower Aquifer performance monitoring program to assess Phase 1 treatment effectiveness and need for Phase 2 treatment
Phase 2		
East Shallow (LNAPL) North Deep (DNAPL) North Shallow (LNAPL) Other Periphery	Thermal Enhanced Recovery	East Shallow (LNAPL) divided into two smaller cells located on either side (North and South) of ISS treatment area. North Shallow (LNAPL) and North Deep (DNAPL) addressed as a single area. Installation of multi-purpose thermal/EAB wells, temperature monitoring wells, and EAB wells Re-purposing of 30 LNAPL/DNAPL recovery wells as fluid extraction and EAB wells Installation of above ground thermal heating/cooling equipment and expansion of GWTP from 80 gpm to 140 gpm throughput rate.

TABLE 3-7a

Components of Alternative 7 – ISS of Expanded Core Area and Thermal Enhanced Recovery

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Remedial Action Target Zone	Component	Description
	Thermal Enhanced Recovery Short-term O&M	Adaptive Approach, apply in the most contaminated areas (as indicated by Phase I monitoring) Concentrate on removing mobile NAPL and perimeter source material, expand based on monitoring data and field observations Extraction wells and injection wells - closer spacing along perimeter less so toward the ISS monolith. Include hydraulic containment extraction wells in the strategy Thermal can be "judiciously" augmented with other methods, wells are compatible with multiple techniques Keep the treatment system simple and recover and reinject heat as much as practical Operate thermal (wet steam) injection as a NAPL recovery, solubilization, and biological degradation enhancement (i.e., remove as much NAPL as practical and expeditiously degrade the remainder) Target subsurface temperature of 120 to 125 degrees Fahrenheit Learn from Phase I NAPL Recovery "what works"
	EAB	Inject air through multi-purpose wells at rates estimated to range from 8 to 25 scfm per well depending on whether one or all three Upper Aquifer compartments are being targeted. In situ biodegradation performance enhanced by residual heat from thermal treatment operations
Sitewide	GWTP – Short-term Operations and Maintenance	Utilizes existing GWTP to treat groundwater from dewatering operations, groundwater generated from hydraulic containment pumping, and water generated from thermal extraction operations Operations continue for up to 10 years
	Passive Groundwater Discharge/ Treatment	Duration varies depending on whether Phase 1 or Phase 1 and Phase 2 is required. Potentially required for up to 34 years.
	Remedial Action Timeframe	Estimate 34 years (assuming Phase 2 remedial action is required)
	Cost	(see cost table below)

Category	Discount Factor: 1.4%	Discount Factor: 7%
Capital - Common Elements	$51.8 million	
Capital Remedial Technology (2016 base year)	$52.3 million	
Short-term O&M (annual)	Ranges from $284,000 to $5.0 million (during thermal treatment)	
Short-term O&M and Periodic (total, non-discounted)	$20.5 million	
Total Present Worth (discounted)	$113.0 million	$82.4 million
Total Non-discounted	$121.8 million	

TABLE 3-7a

Components of Alternative 7 – ISS of Expanded Core Area and Thermal Enhanced Recovery

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Remedial Action Target Zone	Component	Description

Notes:

CY	cubic yard	LNAPL	light non-aqueous phase liquid
DNAPL	dense non-aqueous phase liquid	MNA	monitored natural attenuation
EAB	enhanced aerobic biodegradation	NAPL	non-aqueous phase liquid
FFS	focused feasibility study	O&M	operations and maintenance
GWTP	groundwater treatment plant	OU	operable unit
IC	institutional control	scfm	standard cubic foot per minute
ISS	In situ Solidification/Stabilization		

TABLE 3-7b

Estimates of Soil and NAPL Treatment Volumes for Alternative 7

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Remedial Target	Soil Volume (CY)	NAPL Volume (gallons)	Technology
Phase 1			
Expanded Core	202,180	455,534	ISS
North Deep (DNAPL)	4,746	10,306	NAPL Recovery, EAB
East Shallow (LNAPL)	8,868	10,082	NAPL Recovery, EAB
Phase 2 (if necessary)			
North Deep DNAPL (North of ISS)	91,912	40,786	To be determined
East Shallow LNAPL (North of ISS)	85,891	52,917	To be determined
East Shallow LNAPL (North of ISS)	60,746	37,803	To be determined
Other Discrete Areas	40,174	30,686	To be determined
Subtotals			
Phase 1 Total	215,794	475,922	
Phase 2 Total	278,723	162,192	
No Treatment	261,752	40,758	
Site Total Estimates	**755,018**	**678,872**	

TABLE 3-7c

Estimates of NAPL Recovery during Pumping of Treatment Volumes

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Remedial Target	NAPL Volume (gallons)	Initial Heating (days)	NAPL Recovered (gallons)	Residual NAPL (gallons)	Flushing Rate (gpm)
Phase 1					
Expanded Core	455,534	-	455,534	-	-
Phase 2 (Includes Phase I)					
North NAPL (North of ISS)	51,092	59	19,543	31,549	24
East NAPL (North of ISS)	62,999	58	24,097	38,902	29
East NAPL (South of ISS)	37,803	47	14,460	23,343	17
Other Discrete Areas	30,686	52	11,737	18,949	10
Subtotals					
Phase 1 Total	455,534	-	455,534	-	-
Phase 2 Total	182,580	216	69,837	112,743	80
No Treatment	40,758	-	0	40,758	0
Site Total Estimates	**678,872**	**216**	**525,371**	**153,501**	**80**

TABLE 4-1
CERCLA Remedial Action Alternative Evaluation Criteria
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Threshold Criteria	
Overall Protection of Human Health and the Environment	Alternatives are assessed to determine whether they can adequately protect human health and the environment, in both the short- and long-term, from unacceptable risks posed by hazardous substances, pollutants, or contaminants present at the site by eliminating, reducing, or controlling exposures to levels established during development of remediation goals consistent with §300.430(e)(2)(i). Overall protection of human health and the environment draws on the assessments of other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs. The assessment against this criterion describes how the alternative, as a whole, achieves and maintains protection of human health and the environment.
Compliance with Applicable or Relevant and Appropriate Requirements	Alternatives are assessed to determine whether they attain Applicable or Relevant and Appropriate Requirements under federal environmental laws and state environmental or facility siting laws or provide grounds for invoking one of the waivers identified in Code of Federal Regulations, Title 40, Section 300.430 (f)(1)(ii)(C). This assessment also addresses other information from advisories, criteria, and guidance that the lead and support agencies have agreed is "to be considered."
Balancing Criteria	
Long-Term Effectiveness and Permanence	Alternatives are assessed for the long-term effectiveness and permanence they afford, along with the degree of certainty that the alternative will prove successful. Factors that shall be considered, as appropriate, include the following: (1) Magnitude of residual risk from untreated waste or treatment residuals remaining at the conclusion of the remedial activities. The characteristics of the residuals should be considered to the degree that they remain hazardous, taking into account their volume, toxicity, mobility, and propensity to bioaccumulate. (2) Adequacy and reliability of controls such as containment systems and institutional controls that are necessary to manage treatment residuals and untreated waste. This factor addresses in particular the uncertainties associated with land disposal for providing long-term protection from residuals; the assessment of the potential need to replace technical components of the alternative, such as a cap, a slurry wall, or a treatment system; and the potential exposure pathways and risks posed should the remedial action need replacement.
Reduction of Toxicity Mobility or Volume through Treatment	Alternatives are evaluated to assess the degree to which they employ recycling or treatment that reduces toxicity mobility or volume, including how treatment is used to address the principal threats posed by the site. Factors that shall be considered, as appropriate, include the following: (1) The treatment or recycling processes the alternatives employ and materials they will treat; (2) The amount of hazardous substances, pollutants, or contaminants that will be destroyed, treated, or recycled; (3) The degree of expected reduction in TMV of the waste due to treatment or recycling and the specification of which reduction(s) are occurring; (4) The degree to which the treatment is irreversible;

	(5) The type and quantity of residuals that will remain following treatment, considering the persistence, toxicity, mobility, and propensity to bioaccumulate of such hazardous substances and their constituents; and (6) The degree to which treatment reduces the inherent hazards posed by principal threats at the site.
Short-Term Effectiveness	Alternatives are evaluated to assess the short-term impacts considering the following: (1) Short-term risks that might be posed to the community during implementation of an alternative; (2) Potential impacts on workers during remedial action and the effectiveness and reliability of protective measures; (3) Potential environmental impacts of the remedial action and the effectiveness and reliability of mitigative measures during implementation; and (4) Time until protection is achieved
Implementability	Alternatives are evaluated to assess the ease or difficulty of implementation considering the following as appropriate: (1) Technical feasibility, including technical difficulties and unknowns associated with the construction and operation of a technology, the reliability of the technology, ease of undertaking additional remedial actions, and the ability to monitor the effectiveness of the remedy. (2) Administrative feasibility, including activities needed to coordinate with other offices and agencies and the ability and time required to obtain any necessary approvals and permits from other agencies (for off-site actions); (3) Availability of services and materials, including the availability of adequate off-site treatment, storage capacity, and disposal capacity and services; the availability of necessary equipment and specialists, and provisions to ensure any necessary additional resources; the availability of services and materials; and availability of prospective technologies.
Cost	Alternatives are evaluated with respect to the capital cost, annual operation and maintenance cost, periodic cost, and total life-cycle cost (present worth cost). Present worth costs were estimated using the real discount rate published in Appendix C ("Discount Rates for Cost Effectiveness, Lease Purchase, and Related Analyses") of "Guidelines and Discount Rates for Benefit Cost Analysis of Federal Programs" (OMB Circular A 94), effective through June 2014 and a 7 percent discount rate as specified by *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* (EPA 540 R 00 002). The cost estimates were prepared in accordance with A Guide to Developing and Documenting Cost Estimates During the Feasibility Study (EPA 540 R 00 002), along with Cost Estimating Guide (DOE G 430.1 1). The cost estimates are for comparison purposes and are prepared to meet the 30 to +50 percent range of accuracy recommended in CERCLA Remedial Investigation/Feasibility Study Guidance (EPA/540/G 89/004). The cost estimates are based on specific response action scenarios and assumptions. Detailed sensitivity analyses were not performed to quantify the potential effect of changing key parametric assumptions.

TABLE 4-1
CERCLA Remedial Action Alternative Evaluation Criteria
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Modifying Criteria (not evaluated in the FFS report)	
State Acceptance	This assessment reflects the state's (or support agency's) apparent preferences among or concerns about alternatives.
Community Acceptance	This assessment reflects the community's apparent preferences among or concerns about alternatives.

Notes:

CERCLA Comprehensive Environmental Response, Compensation, and Liability Act
FFS focused feasibility study
LNAPL light non-aqueous phase liquid
NAPL non-aqueous phase liquid
OU operable unit

TABLE 4-2
Detailed Evaluation for Alternative 1 – No Action
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Criterion	Rating	Detailed Analysis
Threshold Criteria		
Overall Protection of Human Health and the Environment	No	**Does not protect human health and the environment:** – Land and groundwater use controls not maintained to protect human health. – NAPL and dissolved phase contaminants would continue to migrate resulting in potential for human and ecological receptor exposure within the intertidal area.
Compliance with Applicable or Relevant and Appropriate Requirements	No	**Does not achieve Applicable or Relevant and Appropriate Requirements:** – Since there is no action, chemical-specific ARARs for marine surface water quality protection would not be achieved.
Balancing Criteria		
Long-term Effectiveness and Permanence	N/A	Alternative 1 fails the threshold criteria, and cannot be selected. Therefore, an evaluation against the balancing criteria was not performed.
Reduction of Toxicity Mobility or Volume through Treatment	N/A	
Short-term Effectiveness	N/A	
Implementability	N/A	
Cost	$0	Although this alternative assumes that routine operations and maintenance of the hydraulic containment remedy would continue through 2016, no costs are included in this FFS.
Modifying Criteria		
State Acceptance **Community Acceptance**		Not evaluated in this FFS. This criterion will be evaluated during the public comment period to be held following issuance of the Proposed Plan

Notes:

FFS focused feasibility study
N/A not applicable
NAPL non-aqueous phase liquid
OU operable unit

TABLE 4-3

Detailed Evaluation for Alternative 2 – Containment

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Criterion	Rating	Detailed Analysis
Threshold Criteria		
Overall Protection of Human Health and the Environment	Yes	**Protects human health and the environment:** – Land use institutional controls and soil cover prevent contact with untreated soil present in top 15 feet. – Groundwater use institutional controls in the Upper and Lower Aquifer protect against direct contact by prohibiting use. – Upper Aquifer containment pumping prevents transport of dissolved phase contaminants to intertidal area. Pumping also removes NAPL lessening the potential for future migration. – Natural attenuation processes reduce dissolved phase contaminant concentrations in Aquitard and Lower Aquifer. – Replacement of the sheet pile wall reduces potential for NAPL migration.
Compliance with Applicable or Relevant and Appropriate Requirements	Yes	**Complies with Applicable or Relevant and Appropriate Requirements:** - Hydraulic and physical containment expected to achieve soil and groundwater preliminary remediation goals that achieve chemical-specific Applicable or Relevant and Appropriate Requirements for marine water quality in the intertidal area. – Modification of existing remedy components and installation of new components would be performed in accordance with action and location-specific Applicable or Relevant and Appropriate Requirements.
Balancing Criteria		
Long-term Effectiveness and Permanence	★☆☆	**Performs less well:** – Estimate 70 percent of the NAPL mass (based on naphthalene removal) would remain at the end of the 100-year remedial action period resulting in significant residual risk. – Maintenance of containment systems (hydraulic, groundwater treatment plant, sheet pile wall, and soil cap) and enforceable land and groundwater use institutional controls would continue during the 100-year remedial action period. However, this maintenance would discontinue after 100 years, therefore, the adequacy and reliability of these controls would decrease over time.
Reduction of Toxicity Mobility or Volume through Treatment	★☆☆	**Performs less well:** – Estimate a 30 percent reduction in NAPL mass through recovery/treatment employing hydraulic containment. Natural attenuation processes (anaerobic biodegradation) would also reduce toxicity mobility or volume but some uncertainty on the actual rate of biodegradation that would occur. – Addresses principal threat (NAPL mobility) through containment strategy.
Short-term Effectiveness	★★☆	**Performs moderately well:** – Poses minimal risk to the community because majority of work occurs onsite with vehicle traffic limited to groundwater treatment plant operators (daily), media changeout (annual), and NAPL transport (annual). – Onsite workers and subcontractors have training and experience that minimize their risk.

TABLE 4-3

Detailed Evaluation for Alternative 2 – Containment

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Criterion	Rating	Detailed Analysis
		– Construction of remaining alternative elements and remedy operations and maintenance poses little risk to the environment if the system remains operational. – This alternative not expected to achieve the NAPL performance goals or remedial action objectives within the 100 -year remedial action timeframe.
Implementability	★★☆	**Performs moderately well:** – Many of the technologies employed by this alternative are currently in use at the Wyckoff site or have been implemented at similar CERCLA wood-treating sites. However, there is limited experience operating these systems for up to 100 years. – It is expected that some administrative coordination will be required for new construction associated with the outfall and sheet pile wall due to site's proximity to waters of the State. – Given the site's location, and longevity of this alternative, there is some uncertainty on whether the materials and services will be readily available for the duration.
Present Worth Cost (base year 2016) Discount Rate : 7.0%	$52.0 million	– Common elements: $43.3 million – Capital cost remedial technology: $2.5 million – Short-term annual operations and maintenance cost: $0.52 million per year for years 1 to 100 – Total operations, maintenance, and periodic costs (non-discounted): $12.6 million
Present Worth Cost (base year 2016) Discount Rate : 1.4%	$79.8 million	Same as above
Modifying Criteria		
State Acceptance		Not evaluated in this FFS report. This criterion will be evaluated during the public comment period to be held following issuance of the Proposed Plan
Community Acceptance		

Notes:

CERCLA Comprehensive Environmental Response, Compensation, and Liability Act
FFS focused feasibility study
N/A not applicable
NAPL non-aqueous phase liquid
O&M operations and maintenance
OU operable unit

TABLE 4-4

Detailed Evaluation for Alternative 4 – In situ Solidification/Stabilization

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Criterion	Rating	Detailed Analysis
Threshold Criteria		
Overall Protection of Human Health and the Environment	Yes	**Protects human health and the environment** – Land use institutional controls and soil cover protect human health and ecological receptors from contact with ISS treated soil present in top 15 feet. – Groundwater use institutional controls for the Upper and Lower Aquifer's protect human health by prohibiting groundwater use. – Treatment of NAPL source material protects the environment by reducing the potential for NAPL migration and dissolved phase plume regeneration. – Passive groundwater treatment intercepts low concentration dissolved phase polycyclic aromatic hydrocarbons and pentachlorophenol present in lower portion of Upper Aquifer following ISS treatment thereby preventing transport to intertidal zone. – Natural attenuation processes reduce dissolved phase contaminant concentrations in the Aquitard and Lower Aquifer.
Compliance with Applicable or Relevant and Appropriate Requirements	Yes	**Complies with Applicable or Relevant and Appropriate Requirements:** - Soil and groundwater preliminary remediation goals protective of sediment and surface water chemical-specific Applicable or Relevant and Appropriate Requirements achieved in the treatment zone. – Remedy design and construction would be performed to assure compliance with action and location-specific Applicable or Relevant and Appropriate Requirements.
Balancing Criteria		
Long-term Effectiveness and Permanence	★★★	**Performs very well:** – Estimate that 7 percent of the NAPL source material would remain following in situ solidification/stabilization treatment. This material addressed through passive groundwater treatment and natural attenuation processes. – NAPL source material physically/chemically converted in situ to a durable and insoluble solid posing limited risk to human health and the environment. In situ solidification/stabilization columns evaluated at other sites after 10 years of weathering showed no loss of integrity. – Technology promotes excellent contact between reagent and contaminated material resulting in high degree of treatment effectiveness. – Land use institutional controls would be maintained to prevent intrusion into the ISS treatment zone. However, no restrictions on above-grade land use or construction are necessary. – Groundwater use institutional controls would be maintained for the Upper and Lower Aquifers. These controls used at many CERCLA sites, and are expected to be reliable based on site's proposed future recreational use.

TABLE 4-4

Detailed Evaluation for Alternative 4 – In situ Solidification/Stabilization

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Criterion	Rating	Detailed Analysis
Reduction of Toxicity Mobility or Volume through Treatment	★★★	**Performs very well:** – Estimate 93 percent of the NAPL source zone is treated. – Toxicity reduced by decreasing the concentration and bioavailability of contaminants present in the NAPL. – Mobility reduced by physically/chemically alternating the characteristics of NAPL source material to make it immobile and insoluble. – Volume of NAPL source material is not reduced. Contaminants are not destroyed. – Addresses the principal threat (NAPL mobility and toxicity) through mobility and toxicity reduction.
Short-term Effectiveness	★★☆	**Performs moderately well:** – Community impacts from heavy construction traffic, extended work hours, and heavy equipment noise will occur for 3 years, less than other alternatives. – Onsite workers and subcontractors have training and experience that minimize their risk. Work around rotational, pressurized equipment poses greater risk to workers but controls will be established. – Potential for short-term environmental impacts from heavy equipment use, excavated materials handling, cement batch plant, ex situ treatment, staging and material reuse along a marine shoreline setting. Storm water best management practices would be used to control run-on and run-off effects. – This alternative achieves NAPL mobility reduction performance objective in the shortest time frame (estimate 3 years). Passive groundwater treatment to address remaining 7 percent of non-ISS treated zone completed within about 10 years.
Implementability	★★☆	**Performs moderately well:** – Deep auger mixing and jet grouting are mature technologies used for remediation and ground improvement applications. Large, heavy equipment will pose mobilization and maneuvering challenges. – Deployment is relatively straightforward and quality assurance and quality control processes are well developed. – Several ISS vendors are available, although none are local. – A mix design, similar to that used at other sites assumed. Actual mix design will be developed during remedial design. – It is expected that some administrative coordination will be required for new construction associated with the outfall and sheet pile wall common elements due to site's proximity to waters of the State. – Successful implementation is dependent on locating and removing large subsurface debris that could interfere with the equipment. Excavation of soil to a depth of 7 feet should lessen the potential for obstructions or debris to interfere with equipment. Direct push technology has been used to drill borings to depths of 70 feet at the site, however treatment depths approach auger mixing equipment limits. – The passive groundwater treatment component uses familiar technology but in an innovative manner.

TABLE 4-4

Detailed Evaluation for Alternative 4 – In situ Solidification/Stabilization

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Criterion	Rating	Detailed Analysis
Present Worth Cost (base year 2016) Discount Rate: 7.0%	$88.6 million	− Capital cost common elements: $35.2 million − Capital cost remedial technology: $57.3 million − Short-term annual operations and maintenance cost: Years 0 - 2: $0.8 million; Years 3 – 10: $0.33 million. − Total operations, maintenance, and periodic costs (non-discounted): $2.4 million.
Present Worth Cost (base year 2016) Discount Rate: 1.4%	$93.7 million	− Same as above
Modifying Criteria		
State Acceptance		Not evaluated in this FFS report. This criterion will be evaluated during the public comment period to be held following issuance of the Proposed Plan.
Community Acceptance		

Notes:

CERCLA Comprehensive Environmental Response, Compensation, and Liability Act
FFS focused feasibility study
NAPL non-aqueous phase liquid
OU operable unit

TABLE 4-5

Detailed Evaluation for Alternative 5 – Thermal Enhanced Extraction and ISS

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Criterion	Rating	Detailed Analysis
		Threshold Criteria
Overall Protection of Human Health and the Environment	Yes	**Protects human health and the environment:** – Groundwater institutional controls protect human health by prohibiting Upper Aquifer and Lower Aquifer groundwater use. – Human health is protected by extracting and thermally destroying the NAPL thereby reducing contaminant concentrations in subsurface soil and Upper Aquifer groundwater. – Environment is protected by removing NAPL, thereby preventing its migration, and lessening the potential for the formation and transport of soluble NAPL contaminants to the Lower Aquifer and intertidal areas. – Enhanced aerobic biodegradation reduces residual NAPL concentrations in Upper Aquifer groundwater. Residual thermal effects will increase degradation rates and overall effectiveness. Increased dissolved oxygen concentrations may also improve pore water quality in the intertidal zone. – Natural attenuation processes reduce dissolved phase contaminant concentrations in Aquitard and Lower Aquifer groundwater.
Compliance with Applicable or Relevant and Appropriate Requirements	Yes	**Complies with Applicable or Relevant and Appropriate Requirements:** – Soil and groundwater preliminary remediation goals protective of sediment and surface water quality Applicable or Relevant and Appropriate Requirements achieved within the treatment zone. – Remedy design and construction would be performed to assure compliance with action and location-specific Applicable or Relevant and Appropriate Requirements.
Balancing Criteria		
Long-term Effectiveness and Permanence	★★★	**Performs very well:** – Estimate 16 percent of the NAPL source material would remain following thermal and in situ solidification/stabilization treatment. This material would be addressed through enhanced aerobic biodegradation. – NAPL source material heated to enhance mobility and recovery. High-molecular weight polycyclic aromatic hydrocarbons, which comprise less than 15 percent of NAPL source material, may be more difficult to remove due to their physical/chemical properties. However, these contaminants unlikely to pose risk to HHE due to limited mobility and bioavailability. – Employs an array of complementary technologies that are expected to increase overall treatment effectiveness. – Groundwater use controls may have to be maintained for the Upper and Lower Aquifers. These controls are used at many CERCLA sites, and would be reliable based on the site's future recreational use.

TABLE 4-5

Detailed Evaluation for Alternative 5 – Thermal Enhanced Extraction and ISS

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Criterion	Rating	Detailed Analysis
Reduction of Toxicity Mobility or Volume through Treatment	★★★	**Performs very well:** – Estimate that 84 percent of the NAPL source zone treated using thermal and ISS technologies. – Toxicity reduced by removing NAPL mass and decreasing contaminant of concern concentrations in subsurface soil and Upper Aquifer groundwater. – Mobility of NAPL, pentachlorophenol and low-molecular weight polycyclic aromatic hydrocarbons decreased. – Volume of NAPL source material greatly reduced. Vapor phase NAPL constituents destroyed in an above ground thermal oxidation system. Contaminants present in aqueous phase are removed in the groundwater treatment plant and thermally destroyed when the granular-activated carbon media is regenerated. – Addresses the principal threat (NAPL mobility and toxicity) by removing and thermally destroying the NAPL.
Short-term Effectiveness	★★☆	**Performs moderately well:** – Community impacts from increased construction activity, facility operations and maintenance traffic, operations lighting and noise for approximately 10 years. Thermal oxidation and steam generation equipment discharge exhaust to the atmosphere. – Onsite workers and subcontractors have training and experience that minimizes their risks. Steam generation and conveyance pose additional hazards to onsite workers. Piping placed on racks to minimize hazards. – Potential for short-term environmental impacts from construction activity, and thermal oxidation and steam generation equipment operations. Storm water best management practices would be used to reduce the potential for run-on and run-off effects. – This alternative achieves NAPL mobility reduction performance objective in about 10 years. Enhanced aerobic biodegradation requires about 5 more years to degrade remaining NAPL and passive groundwater treatment 14 additional years. – Expected to have the largest greenhouse gas footprint of all the alternatives.

TABLE 4-5

Detailed Evaluation for Alternative 5 – Thermal Enhanced Extraction and ISS

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Criterion	Rating	Detailed Analysis
Implementability	★☆☆	**Performs less well:** – Employs a large number of injection and extraction wells, above ground conveyance piping, and treatment system equipment. Intensive process control monitoring required. – Uses technologies that have been successfully deployed elsewhere. However, employs an innovative piece of equipment to manage naphthalene crystallization that resulted in early shutdown of the previous steam pilot. This piece of equipment is not off-the-shelf and will have to be custom fabricated and its effectiveness confirmed resulting in some performance uncertainty. – Requires close coordination/sequencing of the NAPL recovery, thermal, in situ solidification/stabilization and enhanced anaerobic biodegradation treatment phases. Complex remedy. – Energy intensive requiring onsite energy generation using non-renewable (propane) energy source. – Passive groundwater treatment is included as a polishing step for low concentration aqueous contamination. Reliance on tidal induced gradient to induce flow through granular-activated carbon treatment vessels is innovative but unproven.
Present Worth Cost (base year 2016) Discount Rate: 7.0%	$120.1 million	– Capital cost common elements: $51.8 million – Capital cost remedial technology: $51.0 million – Short-term annual operations and maintenance costs: Range from $0.3 million to $9.3 million – Total operations, maintenance, and periodic costs (non-discounted): $46.3 million
Present Worth Cost (base year 2016) Discount Rate: 1.4%	$142.1 million	– Same as above
Modifying Criteria		
State Acceptance		Not evaluated in this FFS report. This criterion will be evaluated during the public comment period to be held following issuance of the Proposed Plan.
Community Acceptance		

Notes:

CERCLA Comprehensive Environmental Response, Compensation, and Liability Act
FFS focused feasibility study
NAPL non-aqueous phase liquid
OU operable unit

TABLE 4-6

Detailed Evaluation for Alternative 6 – Excavation, Thermal Desorption, and Thermal Enhanced Extraction

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Criterion	Rating	Detailed Analysis
Threshold Criteria		
Overall Protection of Human Health and the Environment	Yes	**Protects human health and the environment** – Human health protected by excavation and MTTD treatment of NAPL contaminated material to a depth of 20 feet in the Core Area, followed by NAPL recovery and thermal enhanced extraction from remainder of the treatment zones. – Excavation and MTTD treatment provides the highest level of protection for human health in the ground surface to 15 foot depth exposure horizon. – Groundwater institutional controls protect human health by prohibiting Upper Aquifer and Lower Aquifer groundwater use. – Environment is protected by removing mobile NAPL and soluble NAPL contaminants from subsurface soil and Upper Aquifer groundwater thereby preventing migration to the intertidal area. – Enhanced anaerobic biodegradation reduces residual NAPL concentrations in the Upper Aquifer further. Residual thermal effects increase degradation rates and overall effectiveness. Increased dissolved oxygen concentrations may also improve pore water quality in intertidal zone. – Natural attenuation processes reduce dissolved phase contaminant concentrations in Aquitard and Lower Aquifer groundwater. Residual heat from thermal treatment may increase attenuation rates.
Compliance with Applicable or Relevant and Appropriate Requirements	Yes	**Complies with Applicable or Relevant and Appropriate Requirements:** – Soil and groundwater preliminary remediation goals protective of sediment and surface water quality Applicable or Relevant and Appropriate Requirements achieved within the treatment zone. – This alternative expected to achieve unrestricted use/unrestricted exposure Applicable or Relevant and Appropriate Requirements within the ground surface to 15 foot depth exposure interval in the Core Area. – Remedy design and construction would be performed to assure compliance with action and location-specific Applicable or Relevant and Appropriate Requirements.
Balancing Criteria		
Long-term Effectiveness and Permanence	★★★	**Performs very well:** – Estimate 15 percent of the NAPL would remain following excavation, NAPL recovery, and thermal treatment. Balance of NAPL source material treated using EAB. – Excavation and MTTD treatment in upper portion of the Core Area eliminates need for land use controls. – NAPL source material in lower portion of the Core Area and remaining target zones heated to mobilize transport thus facilitating their removal. High-molecular weight polycyclic aromatic hydrocarbon, which comprise less than 15 percent of NAPL source material, may be more difficult to remove due to their physical/chemical properties. However, these contaminants unlikely to pose a threat to human health and the environment due to their limited mobility and bioavailability. – Employs an array of complementary technologies to increase effectiveness.

TABLE 4-6

Detailed Evaluation for Alternative 6 – Excavation, Thermal Desorption, and Thermal Enhanced Extraction

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Criterion	Rating	Detailed Analysis
		– Groundwater use controls may have to be maintained for the Upper and Lower aquifers. These controls used at many CERCLA sites, and would be reliable based on the site's future recreational use.
Reduction of Toxicity Mobility or Volume through Treatment	★★★	**Performs very well:** – Estimate 85 percent of the NAPL source zone treated using excavation, MTTD, NAPL recovery, and thermal technologies. – Toxicity reduced by removing NAPL mass and decreasing contaminant concentrations in subsurface soil and groundwater. – Mobility reduced by removing NAPL mass especially the pentachlorophenol and low molecular weight polycyclic aromatic hydrocarbon fraction. – Volume of NAPL source material is reduced. Soil contaminants and vapor phase contaminants are destroyed in an above ground thermal oxidation unit. Contaminants present in aqueous phase are removed in the groundwater treatment plant and thermally destroyed when the granular-activated carbon media is reactivated. – Addresses the principal threat (NAPL mobility) by removing the NAPL, and treating the waste streams to destroy the contaminants.
Short-term Effectiveness	★★☆	**Performs moderately well:** – Community impacts associated with increased construction activity, and facility operations and maintenance traffic, operations lighting and noise for approximately 15 years. Thermal oxidation and steam generation equipment discharge exhaust to the atmosphere. – Onsite workers and subcontractors have training and experience that minimize their risks. Excavation to depths of 20 feet poses additional hazards to workers. Steam generation and conveyance piping, and thermal oxidation equipment also pose additional hazards to onsite workers. Piping placed on racks to minimize hazards. – Potential for short-term environmental impacts from construction activity, and thermal oxidation and steam generation equipment operations. Stormwater best management practices would be used to reduce the potential for run-on and run-off effects. – This alternative achieves NAPL mobility reduction performance objective in about 15 years. Passive groundwater treatment required for an 18 additional years. – Expected to have a greenhouse gas footprint comparable to Alternative 5.
Implementability	★☆☆	**Performs less well:** – Excavation to depths of 20 feet requires nine separate sheet pile wall cells and dewatering posing significant construction challenges. – Employs a large number of injection and extraction wells, above ground conveyance piping, and treatment system equipment. Intensive process control monitoring required. – Uses technologies that have been successfully deployed elsewhere. However, employs an innovative piece of equipment to manage naphthalene crystallization that resulted in early shutdown of the previous steam pilot. This piece of equipment is not off-the-shelf and will have to be custom fabricated and its effectiveness confirmed before full-scale startup resulting in some performance uncertainty.

TABLE 4-6

Detailed Evaluation for Alternative 6 – Excavation, Thermal Desorption, and Thermal Enhanced Extraction

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Criterion	Rating	Detailed Analysis
		− Requires close coordination/sequencing of the excavation/MTTD, NAPL recovery, thermal, and enhanced aerobic biodegradation treatment phases. More complex remedy. − Energy intensive requiring onsite energy generation. − The passive treatment technology to be implemented following active NAPL source treatment is innovative but unproven.
Present Worth Cost (base year 2016) Discount Rate: 7.0%	$161.5 million	− Capital cost common elements: $51.8 million − Capital cost remedial technology: $111.3 million − Short-term annual operations and maintenance costs: Range from $0.3 million to $9.7 million − Total operations, maintenance, and periodic costs (non-discounted): $46.4 million
Present Worth Cost (base year 2016) Discount Rate: 1.4%	$197.7 million	− Same as above
Modifying Criteria		
State Acceptance		Not evaluated in this FFS report. This criterion will be evaluated during the public comment period to be held following issuance of the Proposed Plan
Community Acceptance		

Notes:
CERCLA Comprehensive Environmental Response, Compensation, and Liability Act
FFS focused feasibility study
MTTD medium temperature thermal desorption
NAPL non-aqueous phase liquid
OU operable unit

TABLE 4-7

Detailed Evaluation for Alternative 7 – ISS of Expanded Core Area and Thermal Enhanced Recovery

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Criterion	Rating	Detailed Analysis
Threshold Criteria		
Overall Protection of Human Health and the Environment	Yes	**Protects human health and the environment:** – Land use institutional controls and soil cover protect human health and ecological receptors from contact with in situ solidification/stabilization treated soil and untreated soil present within the top 15 feet of the former process area. – Groundwater use institutional controls for the potable portion of the Upper and Lower Aquifers protects human health by prohibiting groundwater use. – In situ solidification/stabilization and thermal enhanced recovery of NAPL source material protects the environment by reducing the potential for NAPL migration and dissolved phase plume regeneration. – Enhanced anaerobic degradation treats dissolved phase contaminants present in the Upper Aquifer (Compartment 1B) along the sheet pile well where the potential for migration to the intertidal zone may be greater. – Passive groundwater discharge/treatment provides long-term water balance control and treats low concentration dissolved phase contaminants present in the Upper Aquifer (Compartment 1B) along the sheet pile wall where the potential for migration to intertidal zone is greater.
Compliance with Applicable or Relevant and Appropriate Requirements	Yes	**Complies with Applicable or Relevant and Appropriate Requirements:** – Groundwater PRGs protective of sediment and surface water quality Applicable or Relevant and Appropriate Requirements achieved within the treatment zone. – Remedy design and construction would be performed to assure compliance with action and location-specific Applicable or Relevant and Appropriate Requirements.
Balancing Criteria		
Long-term Effectiveness and Permanence	★★★	**Performs very well:** – Estimate 65 percent of the NAPL source material would be treated using in situ solidification/stabilization and the remaining 20 percent using thermal technology. Less than 15 percent would require treatment using enhanced anaerobic degradation. – NAPL source material in the expanded Core Area physically/chemically converted in situ to a durable and insoluble solid posing limited threat to human health and the environment. In the other target zones, NAPL source material heated to enhance mobility and recovery. – In situ solidification/stabilization technology promotes excellent contact between reagent and contaminated material resulting in high degree of treatment effectiveness in the expanded Core Area. Thermal treatment of NAPL source material present in the other target zones provides for a high level of treatment through use of complementary technologies. – Land use institutional controls would be maintained to prevent intrusion into the in situ solidification/stabilization treatment zone. However, no restrictions on above-grade land use or construction are necessary. – Groundwater use institutional controls would be maintained for the potable portions of the Upper and Lower Aquifers. These controls used at many CERCLA

TABLE 4-7

Detailed Evaluation for Alternative 7 – ISS of Expanded Core Area and Thermal Enhanced Recovery

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Criterion	Rating	Detailed Analysis
		sites, and are expected to be reliable based on site's proposed future recreational use.
Reduction of Toxicity Mobility or Volume through Treatment	★★★	**Performs very well:** – Estimate that 65 percent of the NAPL source material treated using in situ solidification/stabilization and thermal technology. – Toxicity reduced by decreasing the concentration and bioavailability of contaminants present in the NAPL. – NAPL mobility in the expanded Core Area reduced by physically/chemically alternating its characteristics rendering it relatively immobile and insoluble. In the other target zones, NAPL is removed and recovered for offsite thermal destruction. – Volume of NAPL source material present in the expanded Core Area is not reduced and contaminants are not destroyed using in situ solidification/stabilization technology. In the other target zones, significant toxicity, mobility and volume reduction is achieved through direct pumping of NAPL and thermal enhanced recovery and offsite destruction. – Addresses the principal threat (NAPL mobility and toxicity) through mobility reduction (in situ solidification/stabilization), removal (primary and enhanced recovery), and offsite destruction.
Short-term Effectiveness	★★☆	**Performs moderately well:** – Community impacts from heavy construction traffic, extended work hours, and heavy equipment noise associated with in situ solidification/stabilization in the expanded Core Area will occur for 2 years. Impacts from thermal enhanced recovery will occur for about 5 years. – Onsite workers and subcontractors have training and experience that minimize their risks. Work around in situ solidification/stabilization rotational and pressurized equipment poses greater risk to workers but controls will be established. Thermal recovery requires conveyance of high temperature fluids also posing hazards to remedial action workers. – Potential for short-term environmental impacts from heavy equipment use, excavated materials handling, batch plant, ex situ treatment, staging and material reuse along a marine shoreline setting. Dewatering and Upper Aquifer hydraulic containment will reduce potential for environmental impacts to intertidal area and Lower Aquifer. Storm water best management practices would be used control run-on and run-off to minimize effects. – This alternative achieves NAPL mobility reduction performance objective in less than 10 years. Passive groundwater discharge/treatment controls Upper Aquifer water balance and treats residual dissolved phase contaminants prior to discharge.
Implementability	★★☆	**Performs moderately well:** – Deep auger mixing is a mature technology used for remediation and ground improvement applications. Large, heavy equipment will pose mobilization and maneuvering challenges. – In situ solidification/stabilization deployment is relatively straightforward and quality assurance and quality control processes are well developed. – Several in situ solidification/stabilization vendors are available, although none are local.

TABLE 4-7

Detailed Evaluation for Alternative 7 – ISS of Expanded Core Area and Thermal Enhanced Recovery

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Criterion	Rating	Detailed Analysis
		– A mix design, similar to that used at other sites is assumed. Actual mix design will be developed during remedial design. – Primary and enhanced NAPL recovery employs a large number of injection and extraction wells, above ground conveyance piping, and treatment system equipment. Intensive process control monitoring required. – Successful in situ solidification/stabilization implementation is dependent on locating and removing large subsurface debris that could interfere with the equipment. Soil excavation to a depth of 7 feet should lessen the potential for obstructions or debris to interfere with equipment. – The passive groundwater discharge/treatment component uses familiar technology but in an innovative manner.
Present Worth Cost (base year 2016) Discount Rate: 7.0%	$82.4 million	– Capital cost common elements: $51.8 million – Capital cost remedial technology: $52.3 million – Short-term annual operations and maintenance costs: Range from $0.3 million to $5.0 million – Total operations, maintenance, and periodic costs (non-discounted): $21.1 million
Present Worth Cost (base year 2016) Discount Rate: 1.4%	$113.0 million	– Same as above
Breakout (nondiscounted)		
Phase 1	$94.7 million	
Phase 2	$29.9 million	
Modifying Criteria		
State Acceptance		Not evaluated in this FFS report. This criterion will be evaluated during the public comment period to be held following issuance of the Proposed Plan.
Community Acceptance		

Notes:

CERCLA Comprehensive Environmental Response, Compensation, and Liability Act
FFS focused feasibility study
NAPL non-aqueous phase liquid
OU operable unit

TABLE 4-8

Comparative Evaluation of Alternatives

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

<table>
<tr><th>Criterion</th><th>Alternative 1 – No Action</th><th>Alternative 2 - Containment</th><th>Alternative 4 - ISS</th><th>Alternative 5 – Thermal Enhanced Extraction and ISS</th><th>Alternative 6 – Excavation, Thermal Desorption, and Thermal Enhanced Extraction</th><th>Alternative 7 – ISS of Expanded Core Area and Thermal Enhanced Recovery</th></tr>
<tr><td colspan="7">Key Treatment Technologies</td></tr>
<tr><td>Core Area</td><td rowspan="5">Natural attenuation</td><td rowspan="5">Soil cap, hydraulic containment, and ICs</td><td rowspan="5">ISS, soil cap</td><td rowspan="3">Enhanced NAPL recovery, thermal enhanced extraction, EAB</td><td>Upper Core - Excavation, thermal desorption
Lower Core – Enhanced NAPL recovery, thermal-enhanced extraction, EAB</td><td>ISS</td></tr>
<tr><td>East Shallow (LNAPL)</td><td rowspan="3">Enhanced NAPL recovery, thermal-enhanced extraction, EAB</td><td rowspan="3">NAPL recovery, thermal-enhanced recovery, EAB</td></tr>
<tr><td>North Shallow (LNAPL)</td></tr>
<tr><td>North Deep (DNAPL)</td><td>ISS</td></tr>
<tr><td>Other Periphery</td><td>EAB</td><td>EAB</td><td>EAB</td></tr>
<tr><td colspan="7">Percent of NAPL Treated using Key Technology or Technology Pairs</td></tr>
<tr><td>Natural Attenuation</td><td>100</td><td>--</td><td>--</td><td>--</td><td>--</td><td>--</td></tr>
<tr><td>Passive Treatment/Natural Attenuation</td><td>--</td><td>70</td><td>7</td><td>16</td><td>15</td><td>15</td></tr>
<tr><td>Hydraulic Containment</td><td>--</td><td>30</td><td>--</td><td>--</td><td>--</td><td>--</td></tr>
<tr><td>ISS</td><td>--</td><td>--</td><td>93-</td><td>--</td><td>--</td><td>--</td></tr>
<tr><td>Thermal-Enhanced Extraction/ISS</td><td>--</td><td>--</td><td>--</td><td>84</td><td>--</td><td>--</td></tr>
<tr><td>Excavation/Thermal Desorption/Thermal Enhanced Extraction</td><td></td><td>--</td><td>--</td><td>--</td><td>85</td><td>--</td></tr>
<tr><td>ISS/Thermal Enhanced Recovery Treatment</td><td>---</td><td>--</td><td>--</td><td>--</td><td>--</td><td>85</td></tr>
<tr><td colspan="7">Threshold Criteria</td></tr>
<tr><td>Protects HHE</td><td>No</td><td>Yes</td><td>Yes</td><td>Yes</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Complies with ARARs</td><td>No</td><td>Yes</td><td>Yes</td><td>Yes</td><td>Yes</td><td>Yes</td></tr>
</table>

TABLE 4-8

Comparative Evaluation of Alternatives

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

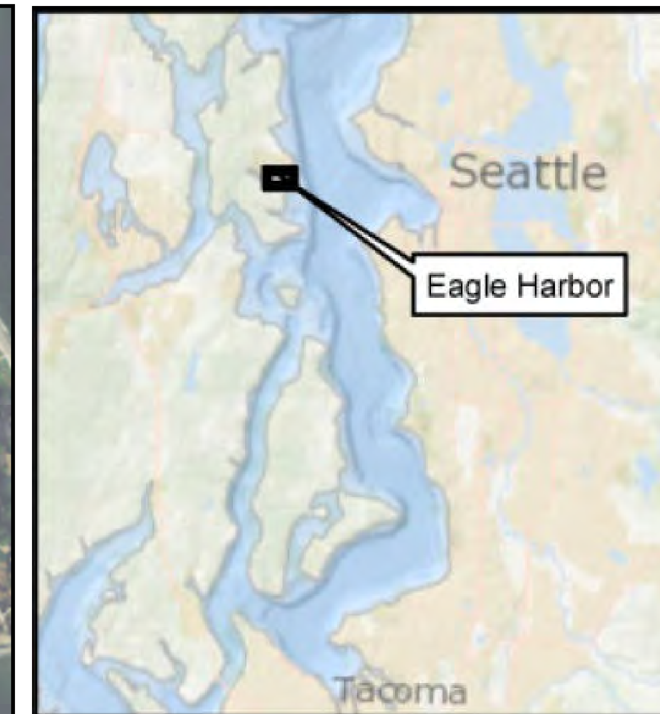
Criterion	Alternative 1 – No Action	Alternative 2 - Containment	Alternative 4 - ISS	Alternative 5 – Thermal Enhanced Extraction and ISS	Alternative 6 – Excavation, Thermal Desorption, and Thermal Enhanced Extraction	Alternative 7 – ISS of Expanded Core Area and Thermal Enhanced Recovery
Balancing Criteria						
Long-term Effectiveness and Permanence	Not evaluated	★☆☆	★★★	★★★	★★★	★★★
Reduction of TMV through Treatment	Not evaluated	★☆☆	★★★	★★★	★★★	★★★
Short-term Effectiveness		★★☆ O&M limited to 100 years	★★☆	★★☆	★★☆	★★☆
Implementability		★★☆	★★☆	★☆☆	★☆☆	★★☆
Cost (millions)						
Total Present Worth Cost – 7.0% discount	$0	$52.0	$88.6	$120.1	$161.5	$82.4
Total Present Worth Cost – 1.4% discount	$0	$79.8	$93.7	$142.1	$197.7	$113.0
Total Non-discounted Cost	$0	$111.0	$95.4	$149.6	$210.0	$124.6
Modifying Criteria						
State Acceptance	Not evaluated in this FFS					
Community Acceptance						

★★★ = The alternative performs very well against the CERCLA balancing criterion with minimal disadvantages or uncertainties

★★☆ = The alternative performs moderately well against the CERCLA balancing criterion but with some disadvantages or uncertainties

★☆☆ = The alternative performs less well against the CERCLA balancing criterion with more disadvantages or uncertainty

Figures



LEGEND

Approximate Operable Unit (OU) Boundaries

- OU-1 FFS Project Area
- OU2/OU4 FFS Boundary
- OU2/OU4 Project Area
- Harbor Boundary
- PZ-11 Monitoring Well
- Approximate Area of Soil Removal Around Monitor Well PZ-11
- Fence

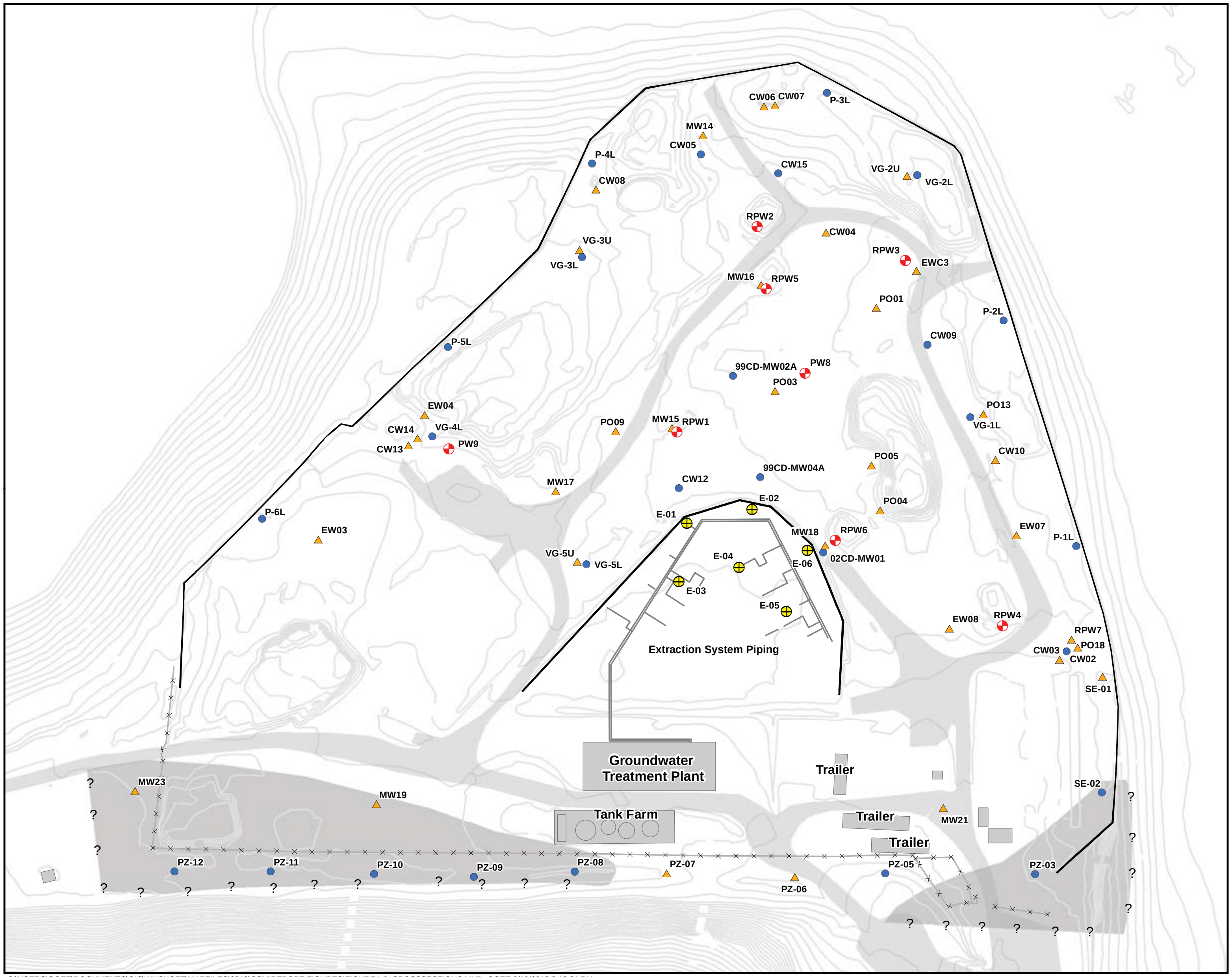
Sources:
Operable Units approximated from Superfund Fact Sheet Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington (USEPA, 1999).

N

0 250 500 1,000 Feet

Figure 1-1
Location of Operable Units
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, WA

C:\USERS\GGEE\DOCUMENTS\GIS\WYCKOFF\MAPFILES\2014\SOIL AND GROUNDWATER OU NAPL - FFS\FIGURE1-1_WYCKOFFOUS_101915.MXD GGEE 10/19/2015 11:26:44 AM



LEGEND

Well Locations

- Monitoring Well, Upper Aquifer
- Monitoring Well, Lower Aquifer
- Extraction Well, Upper Aquifer
- Steam Pilot Well, Upper Aquifer

Existing Site Features

- Current Structures
- Current Buildings
- Current Roads
- Fence
- Pipelines
- Pilot Study Containment Wall
- Sheet Pile Wall
- Ground Surface Contours (ft MLLW)
- Aquitard Thin (<4 ft) to Absent

N

0 50 100 200 Feet

Figure 1-2
Site Map
2013 Conceptual Site Model Update for the Former Process Area
Wyckoff/Eagle Harbor Superfund Site

C:\USERS\GGEE\DOCUMENTS\GIS\WYCKOFF\MAPFILES\2013\CSM\REPORT FIGURES\FIGURE4-6_CROSSSECTIONS.MXD GGEE 9/19/2013 3:13:21 PM

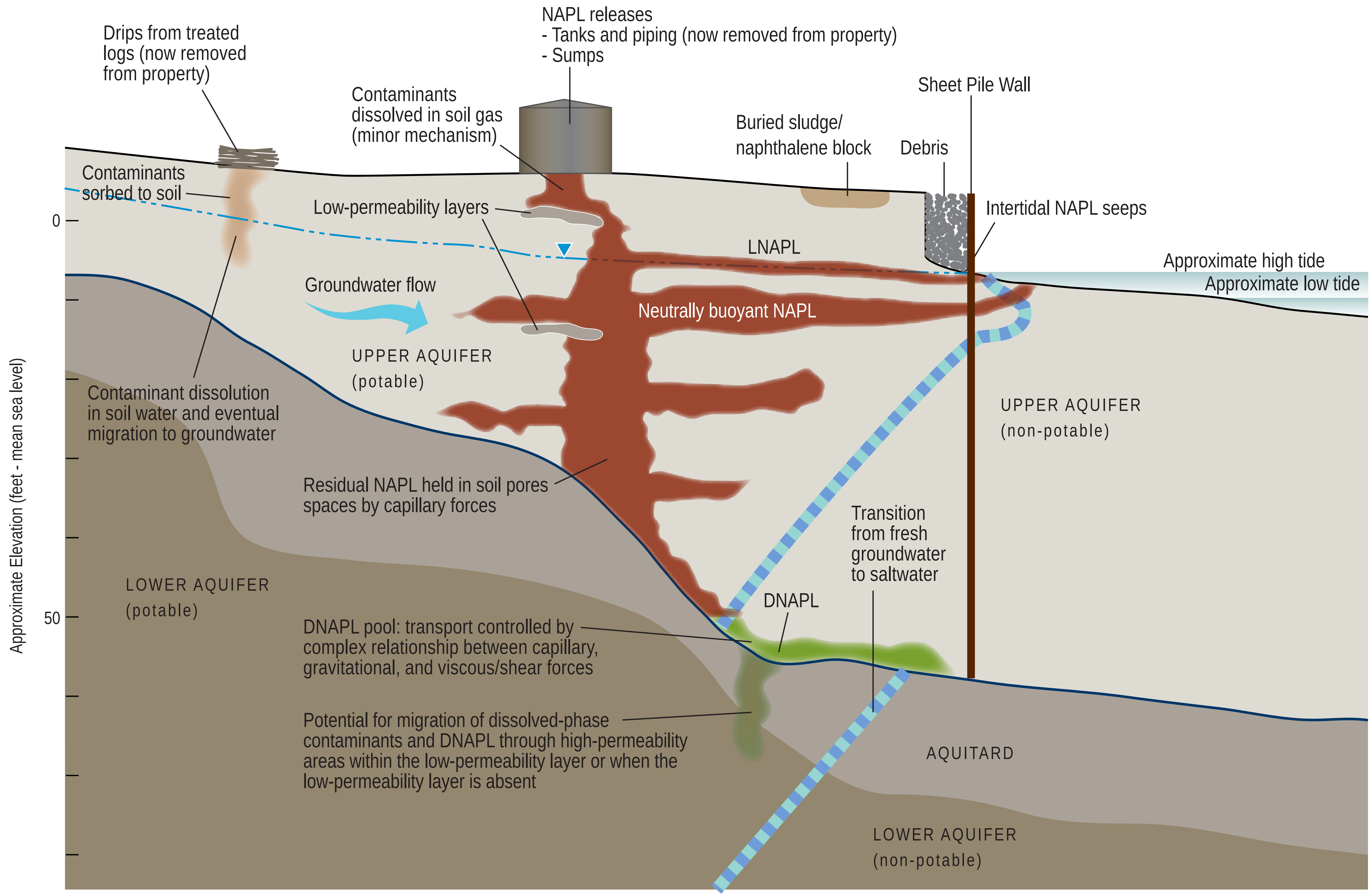
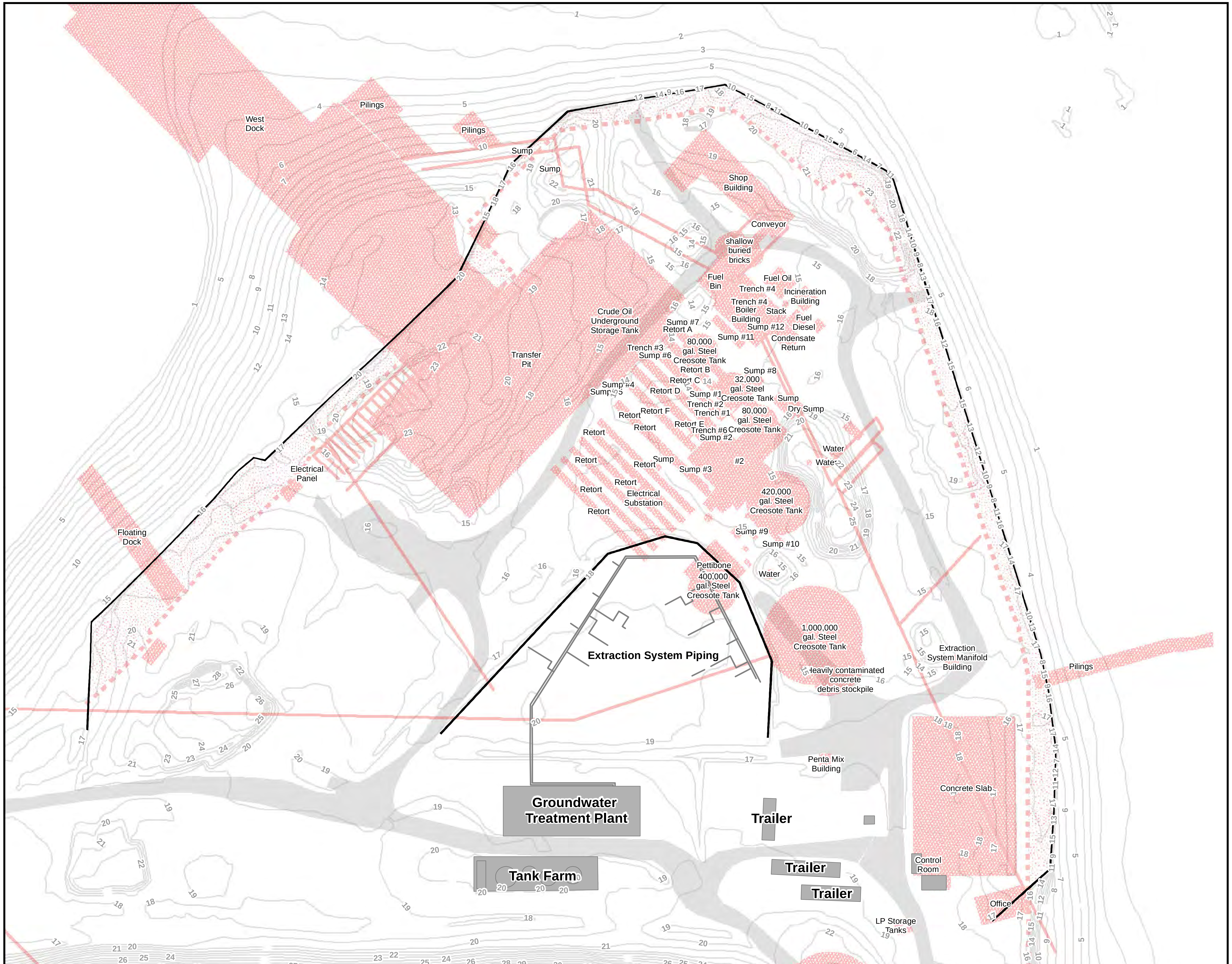


Figure 1-3
Conceptual Hydrologeologic Model for Soil and Groundwater Operable Unit
Wyckoff OU-2/OU4 and OU-1
Bainbridge Island, WA

CH2MHILL

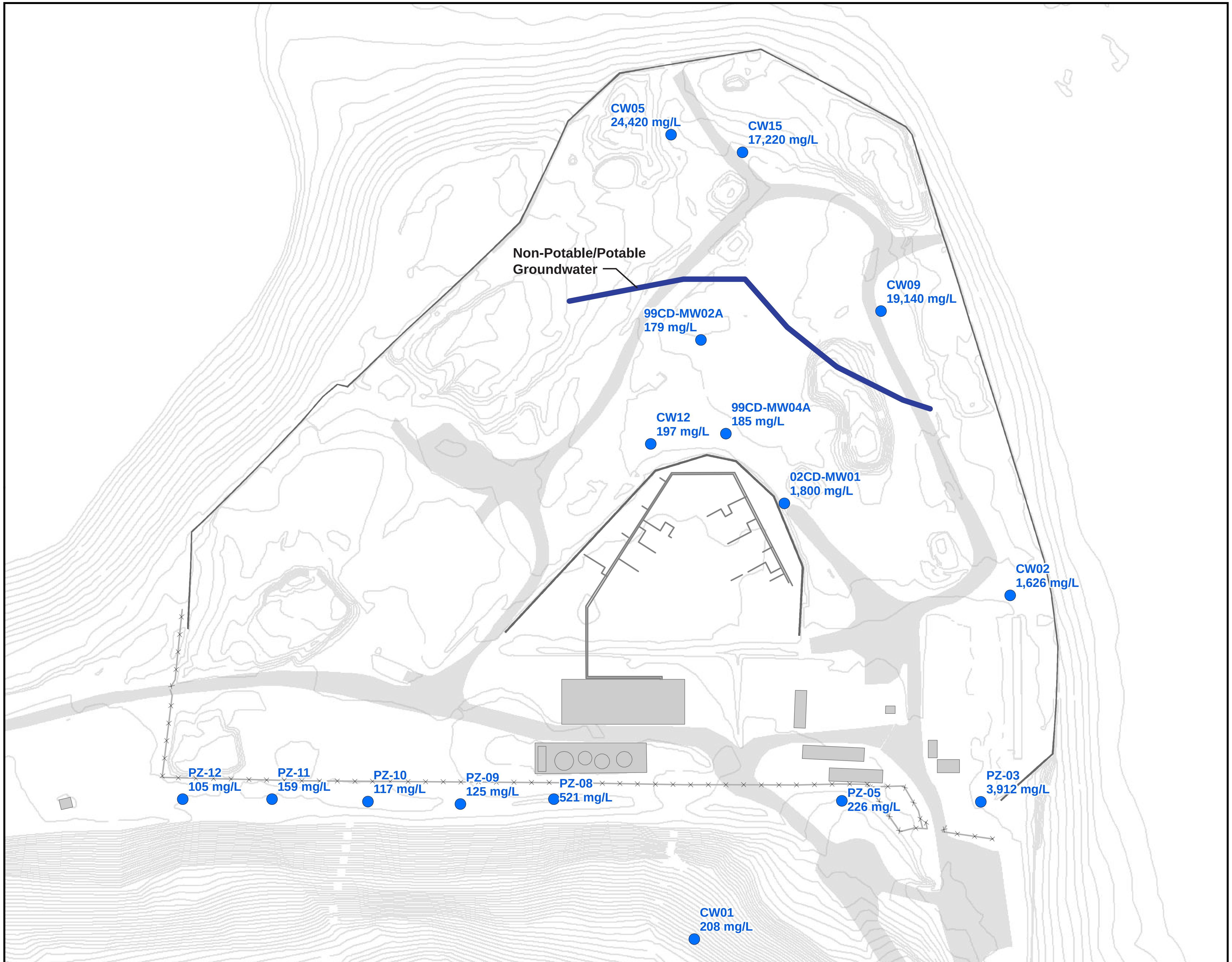


LEGEND

- Potential remaining foundations
- Potential buried features
- Old bulk head
- Debris fill between old bulk head and sheet pile wall
- Current structures
- Sheet pile wall
- Pipelines
- Current roads
- Ground surface contours (ft MLLW)

Figure 1-4
Potential Foundation Locations
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, WA

C:\USERS\GGEE\DOCUMENTS\GIS\WYCKOFF\MAPFILES\2014\SOIL AND GROUNDWATER OU NAPL - FFS\FIGURE1-4_POTENTIALFOUNDATIONLOCATIONS.MXD GGEE 9/18/2014 1:10:57 PM



LEGEND

Lower Aquifer well and calculated TDS (mg/L)

Existing site features

Current structures
Current buildings
Current roads
Fence
Pipelines
Pilot study containment wall
Sheet pile wall
Ground surface contours (ft MLLW)

Labels

CW09 Well ID
19,140 mg/L Calculated TDS (mg/L)

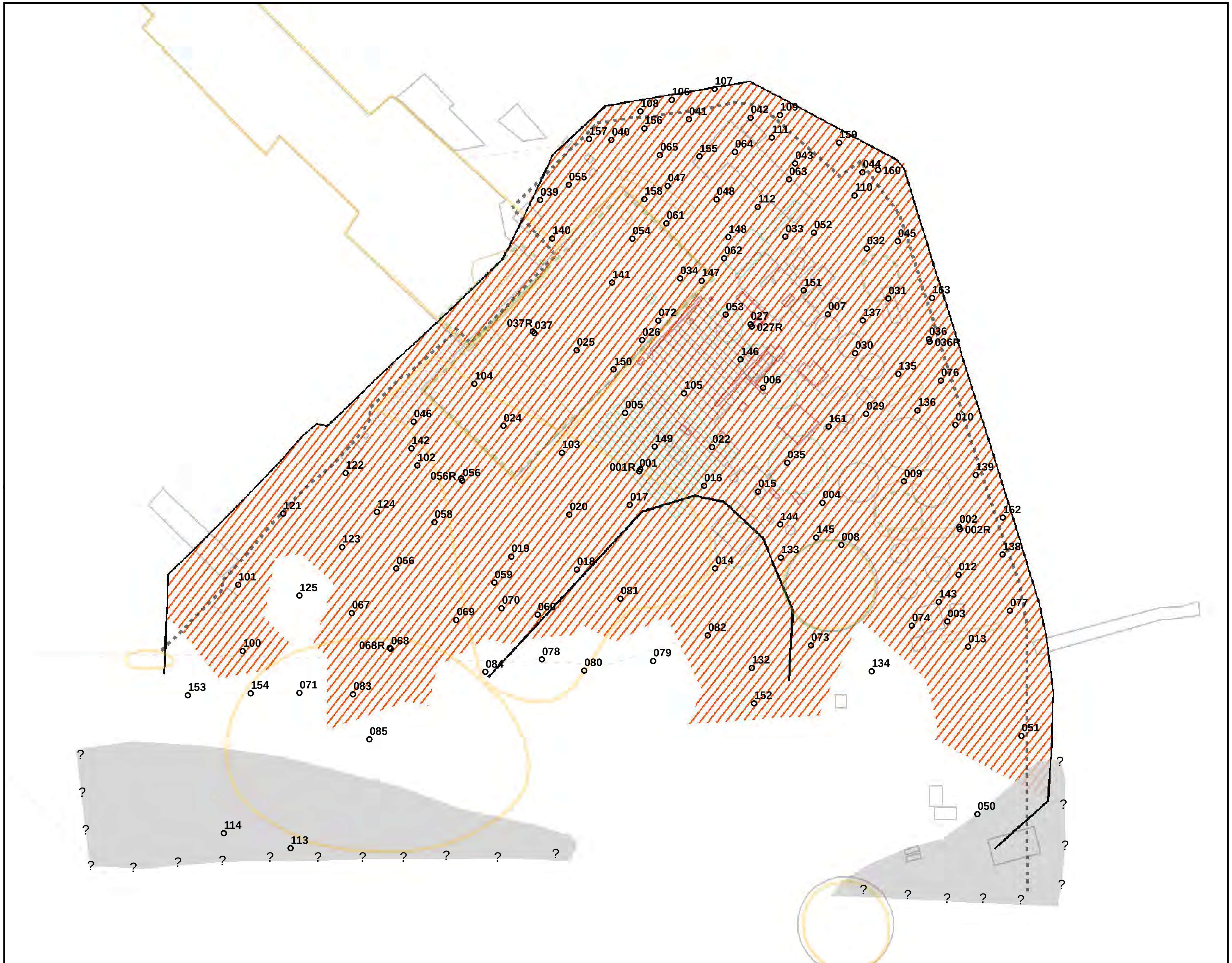
Note:
TDS = Total dissolved solids
mg/L = milligrams per Liter

N

0 50 100 200 Feet

Figure 1-5
Lower Aquifer Total Dissolved Solid Concentrations
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wykcoff/Eagle Harbor Superfund Site, Bainbridge Island, WA

C:\USERS\GGEE\DOCUMENTS\GIS\WYCKOFF\MAPFILES\2014\SOIL AND GROUNDWATER OU NAPL - FFS\FIGURE1-5_CALCULATEDTDS.MXD GGEE 9/18/2014 1:14:47 PM



LEGEND

Remedial action target area for Upper Aquifer (TarGOST >= 10%RE)

TarGOST Location

Historic features and potential source areas

Historic features

Historic features identified from 1917 Sanborn map

Trenching and other features of interest identified in April 1989 map

Site remediation excavation performed in 1992 through 1994

Potential primary NAPL sources (sumps, trenches, and other features with observed contamination)

Potential secondary NAPL source areas

Bulk head prior to current sheet pile wall

Current outer and inner sheet pile wall

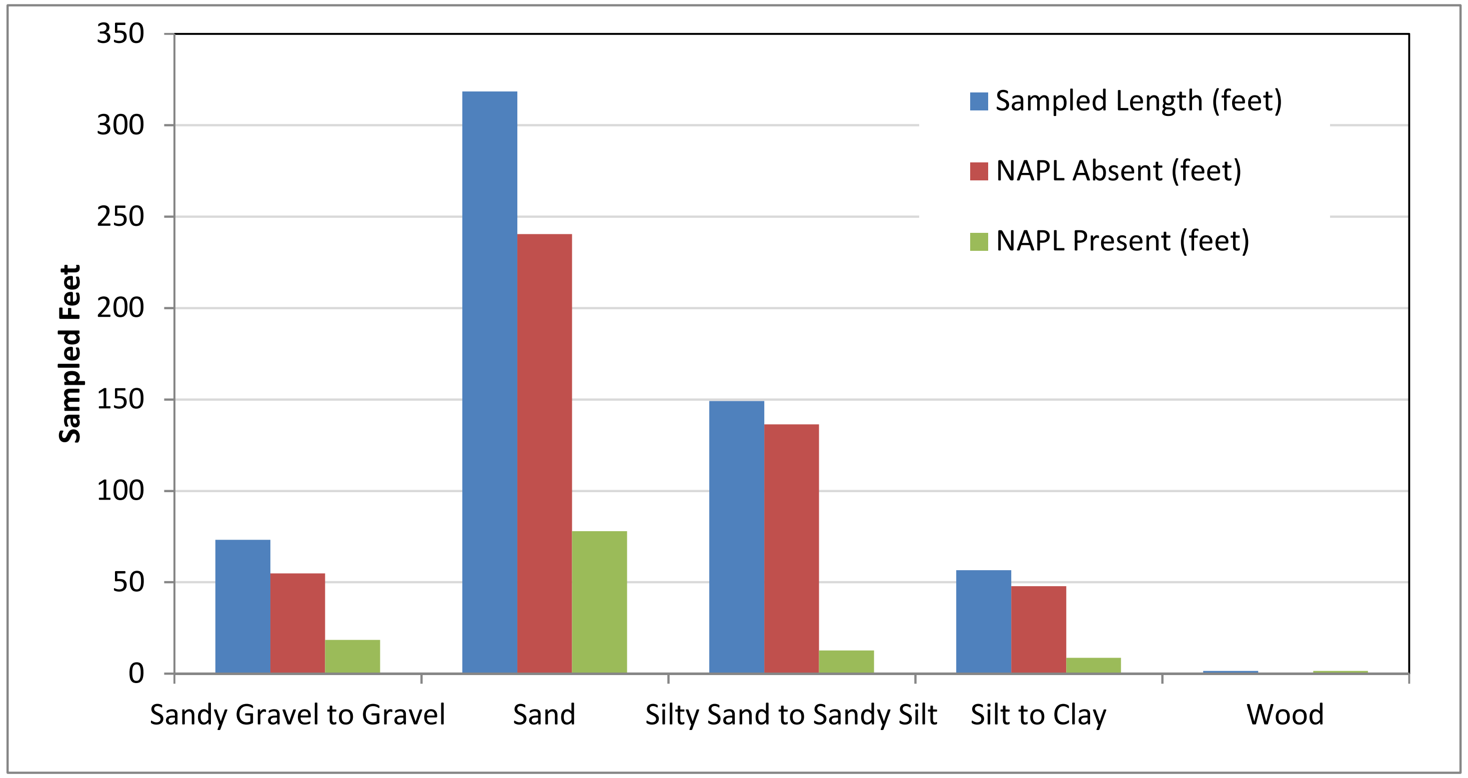
Aquitard thin (<4 ft) to absent

Sources:
Bulk Head Prior to Current Sheet Pile Wall digitized from current sheet pile wall design drawings (USACE, 2000)
Some sumps and trenches were digitized from "Figure 1 Site Location" (Environment and Ecology, 1995)
Sumps and Trenches were digitized from "Figure B Area 1 Trenches and Sumps"; "Figure C Area 2 Drums, Sumps, 7 Tanks"; "Figure D Area 3 Containers, Drums, Sumps, Tanks & Trenches" (Environment and Ecology, 1995)
Secondary NAPL Source Locations digitized from "Figure 2-1 Wycoff Site Vicinity Map" (CH2M HILL, 1993)
Trenching observations digitized from 1989 hand markup.
Prioritizing of source areas conducted 2012.
Prior remediation excavation areas from 1992 through 1994 digitized from Ecology and Environment, Inc., 1995.

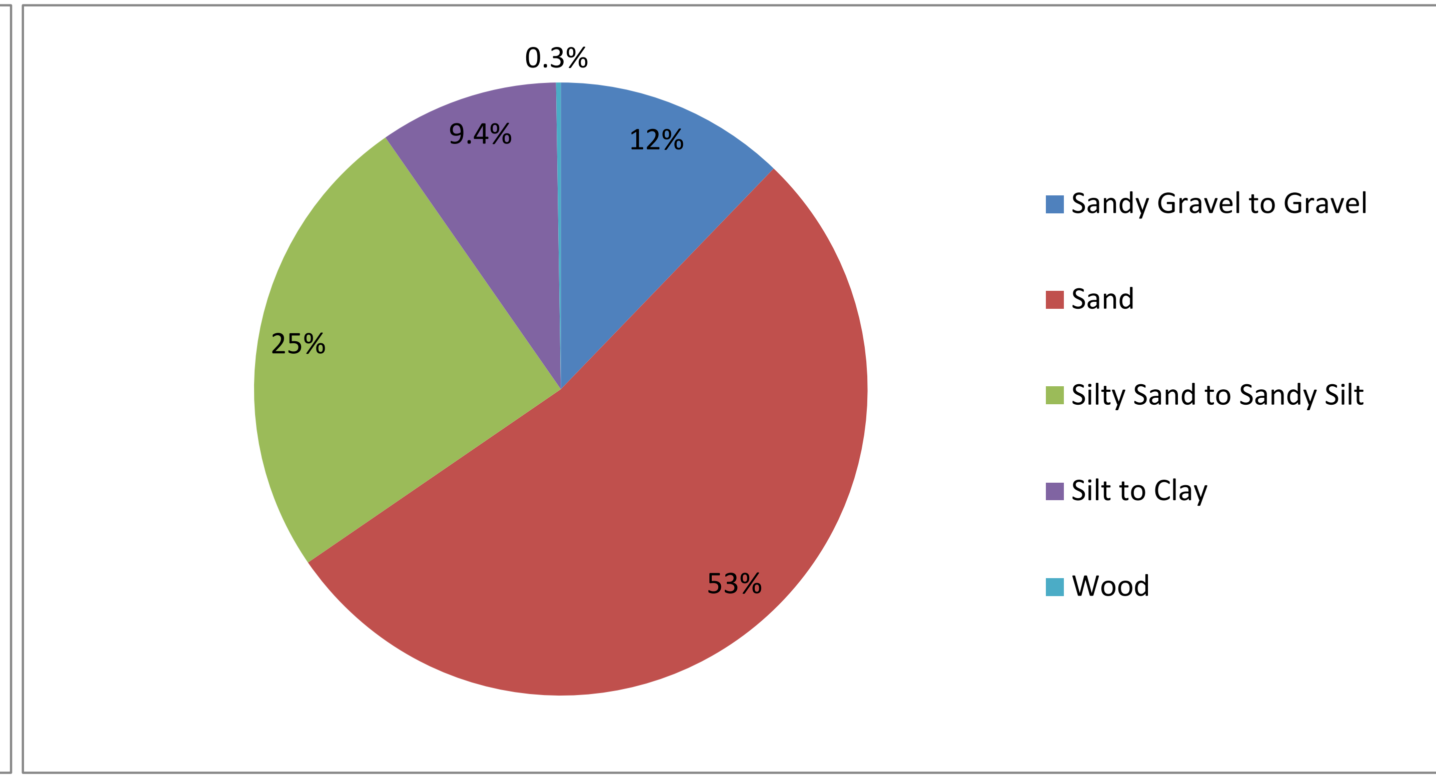
N

0 50 100 200 Feet

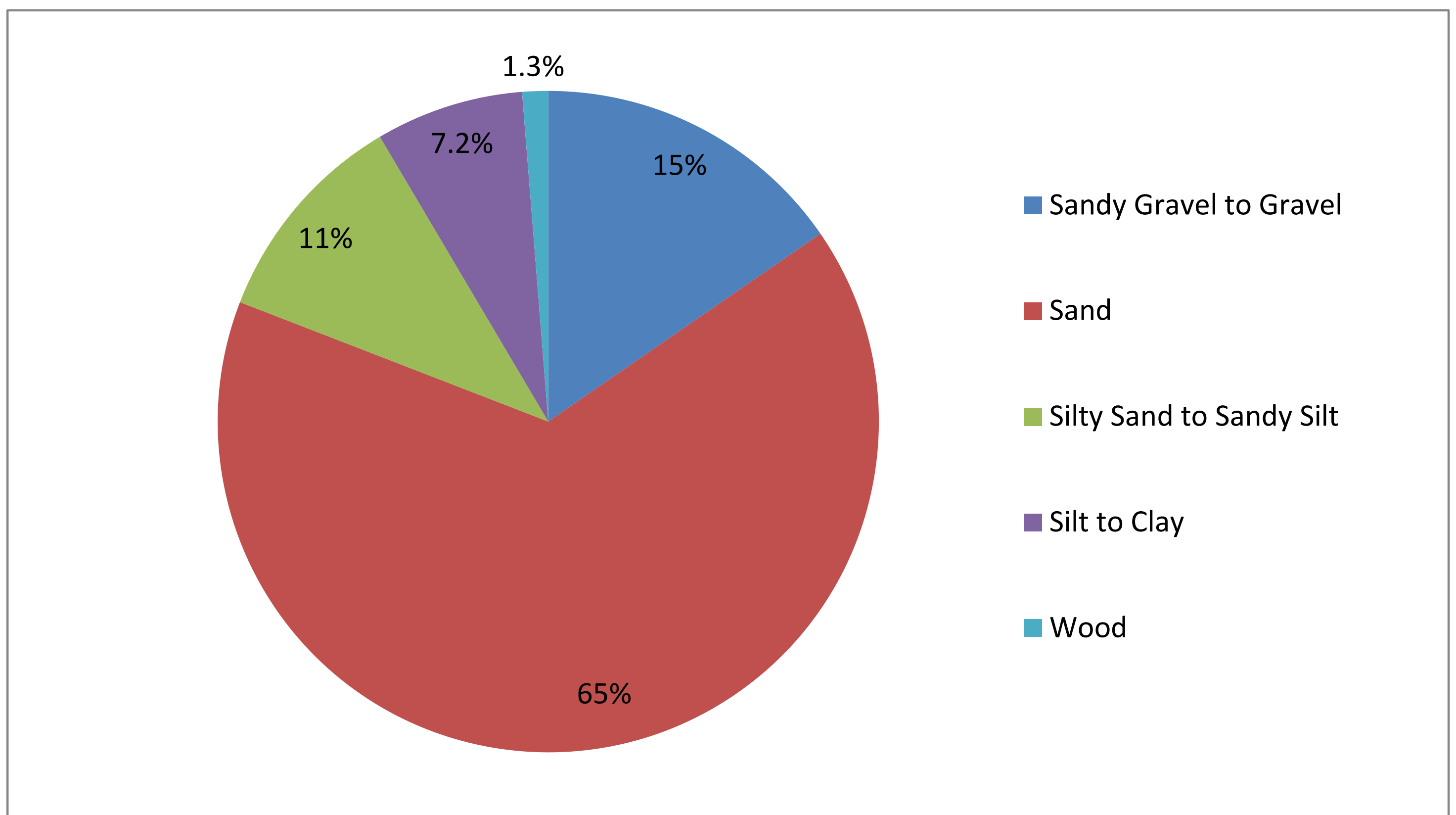
Figure 1-6
Former Process Area TarGOST Boring Locations and NAPL Remedial Action Target Area
Soil and Groundwater OUs (OU2/OU4) NAPL FFS *Wyckoff/ Eagle Harbor Superfund Site, Bainbridge Island, WA*



Summary of Lithology and NAPL Absence/Presence by feet



Summary of Lithology by Percentage of Confirmation Boring Footage

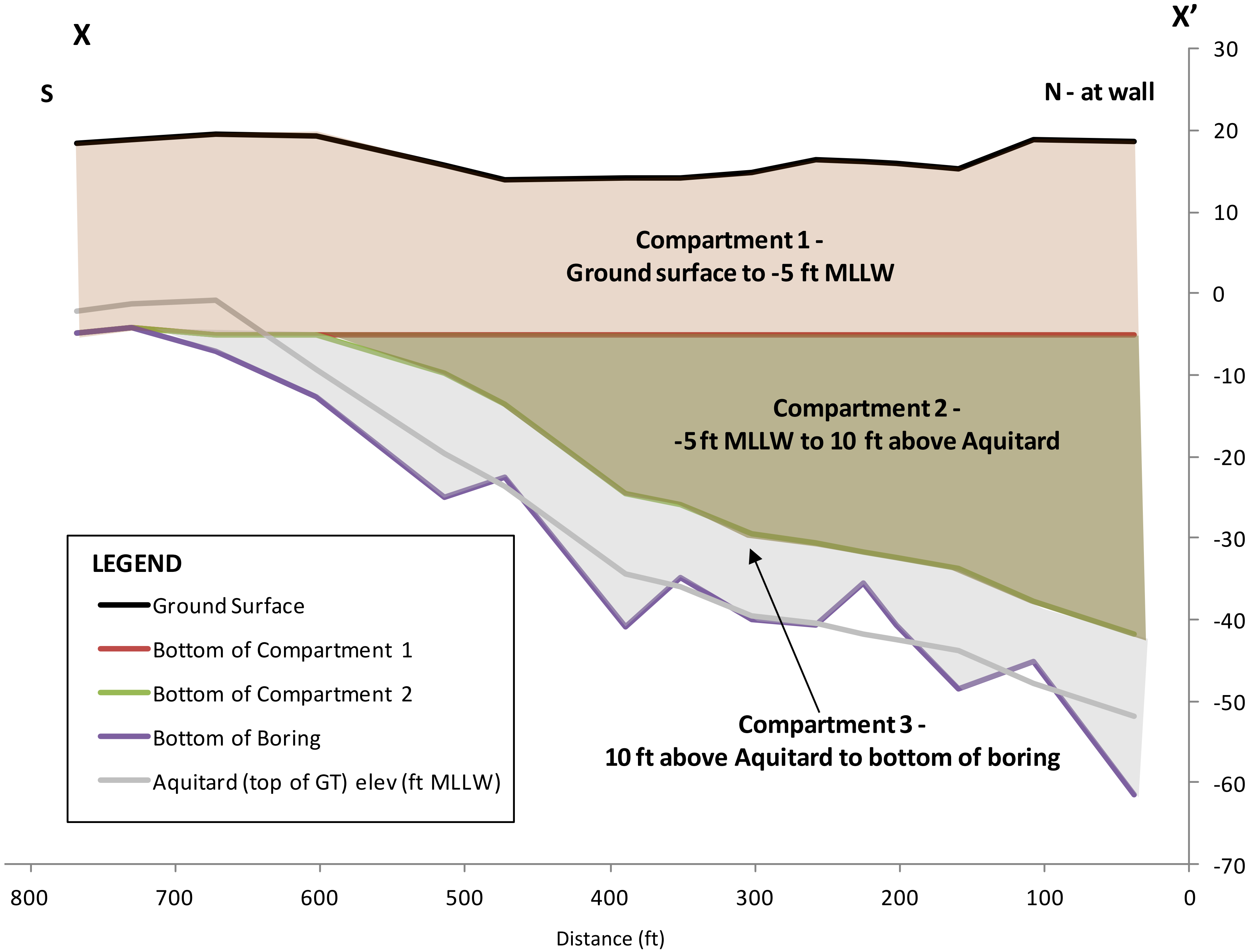


Summary of NAPL Presence in Lithology by Total Observed NAPL

Data Table

Lithology	Sampled Length (feet)	NAPL Absent (feet)	NAPL Present (feet)
Sandy Gravel to Gravel	73	55	18
Sand	318	240	78
Silty Sand to Sandy Silt	149	136	13
Silt to Clay	56	48	8.6
Wood	1.5	0.0	1.5
Grand Total	**598**	**479**	**119**

Figure 1-7
Confirmation Boring Lithology and NAPL Observations
by Selected USCS Soil Classes
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, WA



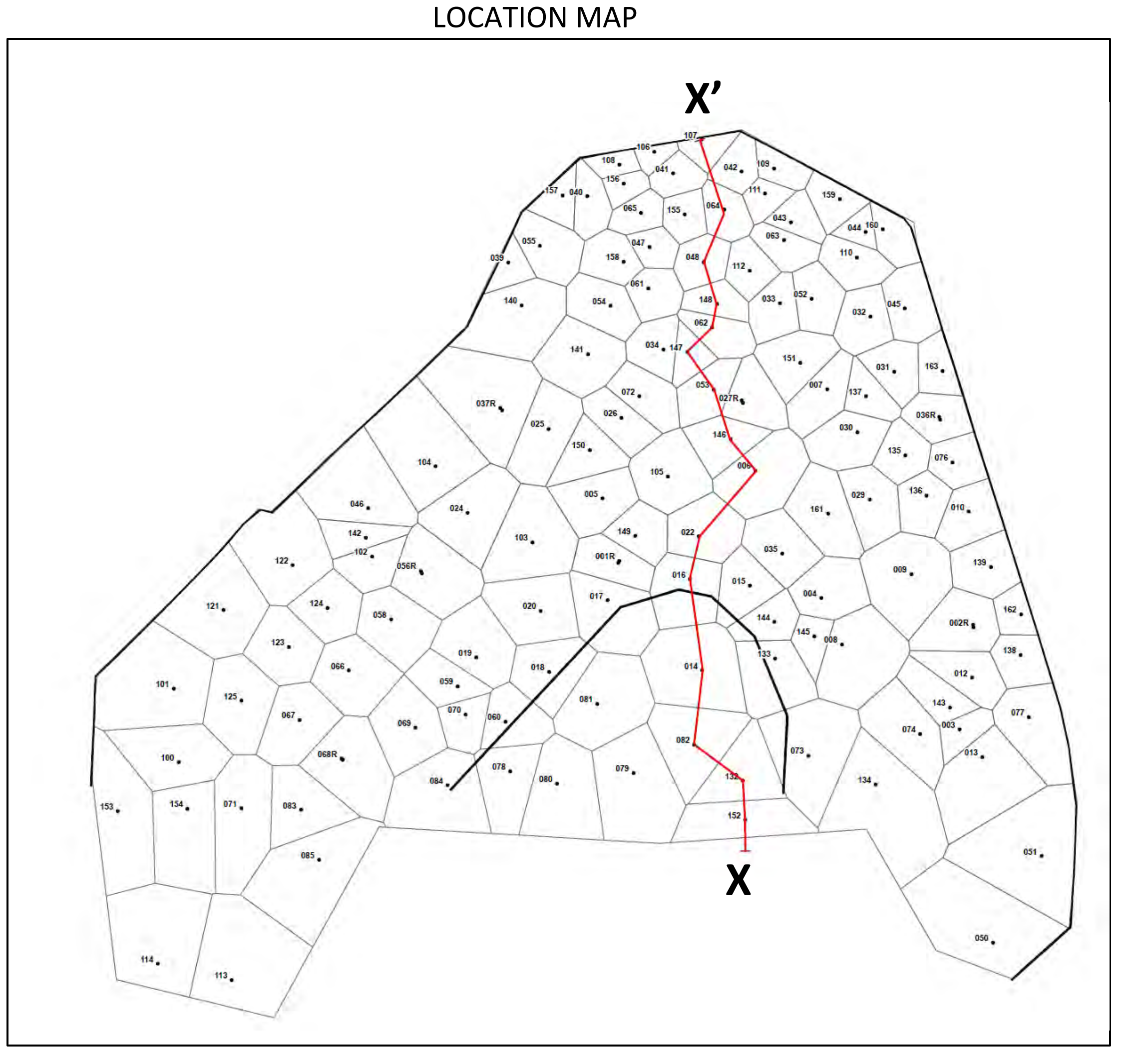
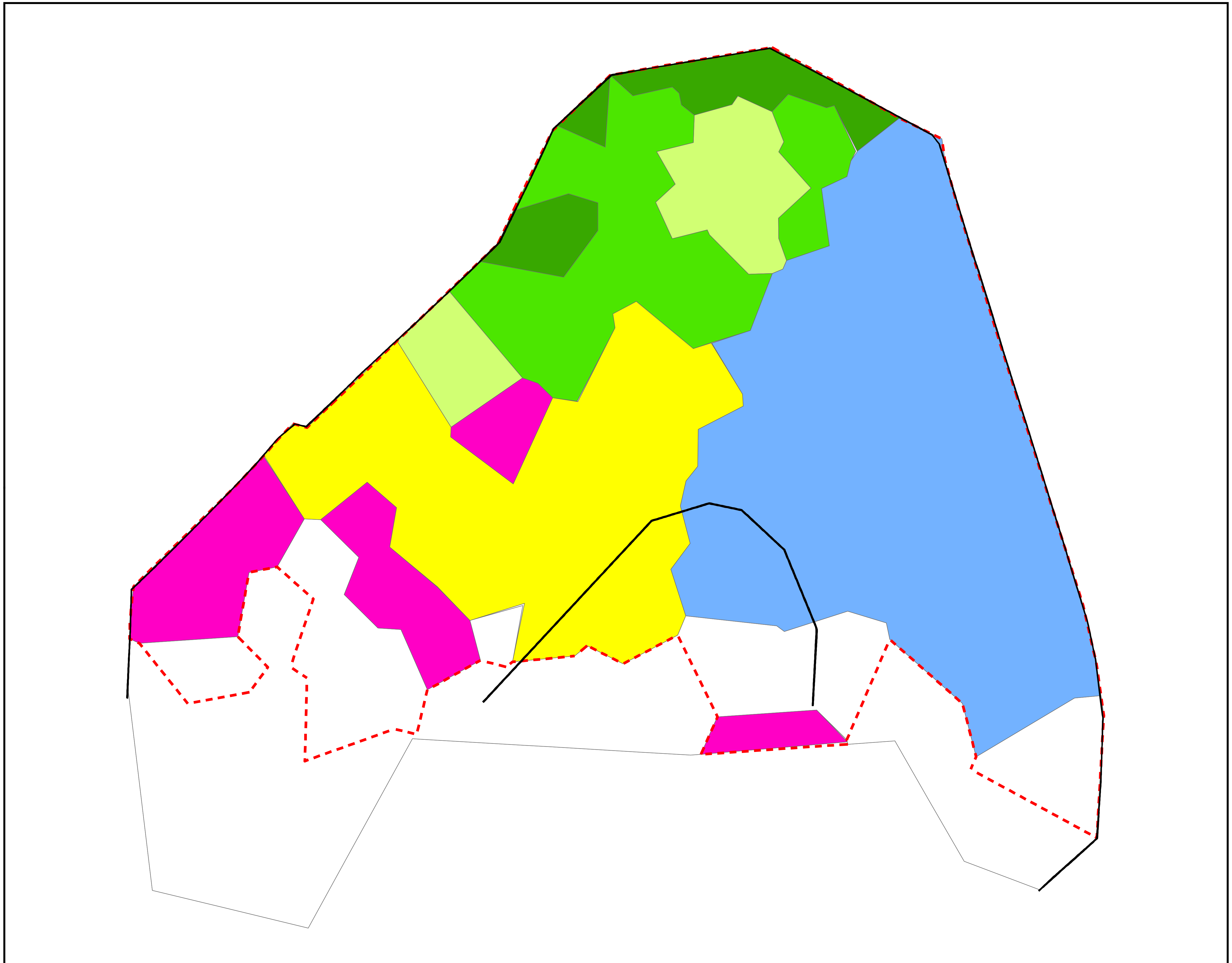


Figure 1-8
Fence Diagram Illustrating Compartment Thicknesses
in Upland Area
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, WA



LEGEND

Outline of periphery area

Core and periphery sub-area identification

Core Area

East Shallow (LNAPL) Periphery Sub-area

North Deep (DNAPL) Periphery Sub-area

North Shallow (LNAPL) Periphery Sub-area

North Shallow & Deep Periphery Sub-area Overlap

Other Periphery Sub-area

No Treatment Area

Current outer and inner sheet pile wall

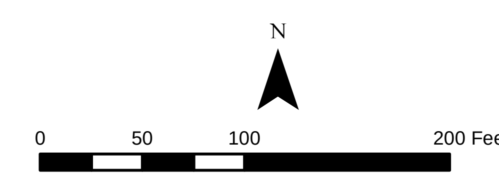


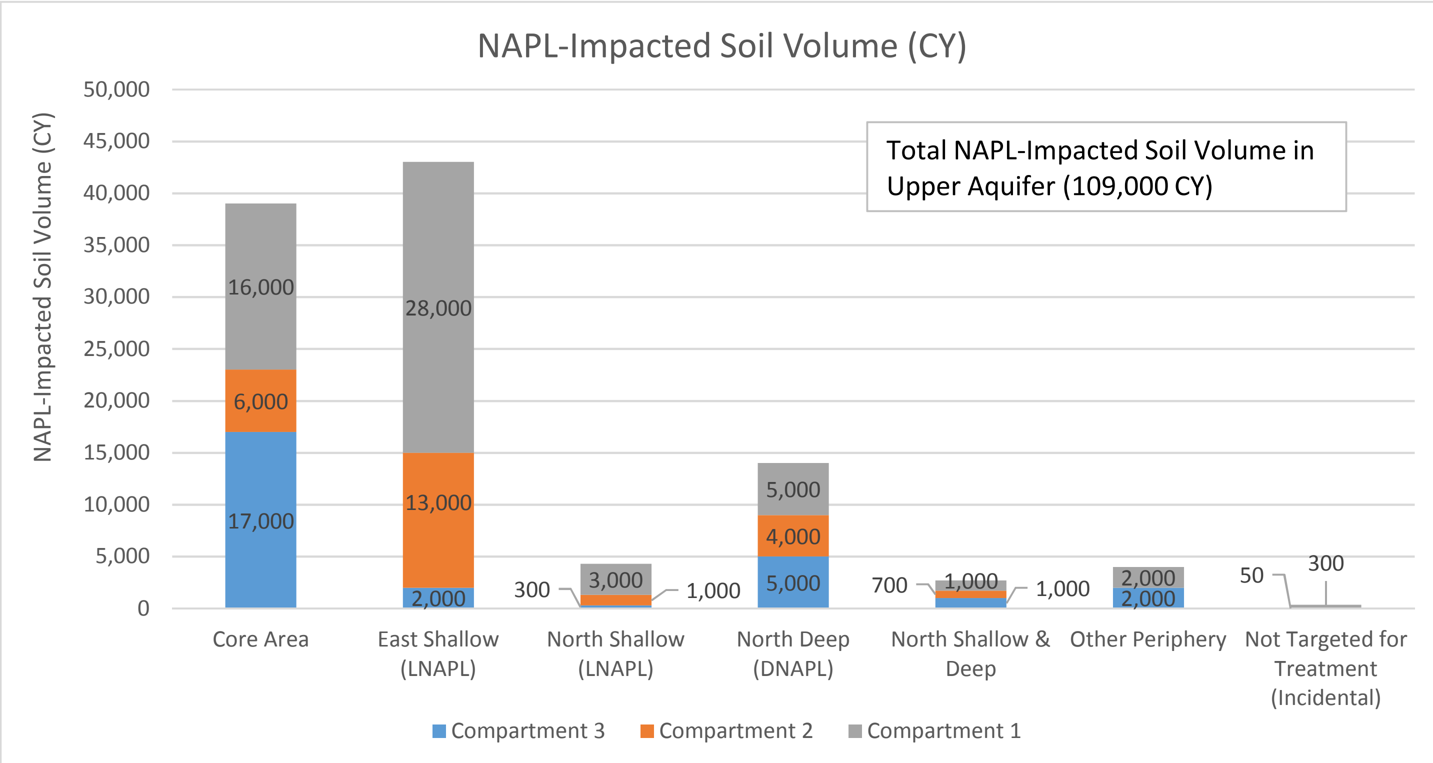
Figure 1-9

NAPL Remedial Action Target Zones

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, WA

C:\USERS\GGEE\DOCUMENTS\GIS\WYCKOFF\MAPFILES\2014\SOIL AND GROUNDWATER OU NAPL - FFS\FIGURE1-9_COREVPERIPHERYSUBAREASREV.MXD GGEE 9/18/2014 1:59:17 PM



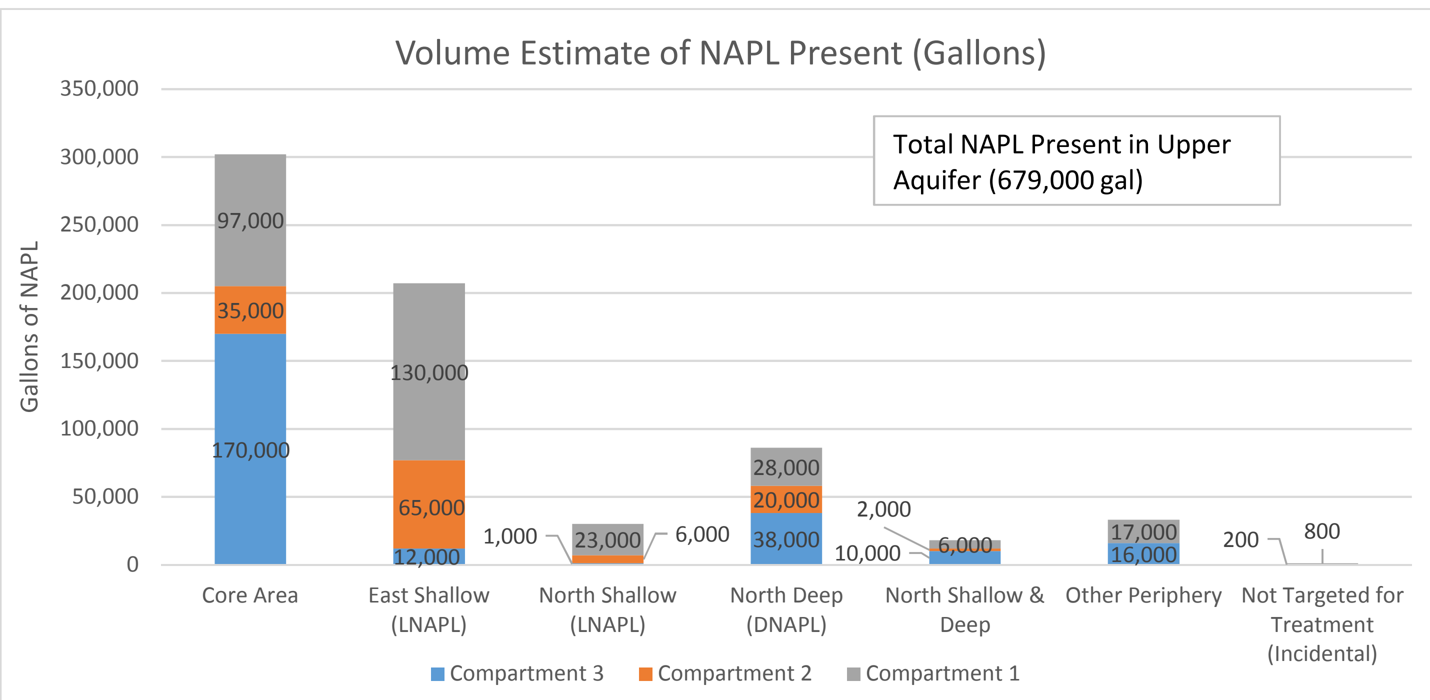
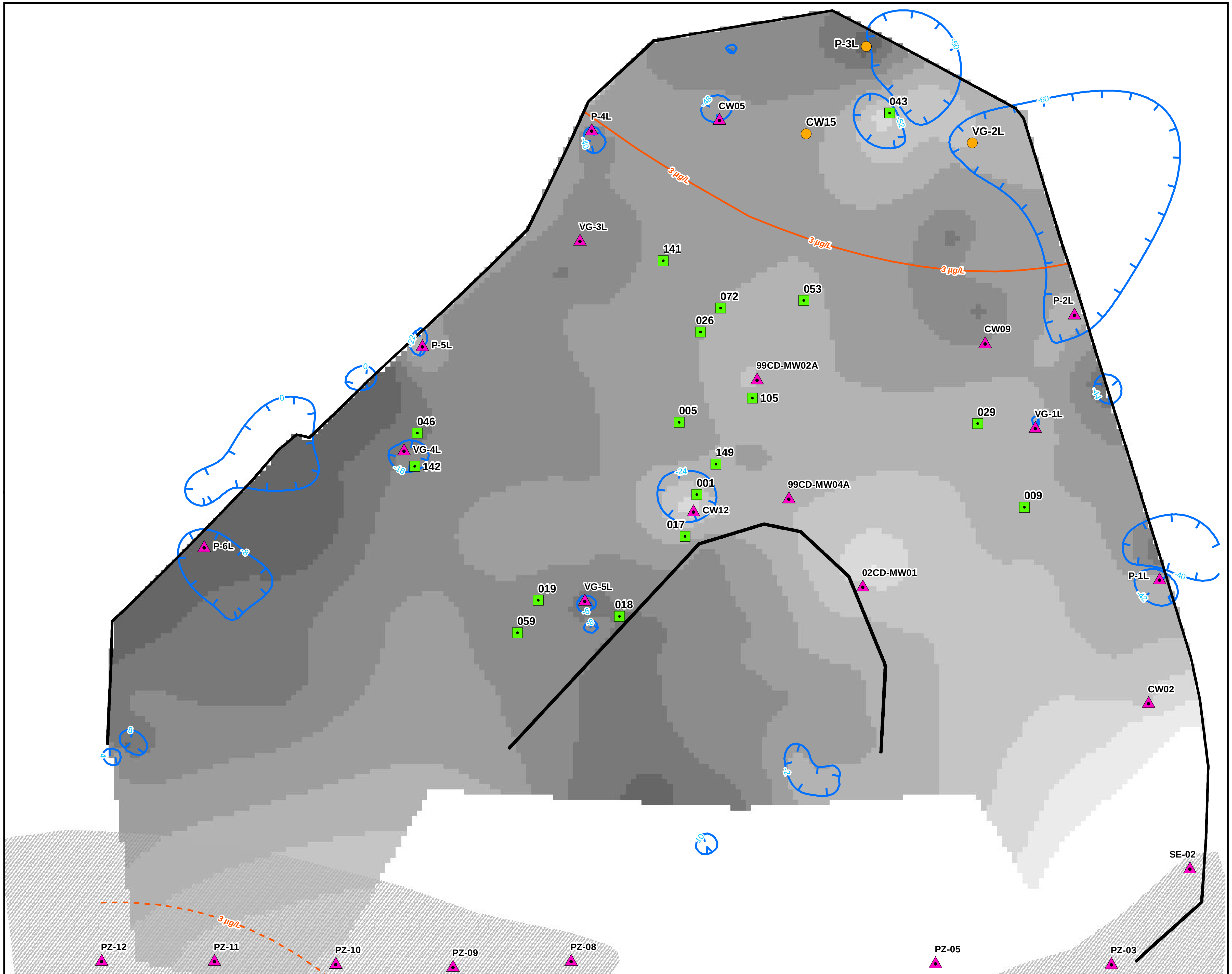


Figure 1-10
NAPL Quantities in Upper Aquifer Remedial Action Target Zones
Wyckoff Soil and Groundwater OU FFS
Bainbridge Island, WA



LEGEND

- TarGOST location where NAPL pool height at aquitard > 9.4 feet
- Lower Aquifer well with observed NAPL presence
- Lower Aquifer well
- Acenaphthene isopleth (3 µg/L)
- Inferred acenaphthene isopleth (3 µg/L)
- Aquitard surface depressions

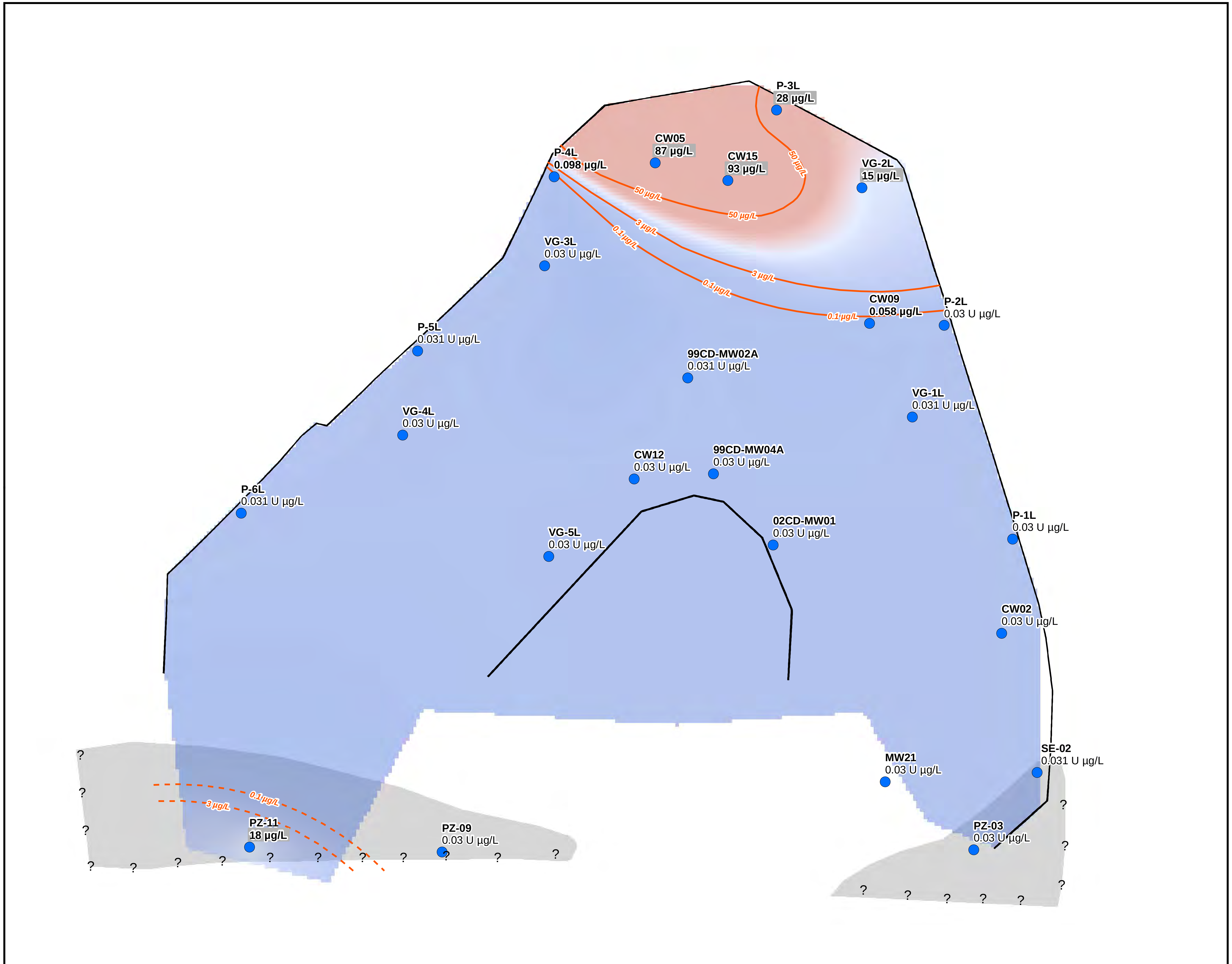
Aquitard thickness (ft MLLW)

- <0
- 0 - 5
- 5 - 10
- 10 - 15
- 15 - 20
- 20 - 25
- 25 - 30
- 30 - 35
- >35
- Aquitard thin (<4 ft) to absent

Notes:
Acenaphthene groundwater cleanup level of 3.0 µg/L established in the Wyckoff ROD 2/2000.
µg/L = micrograms per Liter
ft MLLW = feet mean low low water

Figure 1-11
Aquitard Observations for Assessing Potential for NAPL Migration to Lower Aquifer
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, WA

C:\USERS\GGEE\DOCUMENTS\GIS\WYCKOFF\MAPFILES\2014\SOIL AND GROUNDWATER OU NAPL - FFS\FIGURE1-10_AQUITARD.MXD GGEE 9/18/2014 2:03:00 PM



LEGEND

- Acenaphthene measured May 2013 (µg/L)
- Acenaphthene isopleth (0.1, 3, and 50 µg/L)
- Inferred acenaphthene isopleth
- Current sheet pile wall
- Aquitard thin (<4 ft) to absent

Interpolated acenaphthene concentration (µg/L)

High : 90

Low : 0

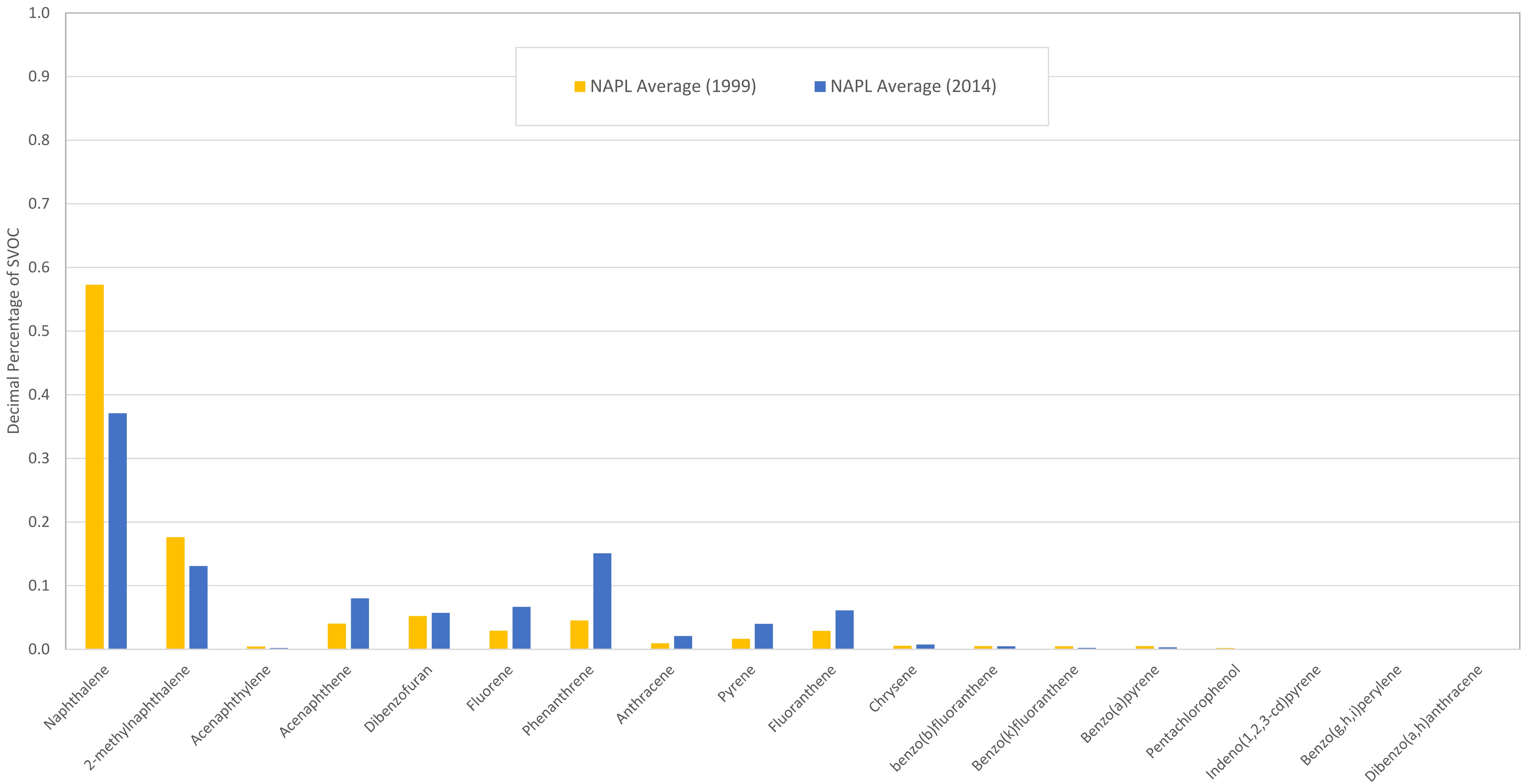
Notes:
Bold values = acenaphthene was detected in well.
Shaded/Bold values = acenaphthene exceeds groundwater cleanup level of 3.0 µg/L established in the Wyckoff ROD 2/2000.
µg/L = micrograms per Liter

N

0 50 100 200 Feet

Figure 1-12
Lower Aquifer Acenaphthene Concentration Isopleths - May 2013
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, WA

C:\USERS\GGEE\DOCUMENTS\GIS\WYCKOFF\MAPFILES\2014\SOIL AND GROUNDWATER OU NAPL - FFS\FIGURE1-11_ACENAPHTHENE.MXD GGEE 9/18/2014 2:06:07 PM



Notes: 1999 upland NAPL samples were collected as part of the USACE 2000 field exploration activities (USACE, 2000).
Datasets were evaluated using the EPA Fingerprint Analysis of Leachate Contaminants (FALCON, EPA 2004) analysis to identify the chemical signature of the NAPL samples.

Figure 1-13

NAPL Fingerprint Comparison between 1999 and 2014 Average Data

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, WA

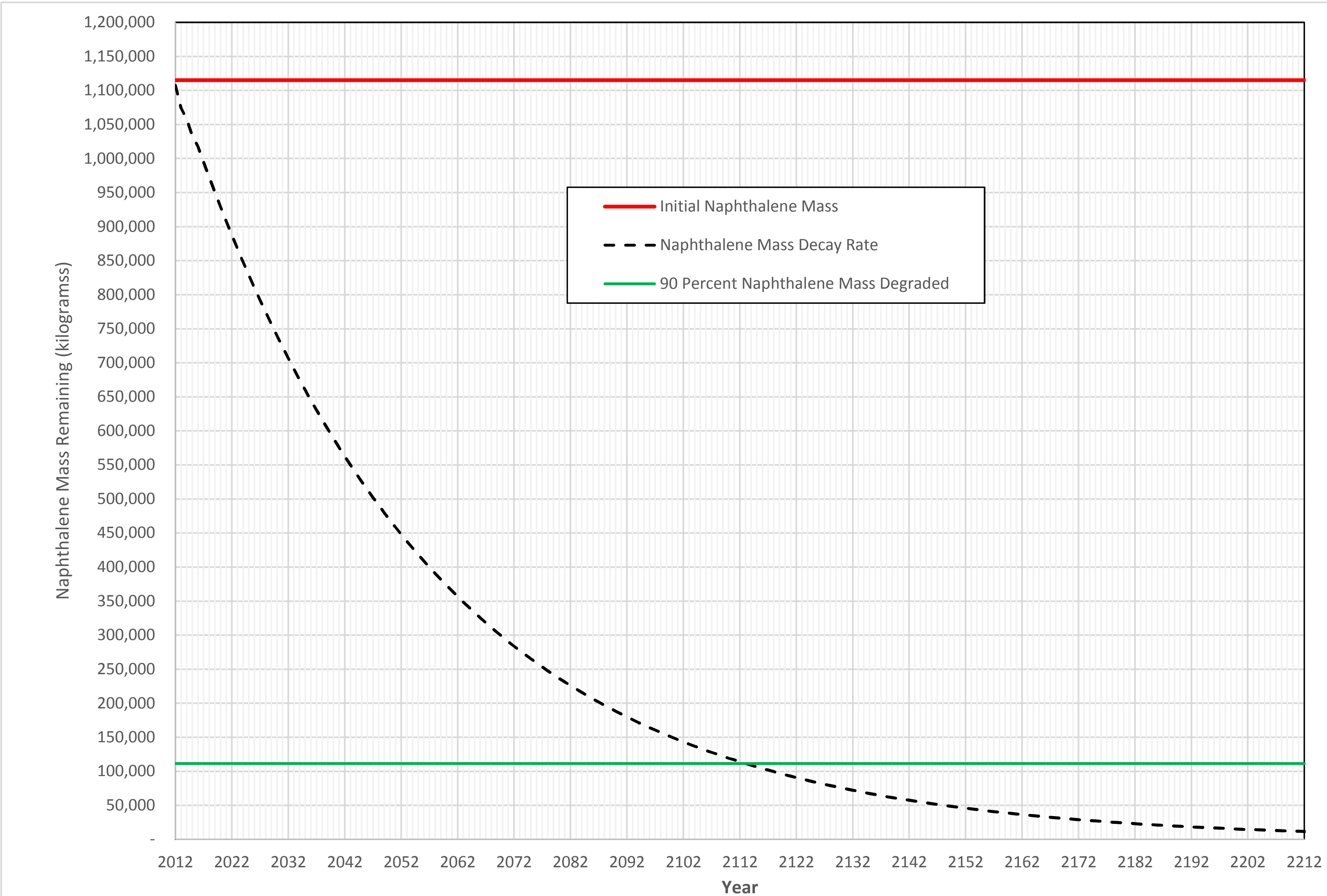
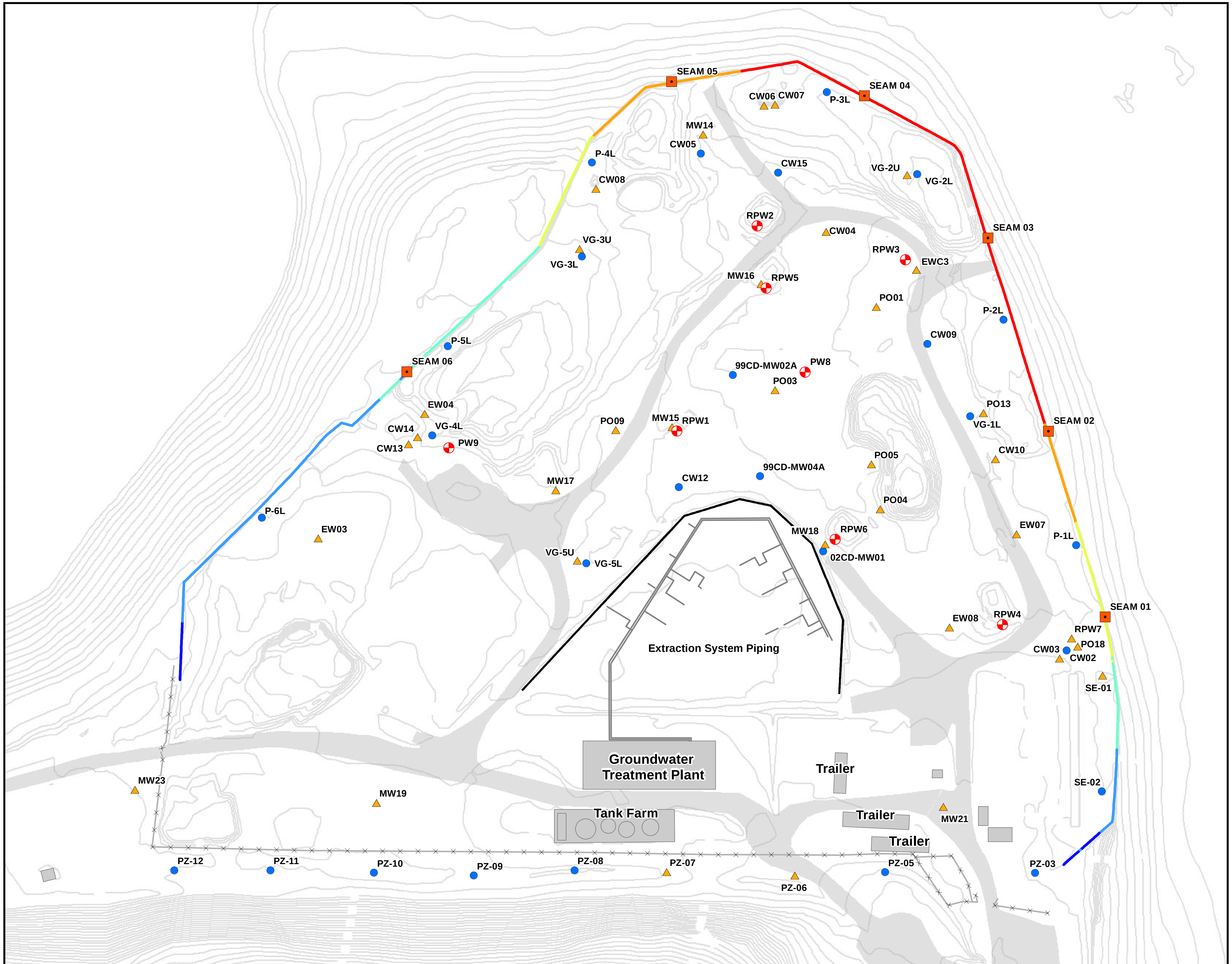


Figure 1-14
Naphthalene Mass Decay Projection
Wyckoff Soil and Groundwater OU FFS
Bainbridge Island, WA



LEGEND

Well locations

- Monitoring well, Upper Aquifer
- Monitoring well, Lower Aquifer
- Extraction well, Upper Aquifer
- Sheet pile wall seams

Sheet pile wall

(color coded by driven elevation ft MLLW)

- -79 - -65
- -64 - -55
- -54 - -45
- -44 - -35
- -34 - -25
- -24 - -15

Existing site features

- Current structures
- Current buildings
- Current roads
- Fence
- Pipelines
- Pilot study containment wall
- Sheet pile wall
- Ground surface contours (ft MLLW)

N

0 50 100 200 Feet

Figure 1-15

Site Map with Sheet Pile Wall, Seam, and Well Locations

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, WA

C:\USERS\GGEE\DOCUMENTS\GIS\WYCKOFF\MAPFILES\2014\SOIL AND GROUNDWATER OU NAPL - FFS\FIGURE1-14_SITEMAP.MXD GGEE 9/18/2014 2:13:59 PM

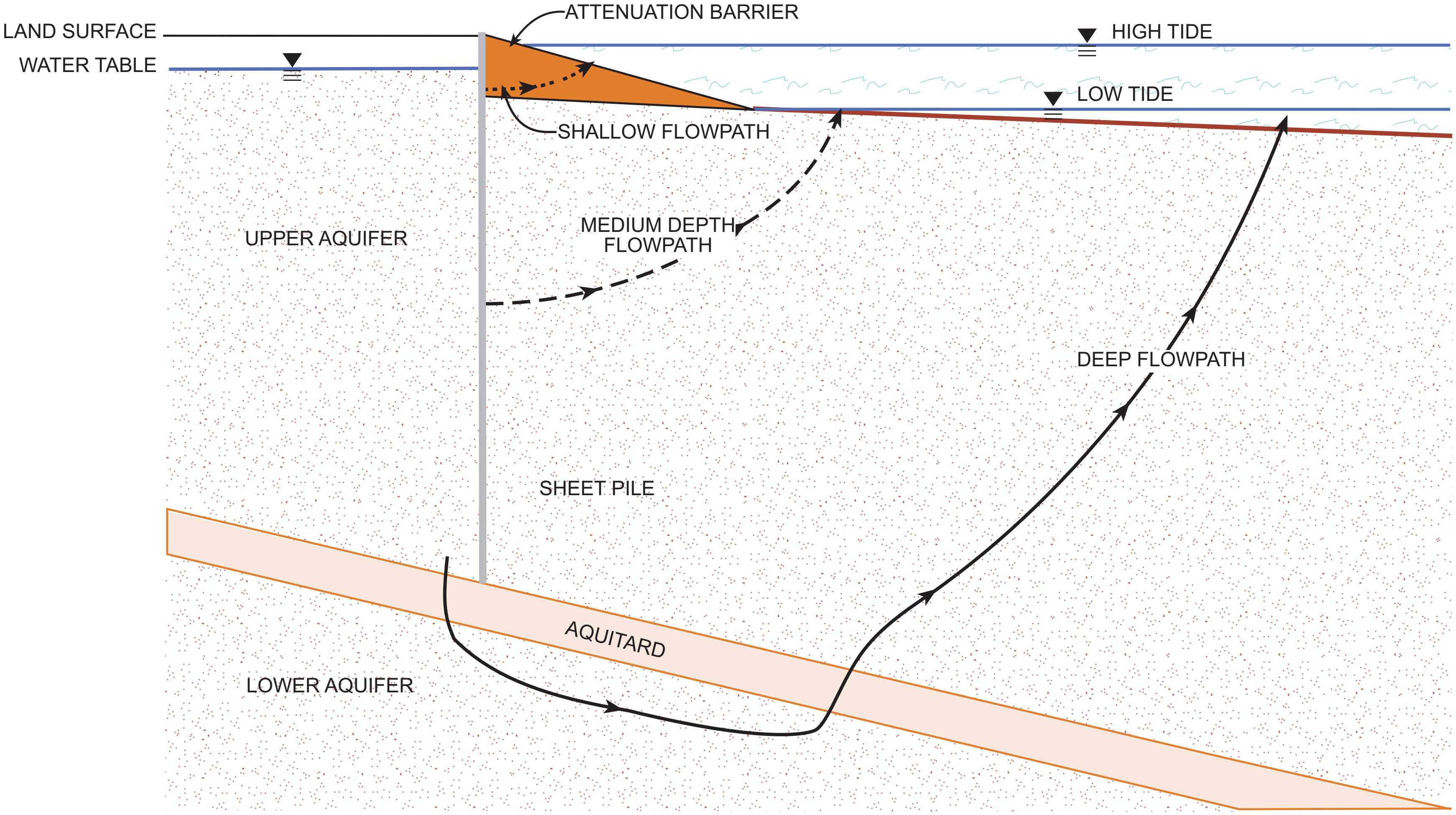


FIGURE 2-1

SCHEMATIC SECTION SHOWING TYPICAL FLOW PATHS

MODELING GROUNDWATER FLOW AND CONTAMINANT TRANSPORT
WYCKOFF/EAGLE HARBOR SUPERFUND SITE

180776-004.FH9

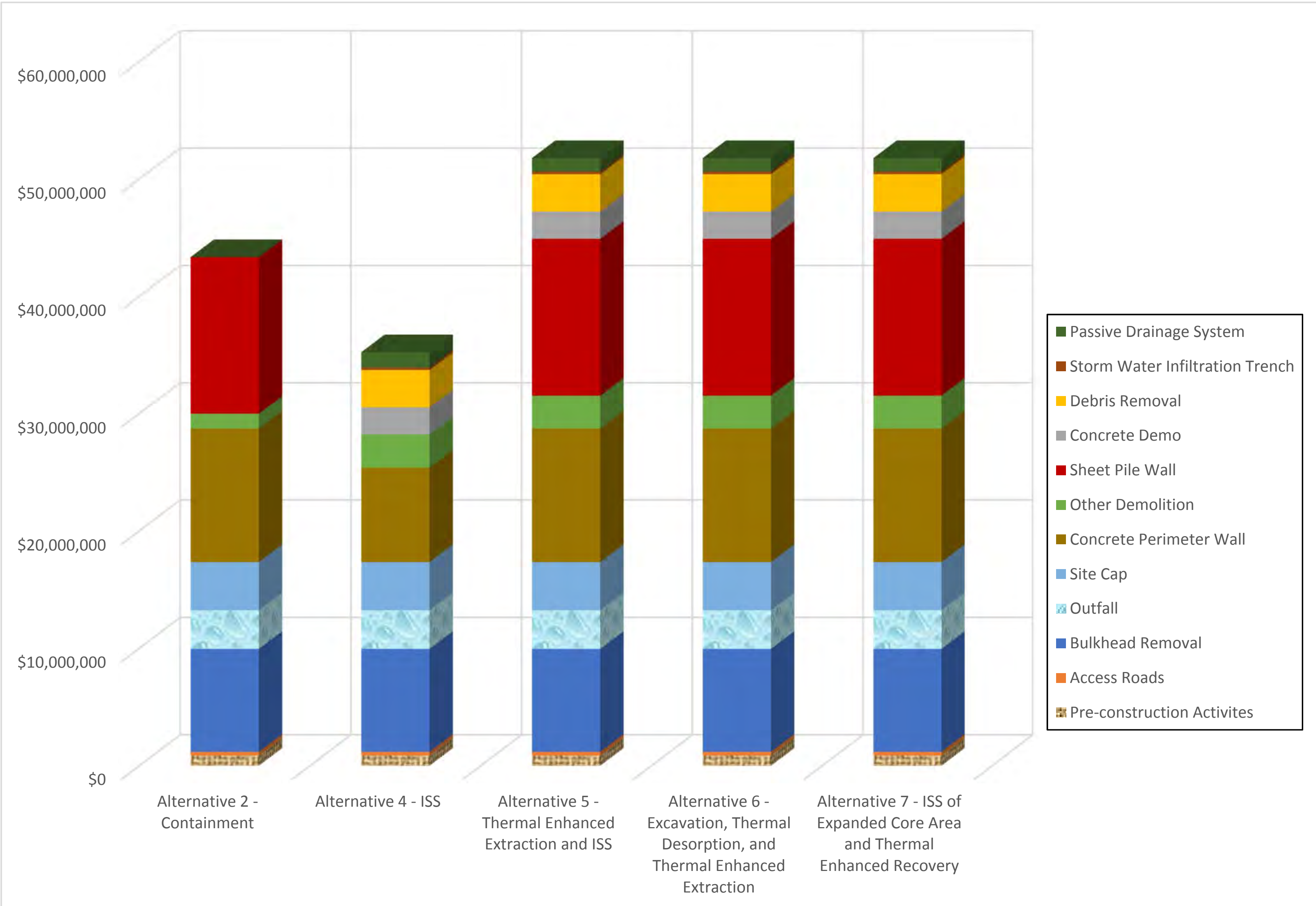
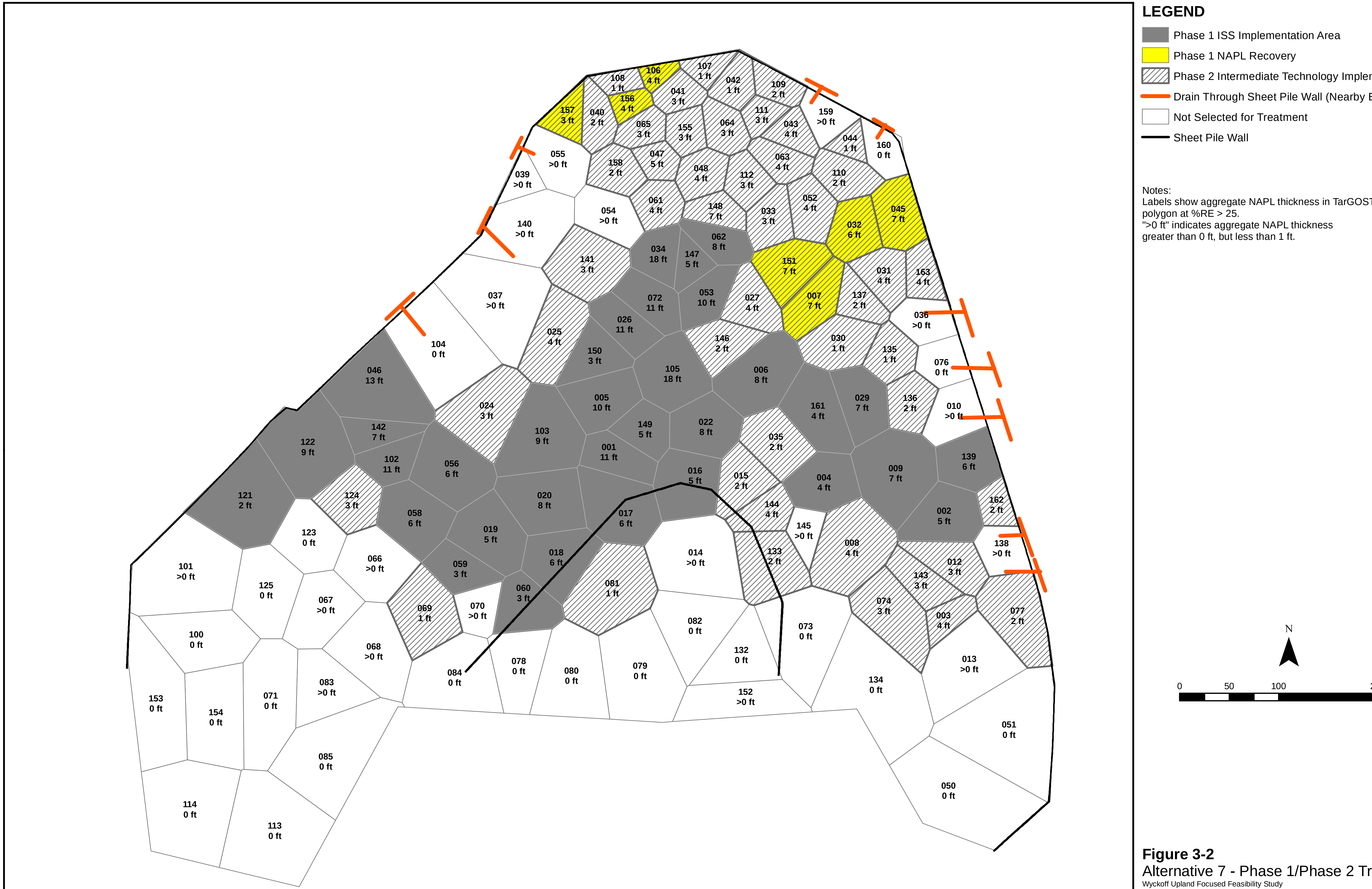


Figure 3-1
Common Element Cost Distribution
Wyckoff Soil and Groundwater OU FFS
Bainbridge Island, WA



LEGEND

- Phase 1 ISS Implementation Area
- Phase 1 NAPL Recovery
- Phase 2 Intermediate Technology Implementation Area
- Drain Through Sheet Pile Wall (Nearby EAB Anticipated)
- Not Selected for Treatment
- Sheet Pile Wall

Notes:
Labels show aggregate NAPL thickness in TarGOST polygon at %RE > 25.
">0 ft" indicates aggregate NAPL thickness greater than 0 ft, but less than 1 ft.

Figure 3-2
Alternative 7 - Phase 1/Phase 2 Treatment Areas
Wyckoff Upland Focused Feasibility Study
Wyckoff/Eagle Harbor Superfund Site

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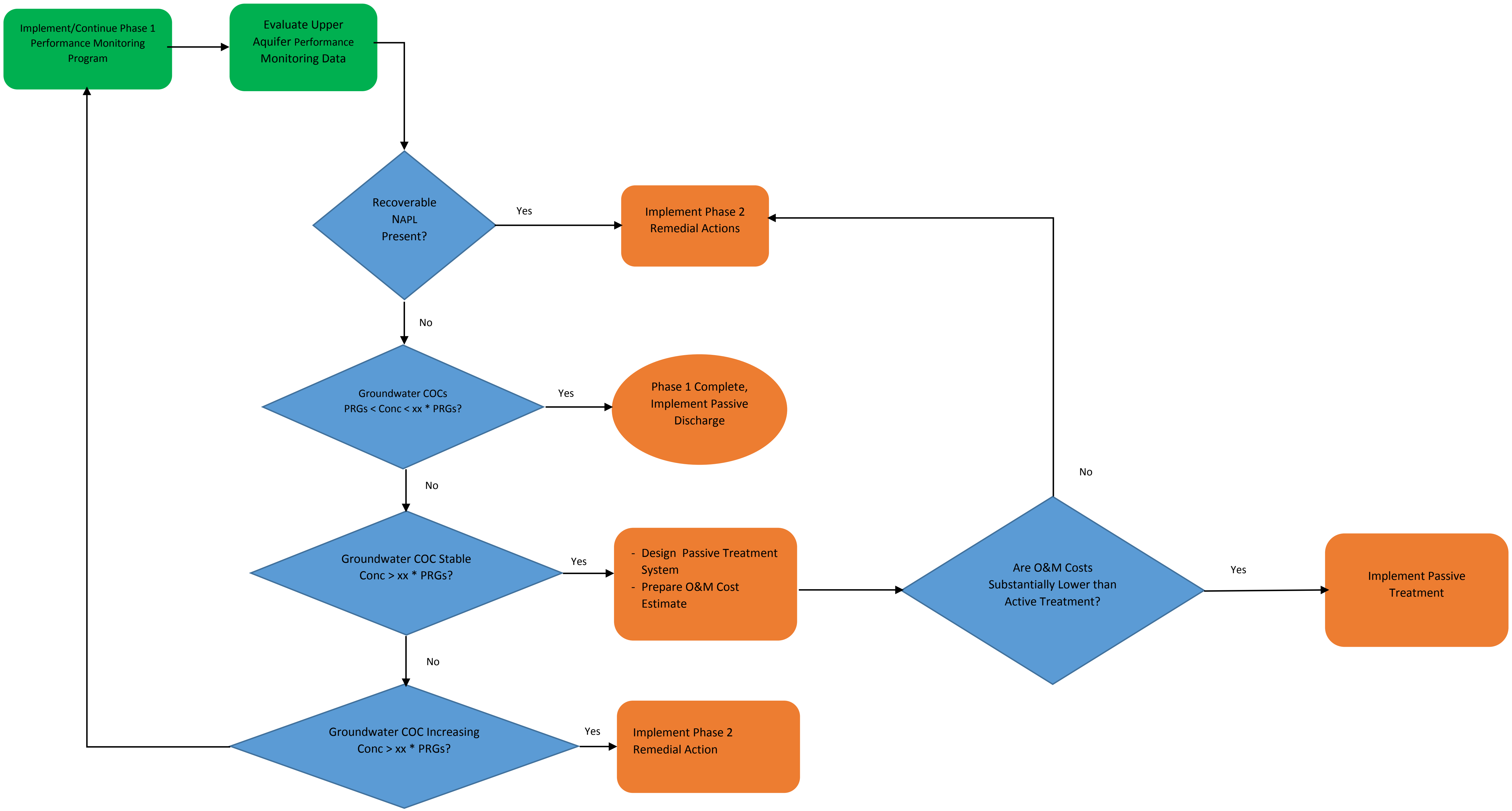


Notes:

Measureable NAPL: Thickness < 0.1 ft
xx = Surface water mixing factor to be determined during remedial design

Figure 3-3a
Upper Aquifer Phase 2 Remedial Action Triggers
OU2/OU4 Focused Feasibility Study
Wyckoff/Eagle Harbor Superfund Site
Bainbridge Island, WA

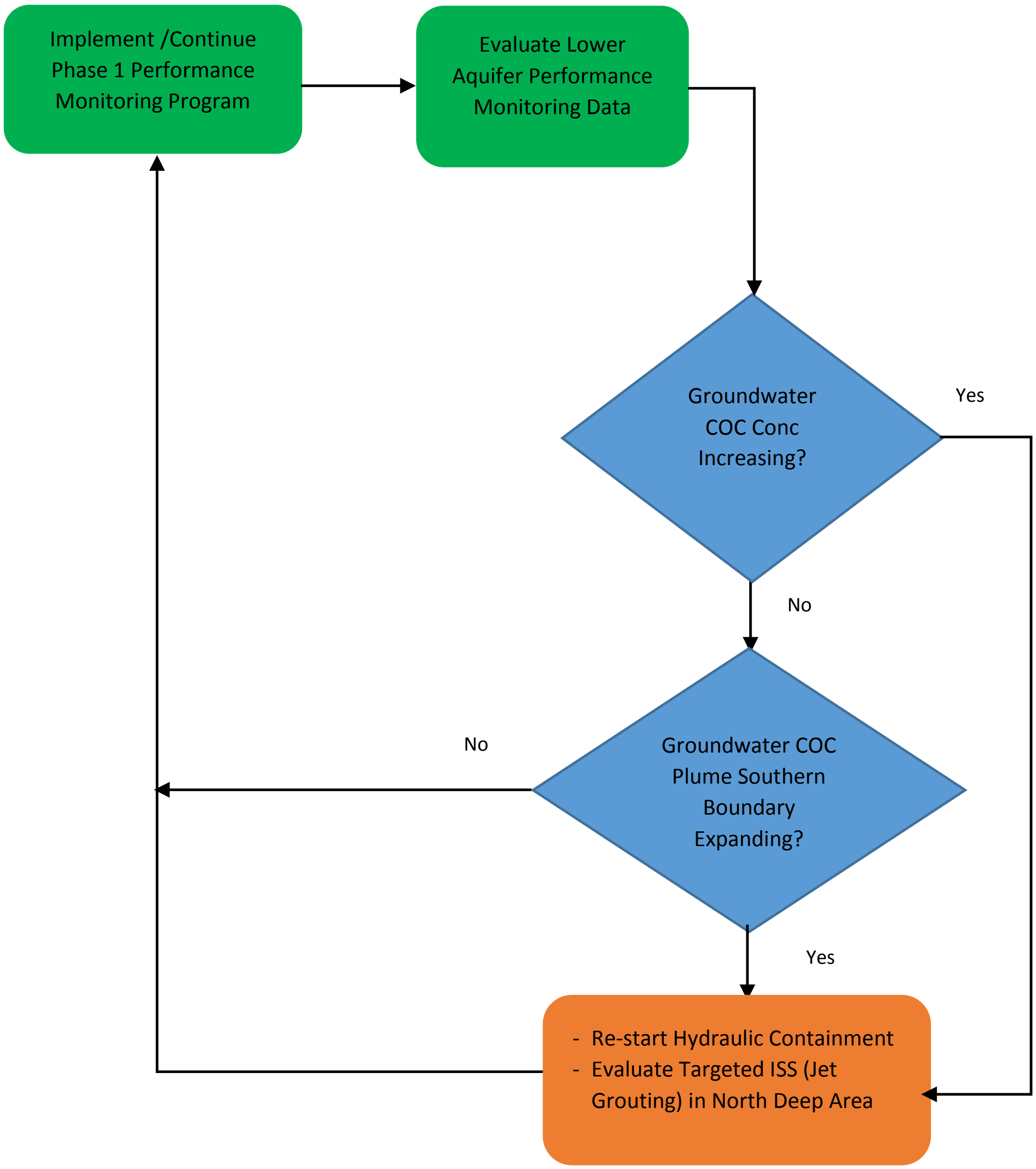
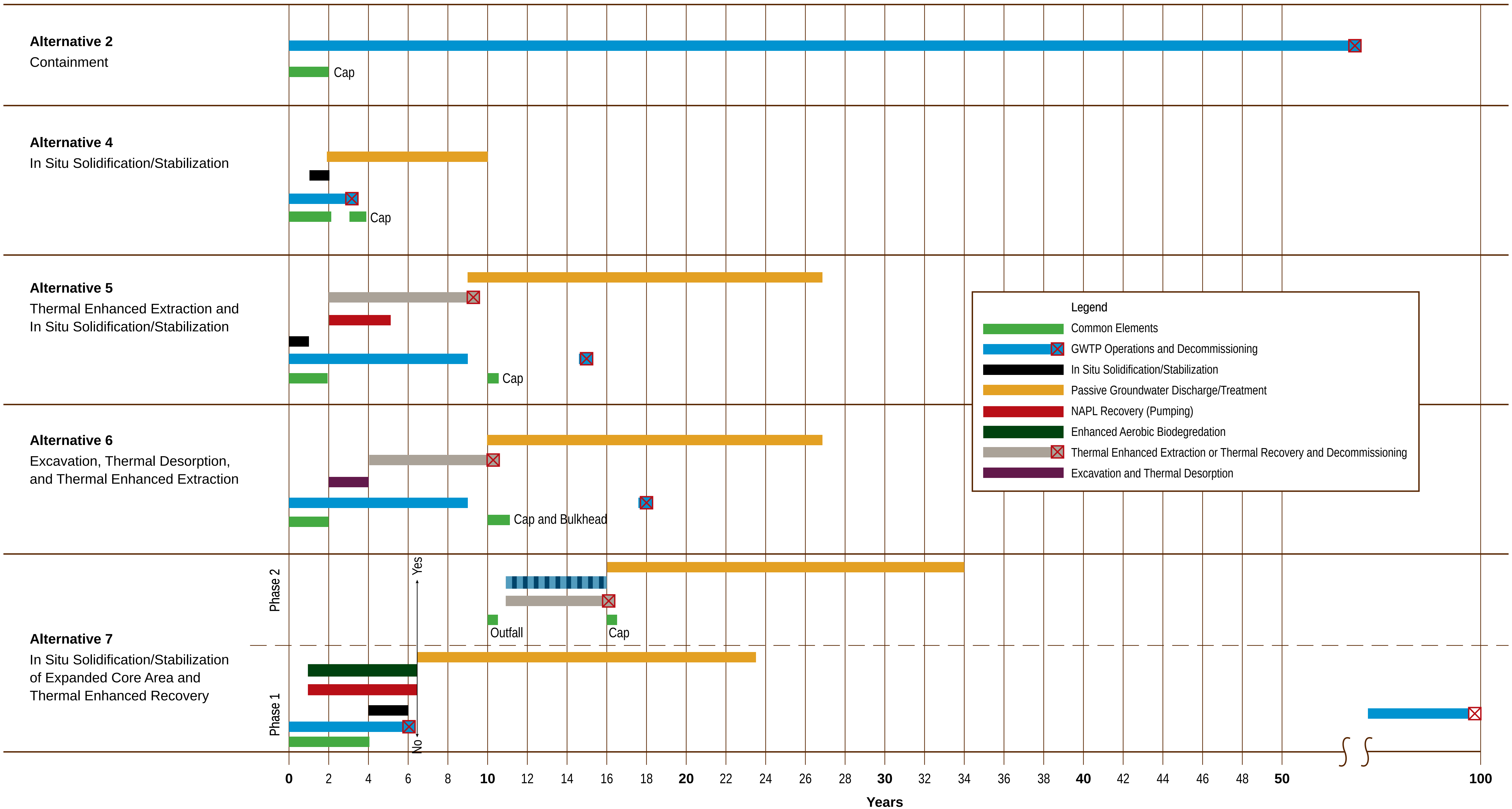


Figure 3-3b
Lower Aquifer Potable Area
Phase 2 Remedial Action Triggers OU2/OU4
Focused Feasibility Study
Wyckoff/Eagle Harbor Superfund Site
Bainbridge Island, WA



Notes:

Alternative 1 – No Action

Alternative 3 – Excavation, Thermal Desorption, and ISCO were screened out and not carried forward for evaluation.

Figure 4-1
Remedial Action Alternative Technology Durations
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site
Bainbridge Island, WA

CH2MHILL.

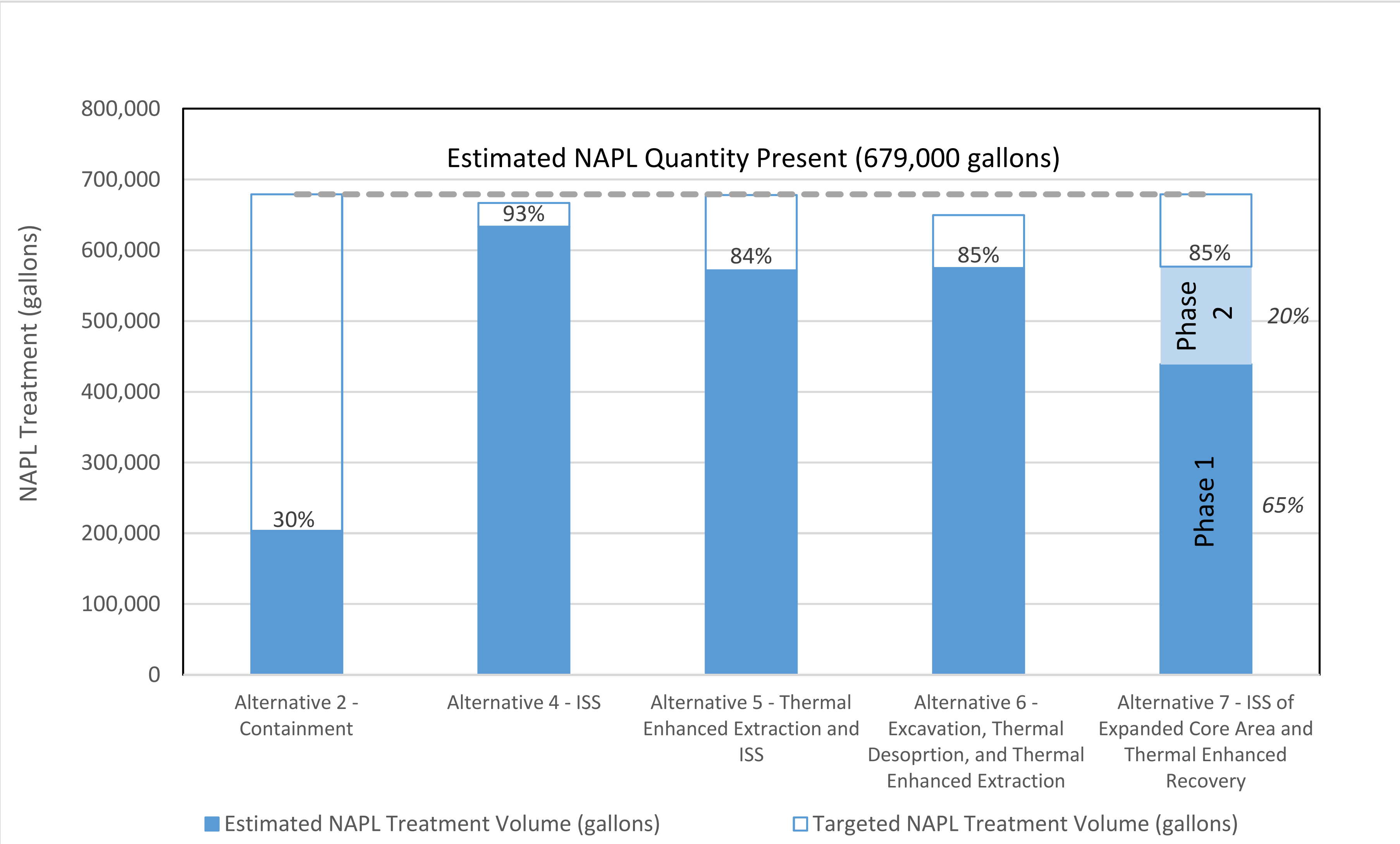


Figure 4-2

Remedial Action Alternative Treatment Comparisons

Wyckoff OU2/OU4 FFS

Bainbridge Island, WA

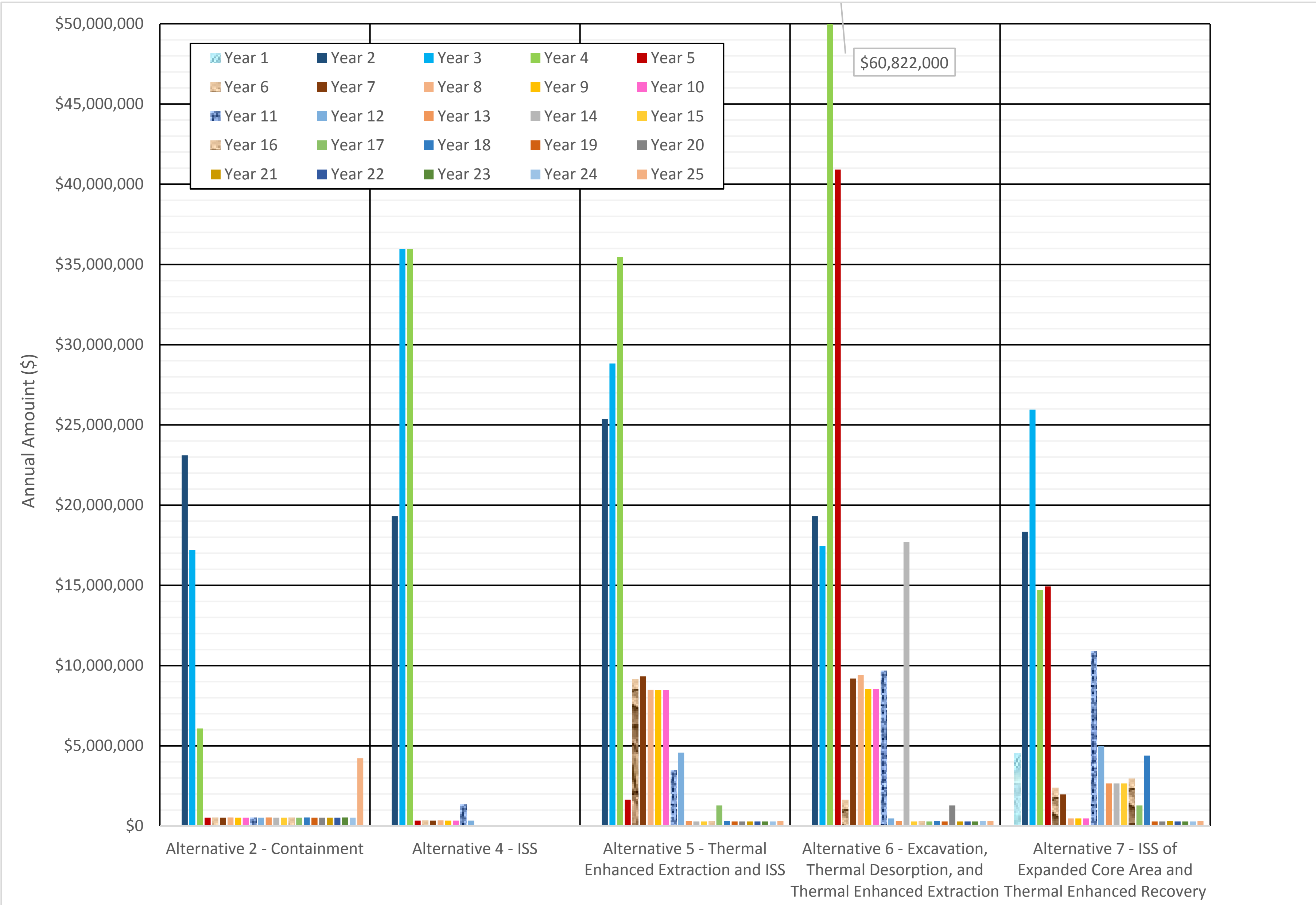


Figure 4-3

Remedial Action Alternative 25-Year Cash Flow Projections

Wyckoff Soil and Groundwater OU FFS

Bainbridge Island, WA

Appendix A
Soil and Groundwater Operable Unit Applicable or Relevant and Appropriate Requirements

TABLE A-1

Applicable, Relevant and Appropriate Requirements

Wyckoff OU2/OU4 NAPL FFS

ARAR	Description	Application for Wyckoff	ARAR Category	Alternatives to Which ARAR May Apply
FEDERAL				
Clean Water Act: Section 304(a)(1)	Surface water quality criteria for the protection of aquatic life and human health	Discharge of groundwater to Eagle Harbor through passive drains system.	Chemical Specific	4, 5, 6, 7
Clean Water Act: Section 401	Protection of water quality from discharge of pollutants into waters of the United States	Dredging and capping sediments may cause dispersion of contaminated sediments causing contamination to move through the water column during cleanup activities.	Action Specific	N/A
Clean Water Act: Section 402	Requirements for point source discharges to water of the U.S.	Discharge of stormwater collected from the surface of the proposed cap. Also discharge of Upper Aquifer groundwater through the proposed passive drainage system	Action Specific	2, 4, 5, 6, 7
Clean Water Act: Section 404(b)(1)	Protection of aquatic ecosystems by dredging or filling waters of the U.S.	Construction of a new perimeter bulkhead wall (depending on alignment) and remedial construction on the beaches	Action Specific	7x (see Section 10)
Endangered Species Act	Protection of endangered or threatened species and critical habitat	Remedy may affect endangered species such as salmon and bull trout.	Action Specific	N/A
Magnuson-Stevens Fisheries Conservation and Management Act	Protection of essential fish habitat	Remedy may affect essential fish habitat for rock fish or other species in Eagle Harbor.	Action Specific	N/A
Clean Air Act	Protection of air quality	Dust from general construction activities, discharges to air from thermal desorption or other remedial actions	Chemical Specific	2, 4, 5, 6, 7
Native American Graves Protection and Repatriation Act	Procedures for handling human remains or sacred objects if discovered	Construction that impacts subsurface soils, particularly in previously undisturbed areas	Location Specific	2, 3, 5, 6, 7
Resource Conservation and Recovery Act Land Disposal Restrictions	Disposal of hazardous waste generated during cleanup activities	Disposal of creosote contaminated debris, NAPL recovered from groundwater, spent treatment media (such as carbon filters)	Action Specific	2, 4, 5, 6, 7

TABLE A-1
Applicable, Relevant and Appropriate Requirements
Wyckoff OU2/OU4 NAPL FFS

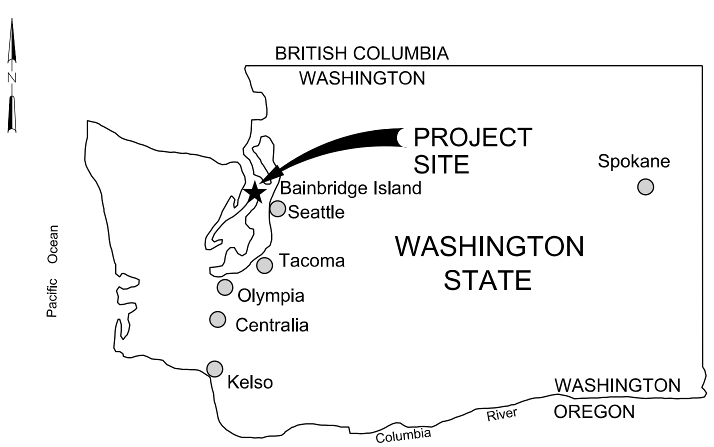
ARAR	Description	Application for Wyckoff	ARAR Category	Alternatives to Which ARAR May Apply
Resource Conservation and Recovery Act Requirements for Incinerators	Requirements for operation of incinerators to protect air quality	Thermal oxidation of contaminated soil vapor. Also, Medium temperature thermal desorption of contaminated soils	Action specific	5, 6
STATE				
Hazardous Waste Management Act Dangerous Waste Regulations	Generation, management and offsite disposal of hazardous waste	Hazardous wastes will likely be generated during remedy implementation that may be designated as a characteristic or listed hazardous waste.	Action Specific	2, 4, 5, 6, 7
Solid Waste Management Reduction and Recycling Act Solid Waste Handling Standards	Requirements for the management and disposal of solid waste	Requirements for upland management of remediation waste designated as a solid waste (e.g., excavated soil, dredged sediments).	Action Specific	2, 4, 5, 6, 7
Model Toxics Control Act (MTCA)	Cleanup standards for soil, groundwater, surface water, and air	If MTCA cleanup standards are more stringent than the federal standards or risk-based concentrations, the promulgated MTCA standards will be used.	Chemical Specific	2, 4, 5, 6, 7
MTCA Sediment Management Standards (SMS)	Cleanup standards for freshwater sediments	If SMS cleanup standards are more stringent than the federal standards or risk-based concentrations, the promulgated SMS standards will be used.	Chemical Specific	
Washington State Water Pollution Control Act Water Quality Standards for Surface Waters of the State of Washington	Surface water quality criteria for the protection of aquatic life and human health	If state WQC standards are more stringent than the federal standards or risk-based concentrations, the promulgated state WQC will be used.	Chemical Specific	2, 4, 5, 6, 7
Washington State Water Pollution Control Act National Pollutant Discharge Elimination System	Standards for discharge of pollutants into waters of the United states	The remedial action will include the discharge of treated water and stormwater to surface water.	Chemical Specific	2, 4, 5, 6, 7

TABLE A-1
Applicable, Relevant and Appropriate Requirements
Wyckoff OU2/OU4 NAPL FFS

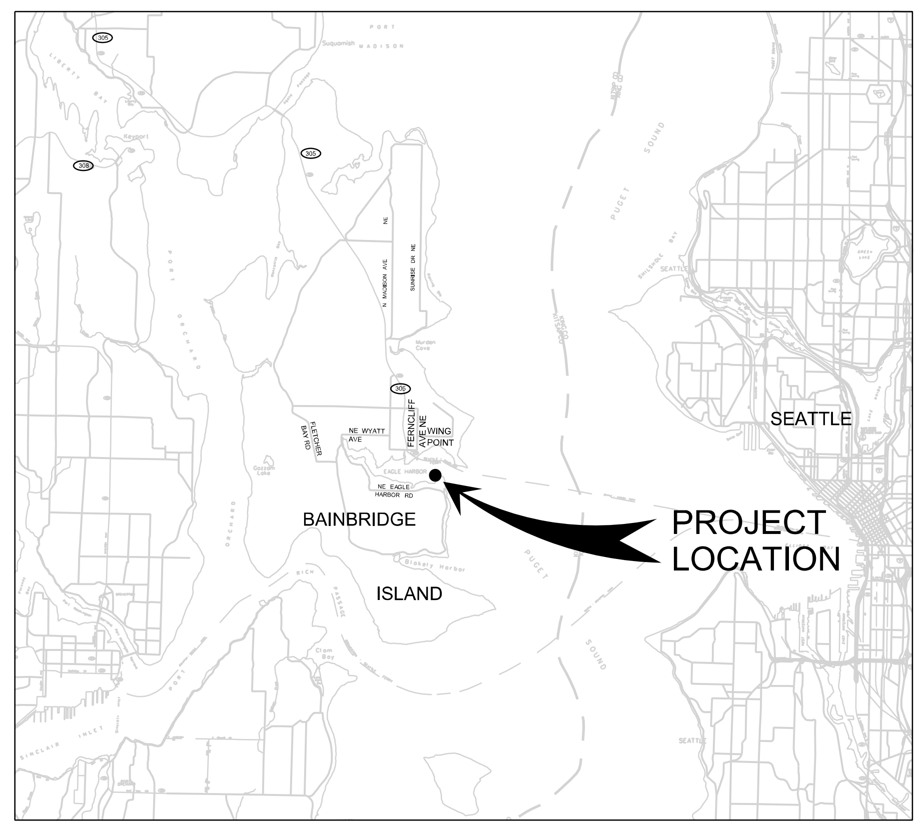
ARAR	Description	Application for Wyckoff	ARAR Category	Alternatives to Which ARAR May Apply
Washington Underground Injection Control Program	Establishes criteria and standards for an underground injection control program for class V injection wells	Remedial activities that involve underground injection such as steam injection for thermal enhanced extraction; injection of oxidants for ISCO treatment; injection of Portland cement and bentonite for ISS	Action Specific	4, 5, 6, 7
Washington State Shoreline Management Act	Establishes wetland and shoreline protection measures for work in the shoreline zone.	Remedial activities on the intertidal beaches	Action Specific	7X (see Section 10)
Washington Clean Air Act	Regulations for Air Pollution Sources, also Puget Sound Clean Air Agency Regulations	Remedial Actions that result in the emission of hazardous air pollutants, including decontamination, demolition and excavation, and thermal desorption	Chemical Specific	2, 4, 5, 6, 7

Appendix B
Remedial Action Alternative Drawings

US ENVIRONMENTAL PROTECTION AGENCY
REGION 10
WYCKOFF FOCUSED FEASIBILITY STUDY
DRAWINGS



VICINITY MAP
NTS



LOCATION MAP
NTS

DWG	DRAWING TITLE
	GENERAL - 001
001-G-001	TITLE SHEET, VICINITY AND LOCATION MAP, INDEX TO DRAWINGS
	COMMON ELEMENTS - 101
101-CE-100	ROAD IMPROVEMENTS
101-CE-101	ROAD IMPROVEMENTS PROFILE
101-CE-102	SITE PLAN - DEMOLITION
101-CE-103	SITE PLAN - OUTFALL
101-CE-104	OUTFALL PROFILE
101-CE-105	SITE PLAN - PASSIVE GROUNDWATER TREATMENT SYSTEM
101-CE-300	DETAILS - REMOVALS AND NEW WALL CONSTRUCTION
101-CE-301	DETAILS - PASSIVE GROUNDWATER TREATMENT
101-CE-302	DETAILS - NEW WALL CONSTRUCTION
	ALTERNATIVE 2 - CONTAINMENT
200-C-100	SITE PLAN - WELLS AND PIPING
200-C-101	SITE PLAN - FINAL CAP
200-C-301	CAP SECTIONS
200-C-302	GWTP PROCESS FLOW DIAGRAM
	ALTERNATIVE 4 - ISS -300
300-C-100	OVERALL SITE PLAN
300-C-101	SITE PLAN - ISS TREATMENT
300-C-102	SITE PLAN - JET GROUT TREATMENT
300-C-103	PASSIVE GROUNDWATER TREATMENT SYSTEM
300-C-300	ISS CROSS SECTIONS ISS/JET GROUT
300-C-301	ISS PROGRESSION ISS/JET GROUT
300-C-600	PROCESS FLOW DIAGRAM
	ALTERNATIVE 5- THERMAL ENHANCED EXTRACTION AND ISS
400-C-100	SITE PLAN - NAPL EXTRACTION & COVER
400-C-101	SITE PLAN - THERMAL WELLS AND JET GROUT TREATMENT
400-C-102	VAPOR REMOVAL FROM AND AIR INECTION INTO COVER (JET GROUT)
400-C-103	SITE PLAN - ENHANCED AEROBIC
400-C-104	PIPING PLAN
400-C-500	WELLHEAD DETAILS
400-C-600	PROCESS FLOW DIAGRAM 1
400-C-601	EXISTING EQUIPMENT PROCESS FLOW DIAGRAM
400-C-602	PROCESS FLOW DIAGRAM 2
400-M-101	TREATMENT SYSTEM PLAN
	ALTERNATIVE 6- EXCAVATION, THERMAL DESORPTION, AND THERMAL ENHANCED EXTRACTION
500-C-100	OVERALL SITE PLAN
500-C-101	SITE PLAN - NAPL EXTRACTION & COVER, THERMAL
500-C-102	COVER PIPING, BIOSPARGING, VAPOR REMOVAL AND AIR INJECTION
500-C-103	PIPING PLAN
500-C-104	SITE PLAN - ENHANCED AEROBIC PLAN
500-C-600	ALT 6 MTTD PROCESS FLOW DIAGRAM
	ALTERNATIVE 7- ISS OF EXPANDED CORE AREA AND THERMAL ENHANCED RECOVERY
700-C-100	OVERALL SITE PLAN
700-C-101	ISS NORTH PROFILES
700-C-102	ISS NORTH PROFILES
700-C-103	ISS SOUTH PROFILES
700-C-104	ISS SOUTH PROFILES
700-C-105	ISS ISOPACH
700-C-106	NAPL EXTRACTION, GW EXTRACTION AND EAB SITE PLAN
700-C-107	NAPL EXTRACTION, GW EXTRACTION AND EAB SITE PLAN NORTH EXPANSION
700-C-108	PASSIVE GROUNDWATER TREATMENT SYSTEM
700-C-109	PHASE II THERMAL SITE LAYOUT
700-C-110	THERMAL WELL SITE PLAN ENLARGEMENTS
700-C-111	THERMAL WELL SITE PLAN ENLARGEMENTS
700-C-112	THERMAL DETAILS (WELL HEAD & PIPE RACK DETAIL)

PRELIMINARY

REVISION					DSGN	DR	CHK	APVD
NO.	DATE		BY	APVD		BT	BT	KTS

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL®

WYCKOFF FFS
TITLE SHEET, VICINITY AND LOCATION MAP, INDEX TO DRAWINGS

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	OCTOBER 2015
PROJ	438527
DWG	001-G-001
SHEET	of

GENERAL NOTES

1. CLEAR, GRUB, AND PREPARE SUBGRADE IN NEW ROAD AREA. PROVIDE TEMPORARY EROSION CONTROL AND SILT FENCING.

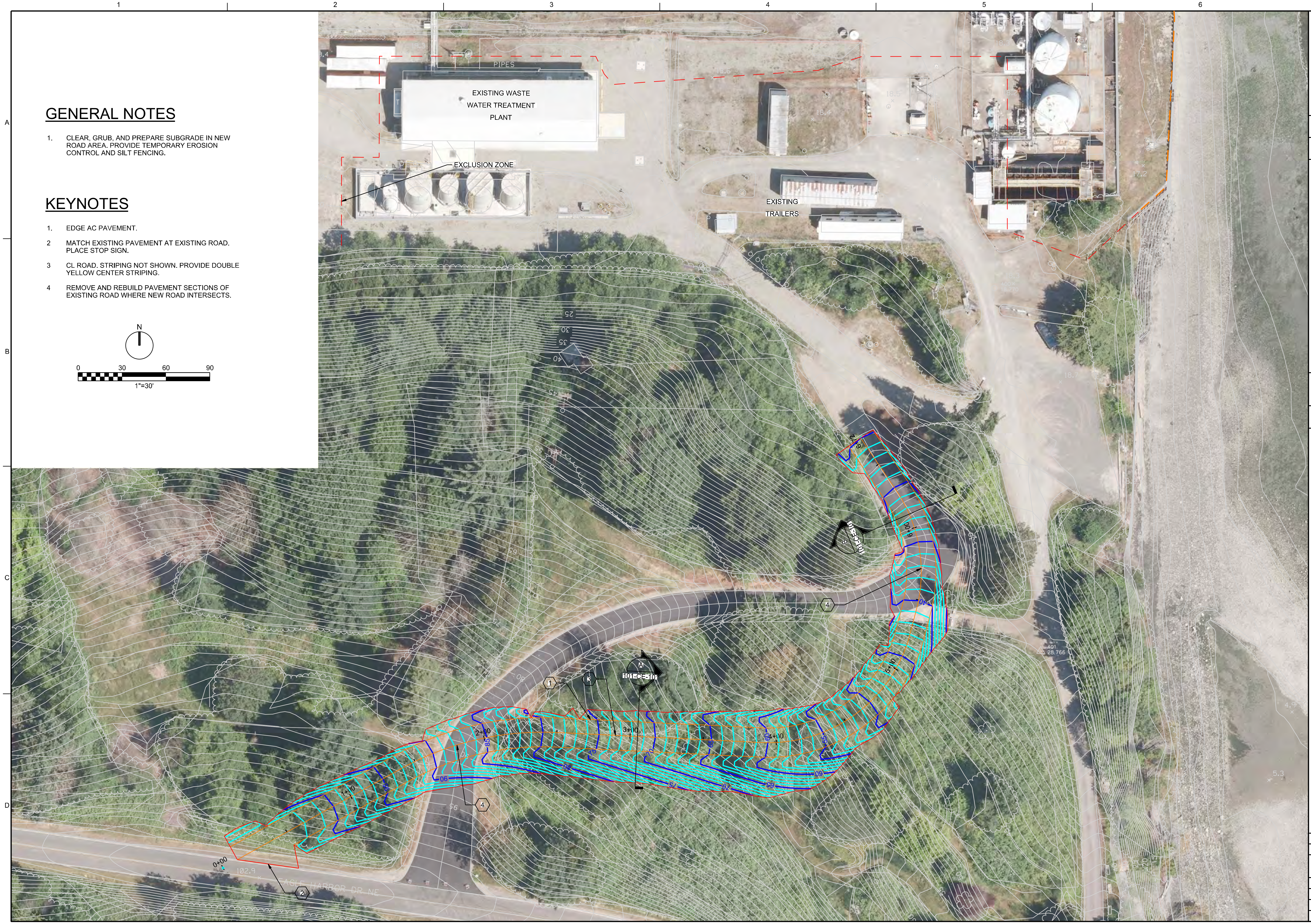
KEYNOTES

1. EDGE AC PAVEMENT.
2. MATCH EXISTING PAVEMENT AT EXISTING ROAD. PLACE STOP SIGN.
3. CL ROAD. STRIPING NOT SHOWN. PROVIDE DOUBLE YELLOW CENTER STRIPING.
4. REMOVE AND REBUILD PAVEMENT SECTIONS OF EXISTING ROAD WHERE NEW ROAD INTERSECTS.

N

0 30 60 90

1"=30'



CH2MHILL®

COMMON ELEMENTS
ROAD IMPROVEMENTS

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

NO.	DATE	REVISION	BY	APVD

DSGN	DR	CHK	APVD
BCT	BCT	KTS	

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1"=40 FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	101-CE-100
SHEET	of

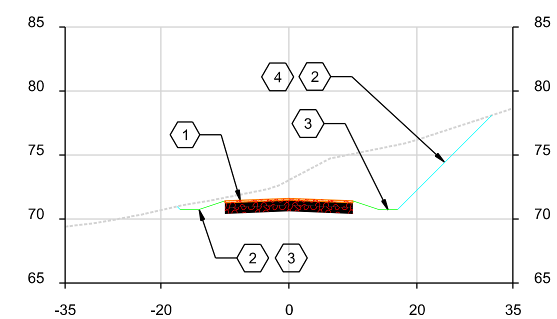
PLANNING PURPOSES ONLY. NOT FOR CONSTRUCTION

GENERAL NOTES

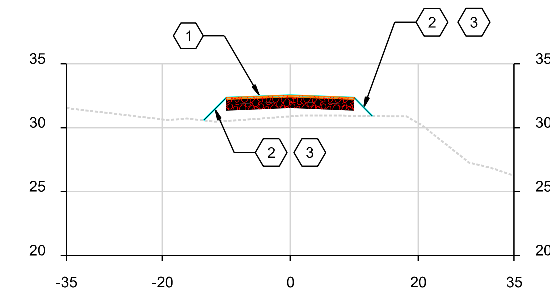
1. CLEAR, GRUB, AND PREPARE SUBGRADE IN NEW ROAD AREA. PROVIDE TEMPORARY EROSION CONTROL AND SILT FENCING.

KEYNOTES

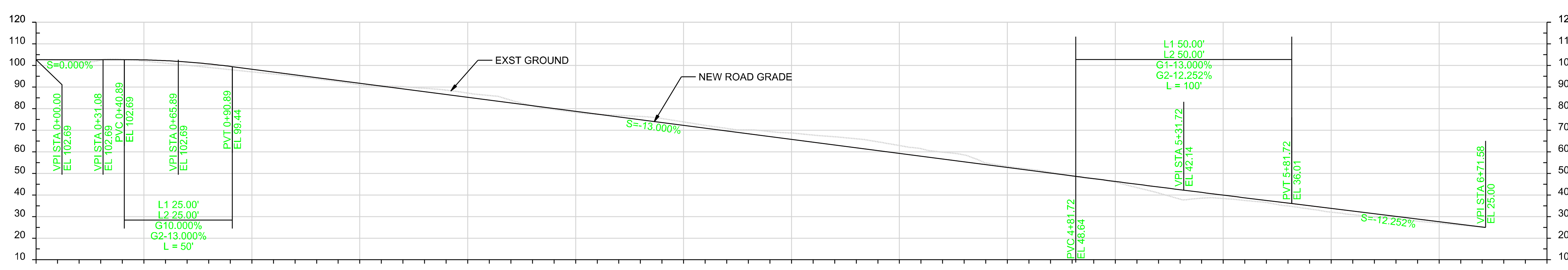
1. 4" ACP OVER 10" BASE COURSE.
2. PROVIDE EROSION CONTROL FOR ALL EXCAVATED SLOPES OR AREAS DISTURBED DURING CONSTRUCTION.
3. PROVIDE HAY BALES EVERY 10 FEET ALONG DRAINAGE FLOW PATHS, BOTH SIDES OF ROAD.
4. 2:1 SLOPE.



A ROAD CROSS SECTION
1"=15'-0" HORIZ 1"=7.5' VERT
101-CE-100



B ROAD CROSS SECTION
1"=15'-0" HORIZ 1"=7.5' VERT
101-CE-100



ROAD PROFILE
1"=30'-0"

NO.	DATE	REVISION	BY	APVD

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FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL®

COMMON ELEMENTS
ROAD IMPROVEMENTS PROFILE

VARIES
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	101-CE-101
SHEET	of

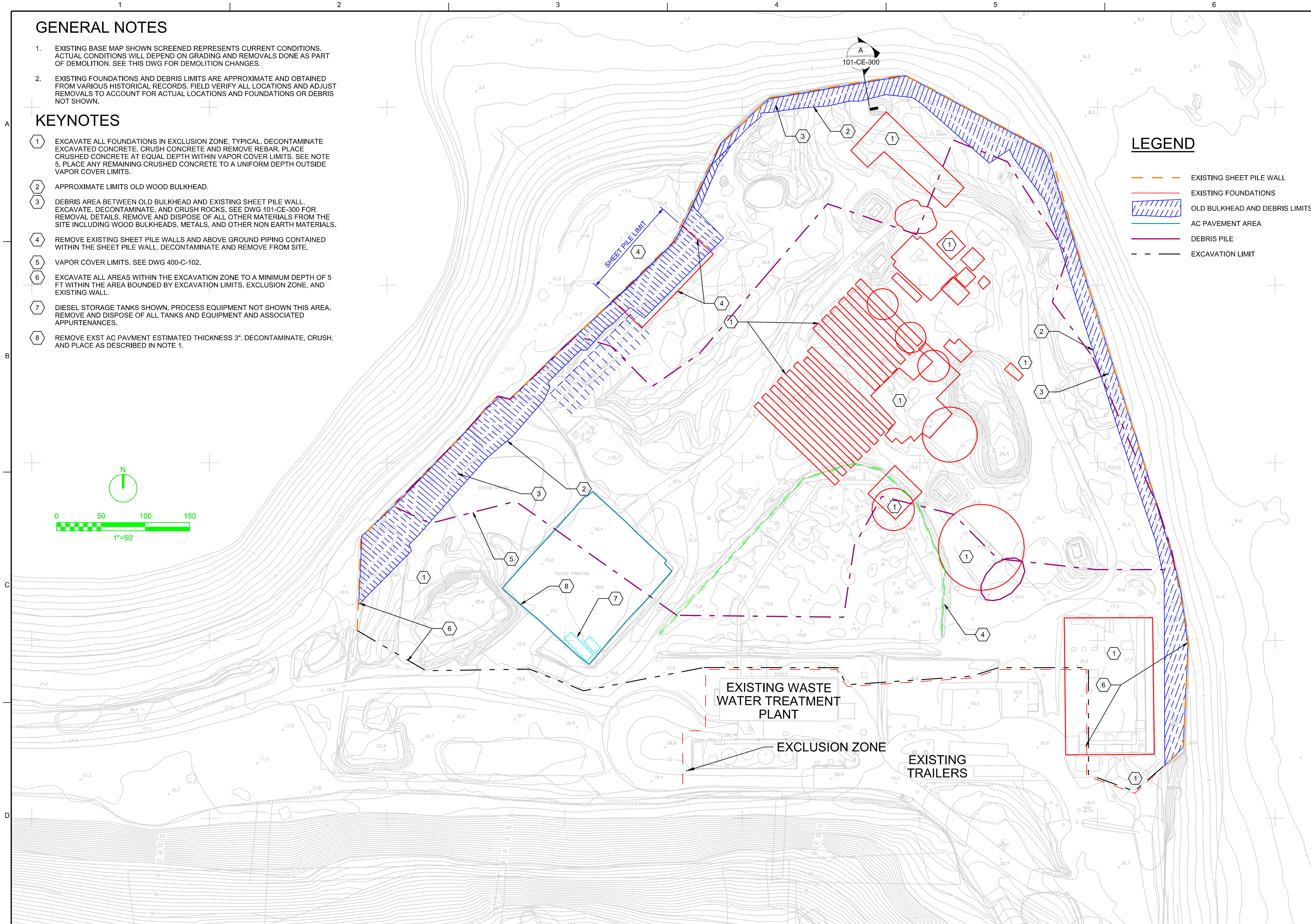
PLANNING PURPOSES ONLY. NOT FOR CONSTRUCTION

GENERAL NOTES

1. EXISTING BASE MAP SHOWN SCREENED REPRESENTS CURRENT CONDITIONS. ACTUAL CONDITIONS WILL DEPEND ON GRADING AND REMOVALS DONE AS PART OF DEMOLITION. SEE THIS DWG FOR DEMOLITION CHANGES.
2. EXISTING FOUNDATIONS AND DEBRIS LIMITS ARE APPROXIMATE AND OBTAINED FROM VARIOUS HISTORICAL RECORDS. FIELD VERIFY ALL LOCATIONS AND ADJUST REMOVALS TO ACCOUNT FOR ACTUAL LOCATIONS AND FOUNDATIONS OR DEBRIS NOT SHOWN.

KEYNOTES

1. EXCAVATE ALL FOUNDATIONS IN EXCLUSION ZONE, TYPICAL. DECONTAMINATE EXCAVATED CONCRETE. CRUSH CONCRETE AND REMOVE REBAR. PLACE CRUSHED CONCRETE AT EQUAL DEPTH WITHIN VAPOR COVER LIMITS. SEE NOTE 5. PLACE ANY REMAINING CRUSHED CONCRETE TO A UNIFORM DEPTH OUTSIDE VAPOR COVER LIMITS.
2. APPROXIMATE LIMITS OLD WOOD BULKHEAD.
3. DEBRIS AREA BETWEEN OLD BULKHEAD AND EXISTING SHEET PILE WALL. EXCAVATE, DECONTAMINATE, AND CRUSH ROCKS. SEE DWG 101-CE-300 FOR REMOVAL DETAILS. REMOVE AND DISPOSE OF ALL OTHER MATERIALS FROM THE SITE INCLUDING WOOD BULKHEADS, METALS, AND OTHER NON EARTH MATERIALS.
4. REMOVE EXISTING SHEET PILE WALLS AND ABOVE GROUND PIPING CONTAINED WITHIN THE SHEET PILE WALL. DECONTAMINATE AND REMOVE FROM SITE.
5. VAPOR COVER LIMITS. SEE DWG 400-C-102.
6. EXCAVATE ALL AREAS WITHIN THE EXCAVATION ZONE TO A MINIMUM DEPTH OF 5 FT WITHIN THE AREA BOUNDED BY EXCAVATION LIMITS, EXCLUSION ZONE, AND EXISTING WALL.
7. DIESEL STORAGE TANKS SHOWN. PROCESS EQUIPMENT NOT SHOWN THIS AREA. REMOVE AND DISPOSE OF ALL TANKS AND EQUIPMENT AND ASSOCIATED APPURTENANCES.
8. REMOVE EXST AC PAVMENT ESTIMATED THICKNESS 3". DECONTAMINATE, CRUSH, AND PLACE AS DESCRIBED IN NOTE 1.



LEGEND

- EXISTING SHEET PILE WALL
- EXISTING FOUNDATIONS
- OLD BULKHEAD AND DEBRIS LIMITS
- AC PAVEMENT AREA
- DEBRIS PILE
- EXCAVATION LIMIT

NO.	DATE	REVISION	BY	APVD

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FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL®

COMMON ELEMENTS - DEMOLITION
SITE PLAN - DEMOLITION

1"=50 FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	101-CE-102
SHEET	of

PLANNING PURPOSES ONLY. NOT FOR CONSTRUCTION

GENERAL NOTES

1. CONSTRUCT OUTFALL AFTER NEW SHEET PILE WALL CONSTRUCTION AND BEFORE SITE ACTIVITIES THAT REQUIRE STORMWATER COLLECTION AND DISCHARGE.
2. EXISTING CONTOURS SHOWN SCREENED. BATHYMETRY CONTOURS SHOWN BOLD

KEYNOTES

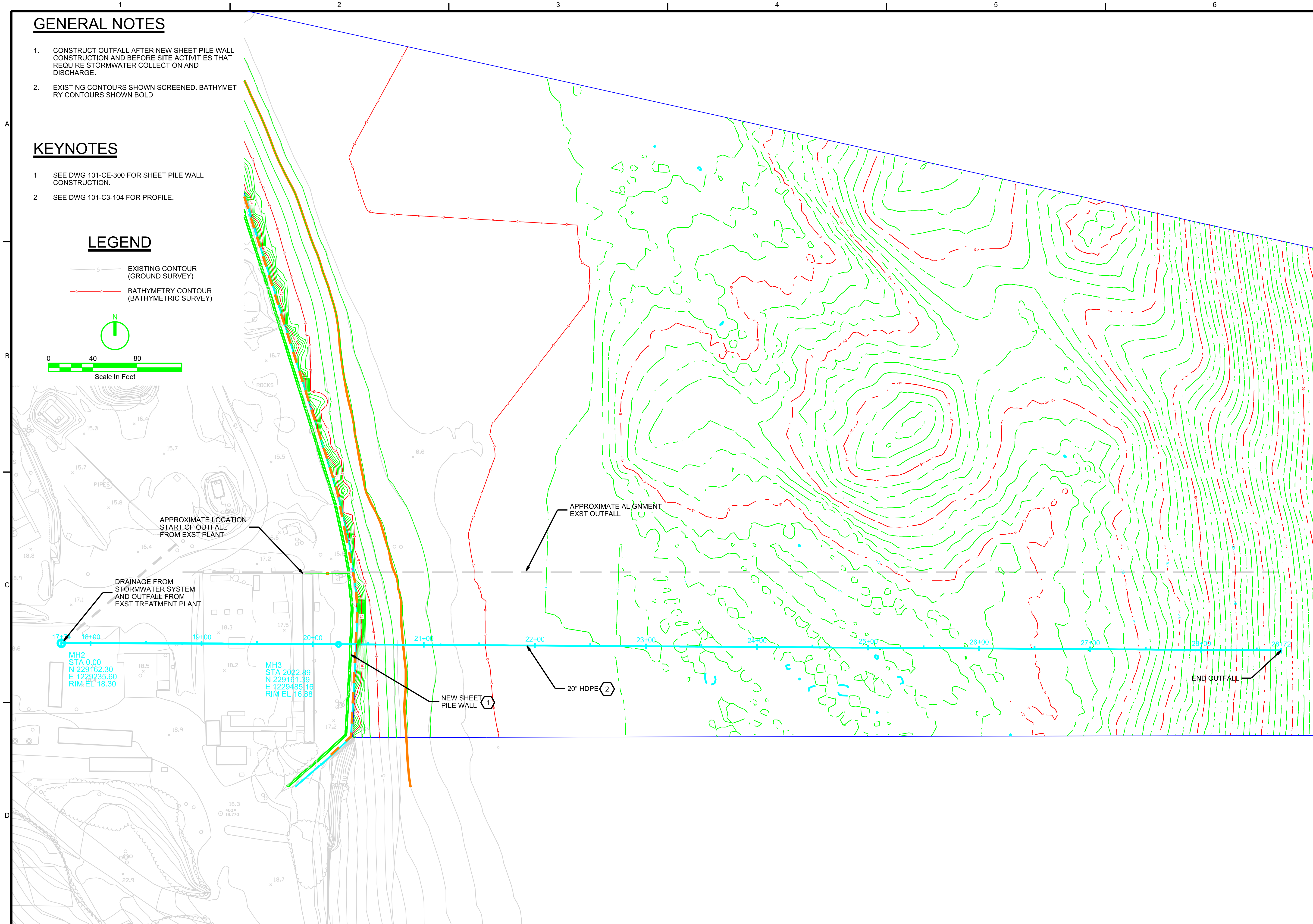
1 SEE DWG 101-CE-300 FOR SHEET PILE WALL CONSTRUCTION.

2 SEE DWG 101-C3-104 FOR PROFILE.

LEGEND

EXISTING CONTOUR (GROUND SURVEY)

BATHYMETRY CONTOUR (BATHYMETRIC SURVEY)



FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

COMMON ELEMENTS
SITE PLAN - OUTFALL

CH2MHILL®

NO.	DATE	REVISION	BY	APVD

DSGN KTS | DR BCT | CHK BCT | APVD

1"=40 FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	101-CE-103
SHEET	of

PLANNING PURPOSES ONLY. NOT FOR CONSTRUCTION

GENERAL NOTES

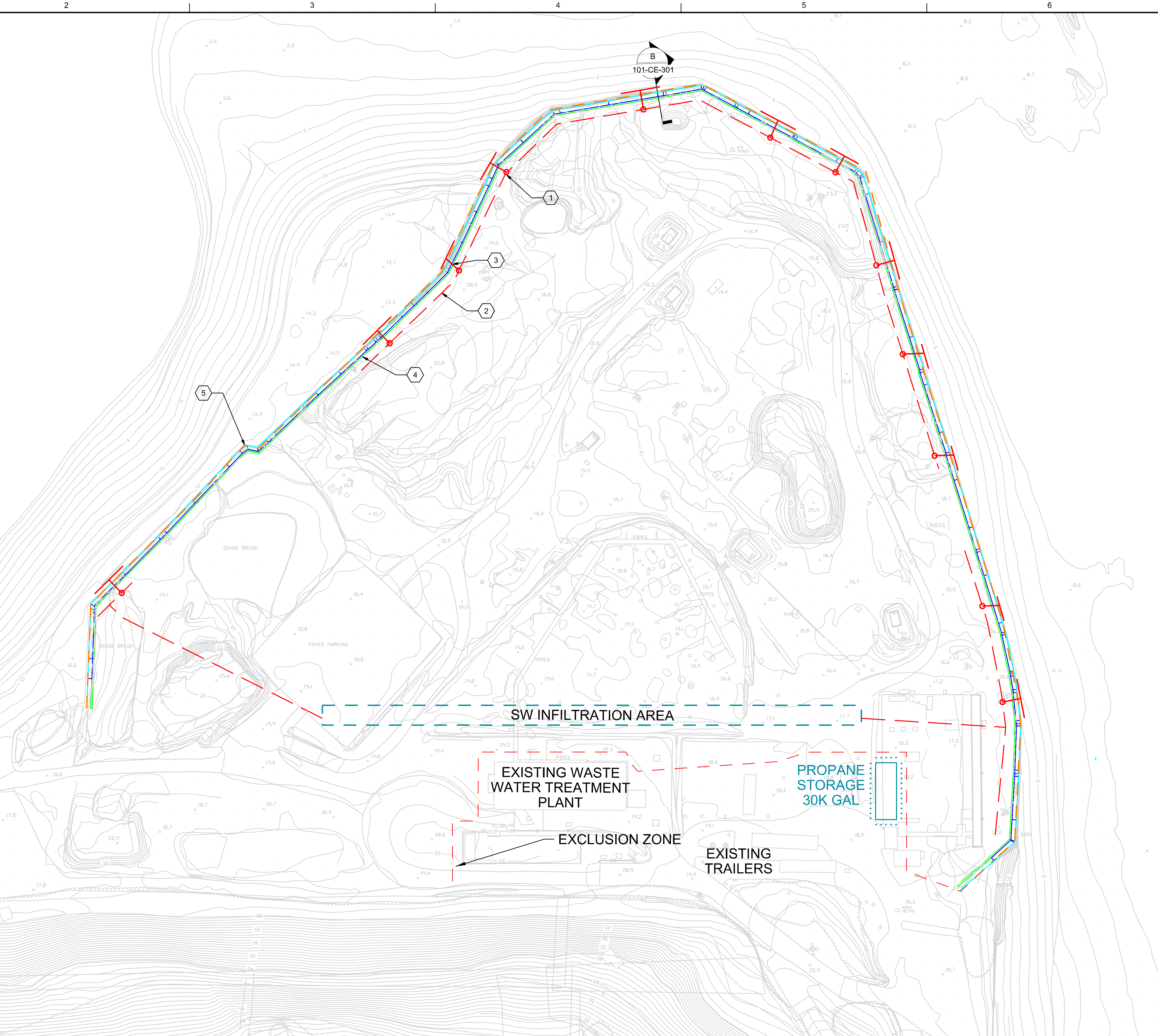
1. EXISTING BASE MAP SHOWN SCREENED REPRESENTS CURRENT CONDITIONS. ACTUAL CONDITIONS WILL DEPEND ON GRADING AND REMOVALS DONE AS PART OF DEMOLITION. SEE DWG 101-CE-102 FOR DEMOLITION CHANGES.
2. SCHEMATIC LOCATOINS SHOWN

KEYNOTES

1. GROUNDWATER TREATMENT SYSTEM MANHOLE.
2. FRENCH DRAIN.
3. DRAIN PIPE THROUGH SHEET PILE WALL
4. NEW SHEET PILE WALL
5. EXST SHEET PILE WALL

LEGEND

- EXST SHEET PILE WALL
- NEW SHEET PILE WALL (SHEET PILE AND CONCRETE)
- NEW TREATEMENT SYSTEM MANHOLE
- NEW FRENCH DRAIN
- NEW DRAIN PIPE THROUGH WALLS



NO. | DATE | REVISION | BY | APVD

DSGN SM | DR SM | CHK BCT | APVD SM

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

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COMMON ELEMENTS
SITE PLAN
PASSIVE GROUNDWATER TREATMENT SYSTEM

1"=50 FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	OCTOBER 2015
PROJ	438527
DWG	101-CE-105
SHEET	of

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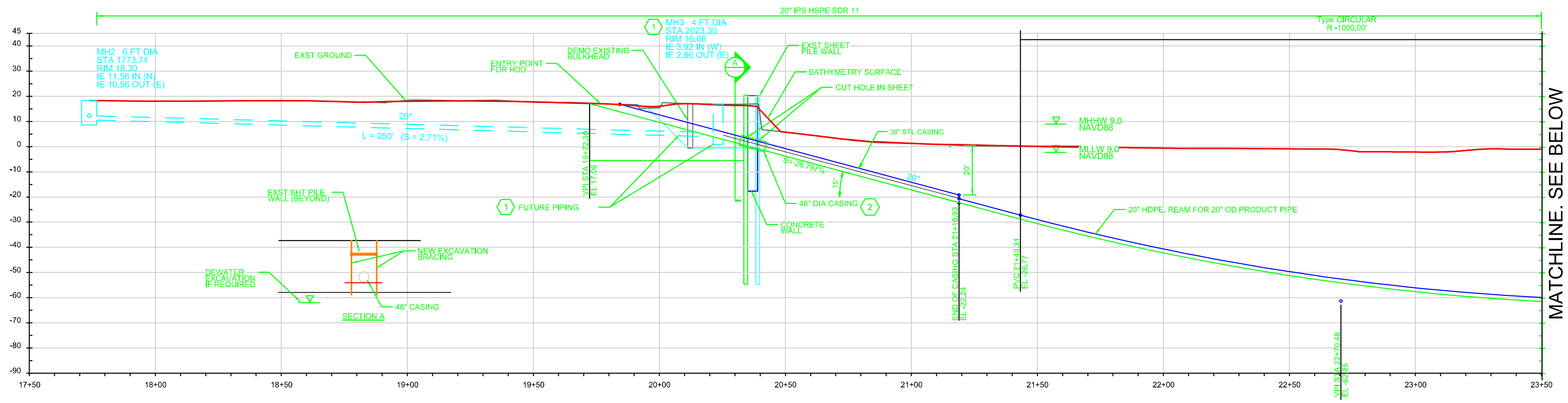
GENERAL NOTES

1. SEE DWG 101-CE-103 FOR PLAN VIEW.
2. APPLIES TO ALTERNATIVES 2, 5, 6. SIMILAR WALL AREA CONSTRUCTION FOR ALTERNATIVE 4. SEE DWG 101-CE-300 FOR EXISTING AND NEW WALL DETAILS.

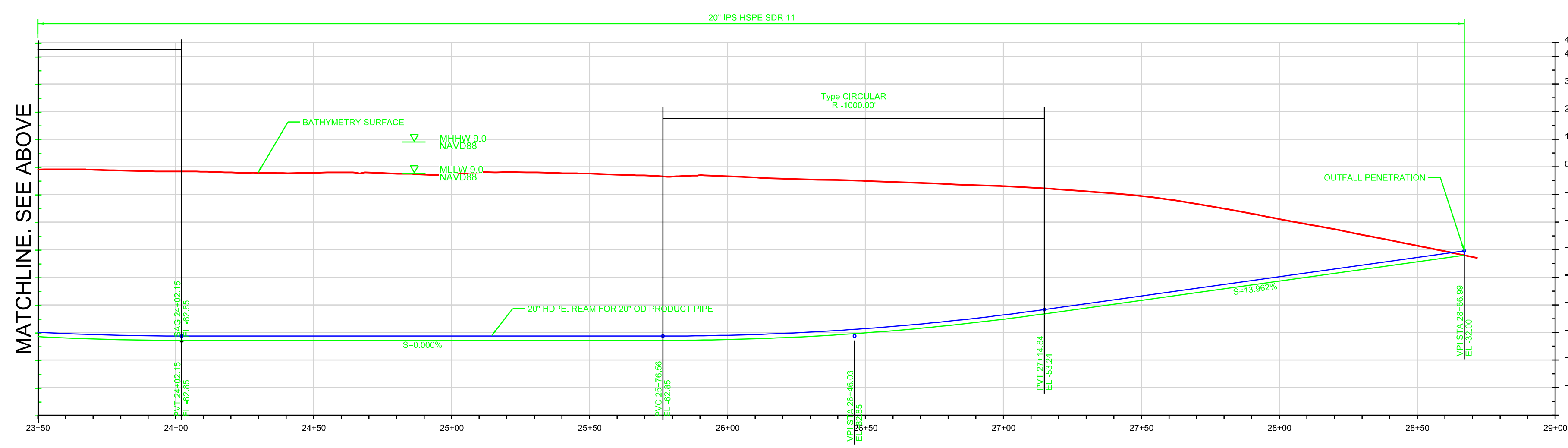
KEYNOTES

1. STORMWATER/DRAIN PIPING AND MANHOLES PLACED AFTER OUTFALL CONSTRUCTION. SEE SCHEDULE FOR TIMING.
2. SEAL ANNULUS AFTER CASING INSTALLATION FOR WATERTIGHT SEAL



OUTFALL PROFILE

1"=30'-0"



OUTFALL PROFILE

1"=30'-0"

NO.	DATE	REVISION	BY	APVD

DSGN KTS | DR BCT | CHK BCT | APVD

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL

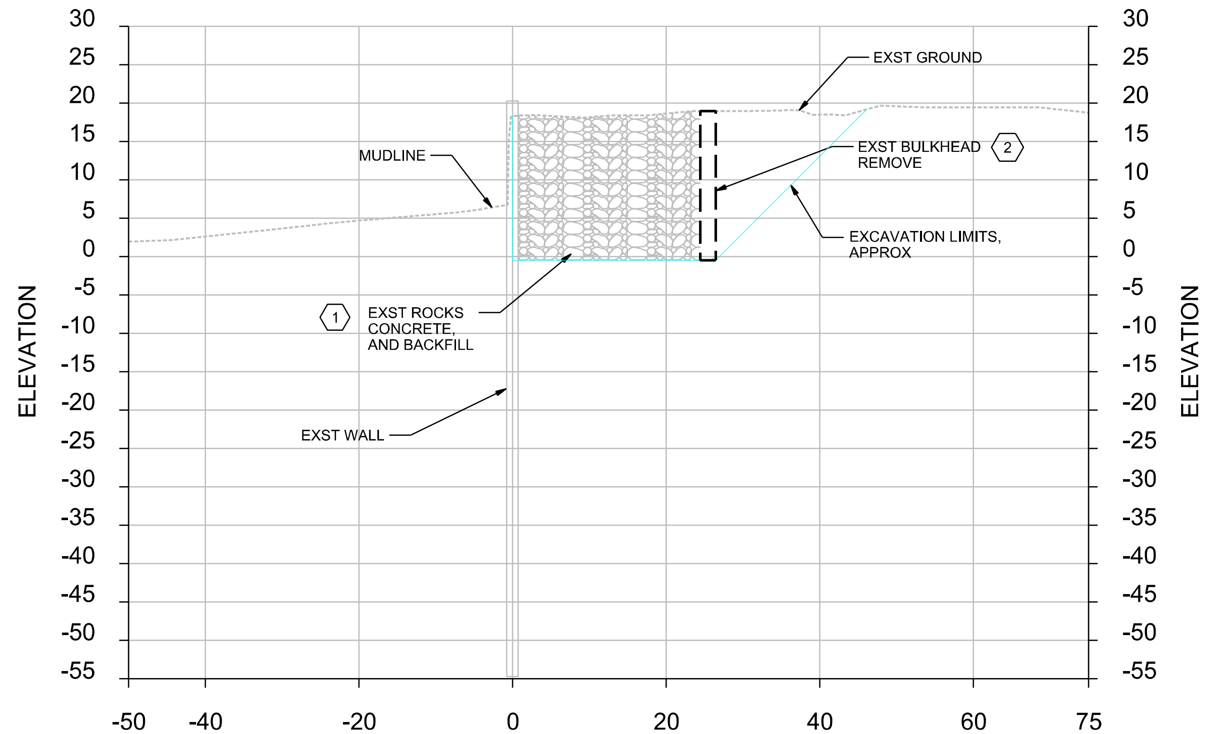
COMMON ELEMENTS
OUTFALL PROFILE

1"=30 FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	101-CE-104
SHEET	of

PLANNING PURPOSES ONLY. NOT FOR CONSTRUCTION

1 | 2 | 3 | 4 | 5 | 6



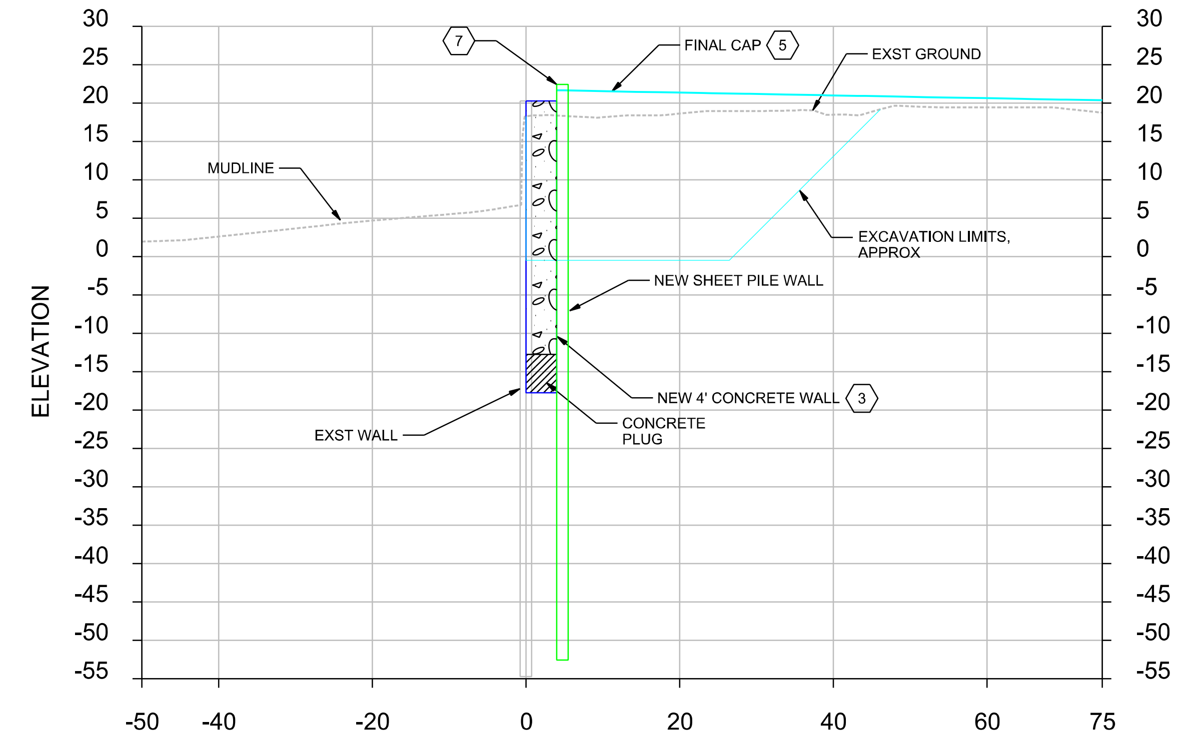
A REMOVALS/DEMOLITION
1"=25'
101-CE-102

CONSTRUCTION SEQUENCE ALTERNATIVE 4

1. REMOVE MATERIALS AS SHOWN IN REMOVALS/DEMOLTION.
2. MAINTAIN WATER LEVEL IN EXCAVATION AREA TO NO MORE THAN 16 FT ABOVE TIDE LEVEL AT ALL TIMES UNTIL BACKFILL IS PLACED
3. PLACE AND COMPACT BACKFILL
4. ISS TREAT SITE
5. EXCAVATE MATERIAL BEHIND EXISTING SHEET PILE WALL.
6. POUR NEW CONCRETE WALL
7. CONSTRUCT FINAL COVER

KEYNOTES

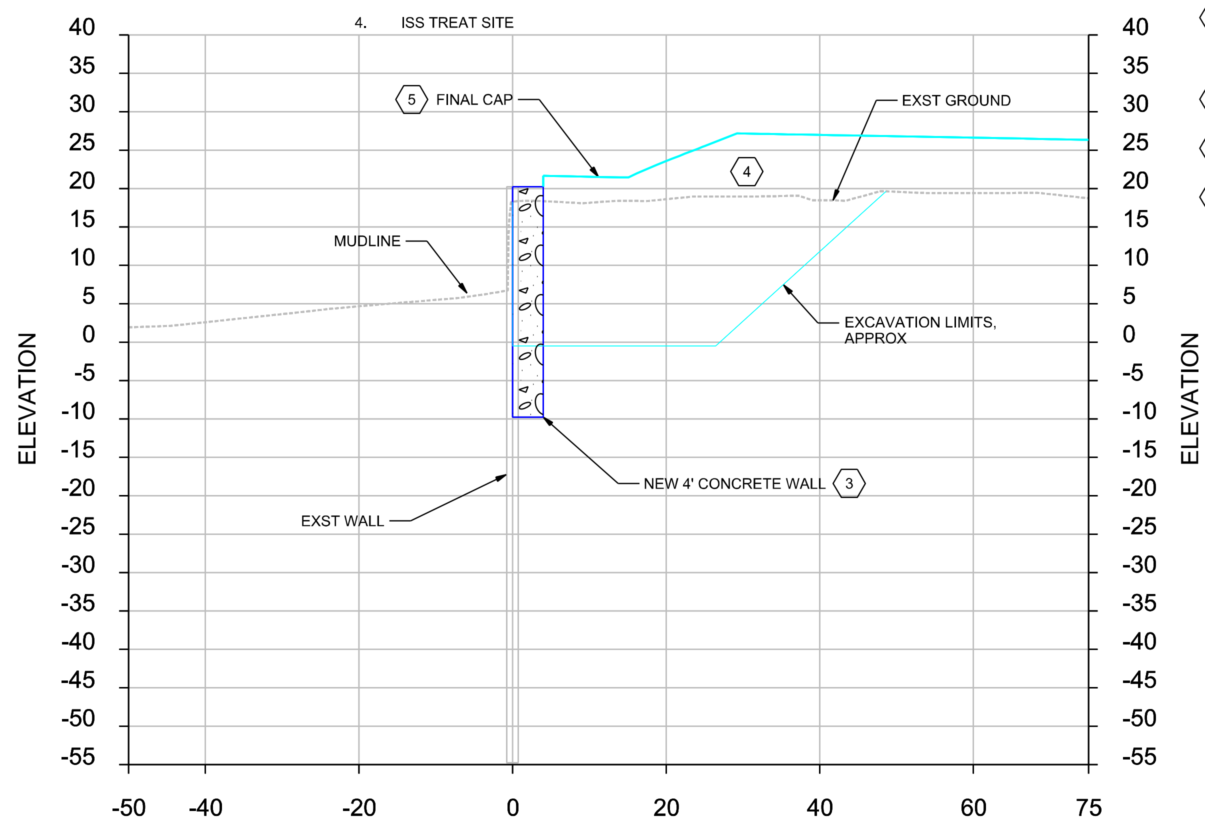
1. REMOVE, DECONTAMINATE, CRUSH TO 2" MINUS SIZE. REMOVE ALL REBAR AND DELETERIOUS MATERIAL.
2. REMOVE BULKHEAD PILING. HEIGHT, WIDTH, AND NUMBER OF PILINGS VARY.
3. REINFORCEMENT #8's, 12" O.C. EW EF.
4. FILL DEPTH VARIES. APPROX. 6 FT OF SWELL WILL BE GRADED TO ACHEIVE MINIMUM 2% SLOPE OF FINAL COVER.
5. FINAL CAP. SEE DET 2 ON 200-C-301.
6. FILL REQUIRED TO ACHIEVE 2% MIN SLOPE OF FINAL CAP.
7. SHEET PILE WALL ELEVATION VARIES. MAXIMUM WALL ELEVATION = 25.0. NEW SHEET PILE WALL WAS DESIGNED FOR MAXIMUM ELEVATION.



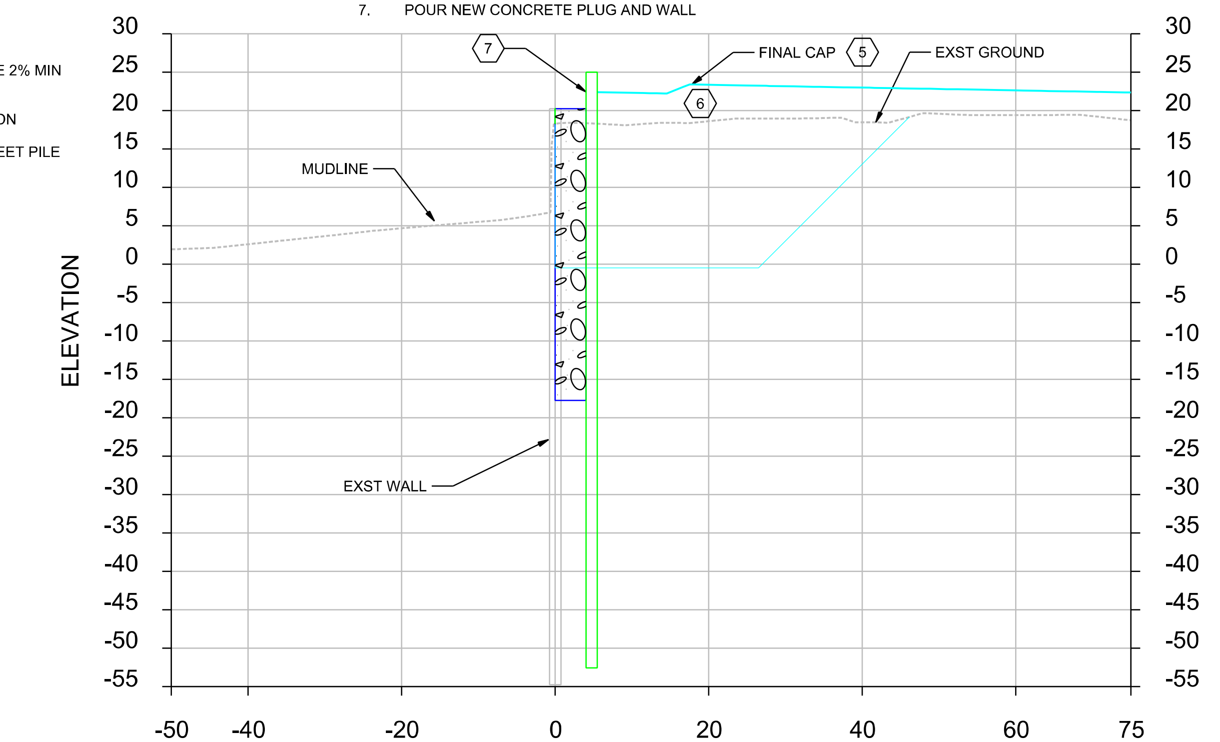
B NEW WALL CONSTRUCTION ALTERNATIVE 2
1"=25'
200-C-101

CONSTRUCTION SEQUENCE ALTERNATIVES 2,5,6

1. REMOVE MATERIALS AS SHOWN IN REMOVALS/DEMOLTION.
2. MAINTAIN WATER LEVEL IN EXCAVATION AREA TO NO MORE THAN 16 FT ABOVE TIDE LEVEL AT ALL TIMES UNTIL BACKFILL IS PLACED
3. PLACE AND COMPACT BACKFILL
4. DRIVE NEW SHEET PILE
5. EXCAVATE MATERIAL BETWEEN NEW AND EXISTING SHEET PILE WALL.
6. CONSTRUCT FINAL COVER
7. POUR NEW CONCRETE PLUG AND WALL



C NEW WALL CONSTRUCTION ALTERNATIVE 4
1"=25'
200-C-101, 300-C-100



D NEW WALL CONSTRUCTION ALTERNATIVES 5, 6
1"=25'
200-C-100, 400-C-100, 500-C-100

NO.	DATE	REVISION	BY	APVD
DSGN		DR	CHK	APVD
		BT	BT	KS

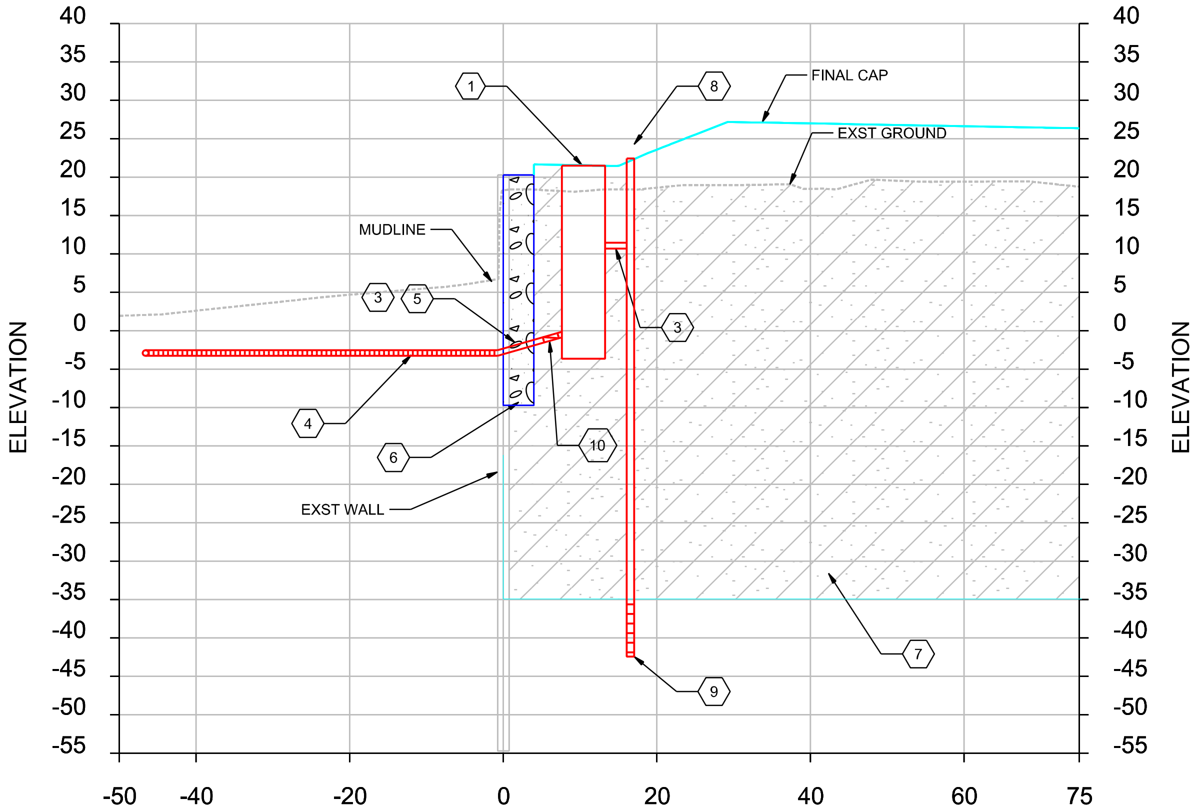
FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL®

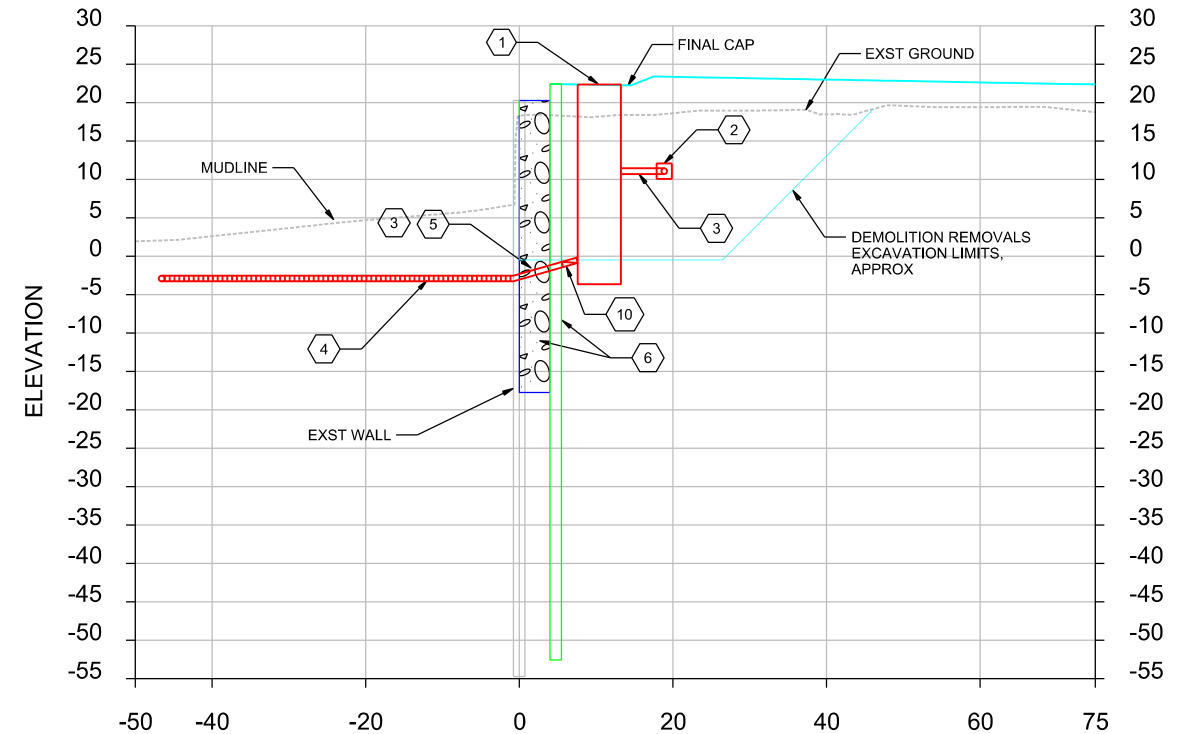
COMMON ELEMENTS
DETAILS - REMOVALS AND NEW WALL CONSTRUCTION

VARIES
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	OCTOBER 2015
PROJ	438527
DWG	101-CE-300
SHEET	of



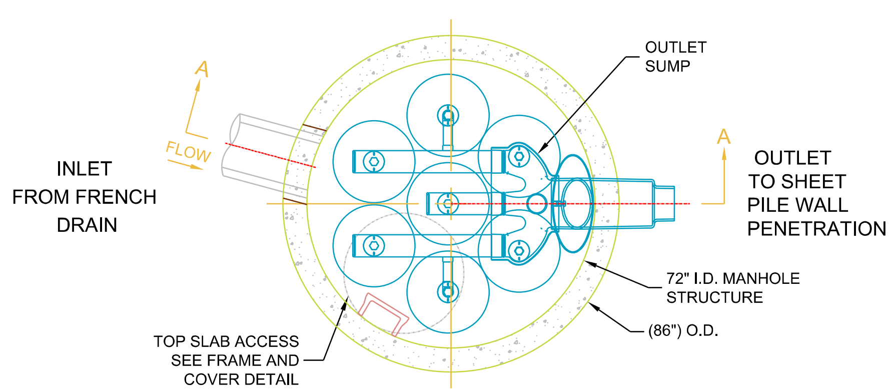
A GROUNDWATER TREATMENT SECTION ALT 4
1"=25'
300-C-103



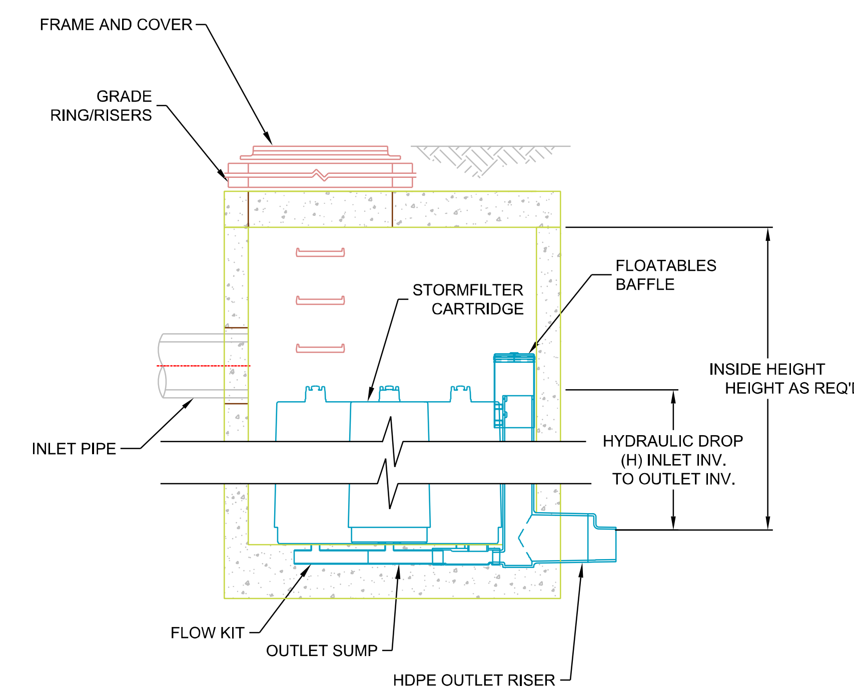
B GROUNDWATER TREATMENT SECTION ALT 5, 6
1"=25'
101-CE-105

KEYNOTES

1. 5 FT DIA CONC MANHOLE WITH CONTECH GAC FILLED STORMFILTERS. SEE DETAIL THIS DWG
2. 2 FT SQUARE TRENCH DRAIN WITH 12" DIAMETER HDPE SDR 11 PERFORATED PIPE. BACKFILL TRENCH WITH DRAIN GRAVEL AND WRAP PERIMETER IN GEOTEXTILE. TEE FITTING FROM FRENCH DRAINS TO CONNECTING PIPE.
3. 12" DIA HDPE SDR 11 CONNECTING PIPE
4. 12" DIA HDPE SDR 11 PERFORATED PIPE. TRENCH IN BEACH. MAINTAIN MINIMUM 4 FT COVER. LENGTH VARIES, SEE DWG 101-CE-105.
5. CORE THROUGH NEW AND EXISTING WALL SECTIONS. PLACE PIPE AND SEAL ANNULUS.
6. NEW WALL COMPONENTS. SEE DWG 101-CE-300
7. ISS TREATED MATERIAL
8. 12" DIA WELL CASING. EXTEND BELOW ISS TREATED MATERIAL. ELEVATION VARIES, SEE ISS TREATMENT TABLE.
9. PERFORATED WELL SCREEN BELOW ISS TREATMENT LIMITS. MINIMUM 4 FT BELOW LIMITS.
10. CHECK VALVE



CONTECH SW MANHOLE PLAN VIEW
NTS



SECTION A-A

NO.	DATE	REVISION	BY	APVD
DSGN BT	DR BT	CHK KS	APVD	

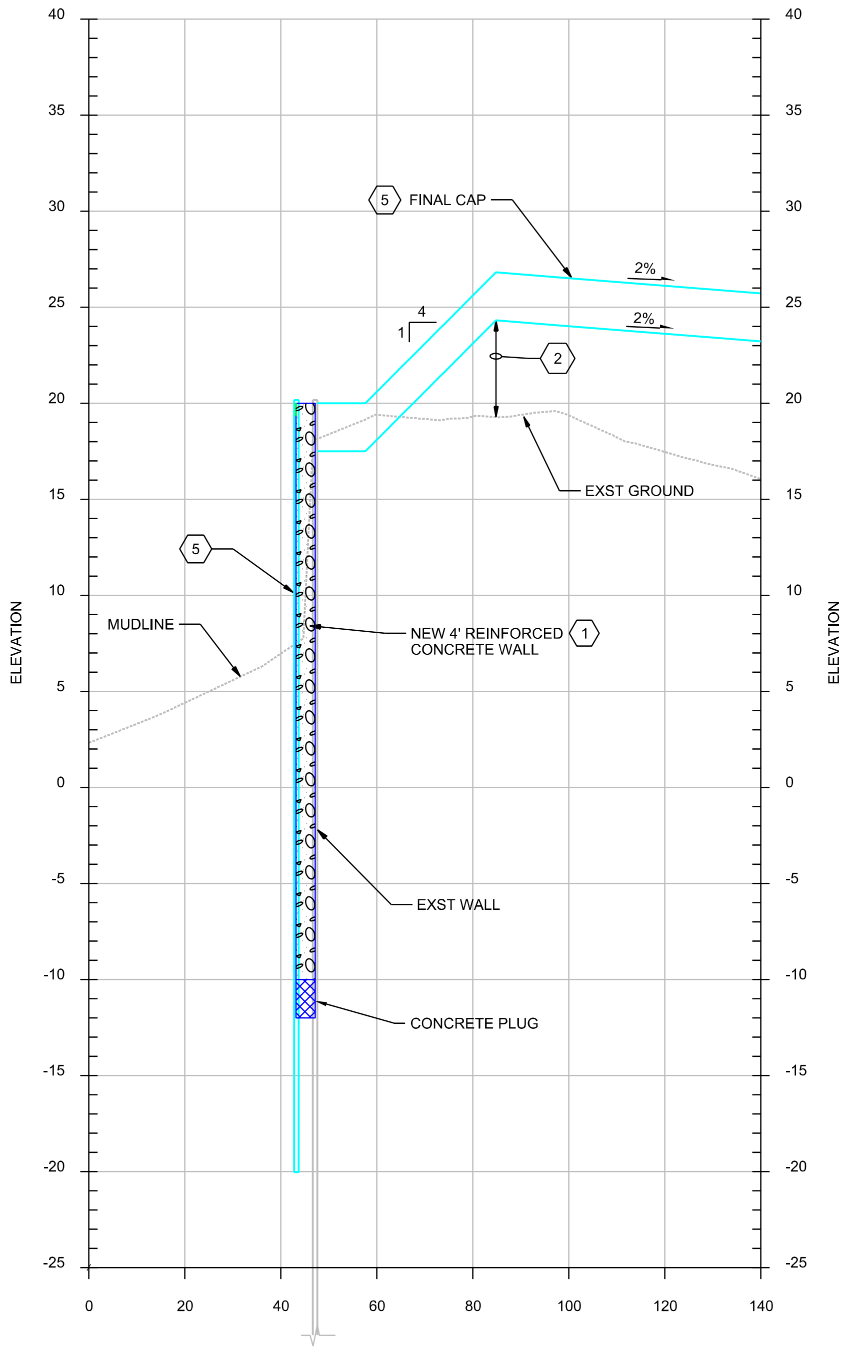
FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL®

COMMON ELEMENTS
DETAILS - PASSIVE GROUNDWATER TREATMENT

VARIES
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	OCTOBER 2015
PROJ	438527
DWG	101-CE-301
SHEET	of



C NEW WALL CONSTRUCTION ALTERNATIVE 7

HORIZ: 1"=20'
VERT: 1"=5'

700-C-120

CONSTRUCTION SEQUENCE ALTERNATIVE 7

1. REMOVE MATERIALS AS SHOWN IN REMOVALS/DEMOLTION.
2. MAINTAIN WATER LEVEL IN EXCAVATION AREA TO NO MORE THAN 16 FT ABOVE TIDE LEVEL AT ALL TIMES UNTIL BACKFILL IS PLACED
3. PLACE AND COMPACT BACKFILL
4. DRIVE NEW SHEET PILE
5. EXCAVATE MATERIAL BETWEEN NEW AND EXISTING SHEET PILE WALL.
6. CONSTRUCT FINAL COVER
7. POUR NEW CONCRETE PLUG AND WALL

KEYNOTES

1. REINFORCEMENT #8's, 12" O.C. EW EF.
2. FILL DEPTH VARIES. SWELL WILL BE GRADED TO ACHEIVE MINIMUM 2% SLOPE OF FINAL COVER.
3. FINAL CAP. SEE DET 2 ON 200-C-301.
4. FILL REQUIRED TO ACHIEVE 2% MIN SLOPE OF FINAL CAP.
5. SHEET PILE WALL ELEVATION VARIES. MAXIMUM WALL ELEVATION = 20.0. NEW SHEET PILE WALL WAS DESIGNED FOR MAXIMUM ELEVATION.

NO.	DATE	REVISION	BY	APVD

DSGN KS | DR BT | CHK BT | APVD

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL

COMMON ELEMENTS
DETAILS - NEW WALL CONSTRUCTION

VARIES
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	OCTOBER 2015
PROJ	438527
DWG	101-CE-302
SHEET	of

GENERAL NOTES

1. EXISTING BASE MAP SHOWN SCREENED REPRESENTS CURRENT CONDITIONS. ACTUAL CONDITIONS WILL DEPEND ON GRADING AND REMOVALS DONE AS PART OF DEMOLTION. SEE DWG 101-CE-103 FOR DEMOLITION CHANGES.
2. COVER GRADES ARE CONCEPTUAL. STORMWATER DITCHES AND GRADING FEATURES ALONG THE PERIMETER WALL ARE NOT SHOWN. GRADING AT WALL DOES NOT REFLECT TRANSITIONING TO MATCH FINAL WALL ELEVATION.

KEYNOTES

1. SEE DWG 200-C101 FOR ALTERNATIVE 2 FINAL COVER.
2. NEW ELECTRICAL AND I&C SYSTEM WILL BE LOCATED IN SAME TRENCH AS PIPE RUN.
3. NEW WELL FIELD WILL HAVE SERVICE POWER FROM EXISITNG MCC.

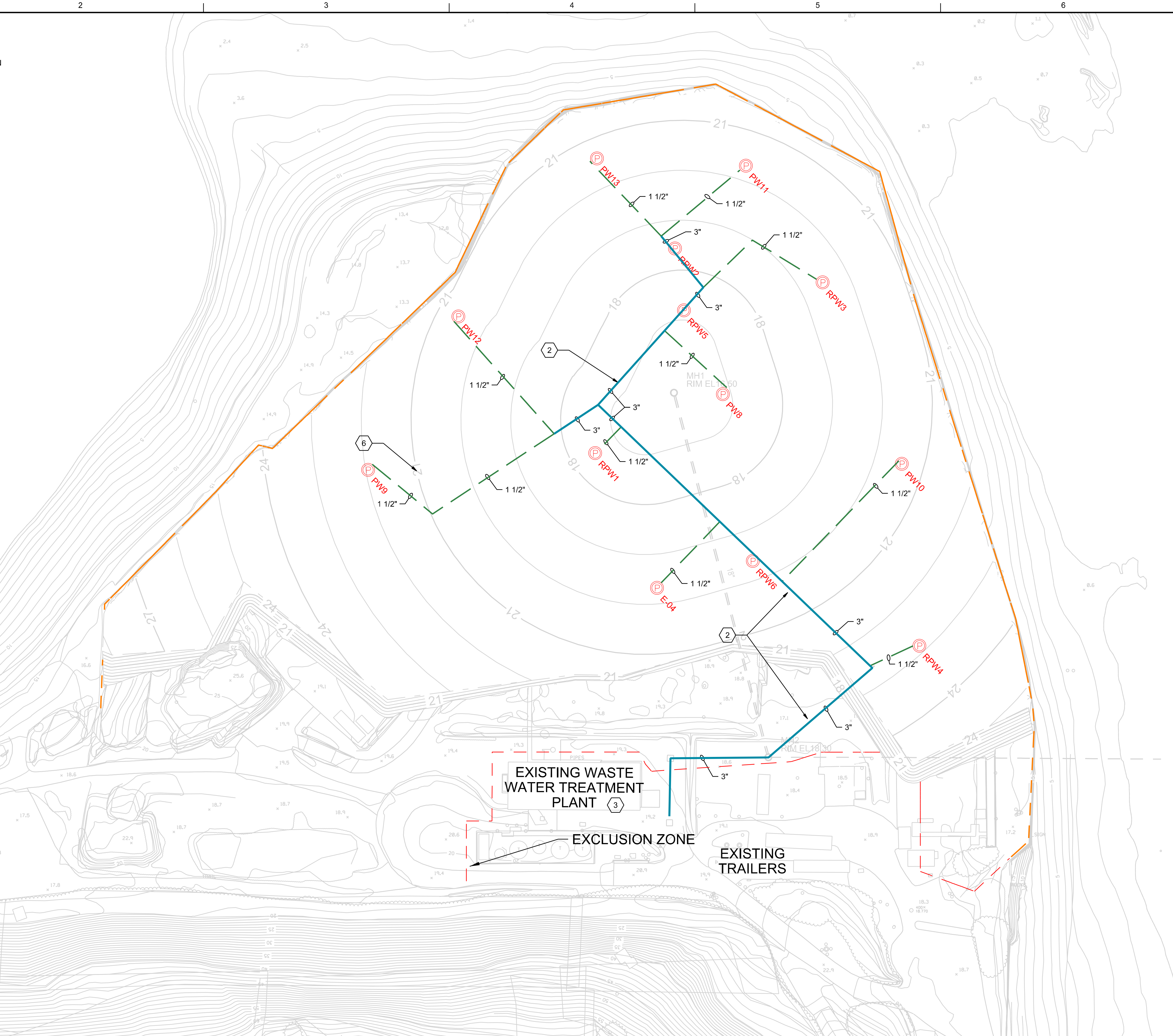
LEGEND

- PIPE RACK
- EXTRACTION WELL PIPING & UTILITY TRENCH
- NEW EXTRACTION PUMP SYSTEMS (PW9)

N

0 50 100 150

1"=50'



FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL®

ALTERNATIVE 2 CONTAINMENT
SITE PLAN - WELLS AND PIPING

NO.	DATE	REVISION	BY	APVD
DSGN	DR	CHK	APVD	
	MD	DS	MD	

1"=50 FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	200-C-100
SHEET	of

PLANNING PURPOSES ONLY. NOT FOR CONSTRUCTION

GENERAL NOTES

1. EXISTING BASE MAP SHOWN SCREENED REPRESENTS CURRENT CONDITIONS. ACTUAL CONDITIONS WILL DEPEND ON GRADING AND REMOVALS DONE AS PART OF DEMOLITION. SEE DWG 101-CE-102 FOR DEMOLITION CHANGES.
2. COVER GRADES ARE CONCEPTUAL FOR ALTERNATIVES 2, 4, 5, AND 6. STORMWATER DITCHES AND GRADING FEATURES ALONG THE PERIMETER WALL ARE NOT SHOWN.
3. COVER GRADES FOR ALTERNATIVE 4 (ISS) ARE NOMINALLY 6 FT HIGHER THAN SHOWN EXCEPT THE GRADING WILL TRANSITION TO THE ELEVATIONS AT THE NEW SHEET PILE WALL AS SHOWN. SEE THE ISS SECTION ON 101-CE-300 FOR TRANSITION.

KEYNOTES

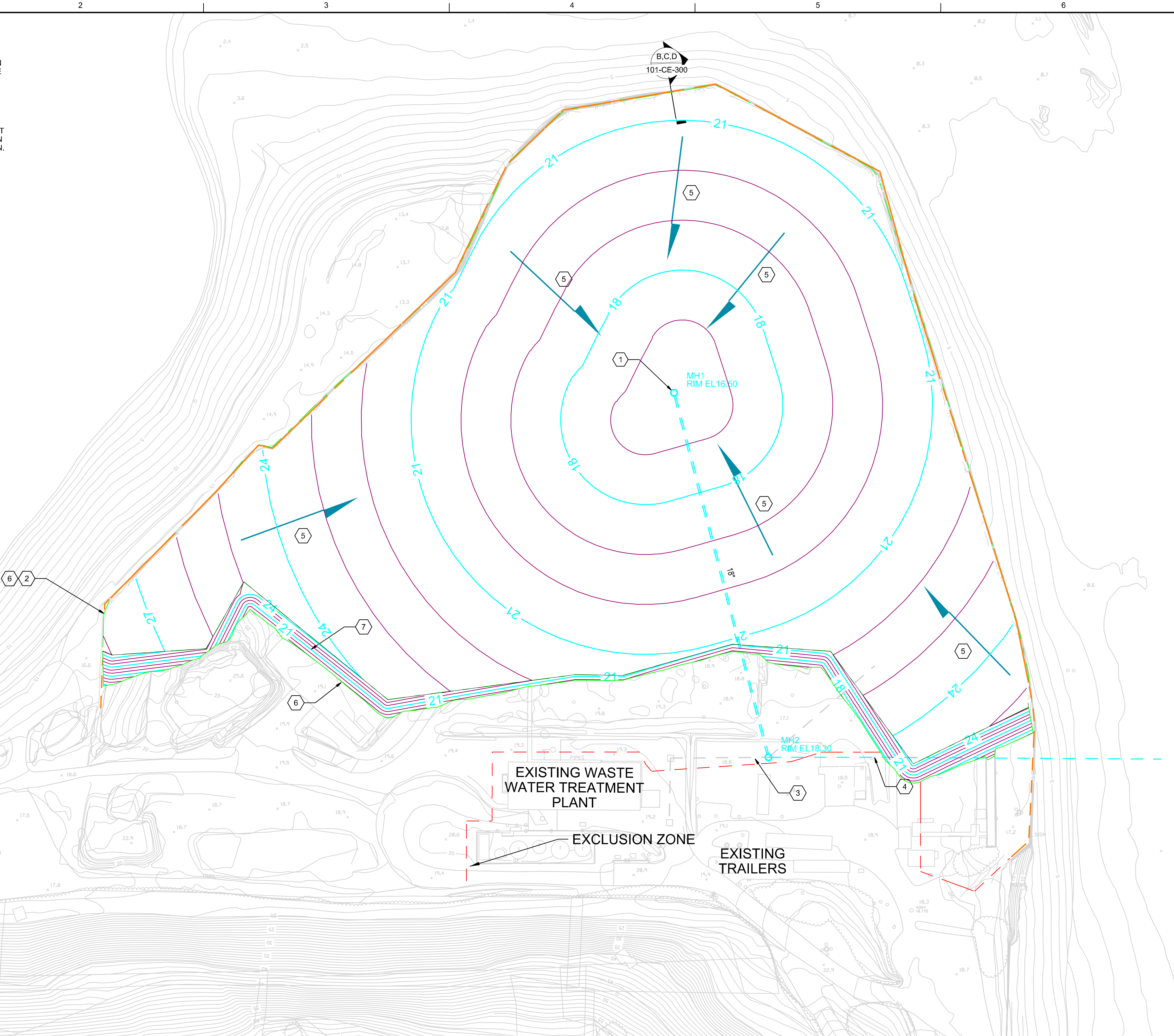
1. MH1 WITH BIRDCAGE DEBRIS BARRIER. LOCATE 72" DIAMETER MANHOLE AT LOW POINT OF COVER.
2. NEW PERIMETER WALL MAXIMUM ELEVATION 25.0 FT. GRADING FEATURES FOR COVER ELEVATIONS ABOVE 25 FT NOT SHOWN.
3. APPROXIMATE LOCATION EXISTING OUTFALL PIPING FROM TREATMENT PLANT. INTERCEPT EXISTING PIPE AND CONNECT TO NEW 72" MANHOLE.
4. NEW OUTFALL PIPE. SEE DWG 101-CE-104.
5. COVER SLOPE NOMINALLY 2% AWAY FROM COVER BOUNDARY TO CENTER OF SITE LOW POINT AT MH1.
6. FINAL COVER BOUNDARY.
7. 3:1 SLOPE DOWN TO EXISTING.

LEGEND

NEW PERIMETER WALL AND COVER LIMITS
COVER LIMITS
NEW BURIED SW OR OUTFALL PIPE
24 PROPOSED COVER CONTOUR

N

0 50 100 150
1"=50'



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NO. DATE REVISION BY APVD
DSGN BCT DR BCT CHK TO APVD

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

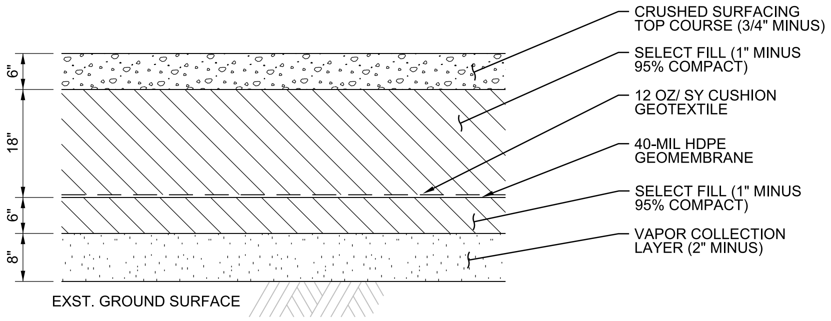
CH2MHILL

ALTERNATIVE 2 CONTAINMENT
SITE PLAN - FINAL CAP

1"=50 FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	200-C-101
SHEET	of

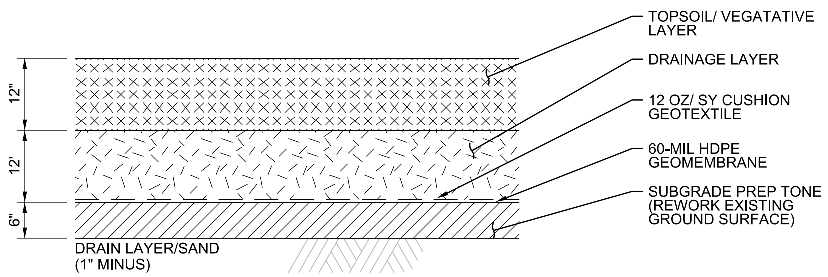
PLANNING PURPOSES ONLY. NOT FOR CONSTRUCTION



1 TEMPORARY VAPOR CAP

NTS

400-C-102



2 FINAL CAP

NTS

200-C-101

NO.	DATE	REVISION	BY	APVD

DSGN MWR DR D SUNSERI CHK MWR APVD

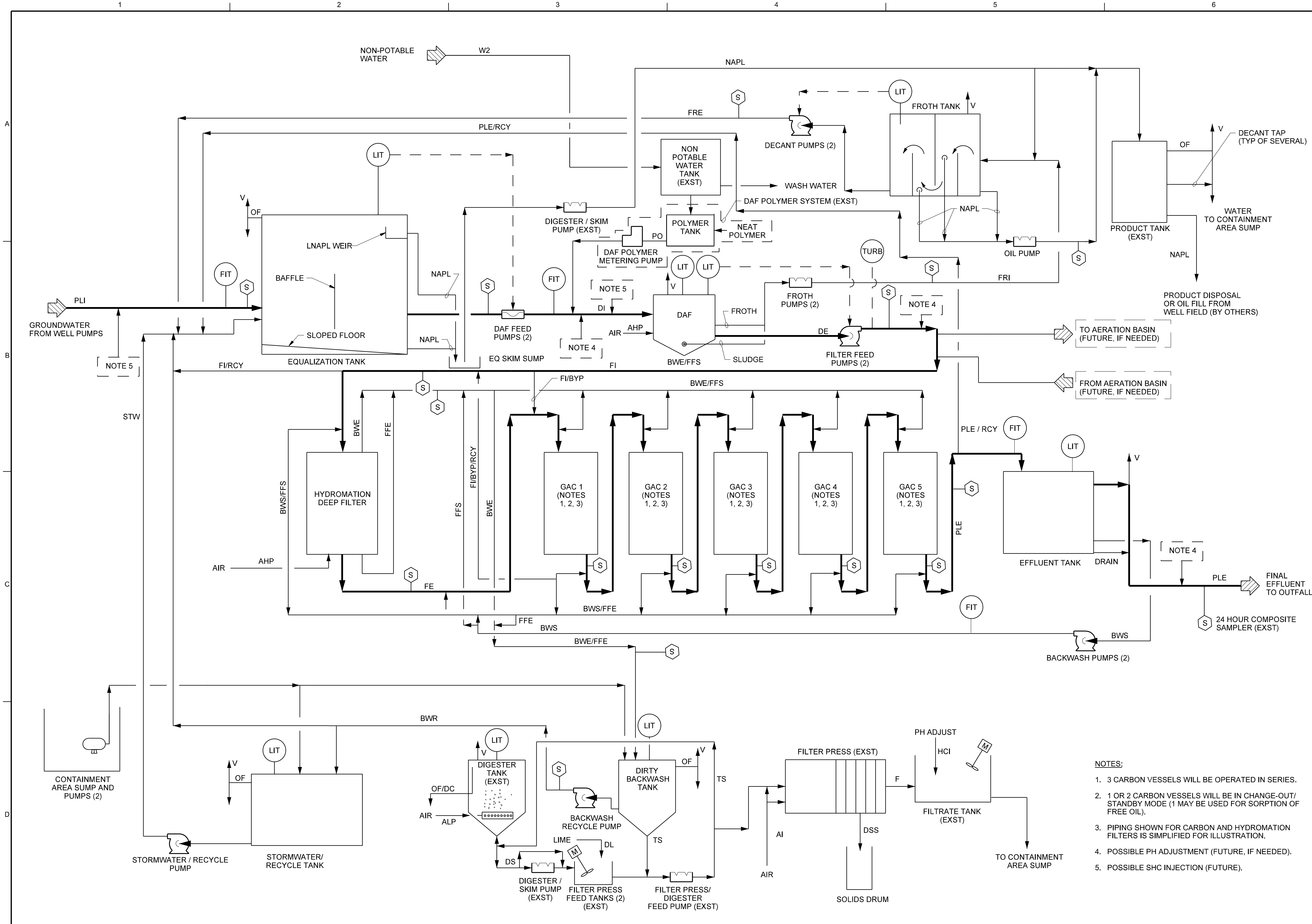
FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL®

ALTERNATIVE 2 CONTAINMENT
CAP SECTIONS

VARIES
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE
PROJ 438527
DWG 200-C-301
SHEET of



NOTES:

1. 3 CARBON VESSELS WILL BE OPERATED IN SERIES.
2. 1 OR 2 CARBON VESSELS WILL BE IN CHANGE-OUT/ STANDBY MODE (1 MAY BE USED FOR SORPTION OF FREE OIL).
3. PIPING SHOWN FOR CARBON AND HYDROMATION FILTERS IS SIMPLIFIED FOR ILLUSTRATION.
4. POSSIBLE PH ADJUSTMENT (FUTURE, IF NEEDED).
5. POSSIBLE SHC INJECTION (FUTURE).

NO.	DATE	REVISION	BY	APVD
DSGN	DR	CHK	APVD
BS	BS	VMS	BS

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL

ALTERNATIVE 2
GWTP
PROCESS FLOW DIAGRAM

NTS
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	OCTOBER 2015
PROJ	438527
DWG	200-C-302
SHEET	of

GENERAL NOTES

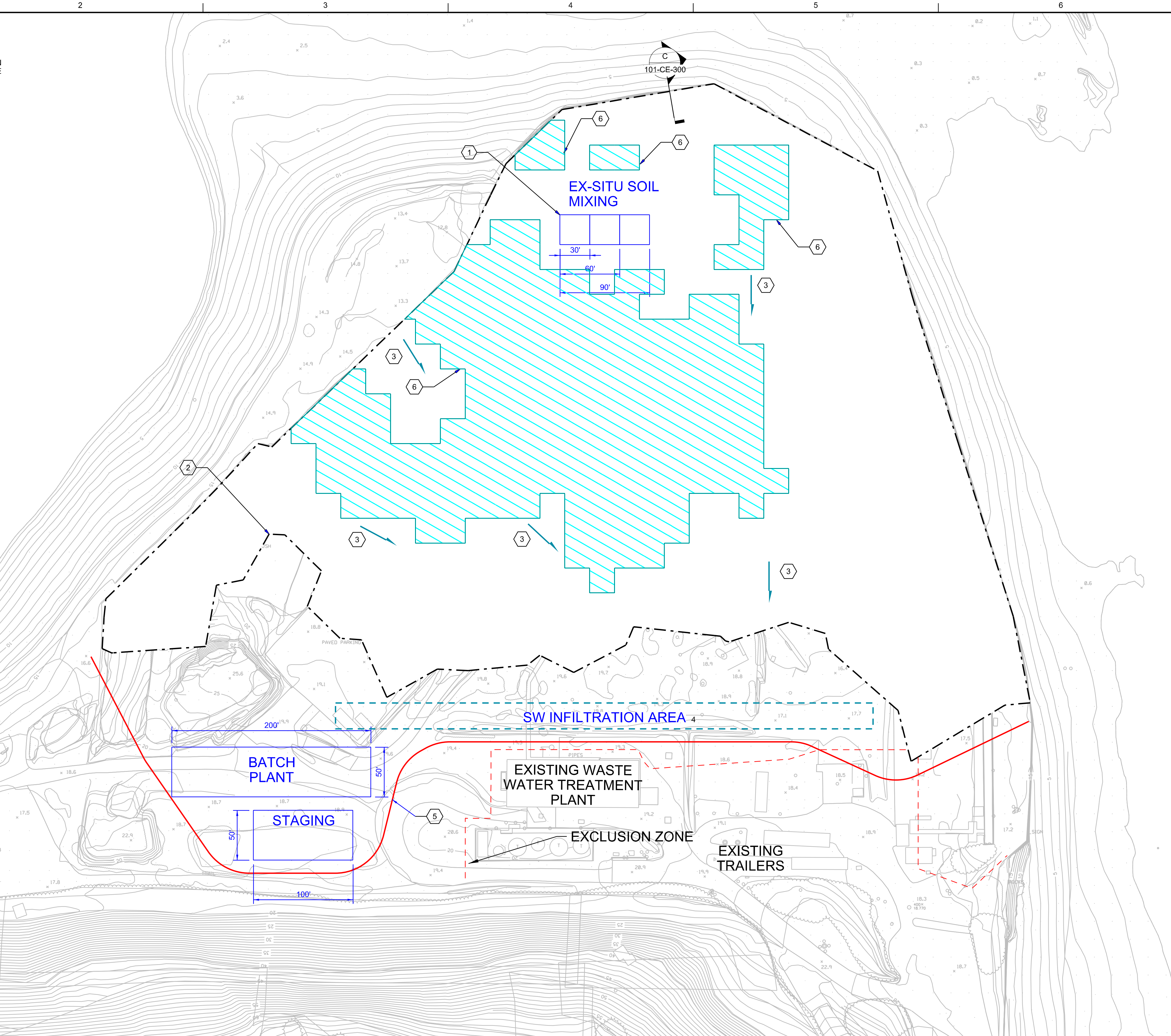
1. EXISTING BASE MAP SHOWN SCREENED REPRESENTS CURRENT CONDITIONS. ACTUAL CONDITIONS WILL DEPEND ON GRADING AND REMOVALS DONE AS PART OF DEMOLITION. SEE DWG 101-CE-102 FOR DEMOLITION CHANGES.
2. EXCAVATE ALL ISS TREATMENT AREAS TO 7 FEET BELOW GRADE BEFORE TREATMENT. AMEND SOIL WITH CEMENT AND PLACE AND GRADE AFTER ISS TREATMENT.
3. SEE DWG 300-C-300 FOR THE SEQUENTIAL STEPS OF ISS/JET GROUT TREATMENT.

KEYNOTES

1. 3 - 30 FT SQUARE MIXING CELLS. MOVE AREA AS TREATMENT PROGRESSES.
2. ISS TREATMENT BOUNDARY. SEE 101-C-100 AND 100-C-102 FOR ISS AND JET GROUT AREAS. TOTAL AREA =7.7218 ACRES
3. SLOPE GRADED AREA TO DRAIN TO SW INFILTRATION AREA AS CONSTRUCTION PROGRESSES.
4. SW INFILTRATION/POND AREA. PROVIDE 10FT DEEP GRAVEL TRENCH AND SURFACE. AREA = 10800 SQ FT.
5. PROVIDE 5 FT HIGH BERM ALL AROUND FACILITY TO PREVENT FLOODING.
6. FULL DEPTH TREATMENT BOUNDARY. ALL AREA WITHIN BOUNDARY TREATED FROM EXST GROUND SURFACE TO TARGOST REFUSAL DEPTH.

LEGEND

- TREATMENT LIMITS
- BERM
- SW INFILTRATION AREA
- FULL DEPTH TREATMENT



NO. | DATE | REVISION | BY | APVD

DSGN | DR | CHK | APVD

TO | BCT | TO

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

ALTERNATIVE 4 ISS TREATMENT
ISS SITE PLAN

CH2MHILL®

1"=50 FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	OCTOBER 2015
PROJ	438527
DWG	300-C-100
SHEET	of

PLANNING PURPOSES ONLY. NOT FOR CONSTRUCTION

GENERAL NOTES

1. EXISTING BASE MAP SHOWN SCREENED REPRESENTS CURRENT CONDITIONS. ACTUAL CONDITIONS WILL DEPEND ON GRADING AND REMOVALS DONE AS PART OF DEMOLITION. SEE DWG 101-CE-102 FOR DEMOLITION CHANGES.
2. ALPHA-NUMERIC GRIDS ARE 25 FT SQUARE.

KEYNOTES

1. ISS CRUST ZONE OF HIGHER UNCONFINED COMPRESSIVE STRENGTH.
2. ISS AUGER MIXING TO START APPROX. 7' BELOW EXISTING GRADE.

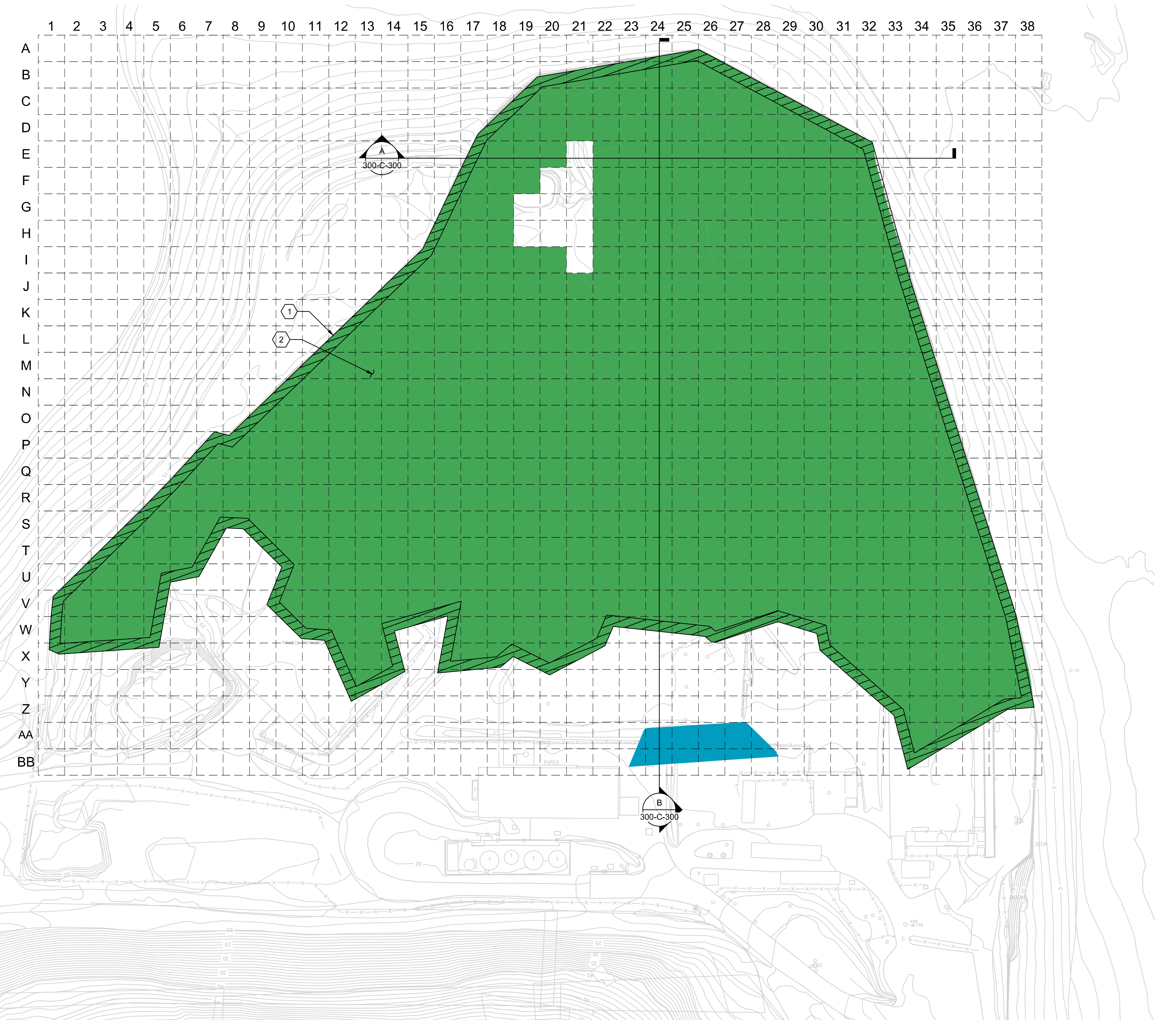
LEGEND

- ISS TREATMENT LIMITS
- 8' EXCAVATION ONLY, EX-SITU SOIL MIX AND REPLACE
- ISS CRUST

N

0 50 100 150

1"=50'



FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

NO. | DATE | REVISION | BY | APVD
DSGN | DR | CHK | APVD
TO | TO | BCT

CH2MHILL

ALTERNATIVE 4 ISS TREATMENT
SITE PLAN
ISS TREATMENT

1"=50 FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE
PROJ 438527
DWG 300-C-101
SHEET of

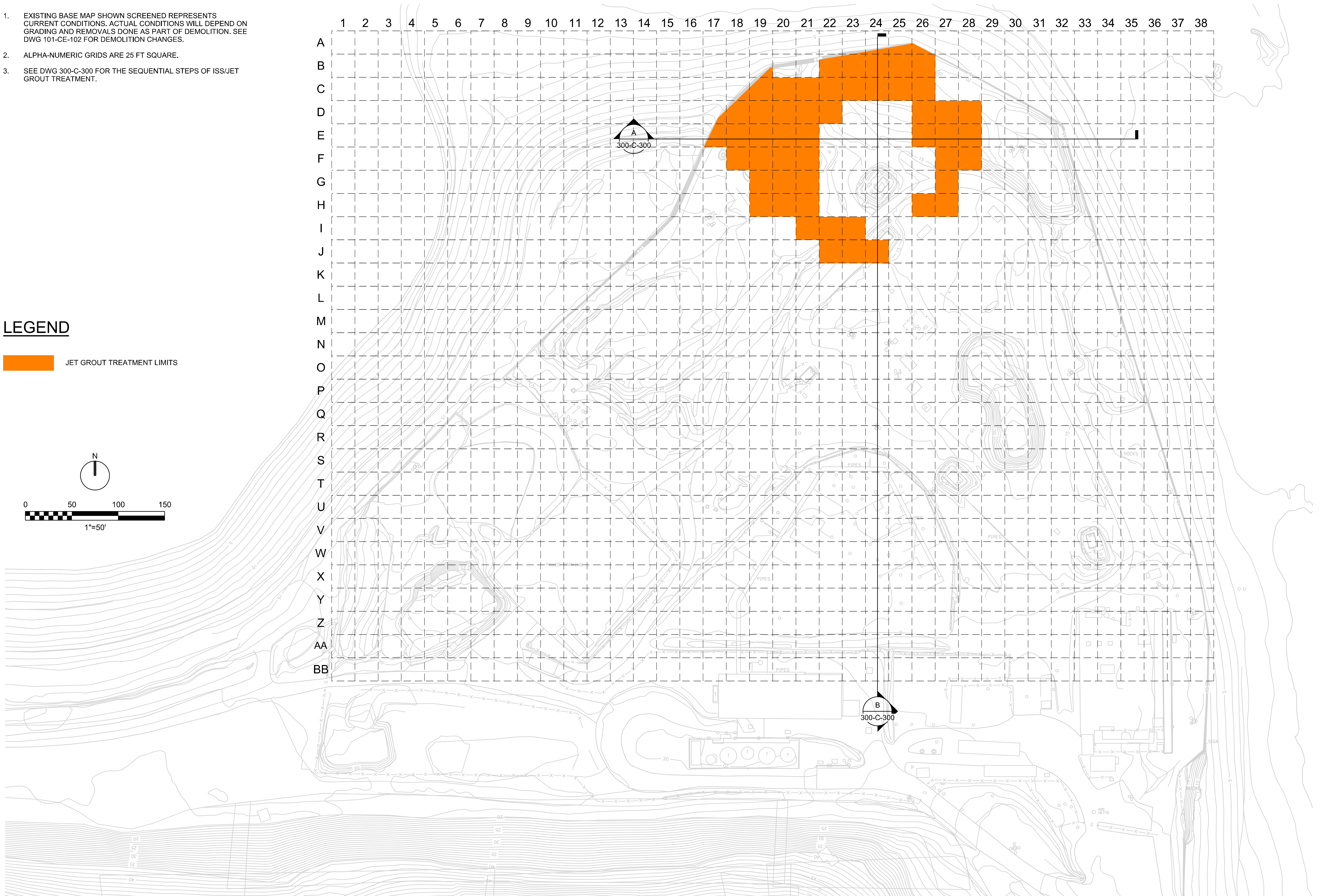
PLANNING PURPOSES ONLY. NOT FOR CONSTRUCTION

GENERAL NOTES

1. EXISTING BASE MAP SHOWN SCREENED REPRESENTS CURRENT CONDITIONS. ACTUAL CONDITIONS WILL DEPEND ON GRADING AND REMOVALS DONE AS PART OF DEMOLITION. SEE DWG 101-CE-102 FOR DEMOLITION CHANGES.
2. ALPHA-NUMERIC GRIDS ARE 25 FT SQUARE.
3. SEE DWG 300-C-300 FOR THE SEQUENTIAL STEPS OF ISS/JET GROUT TREATMENT.

LEGEND

JET GROUT TREATMENT LIMITS



N

0 50 100 150
1"=50'

NO.	DATE	REVISION	BY	APVD

DSGN | DR | CHK JP | APVD

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL®

ALTERNATIVE 4 ISS
SITE PLAN
JET GROUT TREATMENT

1"=50 FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	300-C-102
SHEET	of

GENERAL NOTES

1. EXISTING BASE MAP SHOWN SCREENED REPRESENTS CURRENT CONDITIONS. ACTUAL CONDITIONS WILL DEPEND ON GRADING AND REMOVALS DONE AS PART OF DEMOLITION. SEE DWG 101-CE-102 FOR DEMOLITION CHANGES.
2. SEE DWG 300-C-102 FOR ISS TREATMENT DETAILS NOT DESCRIBED ON THIS DWG.

KEYNOTES

1. GROUNDWATER TREATMENT SYSTEM MANHOLE.
2. COLLECTION MANHOLE.
3. DRAIN PIPE THROUGH SHEET PILE WALL
4. SUBSURFACE DRAIN PIPE

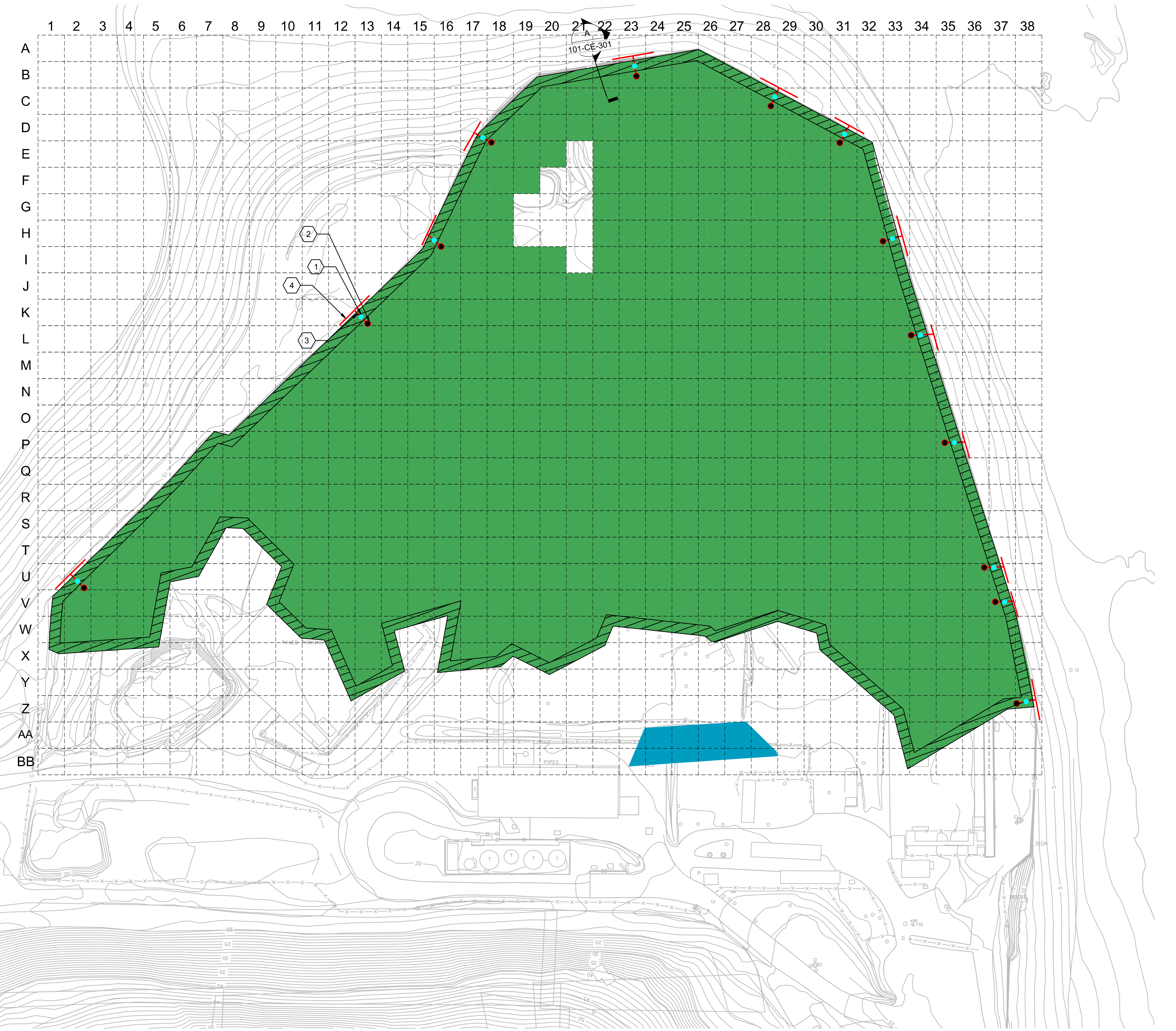
LEGEND

- ISS TREATMENT LIMITS
- 8' EXCAVATION ONLY, EX-SITU SOIL MIX AND REPLACE
- ISS CRUST
- COLLECTION MANHOLE
- TREATMENT WELL
- DRAIN PIPE

N

0 50 100 150

1"=50'



NO.	DATE	REVISION	BY	APVD

DSGN | DR | CHK | APVD
TO | TO | BCT |

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL®

ALTERNATIVE 4 ISS TREATMENT
PASSIVE GROUNDWATER TREATMENT SYSTEM

1"=50 FT

VERIFY SCALE

BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	300-C-103
SHEET	of

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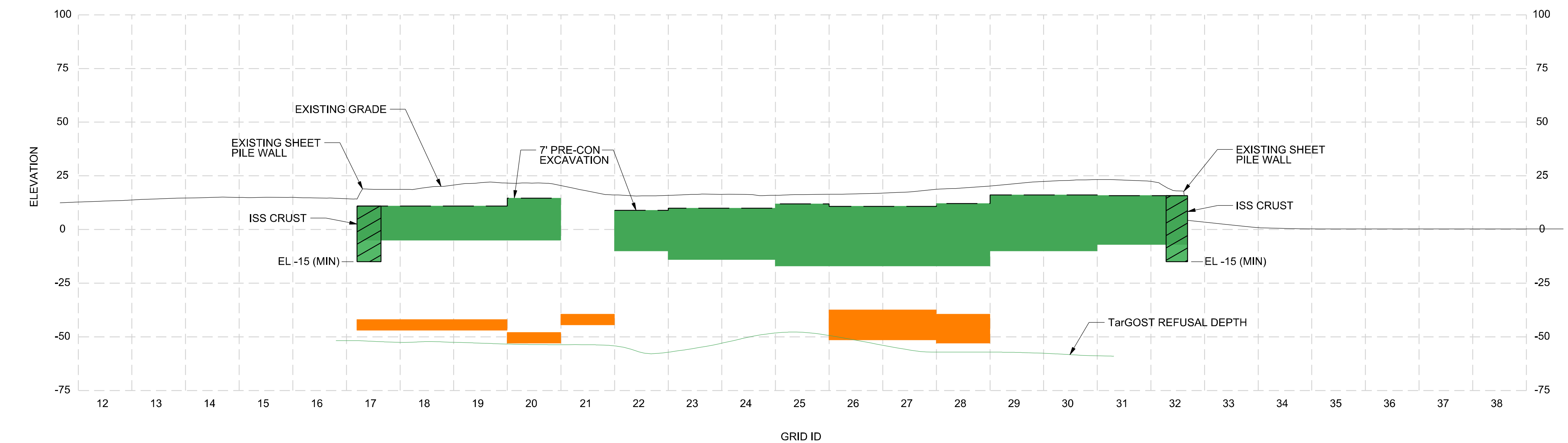
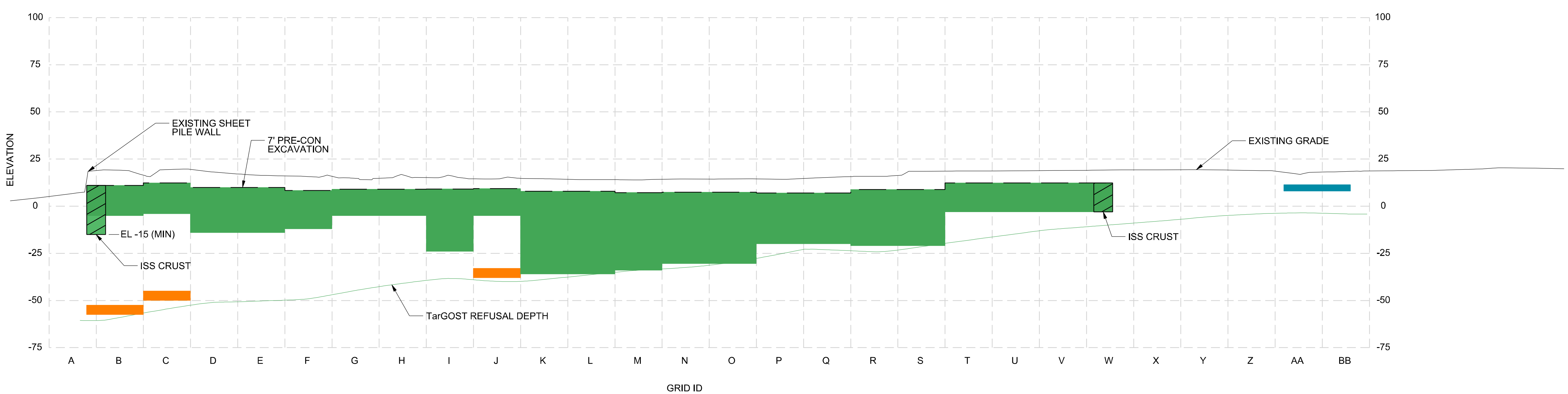


A 300-C-102 WEST / EAST SITE SECTION
SCALE: 1"=30'

NOTE: SEE DWG 300-C-301 FOR CONSTRUCTION SCHEMATICS



B 300-C-102 NORTH / SOUTH SITE SECTION
SCALE: 1"=30'

NOTE: SEE DWG 300-C-301 FOR CONSTRUCTION SCHEMATICS

LEGEND

- ISS TREATMENT LIMITS
- 8' EXCAVATION ONLY, EX-SITU SOIL MIX AND REPLACE
- JET GROUT
- ISS CRUST

CH2MHILL®

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

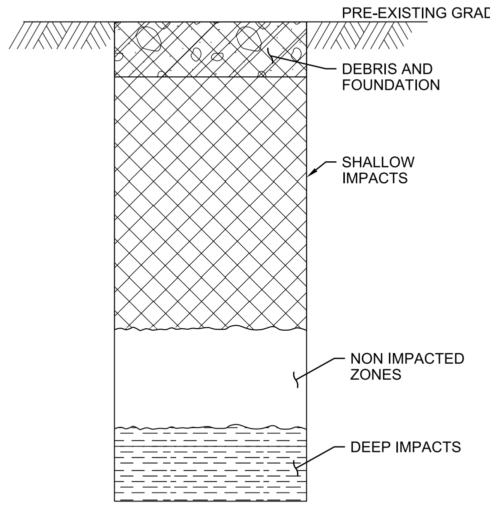
ALTERNATIVE 4 ISS
ISS CROSS SECTIONS
ISS / JET GROUT

NO.	DATE	REVISION	BY	APVD

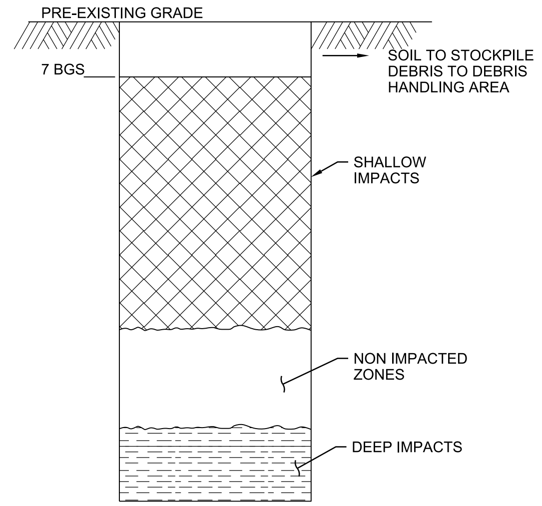
DSGN | DR | CHK JP | APVD

1"=30' FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

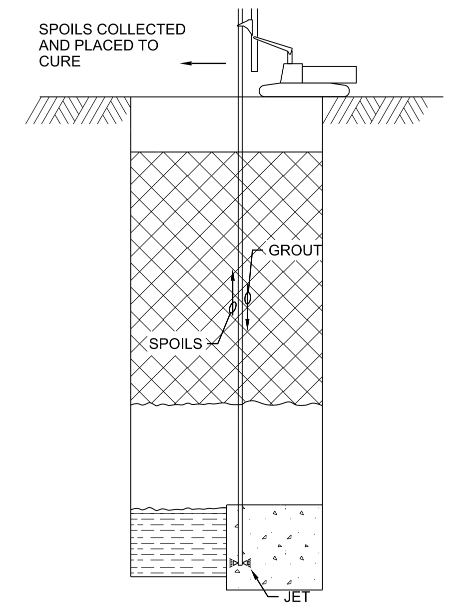
DATE	OCTOBER 2015
PROJ	438527
DWG	300-C-300
SHEET	of



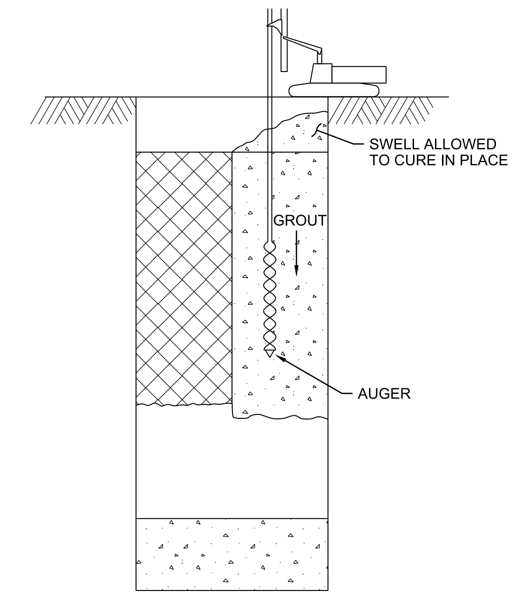
EXISTING CONDITIONS
NTS



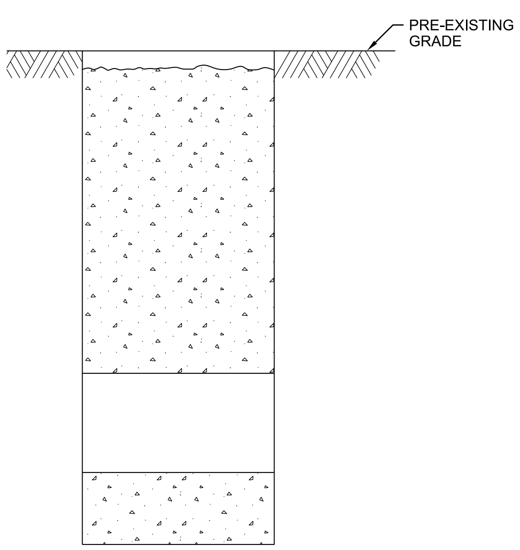
STEP 1
7' EXCAVATION AND
DEBRIS/ FOUNDATION REMOVAL
NTS



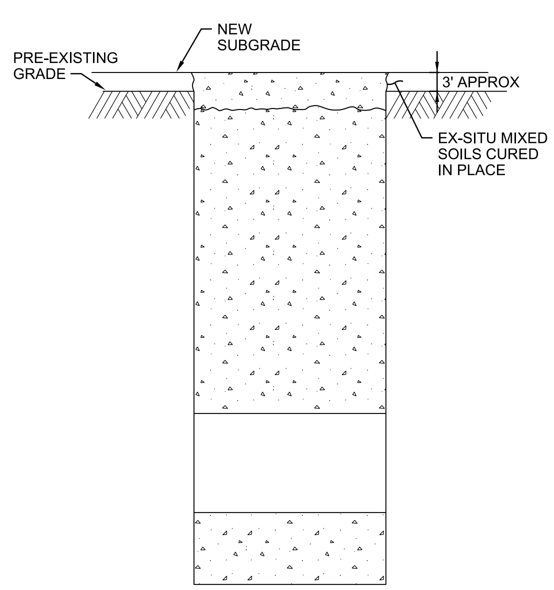
STEP 2
JET GROUT
DEEP IMPACTS
NTS



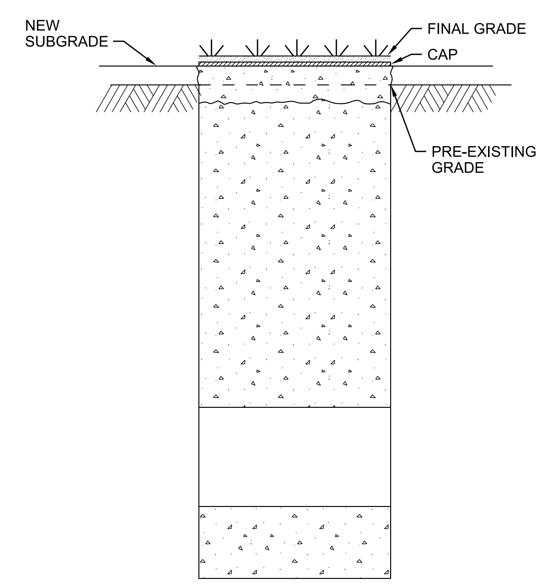
STEP 3
AUGER ISS OF
SHALLOW IMPACTS
NTS



STEP 4
POST ISS CONDITIONS
NTS



STEP 5
EX-SITU MIXING OF
EXCAVATED SOILS AND
PLACEMENT OVER ISS
NTS



STEP 6
CAP PLACEMENT
AND FINAL CONDITIONS
NTS

GENERAL NOTES

1. TYPICAL SCHEMATIC SECTIONS ARE SHOWN FOR THE SEQUENCE OF ISS/JET GROUT CONSTRUCTION BEGINNING WITH EXISTING CONDITIONS AND PROGRESSING THROUGH ISS/JET GROUT ACTIVITIES.

NO.	DATE	REVISION	BY	APVD

DSGN | DR TO | CHK JP TO | APVD

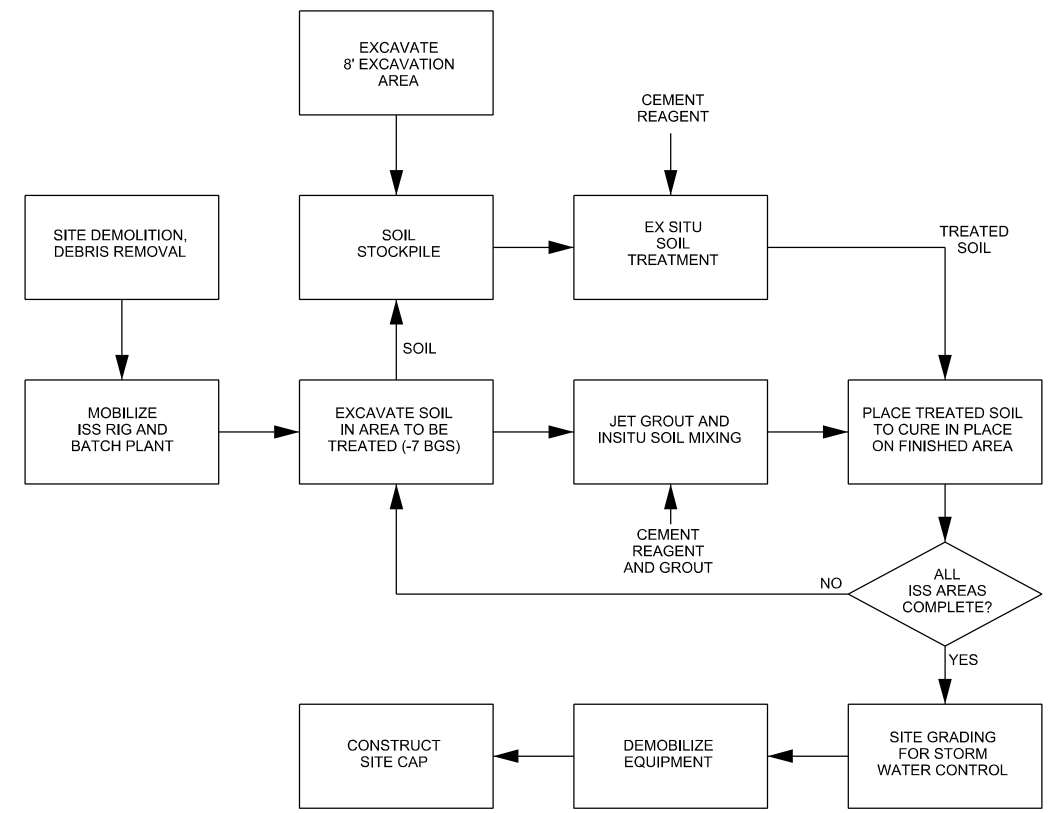
FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL

ALTERNATIVE 4 ISS
ISS PROGRESSION
ISS / JET GROUT

1"=30 FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	300-C-301
SHEET	of



NO.	DATE	REVISION	BY	APVD

DSGN	DR	CHK	APVD
M. DAVIS			

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL®

ALTERNATIVE 4
PROCESS FLOW DIAGRAM

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	OCTOBER 2015
PROJ	438527
DWG	300-C-600
SHEET	of

GENERAL NOTES

1. EXISTING BASE MAP SHOWN SCREENED REPRESENTS CURRENT CONDITIONS. ACTUAL CONDITIONS WILL DEPEND ON GRADING AND REMOVALS DONE AS PART OF DEMOLITION. SEE DWG 101-CE-102 FOR DEMOLITION CHANGES.
2. SEE DRAWING 500-C-100 FOR LOCATION OF DEWATERING WELLS THAT WILL BE USED FOR DEWATERING THERMAL TREATMENT AREAS PRIOR TO STEAM INJECTION.

KEYNOTES

1. NAPL EXTRACTION WELLHEAD. SEE DWG 400-C-500 FOR DETAILS.
2. SEE DWG 400-C-104 FOR PIPING TO EXST WATER TREATMENT PLANT.
3. INSTALL VAPOR COVER BEFORE DRILLING WELLS. BOOT AROUND WELL TO PROVIDE AIRTIGHT SEAL. SEE DWG 200-C-301 FOR DETAILS.
4. SEE DWG 400-C-104 FOR DEWATER WELL PIPING.

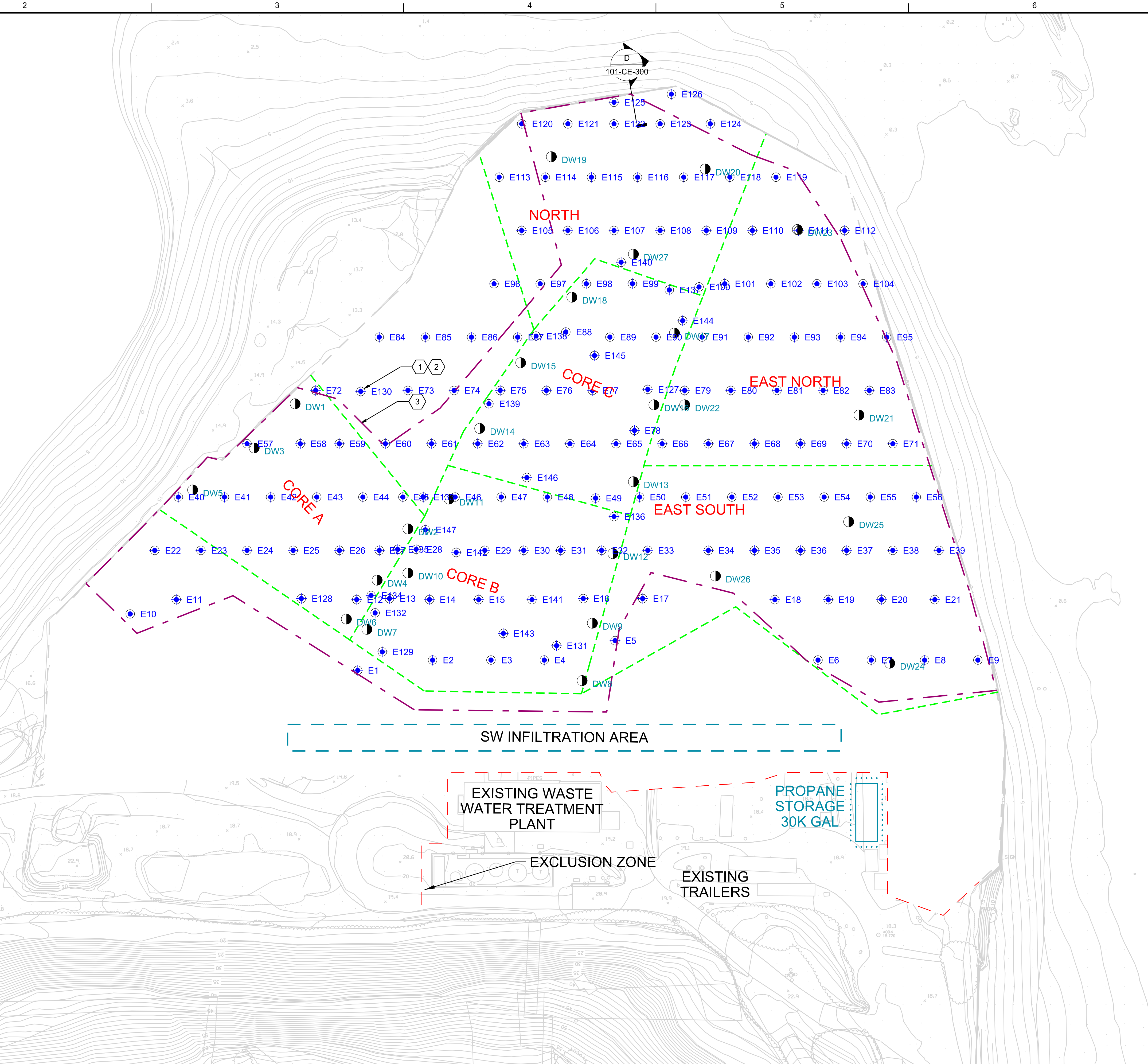
LEGEND

- SHEET PILE WALLS
- E84 EXTRACTION WELL
- VAPOR COVER LIMITS
- DW5 DEWATER WELL

N

0 50 100 150

1"=50'



CH2MHILL

ALTERNATIVE 5 THERMAL
SITE PLAN
NAPL EXTRACTION & COVER

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

NO.	DATE	REVISION	BY	APVD

DSGN BS | DR BCT | CHK BS | APVD

1"=50 FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	400-C-100
SHEET	of

PLANNING PURPOSES ONLY. NOT FOR CONSTRUCTION

GENERAL NOTES

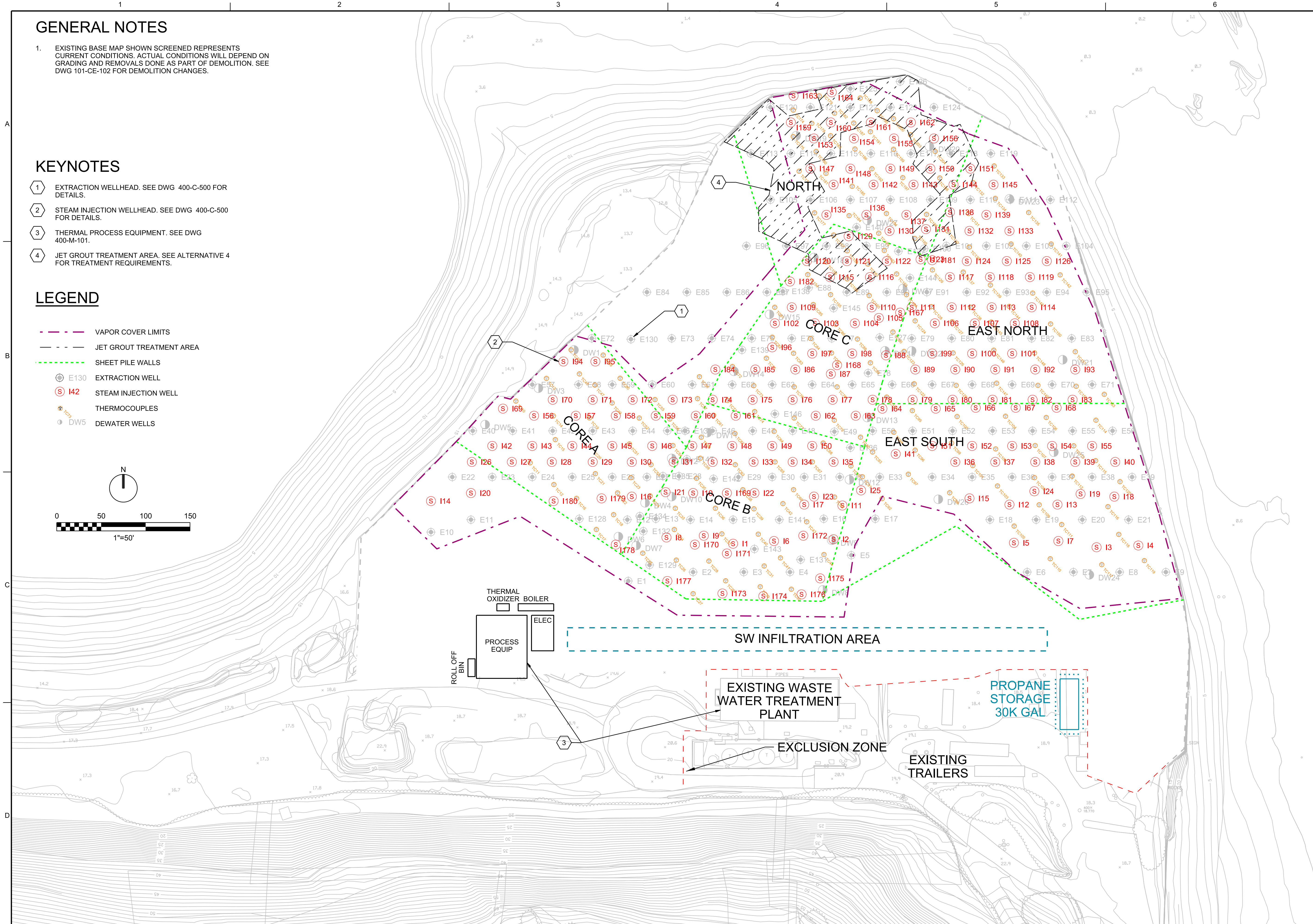
1. EXISTING BASE MAP SHOWN SCREENED REPRESENTS CURRENT CONDITIONS. ACTUAL CONDITIONS WILL DEPEND ON GRADING AND REMOVALS DONE AS PART OF DEMOLITION. SEE DWG 101-CE-102 FOR DEMOLITION CHANGES.

KEYNOTES

1. EXTRACTION WELLHEAD. SEE DWG 400-C-500 FOR DETAILS.
2. STEAM INJECTION WELLHEAD. SEE DWG 400-C-500 FOR DETAILS.
3. THERMAL PROCESS EQUIPMENT. SEE DWG 400-M-101.
4. JET GROUT TREATMENT AREA. SEE ALTERNATIVE 4 FOR TREATMENT REQUIREMENTS.

LEGEND

- VAPOR COVER LIMITS
- JET GROUT TREATMENT AREA
- SHEET PILE WALLS
- E130 EXTRACTION WELL
- I42 STEAM INJECTION WELL
- THERMOCOUPLES
- DW5 DEWATER WELLS



NO.	DATE	REVISION	BY	APVD

DSGN BS | DR BCT | CHK BS | APVD

CH2MHILL®

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

ALTERNATIVE 5 THERMAL
SITE PLAN - THERMAL WELLS AND JET GROUT TREATMENT

1"=50 FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	400-C-101
SHEET	of

PLANNING PURPOSES ONLY. NOT FOR CONSTRUCTION

GENERAL NOTES

1. EXISTING BASE MAP SHOWN SCREENED REPRESENTS CURRENT CONDITIONS. ACTUAL CONDITIONS WILL DEPEND ON GRADING AND REMOVALS DONE AS PART OF DEMOLITION. SEE DWG 101-CE-102 FOR DEMOLITION CHANGES.

KEYNOTES

1. SEE DWG 200-C-301 FOR VAPOR COVER DETAILS.
2. VAPOR EXTRACTION WELLHEAD. 3" SCH 80 CPVC PERFORATED PIPE IN VAPOR LAYER OF VAPOR CAP. SEE DWG 200-C-301. ABOVE GROUND PIPE IS 1-½" CPVC CONNECTED TO VAPOR EXTRACTION HEADER.
3. AIR INJECTION WELLHEAD. 3" SCH 80 CPVC PERFORATED PIPE IN VAPOR LAYER OF VAPOR CAP. SEE DWG 200-C-301. SUPPLY PIPE IS 1-½" CARBON STEEL.
4. THERMAL PROCESS EQUIPMENT. SEE DWG 400-M-101

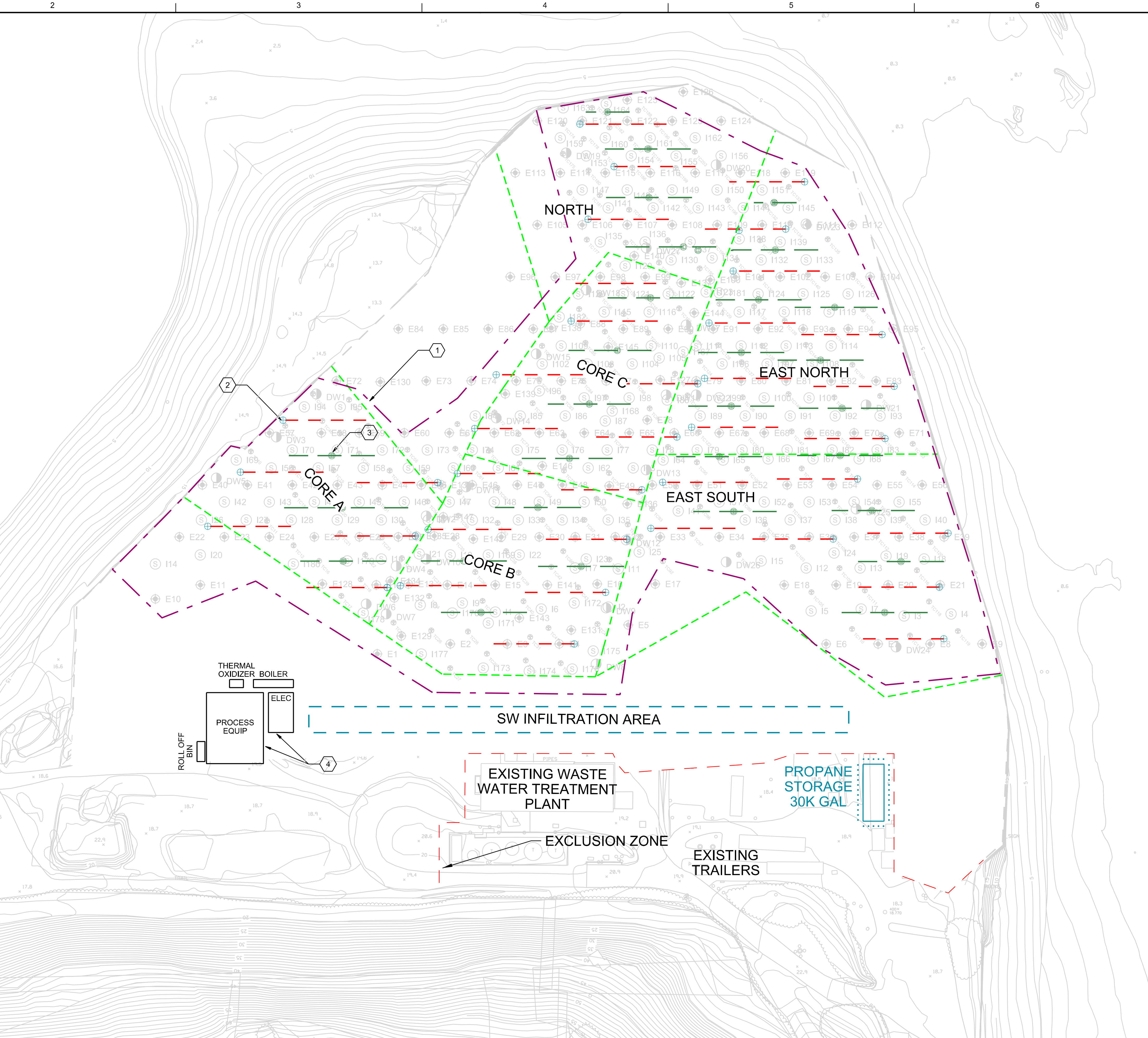
LEGEND

- EXISTING SHEET PILE WALL
- VAPOR COVER LIMITS
- SHEET PILE WALLS
- VAPOR EXTRACTION PIPING AND WELL
- AIR INJECTION PIPING AND WELL
- E84 EXTRACTION WELL
- I42 STEAM INJECTION WELL
- THERMOCOUPLE
- DW1 DEWATER WELL

N

0 50 100 150

1"=50'



CH2MHILL

ALTERNATIVE 5THERMAL

SITE PLAN
VAPOR REMOVAL FROM AND AIR INJECTION INTO COVER (JET GROUT)

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

NO.	DATE	REVISION	BY	APVD

DSGN BS | DR BCT | CHK BS | APVD

1"=50 FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	400-C-102
SHEET	of

PLANNING PURPOSES ONLY. NOT FOR CONSTRUCTION

GENERAL NOTES

1. EXISTING BASE MAP SHOWN SCREENED REPRESENTS CURRENT CONDITIONS. ACTUAL CONDITIONS WILL DEPEND ON GRADING AND REMOVALS DONE AS PART OF DEMOLITION. SEE DWG 101-CE-102 FOR DEMOLITION CHANGES.

KEYNOTES

1. BIOSPARGING WELLHEAD. SEE DWG 400-C-500 FOR DETAILS.
2. BIOSPARGING WELLHEAD CONVERTED FROM STEAM INJECTION WELLHEAD. SEE DWG 400-C-500 FOR DETAILS.
3. THERMAL PROCESS EQUIPMENT. SEE DWG 400-M-101.

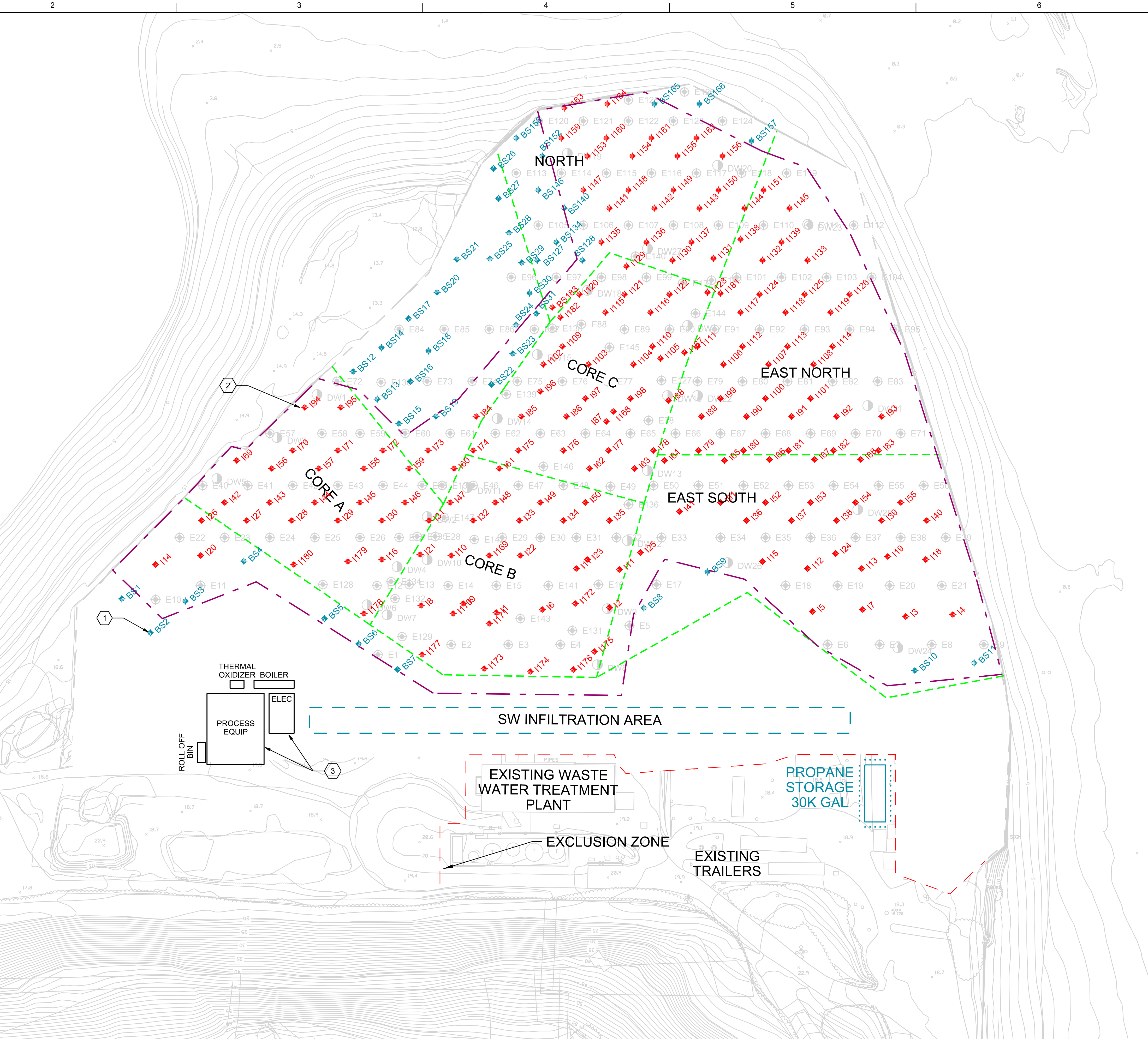
LEGEND

- EXISTING SHEET PILE WALL
- VAPOR COVER LIMITS
- SHEET PILE WALLS
- E130 EXTRACTION WELL
- BS5 BIOSPARGING WELL
- I43 BIOSPARGING WELL CONVERTED FROM STEAM INJECTION WELL
- DW1 DEWATER WELL

N

0 50 100 150

1"=50'



NO.	DATE	REVISION	BY	APVD

DSGN BS
DR BCT
CHK BS
APVD

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL®

ALTERNATIVE 5 THERMAL
SITE PLAN - ENHANCED AEROBIC

1"=50 FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	400-C-103
SHEET	of

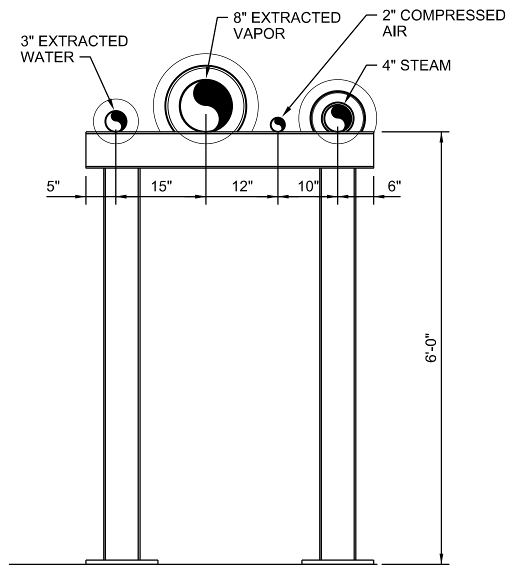
PLANNING PURPOSES ONLY. NOT FOR CONSTRUCTION

LEGEND

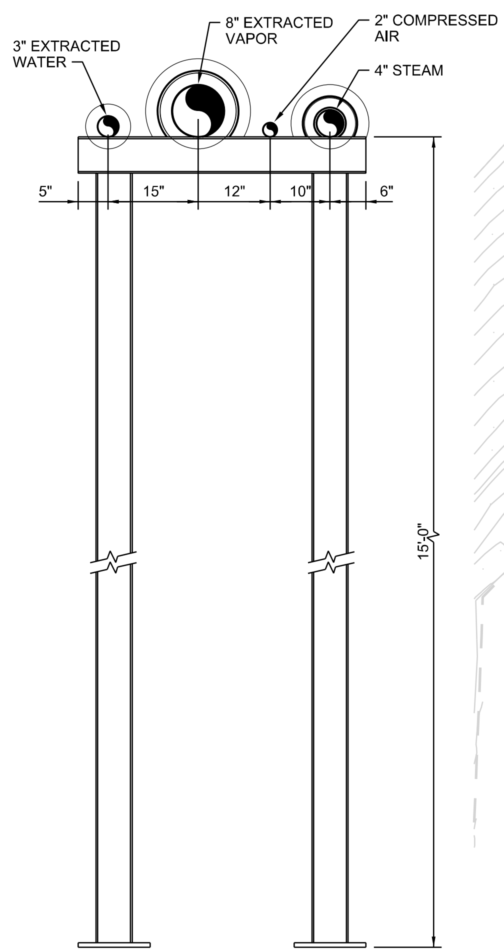
- NON-ELEVATED PIPERACK (dashed line)
- ELEVATED PIPERACK (solid line)
- (S) STEAM WELL
- (●) INJECTION WELL

NOTES:

1. IN GENERAL, THE DISTANCE BETWEEN THE NON-ELEVATED PIPERACKS IS SUFFICIENT SPACING TO ALLOW TRUCK TRAFFIC BETWEEN THE RACKS. DURING DETAILED DESIGN, SOME WELL LOCATIONS AND/ OR PIPE RACKS MAY BE MOVED TO ASSURE MAINTENANCE ACCESS TO WELLS.
2. ELEVATED PIPE RACKS WILL BE AT A HEIGHT AND WILL HAVE COLUMN SPACING TO ALLOW TRUCK TRAFFIC TO PASS UNDERNEATH THE PIPE RACK.
3. AIR INJECTION AND VAPOR EXTRACTION POINTS INTO THE VAPOR COVER ARE NOT SHOWN. LOCATIONS OF THESE WILL BE ADJUSTED AS NEEDED TO ASSURE ACCESS TO WELLS.
4. THERMOCOUPLE LOCATIONS ARE NOT SHOWN. THESE ARE AT GRADE AND WILL HAVE COVERS RATED FOR TRUCK TRAFFIC.
5. ELECTRICAL WIRING WILL BE ROUTED ON CABLE TRAYS LOCATED ABOVE PIPE RACKS.
6. EXTRACTED WATER HEADERS WILL BE USED FOR NAPL EXTRACTION, DEWATERING PRIOR TO STEAM INJECTION, AND GROUNDWATER EXTRACTION DURING STEAM INJECTION. ISOLATION VALVES AND SOME ADDITIONAL PIPE CONNECTIONS MAY BE NEEDED TO ALLOW DEWATERING OF ONE TREATMENT CELL TO OCCUR SIMULTANEOUSLY WITH STEAMING OF ANOTHER CELL.



A SECTION
3/4"=1'-0"



B SECTION
3/4"=1'-0"

PIPE RACK PLAN
1"=40'-0"

NO.	DATE	REVISION	BY	APVD

DSGN M DAVIS | DR D SUNSERI | CHK | APVD

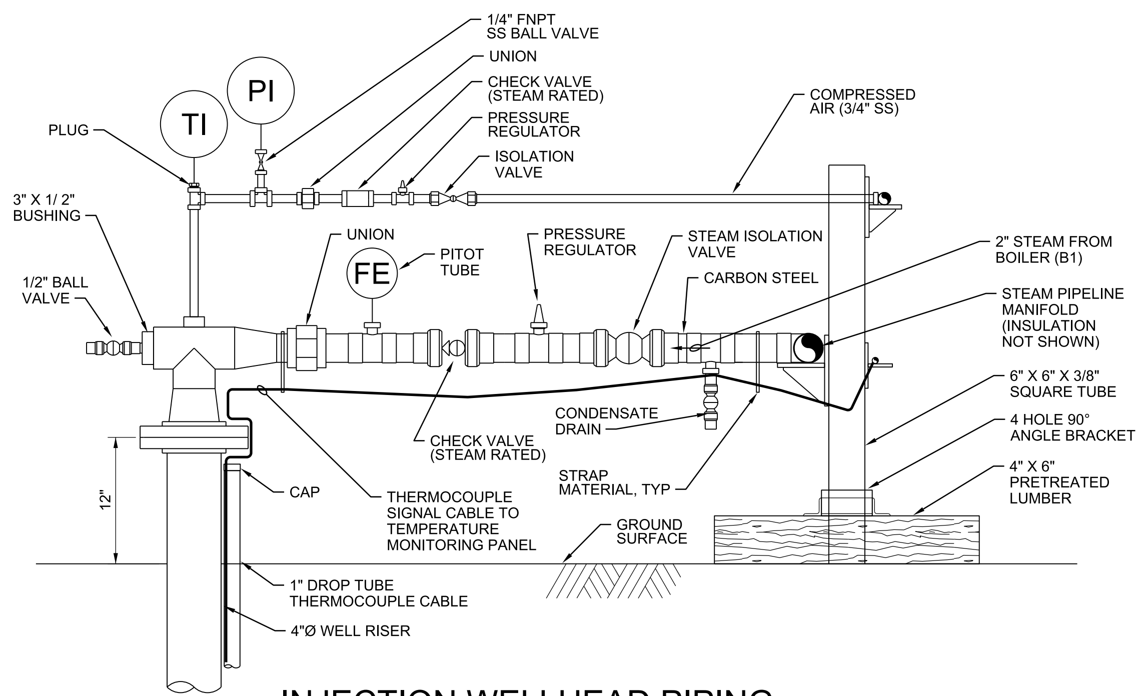
FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL®

ALTERNATIVE 5
PIPING PLAN

1"=40 FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

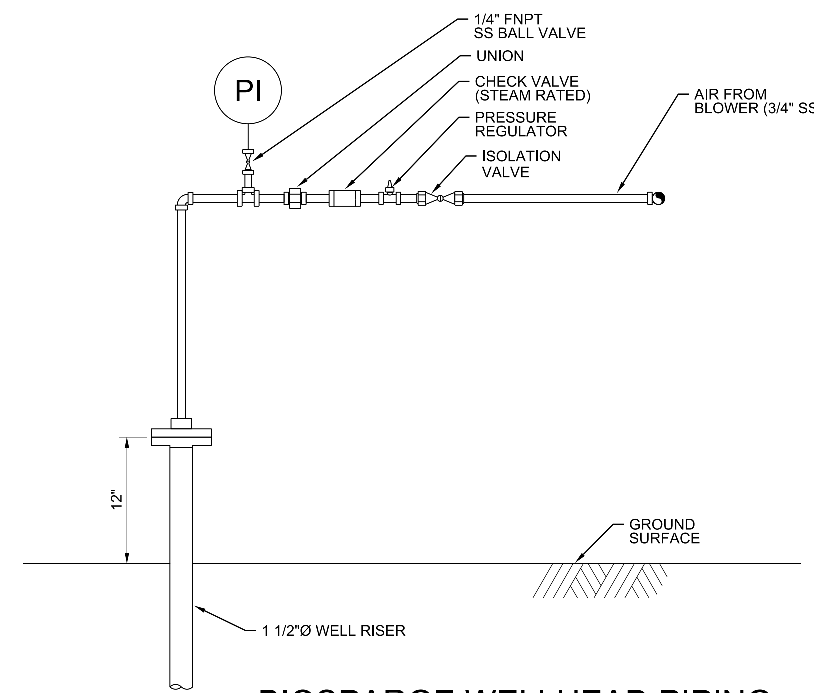
DATE	OCTOBER 2015
PROJ	438527
DWG	400-C-104
SHEET	of



INJECTION WELLHEAD PIPING

NTS

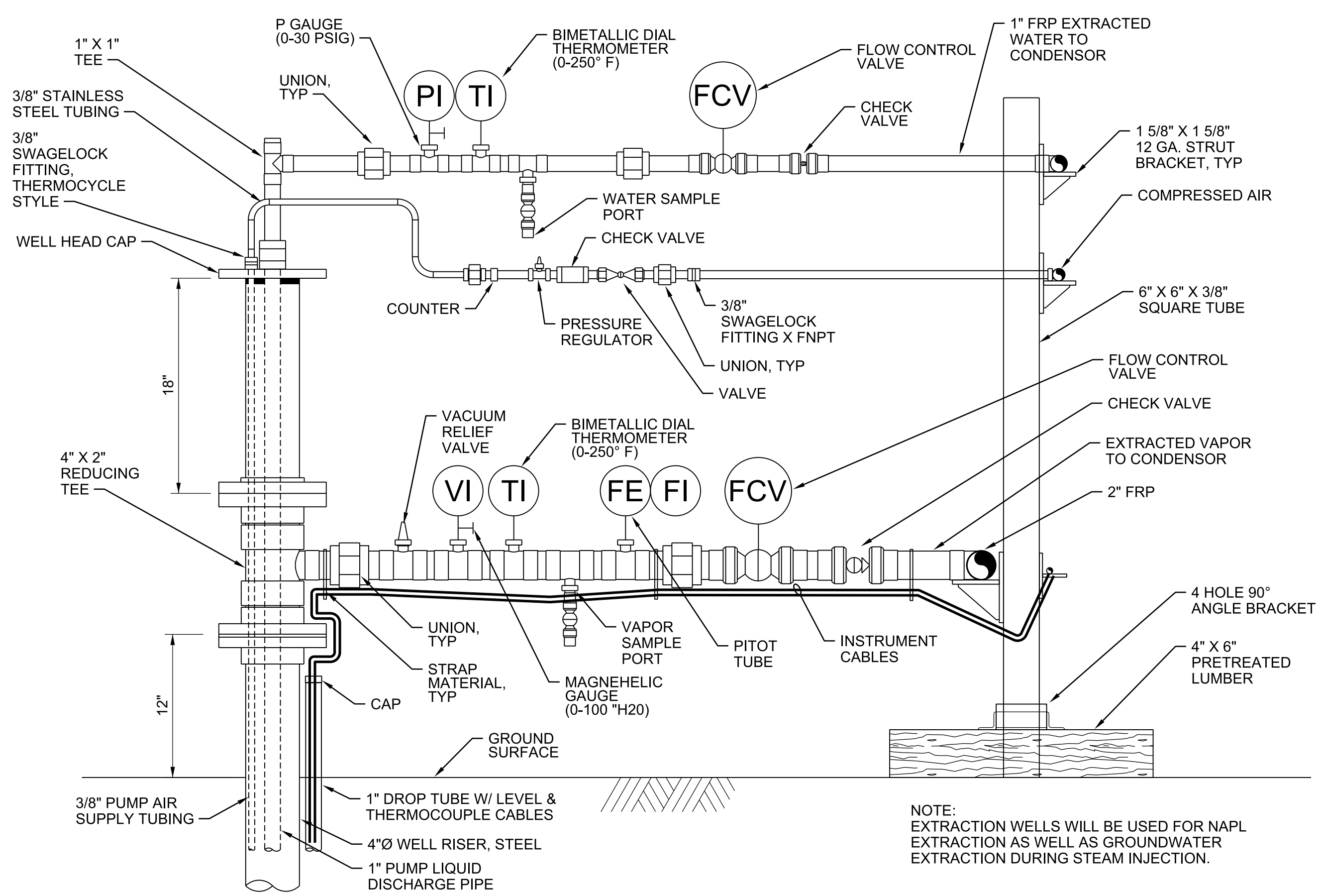
NOTE:
ONCE STEAM INJECTION IS COMPLETE, THESE WELLS WILL BE CONVERTED TO BIOSPARGING. ALL AIR PIPING WILL REMAIN IN-PLACE. STEAM PIPING AND THERMOCOUPLES CAN BE REMOVED.



BIOSPARGE WELLHEAD PIPING

NTS

NOTE:
THIS WELLHEAD IS ONLY USED IN AREAS WHERE NO STEAM INJECTION WELLS HAVE BEEN INSTALLED IN AREAS THAT RECEIVE ISCO TREATMENT, 1 1/2" Ø WELLS USED FOR ISCO WILL BE CONVERTED TO BIOSPARGING ONCE ISCO IS COMPLETE.



NOTE:
EXTRACTION WELLS WILL BE USED FOR NAPL EXTRACTION AS WELL AS GROUNDWATER EXTRACTION DURING STEAM INJECTION.

EXTRACTION WELLHEAD PIPING

NTS

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DSGN C KATZEN | DR D SUNSERI | CHK | APVD

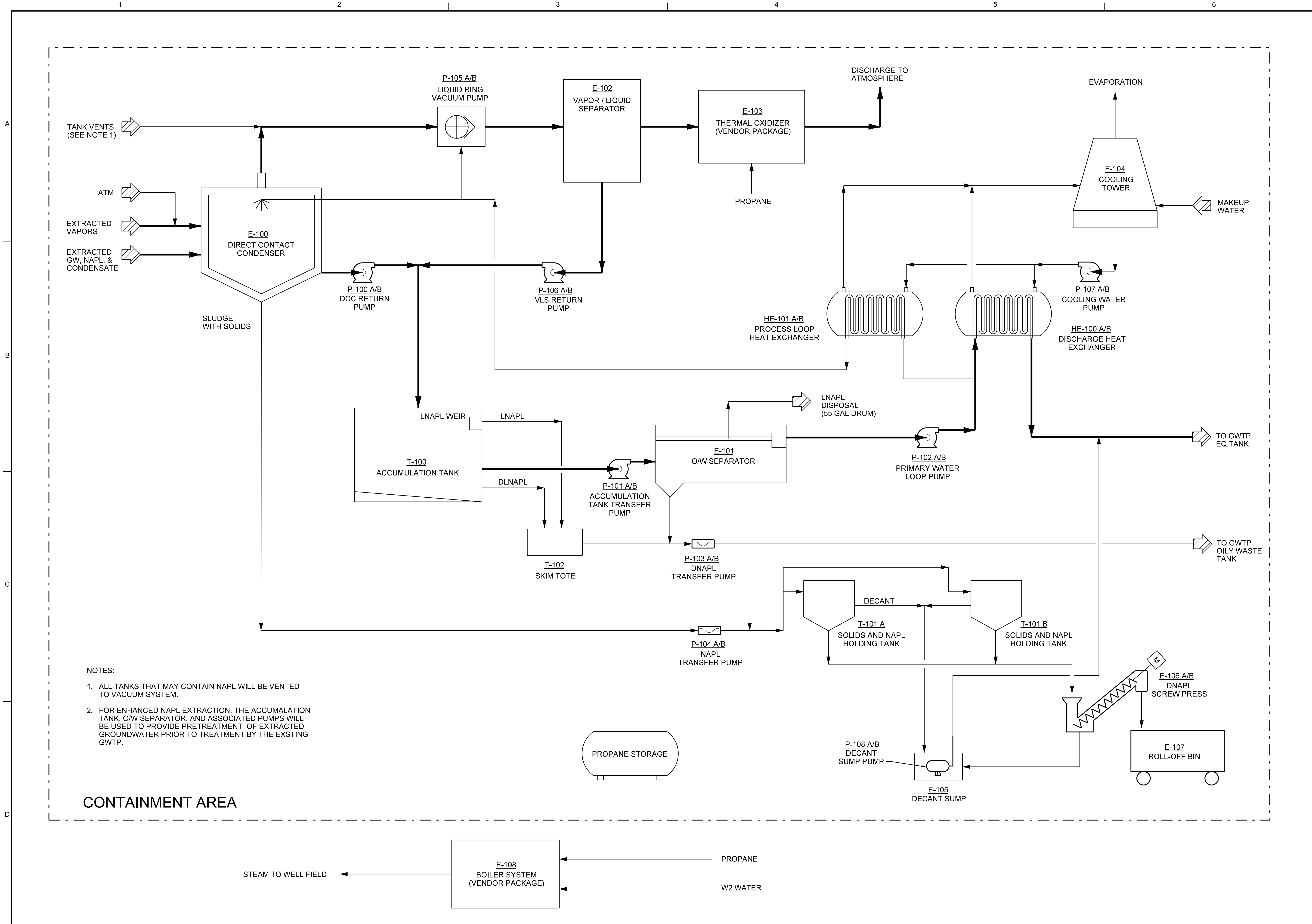
FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL®

WELLHEAD DETAILS

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	400-C-500
SHEET	of



NO.	DATE	REVISION	BY	APVD
DSGN	MD	DR	VMS	CHK	BS	APVD

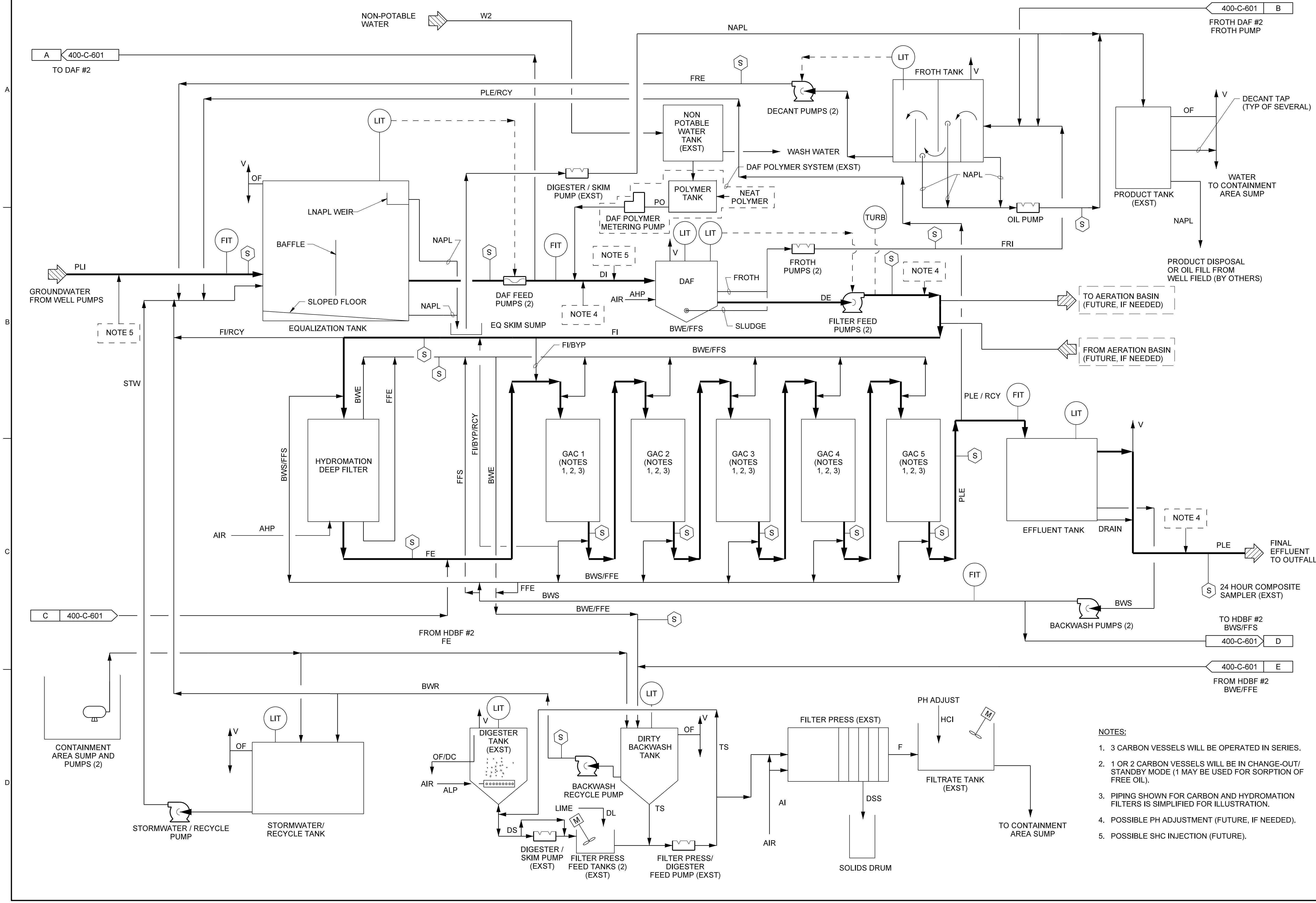
FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL®

ALTERNATIVE 5 THERMAL
PROCESS FLOW DIAGRAM 1

NTS
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	400-C-600
SHEET	of



NOTES:

1. 3 CARBON VESSELS WILL BE OPERATED IN SERIES.
2. 1 OR 2 CARBON VESSELS WILL BE IN CHANGE-OUT/ STANDBY MODE (1 MAY BE USED FOR SORPTION OF FREE OIL).
3. PIPING SHOWN FOR CARBON AND HYDROMATION FILTERS IS SIMPLIFIED FOR ILLUSTRATION.
4. POSSIBLE PH ADJUSTMENT (FUTURE, IF NEEDED).
5. POSSIBLE SHC INJECTION (FUTURE).

NO.	DATE	REVISION	BY	APVD

DSGN BS | DR VMS | CHK BS | APVD

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL®

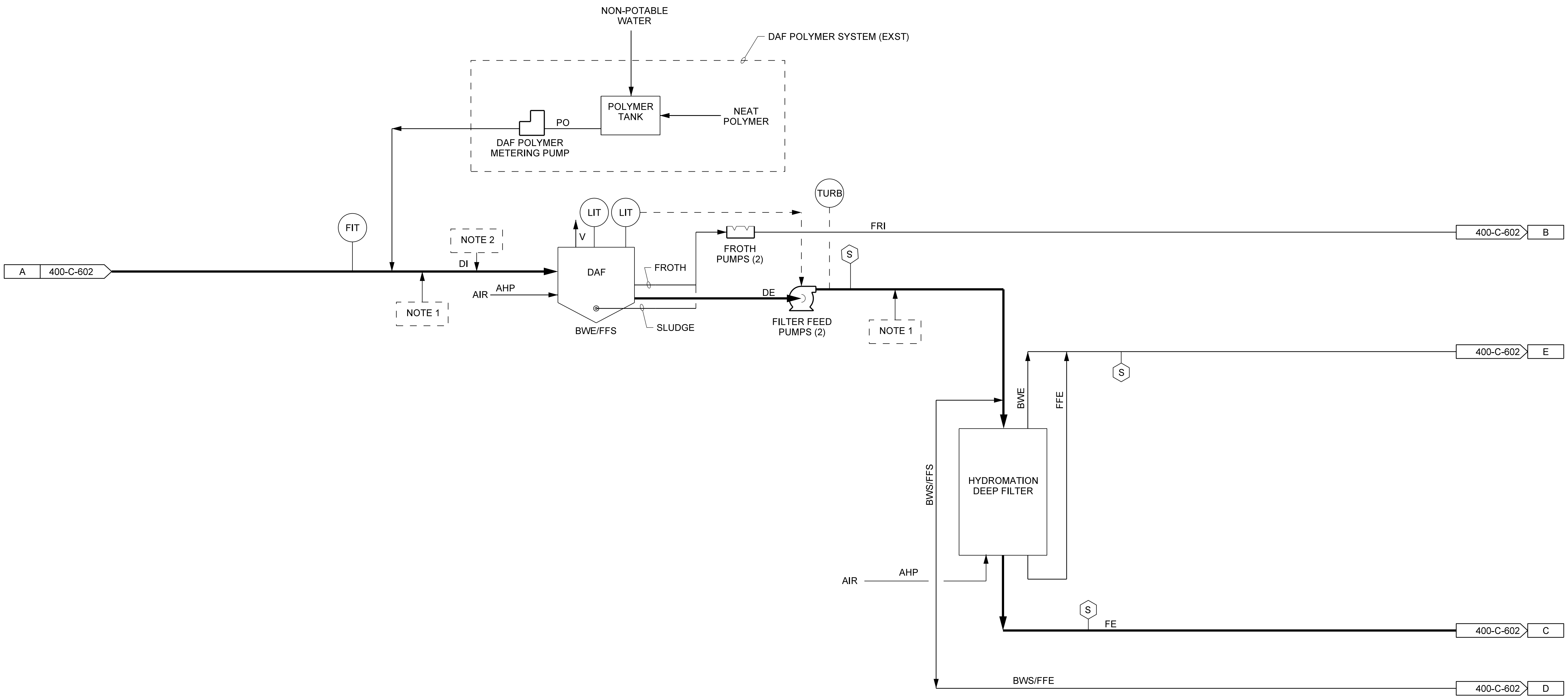
ALTERNATIVE 5 THERMAL
EXISTING EQUIPMENT PROCESS FLOW DIAGRAM

NTS

VERIFY SCALE

BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	400-C-601
SHEET	of



NOTES:

1. POSSIBLE PH ADJUSTMENT (FUTURE, IF NEEDED).
2. POSSIBLE SHC INJECTION (FUTURE).

NO.	DATE	REVISION	BY	APVD
DSGN	DR	CHK	APVD	
	MD	VMS	BS	

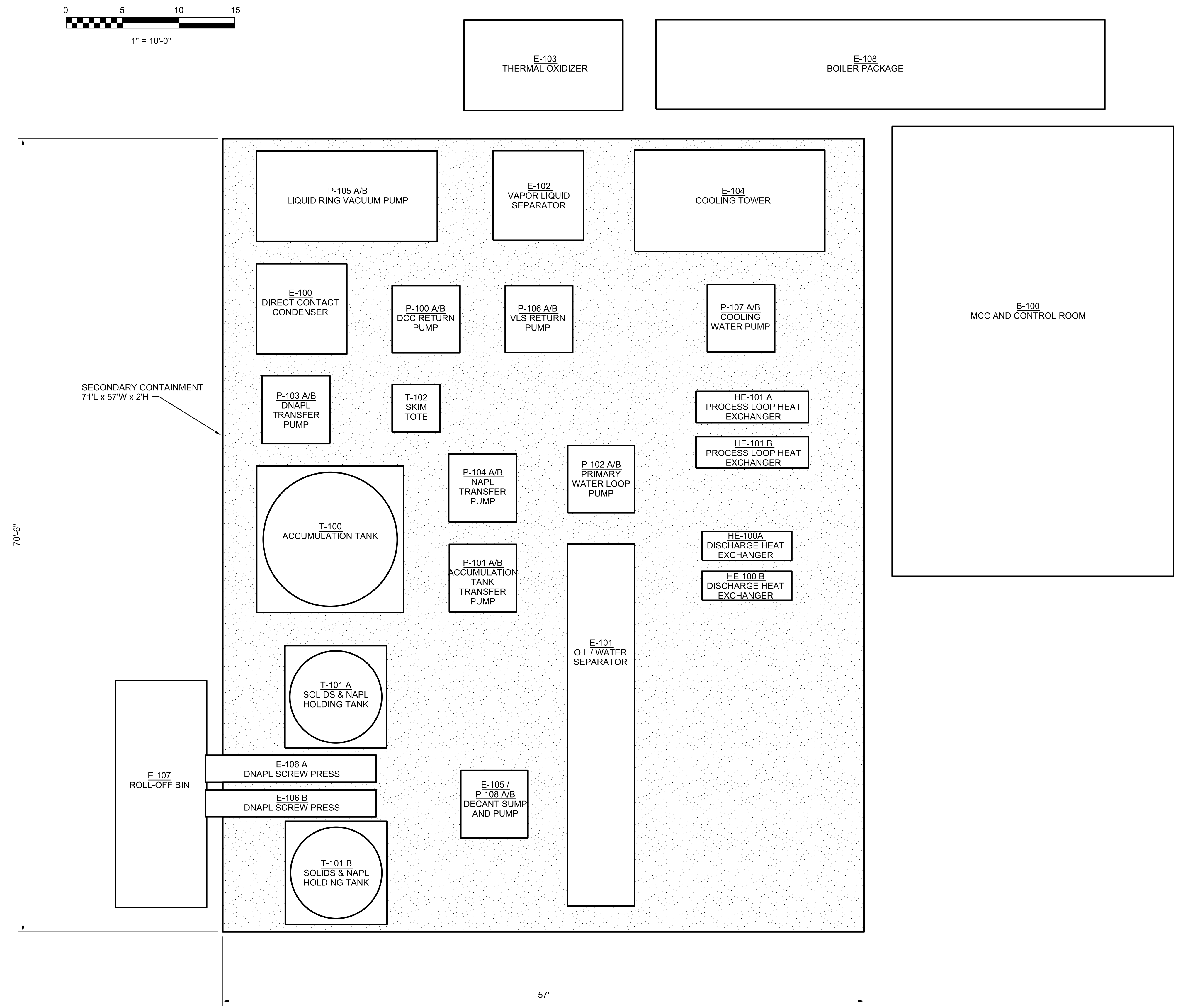
FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL®

ALTERNATIVE 5 THERMAL
PROCESS FLOW DIAGRAM 2

NTS
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	400-C-602
SHEET	of



NO.	DATE	REVISION	BY	APVD

DSGN C. KATZEN | DR V. MAXEY | CHK M. DAVIS | APVD

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL®

ALTERNATIVE 5
TREATMENT SYSTEM PLAN

NTS
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	400-M-101
SHEET	of

$PWURL pw://projectwise.ch2m.com:DEN001/Documents/438527&space;-&space;AES10&space;0079-WYCKOFF&space;GW&space;SOILS/Feasability&space;Study&space;WIP/HY/Dlv/400-M-101_438527.dgn FILENAME: 400-M-101_438527.dgn PLOT DATE: 5/6/2014 PLOT TIME: 6:47:24 PM

GENERAL NOTES

1. EXISTING BASE MAP SHOWN SCREENED REPRESENTS CURRENT CONDITIONS. ACTUAL CONDITIONS WILL DEPEND ON GRADING AND REMOVALS DONE AS PART OF DEMOLITION. SEE DWG 101-CE-102 FOR DEMOLITION CHANGES.
2. SEE TABLE 1 FOR FACILITY SIZES AND CONTENT. SEE DETAILED COST ESTIMATE SPREADSHEET FOR DETAILS.
3. REFER TO DWG 500-C-600 FOR THE MTTD PFD.
4. THE PROPANE TANK WILL BE HARD PIPED BELOW GROUND TO THE MTTD. WATER TO THE DUST CONTROL TANK FROM THE EXISTING WELL SUPPLY WILL BE HARD PIPED. WATER FROM THE STORAGE TANK AT THE WWTP WILL BE HARD PIPED TO THE MTTD FRACTIONATION TANK FOR QUENCH WATER. WATER COLLECTED AT THE PUMP STATIONS ASSOCIATED WITH THE DRAINAGE SYSTEM (SOUTH OF THE TREATED SOIL STOCKPILE AREA) WILL BE HARD PIPED TO INFILTRATION AREA.
5. SOILS THAT ARE SATURATED WITH WATER MAY BE TEMPORARILY STAGED IN AN ADJOINING CONTAMINATED CELL FOR DEWATERING.
6. THE MTTD LAYOUT WILL CHANGE SLIGHTLY IF AN ACID GAS SCRUBBER IS REQUIRED. THE SCRUBBER WOULD FOLLOW THE AFTERBURNER. REFER TO PDF.
7. DEWATERING WILL BE CONDUCTED BY A SERIES OF TWO EXTRACTION WELLS PER SHEETPILE CELL. DEWATERING WOULD BE CONDUCTED SIMULTANEOUSLY AT THE CELL BEING EXCAVATED AND BACKFILLED AS WELL AS THE NEXT CELL TO BE EXCAVATED. OTHER WELLS OUTSIDE THE CORE AREA WILL BE OPERATED AS REQUIRED TO SUPPORT DEWATERING. BURIED HDPE PIPING WITH STUB UPS WILL BE INSTALLED TO THE WWTP. WATER FROM THE WELLS WILL BE CONNECTED TO THIS LINE(S) WITH HOSES AND CAM LOCKS. WELLS WILL BE POWERED BY WHISPER QUITE GENSET(S).
8. AN IMPERMEABLE LINER WILL BE PLACED ON THE BOTTOM SURFACE OF THE EXCAVATION OF EACH CELL PRIOR TO BACKFILL. A GEOSYNTHETIC CLAY LINER (GCL) WILL BE USED.
9. THE SOIL BLENDING AND HANDLING BUILDING WILL BE VENTILATED THROUGH GRANULAR ACTIVATED CARBON (GAC).
10. SEE DWG 500-C-103 FOR DEWATERING WELL PIPING

FACILITY	SIZING: LENGTH	WIDTH	HEIGHT	DIAMETER	AREA	VOLUME	UNIT	COMPONENTS
TREATED SOILS AWAITING ANALYSIS	124	110						ASPHALT PAD. 2X HIGH ECOLOGY BLOCKS FOR CONTAINMENT.
TREATED SOILS STOCKPILE	570	100	14			17706	cy	ASPHALT PAD. 3X HIGH ECOLOGY BLOCKS. MAX 1:1 SIDESLOPES
SOIL BLENDING AND HANDLING	300	100						ASPHALT PAD. 2X HIGH ECOLOGY BLOCKS. SPRUNG BUILDING.
NEW SHEET PILE WALLS					189,255			FROM GROUND SURFACE TO 2' BELOW AQUITARD LAYER. QTO=QUANTITY TAKE OFF
MTTD	110	100						ASPHALT PAD.
DUST CONTROL TANK	40	10						12 FT X 50 FT FRACTIONATION TANK ON GRAVEL PAD
DIESEL TANK	40	10						40 FT X 8 FT ISO TANK DOUBLE CONTAINED ON ASPHALT CONTAINMENT SLAB WITH SUMP AND CURB
PROPANE STORAGE	75	30		11		30,000	gal	2X 10FTX52FT CONC SLABS. 30 BOLLARDS.
FRACTIONATION TANK	40	10	10			60,000	gal	2X TANKS WITH 30 FT X 50 FT CONTAINMENT SLAB
WATER SUPPLY SURGE TANK			4.3	20	314	10,000	gal	20,000 GALLON FRACTIONATION TANK ON GRAVEL PAD
AIR HANDLING/GAC	20	12	15					GRAVEL SURFACING
DECON PAD WITH PWRD WHEEL WASH	40	16						PREFABRICATED MODULAR UNIT WITH POWERED WHEEL WASH AND PRESSURE WASH, CONCRETE PAD AND COLLECTION SUMP. PERIMETER CURBS, SPRAY CURTAINS. HEAVY LOAD RATING.
750 KW GENSET	20	8	11					MODULAR. AC PAVEMENT SECONDARY CONTAINMENT PAD. OPERATES MTTD AND SOIL BLENDING AND HANDLING BUILDING.
20-50 KW GENSETS AT MULTIPLE LOCATIONS TO SUPPORT DEWATERING WELLS, DECON PAD, AND OTHER INFRASTRUCTURE	12	5	5					MODULAR. GRAVEL SURFACING WITH SECONDARY CONTAINMENT
FUEL CELL	40	8	10					GRAVEL SURFACING.
SUMP PUMP/STATION								PRE-FAB 6 FT DIAMETER PUMP STATION CONNECTED TO DRAIN MANHOLE

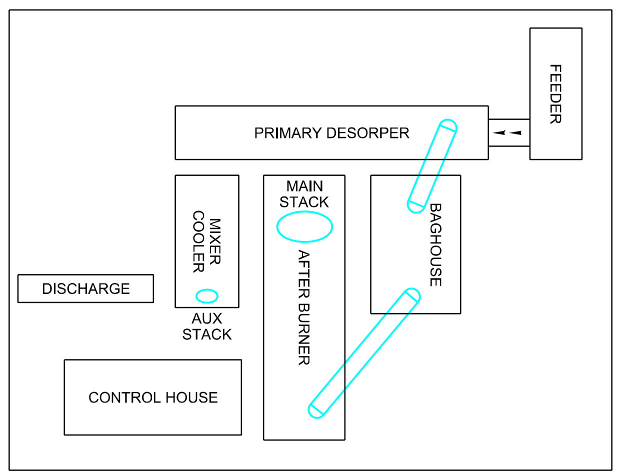
NOTES:
1. ALL DIMENSIONS LENGTH IN FT, AREA SQ FT UNLESS INDICATED OTHERWISE
2. SEE COST SPREADSHEETS FOR DETAILS.

KEYNOTES

1. EXCAVATE CORE AREAS TO 20 FT BELOW EXISTING GROUND AND TREAT WITH MTTD. AFTER THE CORE AREA IS BACKFILLED TREAT WITH THERMAL ENHANCEMENT.
2. AREAS RECEIVE THERMAL ENHANCED EXTRACTION.
3. STORAGE TANK FOR QUENCH WATER SUPPLIED BY EXISTING WELL SUPPLY.
4. PUMP STATIONS FOR DRAINAGE FROM TREATED SOIL STOCKPILE.
5. SOUTH TREATMENT BOUNDARY.
6. AREA RECEIVES NAPL EXTRACTION AND BIOSPARGING ONLY.
7. POLYGON 152. EXCAVATE SOIL TO A DEPTH OF 7 FT AND TREAT.
8. AREAS CAN BE USED FOR STAGING TREATED SOILS (INCLUDING TREATED SOILS AWAITING ANALYSIS) AND SOILS THAT DO NOT REQUIRE MTTD PENDING ANALYSIS.
9. CONSTRUCT STORMWATER INFILTRATION AREA AFTER EXCAVATION OF POLYGON 152. APPROX. 540 FT X 40 FT WITH 7FT PEA GRAVEL.

LEGEND

- APPROXIMATE BOUNDARY EXISTING/REFURBISHED SHEET PILE WALL
- NEW SHEET PILE WALL
- DW22 DEWATER WELL



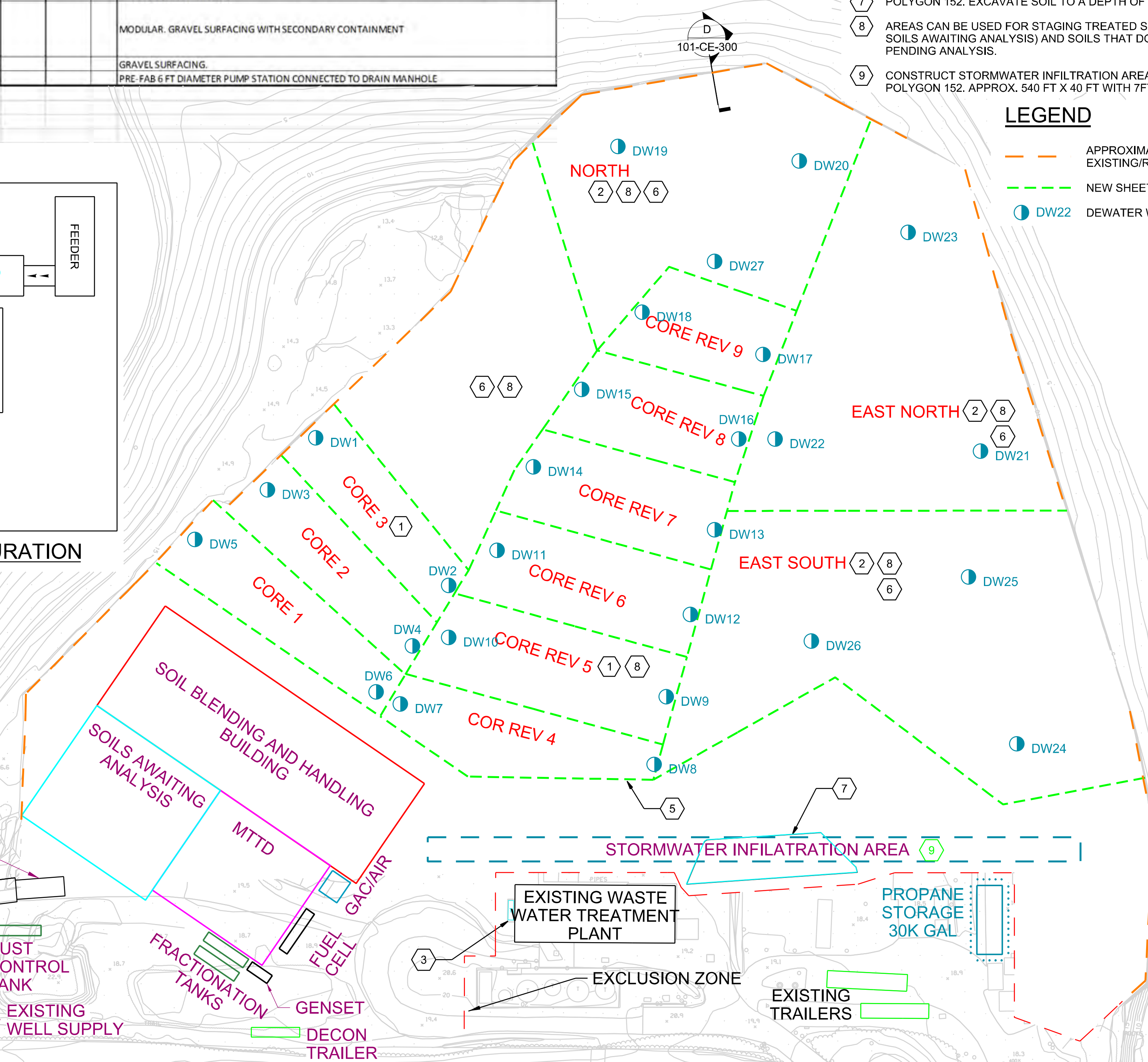
TYPICAL MTTD PAD CONFIGURATION

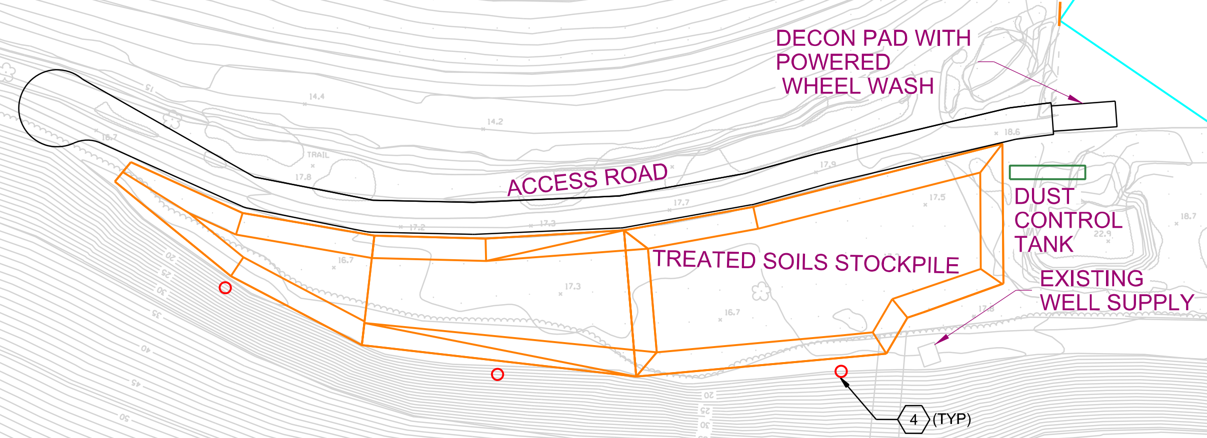
TABLE 2

CORE AREA	VOLUME TO -20FT BGS (cy) (1)	TOP PLANAR AREA (sf)
1	8,922	12,043
2	8,341	11,260
3	7,360	9,936
4	8,581	11,585
5	11,667	15,750
6	10,609	14,323
7	9,804	13,235
8	8,539	11,528
9	7,476	10,092
POLYGON 152		4,210
TOTAL	81,298	113,960

N

0 60 180
1"=60'





NO.	DATE	REVISION	BY	APVD

DSGN AR | DR AR | CHK BCT | APVD

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL®

ALTERNATIVE 6 MTTD
OVERALL SITE PLAN

1"=60 FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	500-C-100
SHEET	of

PLANNING PURPOSES ONLY. NOT FOR CONSTRUCTION

GENERAL NOTES

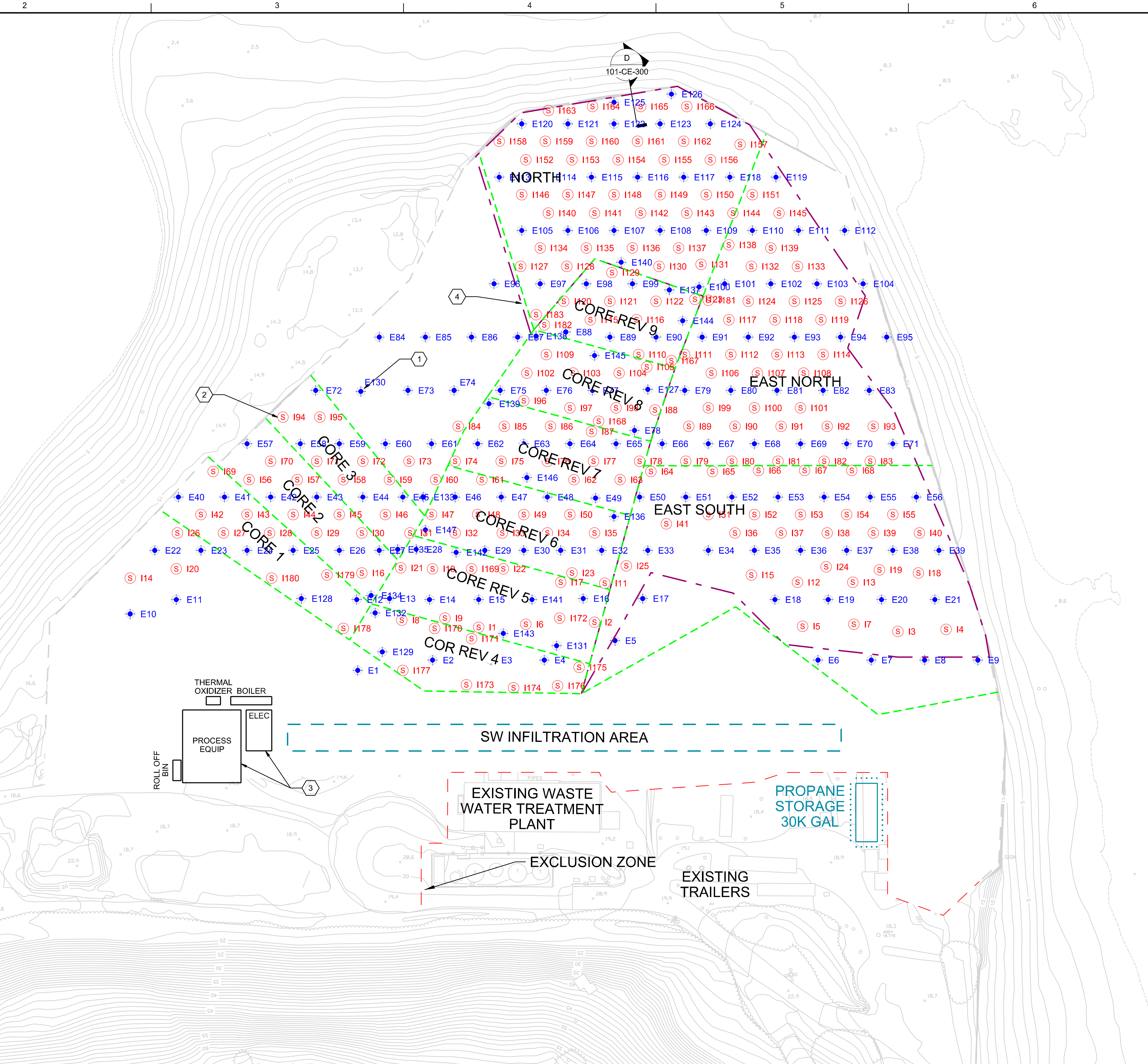
1. EXISTING BASE MAP SHOWN SCREENED REPRESENTS CURRENT CONDITIONS. ACTUAL CONDITIONS WILL DEPEND ON GRADING AND REMOVALS DONE AS PART OF DEMOLITION. SEE DWG 101-CE-102 FOR DEMOLITION CHANGES.

KEYNOTES

1. EXTRACTION WELLHEAD. SEE DWG 400-C-500 FOR DETAILS.
2. STEAM INJECTION WELLHEAD. SEE DWG 400-C-500 FOR DETAILS.
3. THERMAL PROCESS EQUIPMENT. SEE DWG 400-M-101.
4. INSTALL VAPOR COVER BEFORE DRILLING WELLS. BOOT AROUND WELL TO PROVIDE AIRTIGHT SEAL. SEE DWG 200-C-301 FOR DETAILS.

LEGEND

- EXISTING SHEET PILE WALL
- VAPOR COVER LIMITS
- SHEET PILE WALLS
- E130 EXTRACTION WELL
- I42 STEAM INJECTION WELL
- DW3 DEWATER WELL



FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL

ALTERNATIVE 6 THERMAL
SITE PLAN - NAPL EXTRACTION & COVER, THERMAL

NO.	DATE	REVISION	BY	APVD
DSGN	BS	DR	BS	CHK BCT	APVD

1"=50 FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	500-C-101
SHEET	of

PLANNING PURPOSES ONLY. NOT FOR CONSTRUCTION

GENERAL NOTES

1. EXISTING BASE MAP SHOWN SCREENED REPRESENTS CURRENT CONDITIONS. ACTUAL CONDITIONS WILL DEPEND ON GRADING AND REMOVALS DONE AS PART OF DEMOLTION. SEE DWG 101-CE-102 FOR DEMOLITION CHANGES.

KEYNOTES

1. SEE DWG 200-C-301 FOR VAPOR COVER DETAILS.
2. VAPOR EXTRACTION WELLHEAD. 3" SCH 80 CPVC PERFORATED PIPE IN VAPOR LAYER OF VAPOR CAP. SEE DWG 200-C-301. ABOVE GROUND PIPE IS 1-½" CPVC CONNECTED TO VAPOR EXTRACTION HEADER.
3. AIR INJECTION WELLHEAD. 3" SCH 80 CPVC PERFORATED PIPE IN VAPOR LAYER OF VAPOR CAP. SEE DWG 200-C-301. SUPPLY PIPE IS 1-½" CARBON STEEL.
4. THERMAL PROCESS EQUIPMENT. SEE DWG 400-M-101

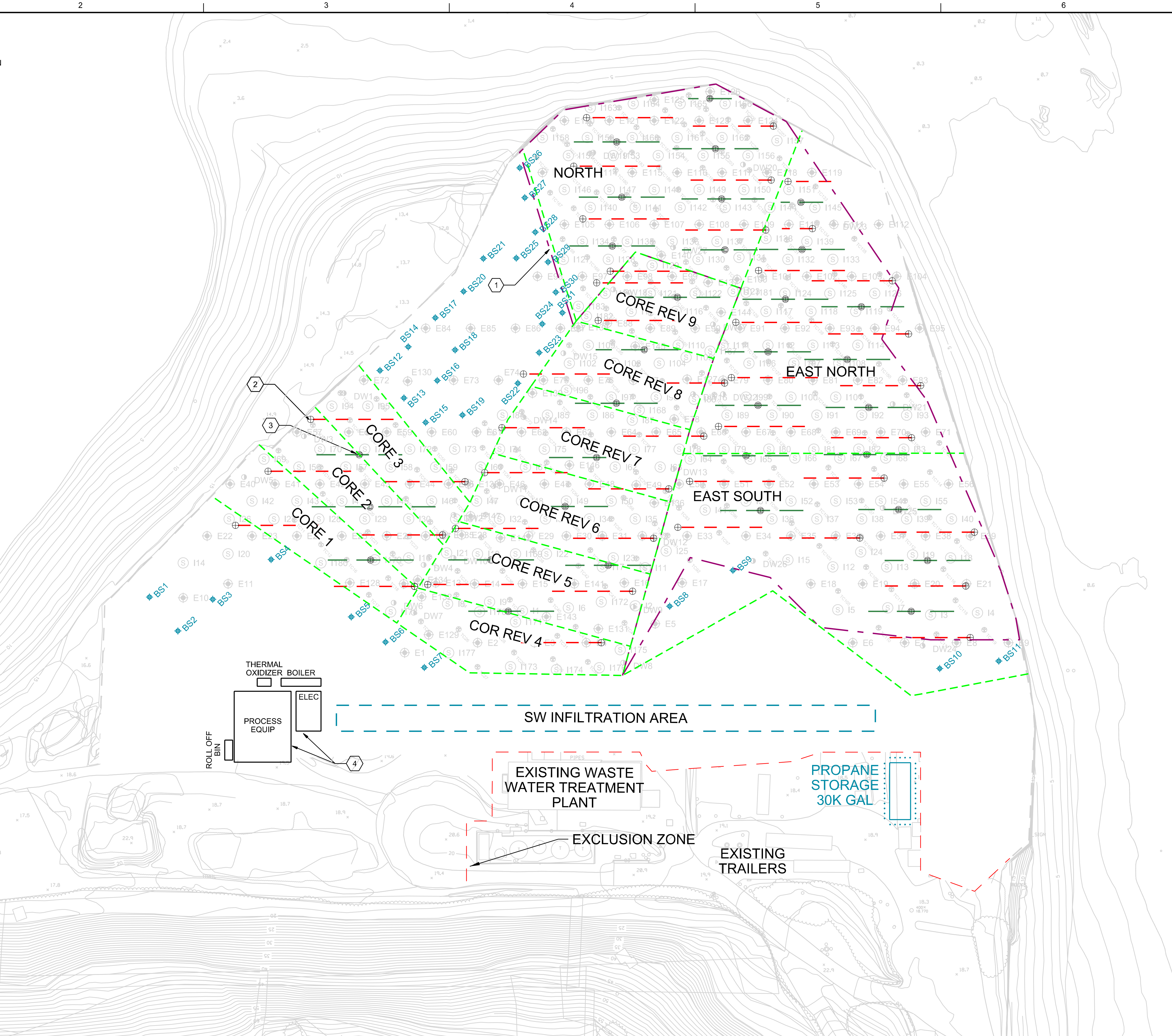
LEGEND

- EXISTING SHEET PILE WALL
- VAPOR COVER LIMITS
- SHEET PILE WALLS
- VAPOR EXTRACTION PIPING AND WELL
- AIR INJECTION PIPING AND WELL
- E84 EXTRACTION WELL
- BS14 BIOSPARGING WELL
- I42 STEAM INJECTION WELL
- THERMOCOUPLE
- DW1 DEWATER WELL

N

0 50 100 150

1"=50'



NO.	DATE	REVISION	BY	APVD

DSGN BS | DR BS | CHK BCT | APVD BS

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL

ALTERNATIVE 6 THERMAL
SITE PLAN
COVER, PIPING, BIOSPARGING, VAPOR REMOVAL AND AIR INJECTION

1"=50 FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE
PROJ 438527
DWG 500-C-102
SHEET of

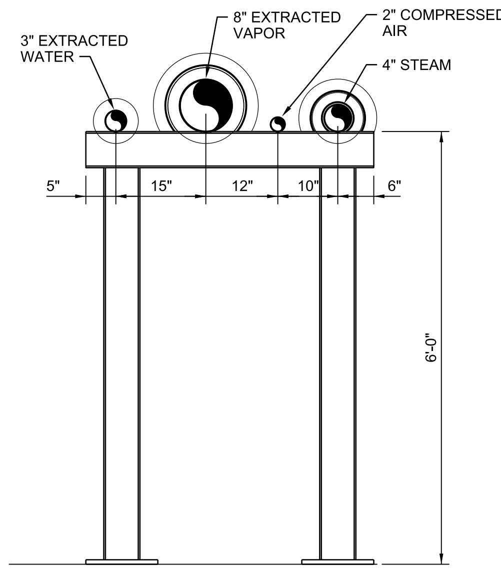
PLANNING PURPOSES ONLY. NOT FOR CONSTRUCTION

LEGEND

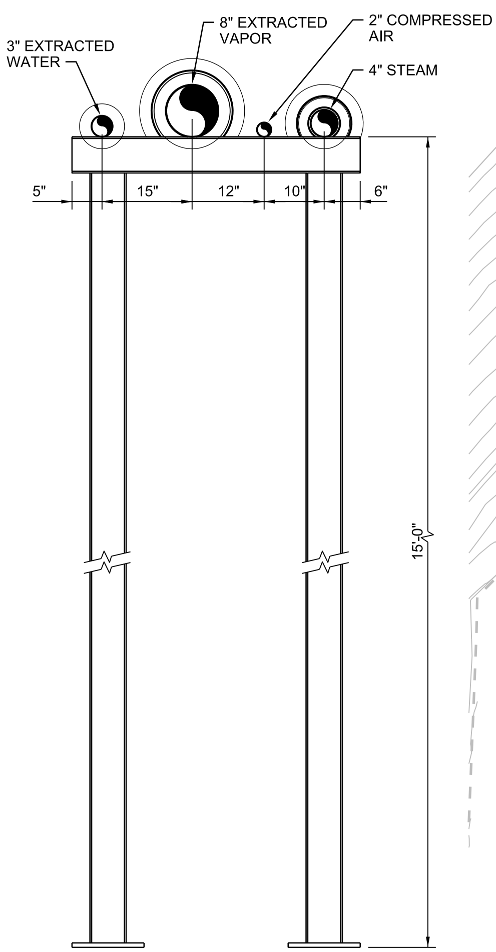
- — — — NON-ELEVATED PIPERACK
- ——— ELEVATED PIPERACK

NOTES:

1. IN GENERAL, THE DISTANCE BETWEEN THE NON-ELEVATED PIPERACKS IS SUFFICIENT SPACING TO ALLOW TRUCK TRAFFIC BETWEEN THE RACKS. DURING DETAILED DESIGN, SOME WELL LOCATIONS AND/ OR PIPE RACKS MAY BE MOVED TO ASSURE MAINTENANCE ACCESS TO WELLS.
2. ELEVATED PIPE RACKS WILL BE AT A HEIGHT AND WILL HAVE COLUMN SPACING TO ALLOW TRUCK TRAFFIC TO PASS UNDERNEATH THE PIPE RACK.
3. AIR INJECTION AND VAPOR EXTRACTION POINTS INTO THE VAPOR COVER ARE NOT SHOWN. LOCATIONS OF THESE WILL BE ADJUSTED AS NEEDED TO ASSURE ACCESS TO WELLS.
4. THERMOCOUPLE LOCATIONS ARE NOT SHOWN. THESE ARE AT GRADE AND WILL HAVE COVERS RATED FOR TRUCK TRAFFIC.
5. ELECTRICAL WIRING WILL BE ROUTED ON CABLE TRAYS LOCATED ABOVE PIPE RACKS.



A SECTION
3/4"=1'-0"



B SECTION
3/4"=1'-0"

PIPE RACK PLAN
1"=40'-0"

NO.	DATE	REVISION	BY	APVD

DSGN M. DAVIS | DR D SUNSERI | CHK | APVD

FOCUSED FEASIBILITY STUDY
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ALTERNATIVE 6
PIPING PLAN

1"=40 FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	500-C-103
SHEET	of

GENERAL NOTES

1. EXISTING BASE MAP SHOWN SCREENED REPRESENTS CURRENT CONDITIONS. ACTUAL CONDITIONS WILL DEPEND ON GRADING AND REMOVALS DONE AS PART OF DEMOLITION. SEE DWG 101-CE-102 FOR DEMOLITION CHANGES.

KEYNOTES

1. BIOSPARGING WELLHEAD. SEE DWG 400-C-500 FOR DETAILS.
2. BIOSPARGING WELLHEAD CONVERTED FROM STEAM INJECTION WELLHEAD. SEE DWG 400-C-500 FOR DETAILS.
3. THERMAL PROCESS EQUIPMENT. SEE DWG 400-M-101.

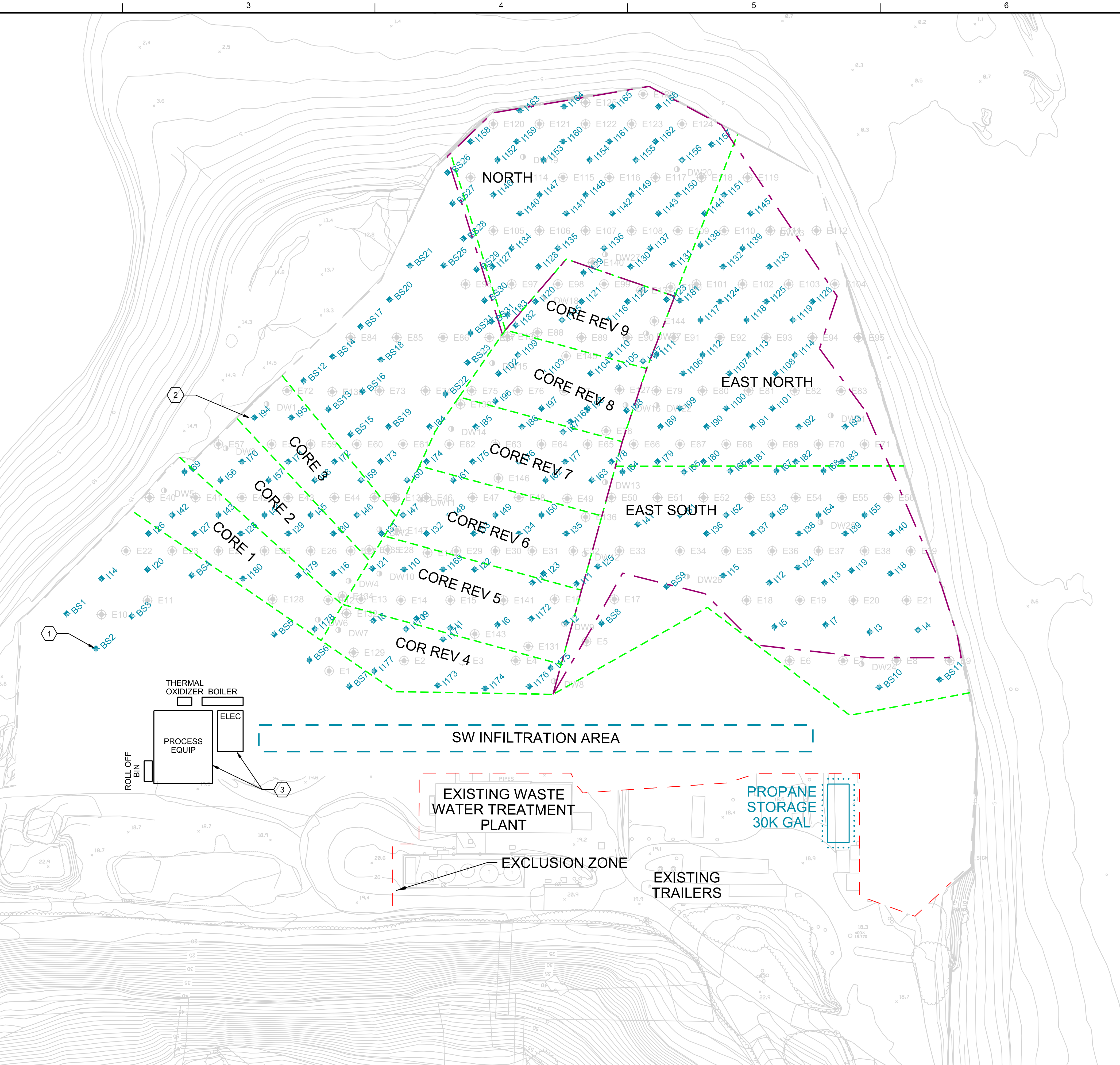
LEGEND

- EXISTING SHEET PILE WALL
- VAPOR COVER LIMITS
- SHEET PILE WALLS
- E130 EXTRACTION WELL
- BS5 BIOSPARGING WELL
- I43 BIOSPARGING WELL CONVERTED FROM STEAM INJECTION WELL
- DW1 DEWATER WELL

N

0 50 100 150

1"=50'



NO.	DATE	REVISION	BY	APVD

DSGN BS | DR BS | CHK BCT | APVD

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

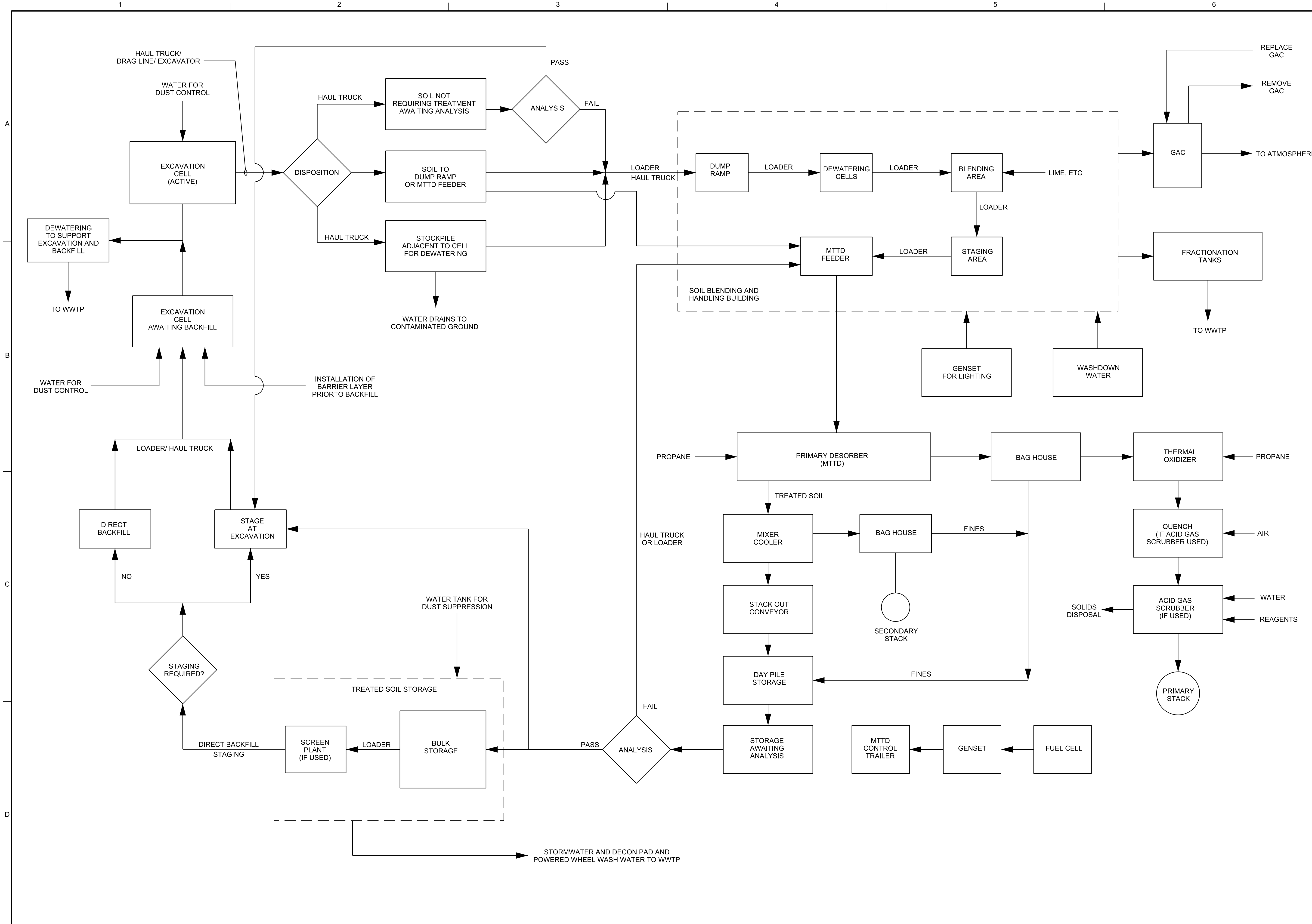
ALTERNATIVE 6 MTTD THERMAL
SITE PLAN - ENHANCED AEROBIC

CH2MHILL®

1"=50 FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	500-C-104
SHEET	of

PLANNING PURPOSES ONLY. NOT FOR CONSTRUCTION



NO.	DATE	REVISION	BY	APVD

DSGN | DR G BURLEY | CHK | APVD

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL

ALTERNATIVE 6 MTTD
PROCESS FLOW DIAGRAM

NTS
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	500-C-600
SHEET	of

GENERAL NOTES

1. EXISTING BASE MAP SHOWN SCREENED REPRESENTS CURRENT CONDITIONS. ACTUAL CONDITIONS WILL DEPEND ON GRADING AND REMOVALS DONE AS PART OF DEMOLITION. SEE DWG 101-CE-102 FOR DEMOLITION CHANGES.
2. EXCAVATE ALL ISS TREATMENT AREAS TO 7 FEET BELOW GRADE BEFORE TREATMENT. AMEND SOIL WITH CEMENT AND PLACE AND GRADE AFTER ISS TREATMENT.

KEYNOTES

1. APPROXIMATE OVERALL TREATMENT AREA WITHIN SHEET PILE WALL.
2. ISS AUGER MIXING TO START APPROX. 7' BELOW EXISTING GRADE.

LEGEND

ISS TREATMENT AREAS

TREATMENT POLYGON AND IDENTIFIER

PRELIMINARY

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

ALTERNATIVE 7 ISS TREATMENT
OVERALL SITE PLAN

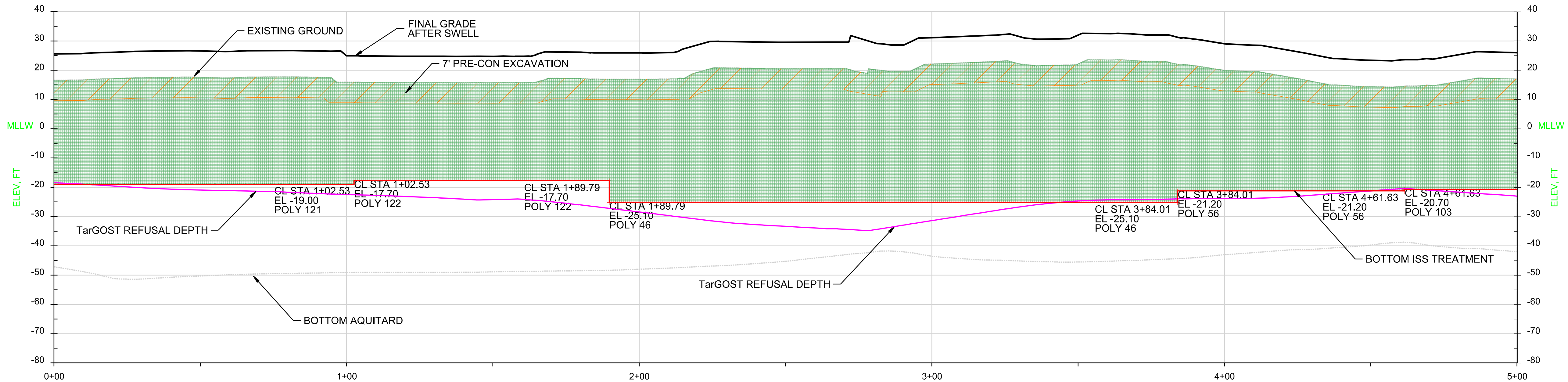
CH2MHILL

1"=50 FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.

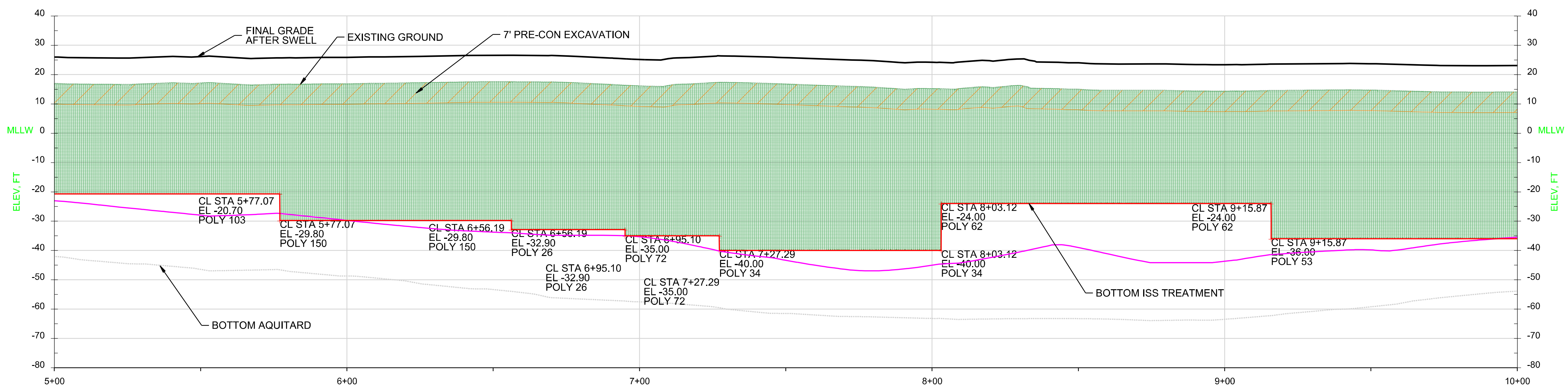
NO.	DATE	REVISION	BY	APVD

DSGN | DR | CHK | APVD

PRELIMINARY



A **NORTH PROFILE**
1"=20'
700-C-100



A **NORTH PROFILE (CONT)**
1"=20'
700-C-100

PRELIMINARY

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL®

ALTERNATIVE 7 ISS TREATMENT
ISS NORTH PROFILES

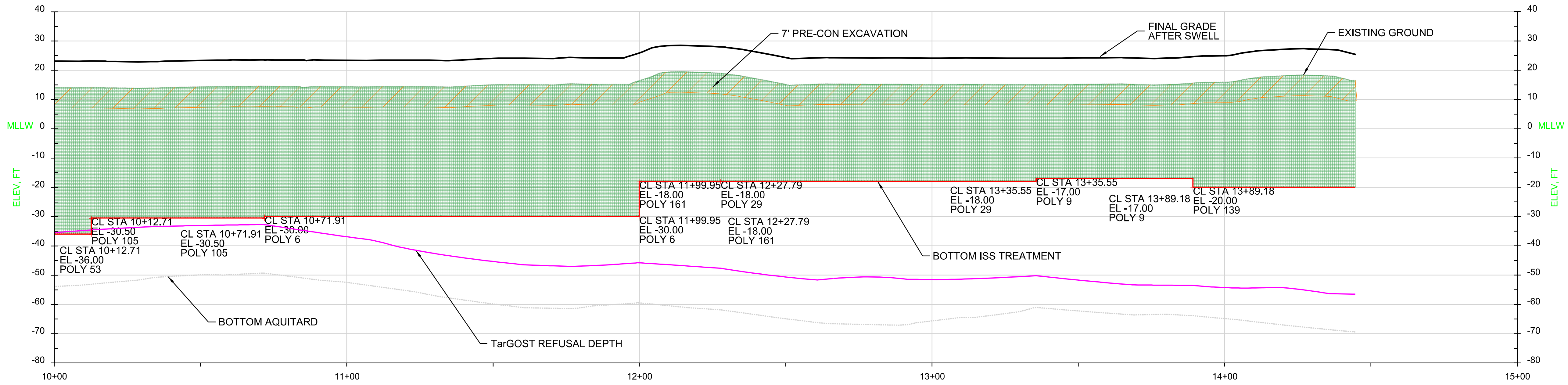
NO.	DATE	REVISION	BY	APVD

DSGN / DR / CHK / APVD: BCT

1"=50 FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	OCTOBER 2015
PROJ	438527
DWG	700-C-101
SHEET	of

PRELIMINARY



A NORTH PROFILE (CONT)

1"=20'

700-C-100

PRELIMINARY

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL®

ALTERNATIVE 7 ISS TREATMENT
ISS NORTH PROFILES

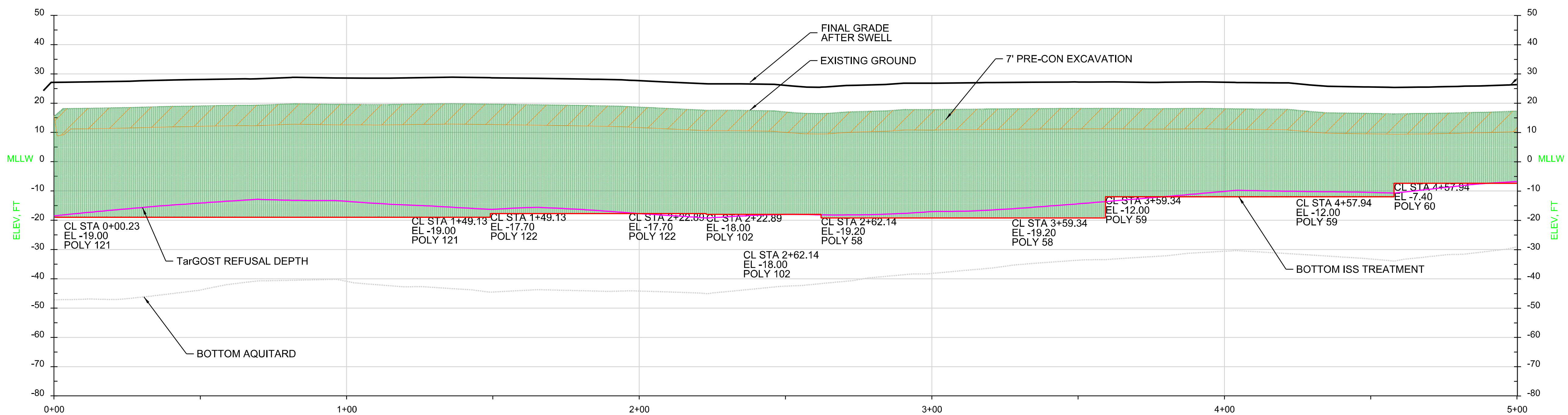
NO.	DATE	REVISION	BY	APVD

DSGN | DR | CHK | APVD
TO | BCT | TO

1"=50 FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	OCTOBER 2015
PROJ	438527
DWG	700-C-102
SHEET	of

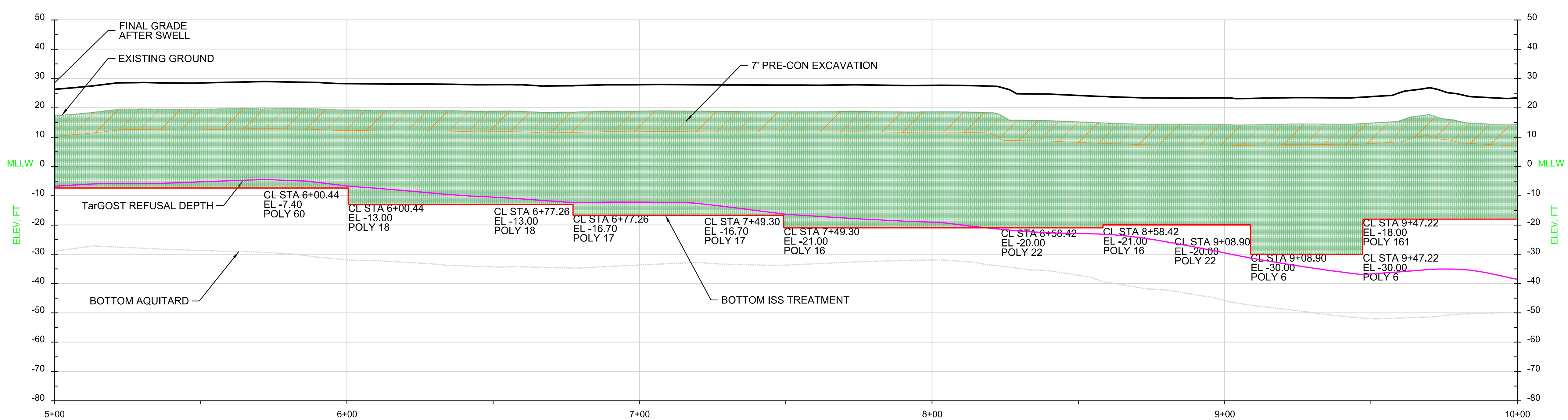
PRELIMINARY



A SOUTH PROFILE

1"=20'

700-C-100



A SOUTH PROFILE (CONT)

1"=20'

700-C-100

PRELIMINARY

NO.	DATE	REVISION	BY	APVD

DSGN	DR	CHK	APVD
	BCT	

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

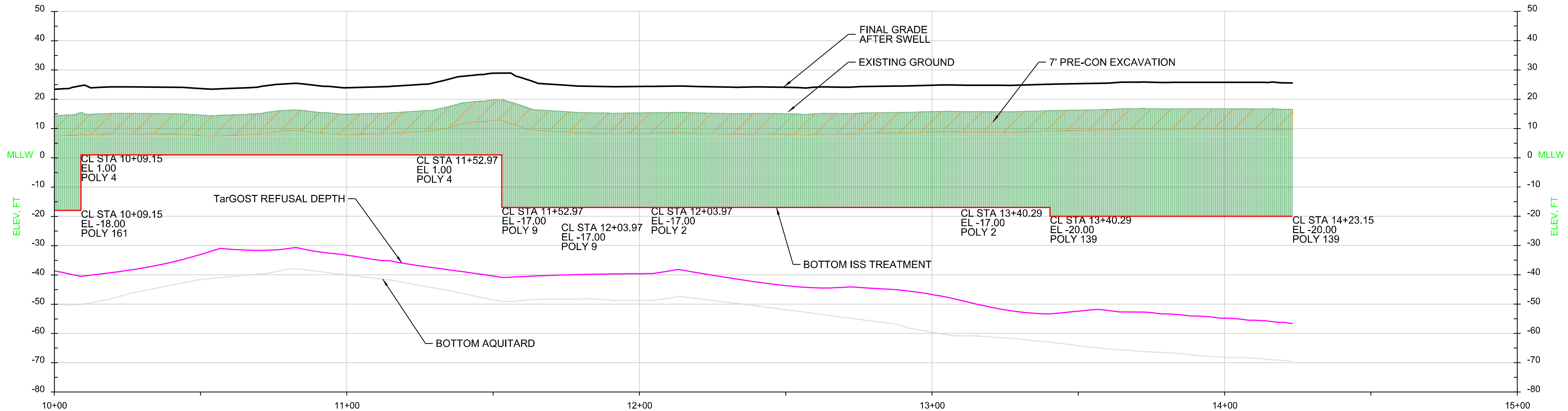
CH2MHILL®

ALTERNATIVE 7 ISS TREATMENT
ISS SOUTH PROFILES

1"=50 FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	OCTOBER 2015
PROJ	438527
DWG	700-C-103
SHEET	of

PRELIMINARY



A SOUTH PROFILE (CONT)

1"=20'

700-C-100

PRELIMINARY

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL

ALTERNATIVE 7 ISS TREATMENT
ISS SOUTH PROFILES

NO.	DATE
REVISION	BY
APVD	
DSGN	DR
CHK	APVD

1"=50 FT

VERIFY SCALE

BAR IS ONE INCH ON ORIGINAL DRAWING.

0 1"

DATE	OCTOBER 2015
PROJ	438527
DWG	700-C-104
SHEET	of

PRELIMINARY

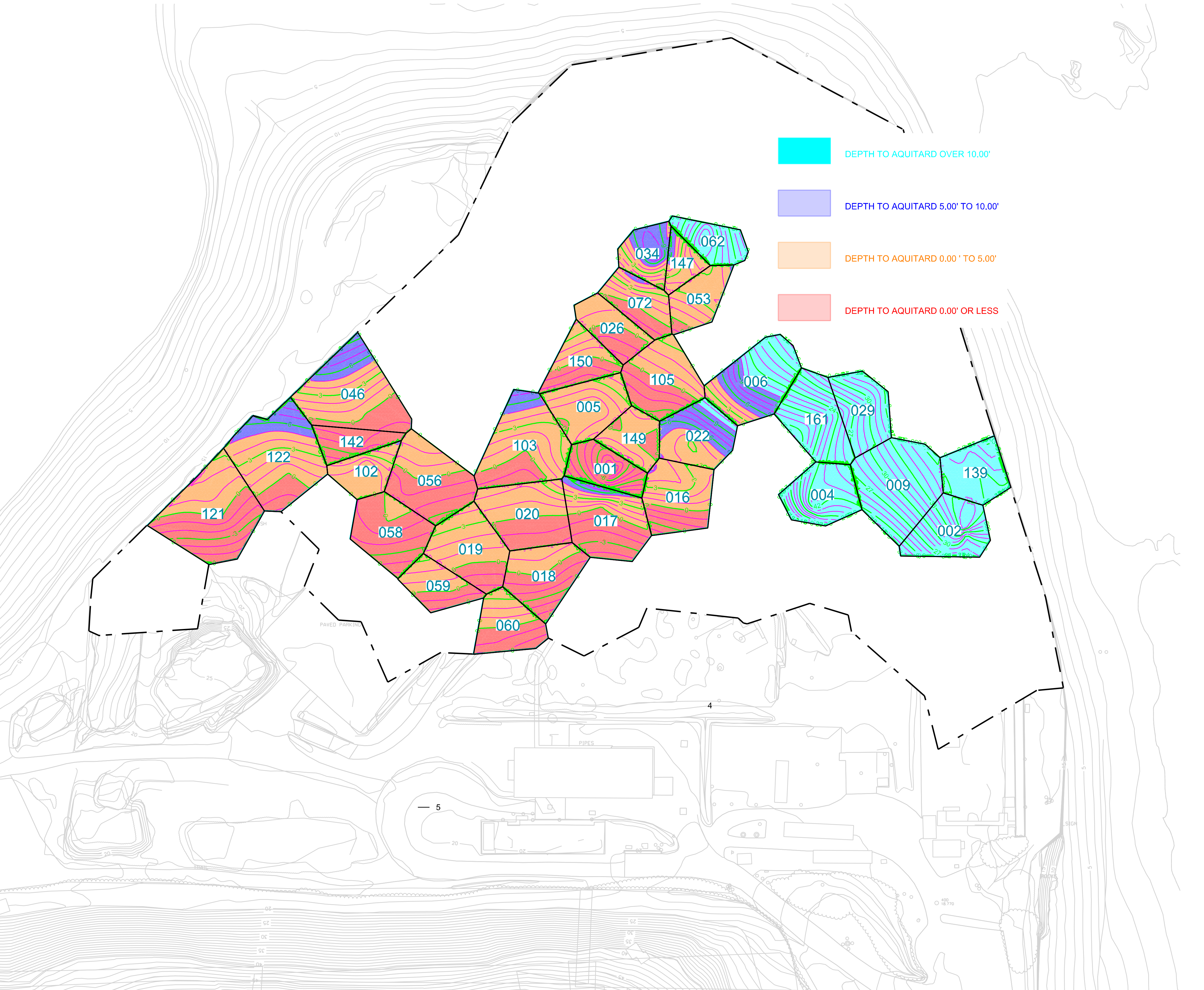
GENERAL NOTES

1. EXISTING BASE MAP SHOWN SCREENED REPRESENTS CURRENT CONDITIONS. ACTUAL CONDITIONS WILL DEPEND ON GRADING AND REMOVALS DONE AS PART OF DEMOLITION. SEE DWG 101-CE-102 FOR DEMOLITION CHANGES.
2. EXCAVATE ALL ISS TREATMENT AREAS TO 7 FEET BELOW GRADE BEFORE TREATMENT. AMEND SOIL WITH CEMENT AND PLACE AND GRADE AFTER ISS TREATMENT.

LEGEND

3+00 — TREATMENT LIMITS AND PROFILE STA. SEE 700-C-100

ISOPACH CONTOUR DIFFERENCE IN ELEVATION BETWEEN BOTTOM OF TREATMENT POLYGON AND TOP OF AQUITARD



PRELIMINARY

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

ALTERNATIVE 7 ISS TREATMENT
ISS ISOPACH

CH2MHILL®

REVISION					
NO.	DATE			BY	APVD
DSGN		DR		CHK	APVD
BCT	TO		TO		

1"=50 FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	OCTOBER 2015
PROJ	438527
DWG	700-C-105
SHEET	of

PRELIMINARY

GENERAL NOTES

1. EXISTING BASE MAP SHOWN SCREENED REPRESENTS CURRENT CONDITIONS. ACTUAL CONDITIONS WILL DEPEND ON GRADING AND REMOVALS DONE AS PART OF DEMOLITION. SEE DWG 101-CE-102 FOR DEMOLITION CHANGES.
2. SCHEMATIC LOCATIONS SHOWN

KEYNOTES

1. EAB WELL, 50 FT SPACING TYP.
2. NEW SHEET PILE WALL.
3. EXST SHEET PILE WALL. COINCIDENT WITH TARGETED TREATMENT AREA BOUNDARY SOME LOCATIONS.
4. CONNECT AIR HEADER TO EXSTING AIR.
5. EXISTING WELL TO BE DEMOLISHED FOR ISS CONSTRUCTION.
6. EXISTING WELL THAT WILL REMAIN AFTER ISS CONSTRUCTION.
7. EXTRACTED WATER FOR TREATMENT IN GWTP.
8. SOUTHERN EDGE OF TARGETED TREATMENT AREA.

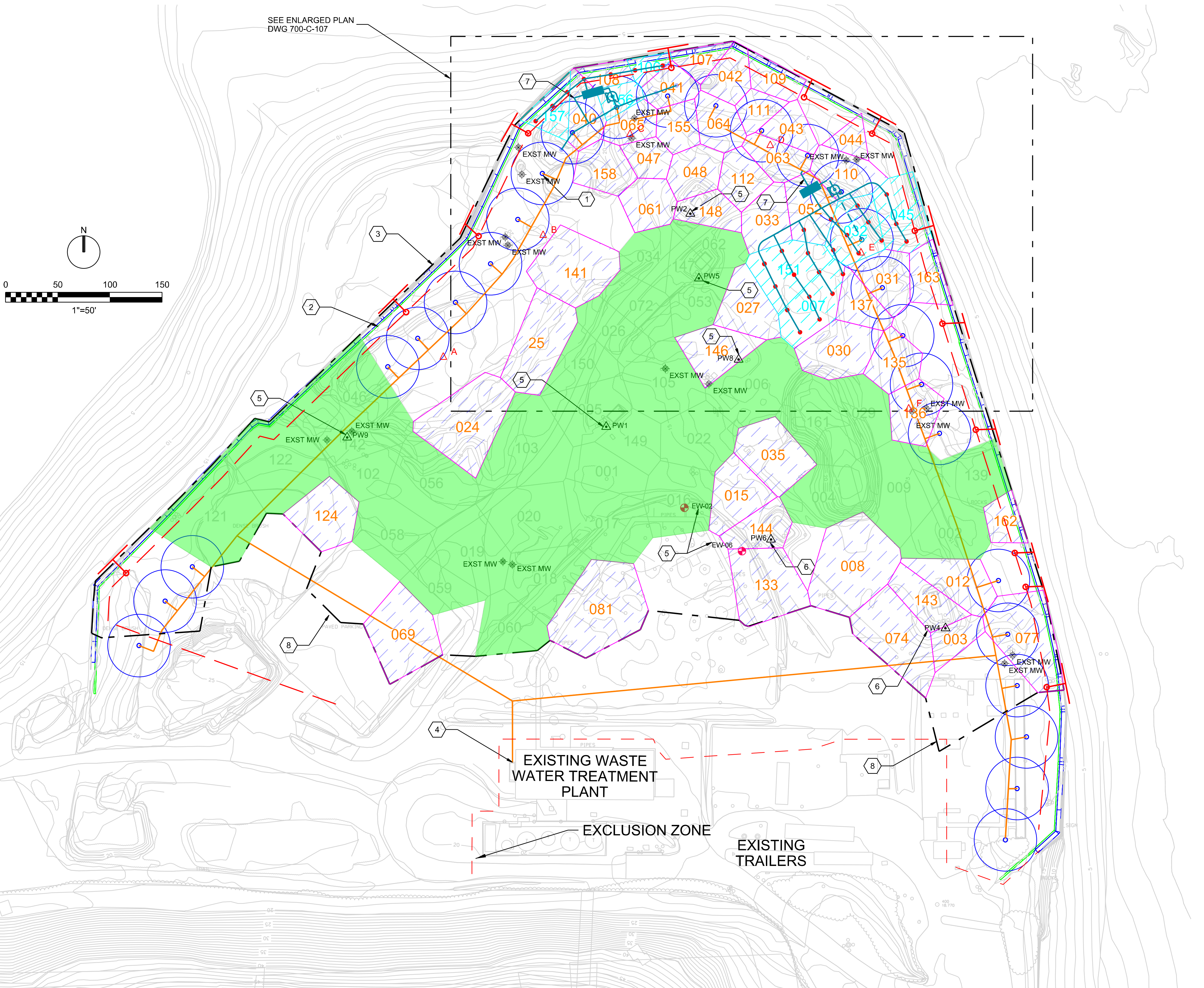
LEGEND

- TARGETED TREATMENT AREA BOUNDARY
- EXST SHEET PILE WALL
- NEW SHEET PILE WALL (SHEET PILE AND CONCRETE)
- AIR SUPPLY LINE AND CONNECTIONS TO WELLS
- NEW PASSIVE TREATEMENT SYSTEM MANHOLE
- NEW DRAIN PIPE THROUGH WALLS
- FRENCH DRAIN
- NEW EAB WELL AND INFLUENCE ZONE (WELL, INFLUENCE ZONE)
- A — NEW GW EXTRACTION WELL
- PW9 — EXST PW WELL
- NEW EAB/INJECTION WELL
- NEW INJECTION WELL
- EXTRACTION WELL
- EXISTING MW
- 142 — PHASE 1 ISS IMPLEMENTATION AREA
- 032 — PHASE 1 NAPL RECOVERY
- 047 — PHASE 2 INTERMEDIATE TECHNOLOGY IMPLEMENTATION AREA

N

0 50 100 150

1"=50'



PRELIMINARY

CH2MHILL

ALTERNATIVE 7 PHASE 1 & 2 TREATMENT AREAS

NAPL EXTRACTION, GW EXTRACTION AND EAB SITE PLAN

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

NO.	DATE	REVISION	BY	APVD

DSGN	DR	CHK	APVD
JG	BCT	KTS	

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	OCTOBER 2015
PROJ	438527
DWG	700-C-106
SHEET	of

PRELIMINARY

GENERAL NOTES

1. EXISTING BASE MAP SHOWN SCREENED REPRESENTS CURRENT CONDITIONS. ACTUAL CONDITIONS WILL DEPEND ON GRADING AND REMOVALS DONE AS PART OF DEMOLITION. SEE DWG 101-CE-102 FOR DEMOLITION CHANGES.
2. SCHEMATIC LOCATIONS SHOWN

KEYNOTES

1. EAB/INJECTION
2. INJECTION WELL, 25 FT SPACING
3. EXTRACTION WELL, DUAL PHASE PUMPING SYSTEM, 25 FT SPACING
4. EQUIPMENT SHED
5. PUMP TO INJECTION WELL FOR RETURN OF EXTRACTED GROUND WATER AFTER NAPL SEPARATION.
6. PIPING, TYP

LEGEND

EXST SHEET PILE WALL

NEW SHEET PILE WALL (SHEET PILE AND CONCRETE)

AIR SUPPLY LINE AND CONNECTIONS TO WELLS

NEW EAB WELL AND INFLUENCE ZONE

WELL

INFLUENCE ZONE

A NEW GW EXTRACTION WELL

PW9 EXST PW WELL

NEW EAB/INJECTION WELL

NEW INJECTION WELL

EXTRACTION WELL

142 PHASE 1 ISS IMPLEMENTATION AREA

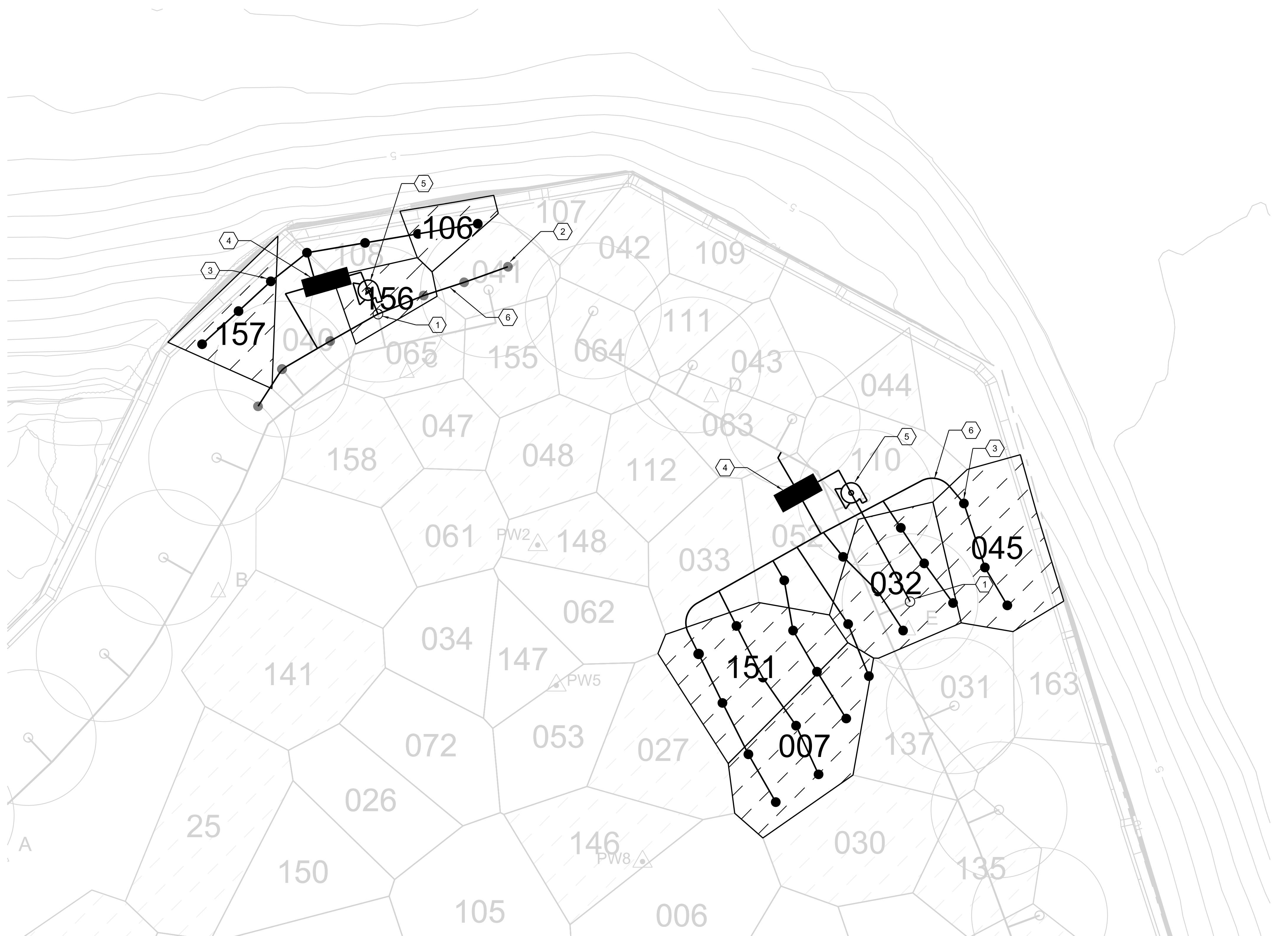
032 PHASE 1 NAPL RECOVERY

047 PHASE 2 INTERMEDIATE TECHNOLOGY IMPLEMENTATION AREA

N

0 5 10 15

1"=25'



PRELIMINARY

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

ALTERNATIVE 7 PHASE 1 & 2 TREATMENT AREAS
NORTH AREA NAPL EXTRACTION, GW EXTRACTION, AND EAB SITE PLAN

CH2MHILL®

NO.	DATE	REVISION	BY	APVD
DSGN JG	DR BCT	CHK KTS	APVD	

	1"=25'
	VERIFY SCALE
	BAR IS ONE INCH ON ORIGINAL DRAWING. 0 1"
DATE	OCTOBER 2015
PROJ	438527
DWG	700-C-107
SHEET	of

PRELIMINARY

GENERAL NOTES

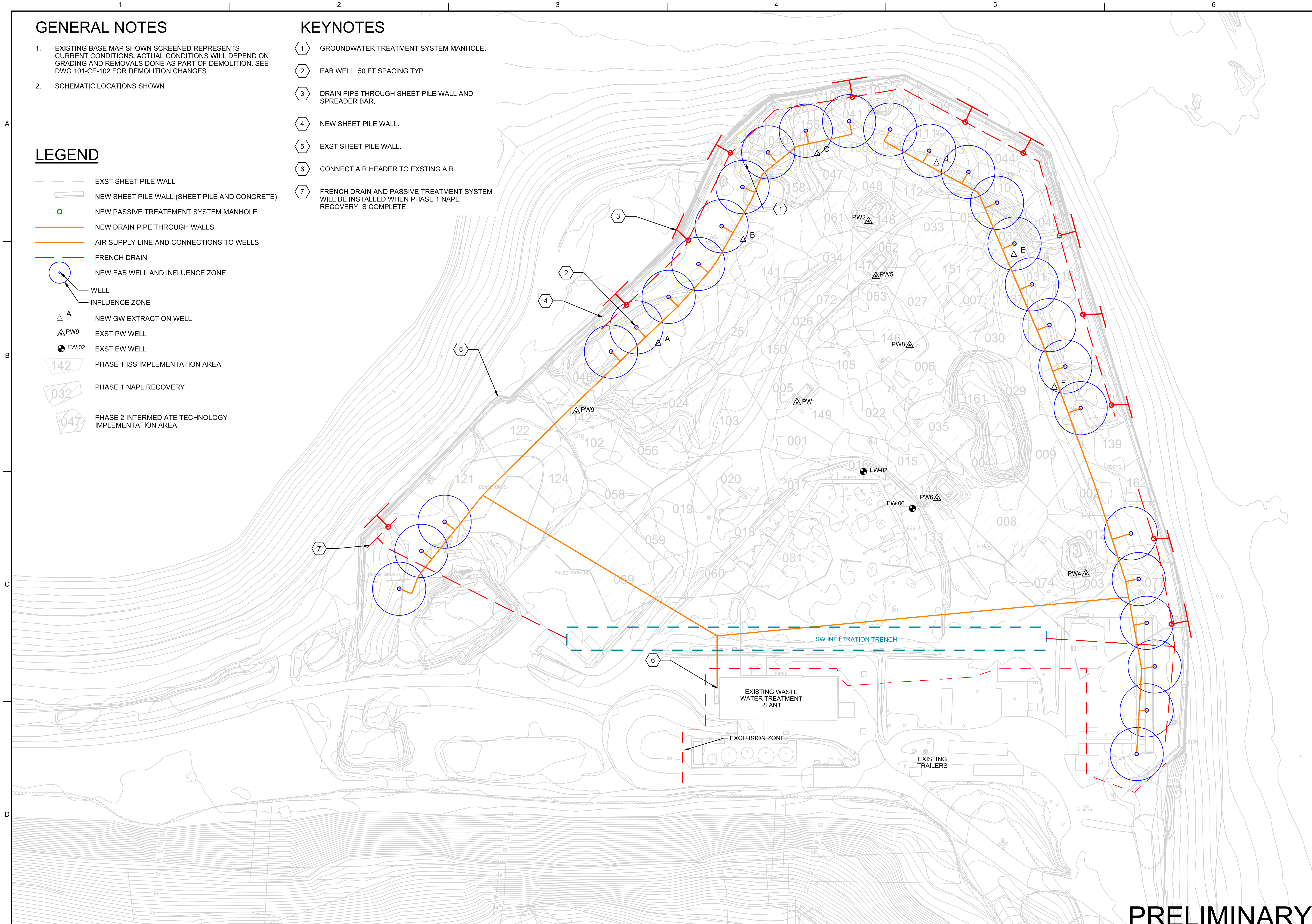
1. EXISTING BASE MAP SHOWN SCREENED REPRESENTS CURRENT CONDITIONS. ACTUAL CONDITIONS WILL DEPEND ON GRADING AND REMOVALS DONE AS PART OF DEMOLITION. SEE DWG 101-CE-102 FOR DEMOLITION CHANGES.
2. SCHEMATIC LOCATIONS SHOWN

KEYNOTES

1. GROUNDWATER TREATMENT SYSTEM MANHOLE.
2. EAB WELL, 50 FT SPACING TYP.
3. DRAIN PIPE THROUGH SHEET PILE WALL AND SPREADER BAR.
4. NEW SHEET PILE WALL.
5. EXST SHEET PILE WALL.
6. CONNECT AIR HEADER TO EXSTING AIR.
7. FRENCH DRAIN AND PASSIVE TREATMENT SYSTEM WILL BE INSTALLED WHEN PHASE 1 NAPL RECOVERY IS COMPLETE.

LEGEND

- EXST SHEET PILE WALL
- NEW SHEET PILE WALL (SHEET PILE AND CONCRETE)
- NEW PASSIVE TREATEMENT SYSTEM MANHOLE
- NEW DRAIN PIPE THROUGH WALLS
- AIR SUPPLY LINE AND CONNECTIONS TO WELLS
- FRENCH DRAIN
- NEW EAB WELL AND INFLUENCE ZONE (WELL; INFLUENCE ZONE)
- A — NEW GW EXTRACTION WELL
- PW9 — EXST PW WELL
- EW-02 — EXST EW WELL
- 142 — PHASE 1 ISS IMPLEMENTATION AREA
- 032 — PHASE 1 NAPL RECOVERY
- 047 — PHASE 2 INTERMEDIATE TECHNOLOGY IMPLEMENTATION AREA



FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

ALTERNATIVE 7 PHASE 1 & 2 TREATMENT AREAS
PASSIVE GROUNDWATER TREATMENT SYSTEM

CH2MHILL

NO.	DATE	REVISION	BY	APVD

DSGN	DR	CHK	APVD
KTS	BCT	CK	

1"=50'

VERIFY SCALE

BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	OCTOBER 2015
PROJ	438527
DWG	700-C-108
SHEET	of

PRELIMINARY

GENERAL NOTES

1. EXISTING BASE MAP SHOWN SCREENED REPRESENTS CURRENT CONDITIONS. ACTUAL CONDITIONS WILL DEPEND ON GRADING AND REMOVALS DONE AS PART OF DEMOLITION. SEE DWG 101-CE-102 FOR DEMOLITION CHANGES.
2. SCHEMATIC LOCATIONS SHOWN

KEYNOTES

1. NEW SHEET PILE WALL.
2. EXST SHEET PILE WALL.

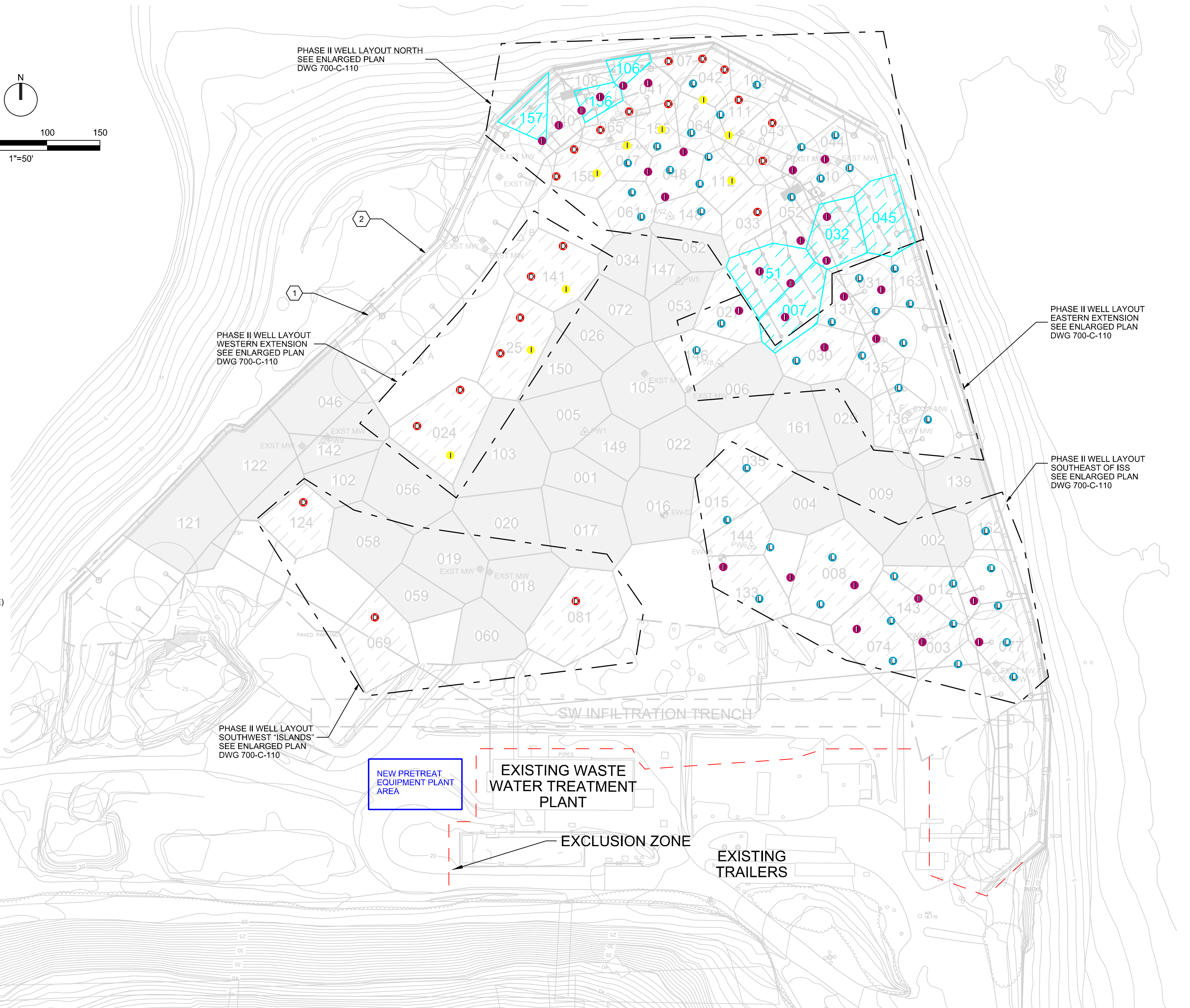
N

0 50 100 150

1"=50'

LEGEND

- EXST SHEET PILE WALL
- NEW SHEET PILE WALL (SHEET PILE AND CONCRETE)
- AIR SUPPLY LINE AND CONNECTIONS TO WELLS
- NEW PASSIVE TREATEMENT SYSTEM MANHOLE
- NEW DRAIN PIPE THROUGH WALLS
- FRENCH DRAIN
- NEW EAB WELL AND INFLUENCE ZONE
  - WELL
  - INFLUENCE ZONE
- A NEW GW EXTRACTION WELL
- PW9 EXST PW WELL
- NEW EAB/INJECTION WELL
- NEW INJECTION WELL
- EXTRACTION WELL
- PHASE II EXT WELL (SCREENED FULL SATURATED INTERVAL)
- PHASE II EXT WELL (SCREENED 30-FT INTO SATURATED ZONE)
- PHASE II INJ WELL NEST (TWO WELLS: SHALLOW/DEEP)
- PHASE II INJ WELL (SCREENED 15-FT INTO SATURATED ZONE)
- 142 PHASE 1 ISS IMPLEMENTATION AREA
- 032 PHASE 1 NAPL RECOVERY
- 047 PHASE 2 INTERMEDIATE TECHNOLOGY IMPLEMENTATION AREA



PRELIMINARY

NO.	DATE	REVISION	BY	APVD

DSGN BS | DR | CHK BCT | APVD KTS

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL®

ALTERNATIVE 7 PHASE 2 TREATMENT AREAS
PHASE 2 THERMAL SITE LAYOUT

1"=50'

VERIFY SCALE

BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	OCTOBER 2015
PROJ	438527
DWG	700-C-109
SHEET	of

PRELIMINARY

GENERAL NOTES

1. EXISTING BASE MAP SHOWN SCREENED REPRESENTS CURRENT CONDITIONS. ACTUAL CONDITIONS WILL DEPEND ON GRADING AND REMOVALS DONE AS PART OF DEMOLITION. SEE DWG 101-CE-102 FOR DEMOLITION CHANGES.
2. SCHEMATIC LOCATIONS SHOWN

KEYNOTES

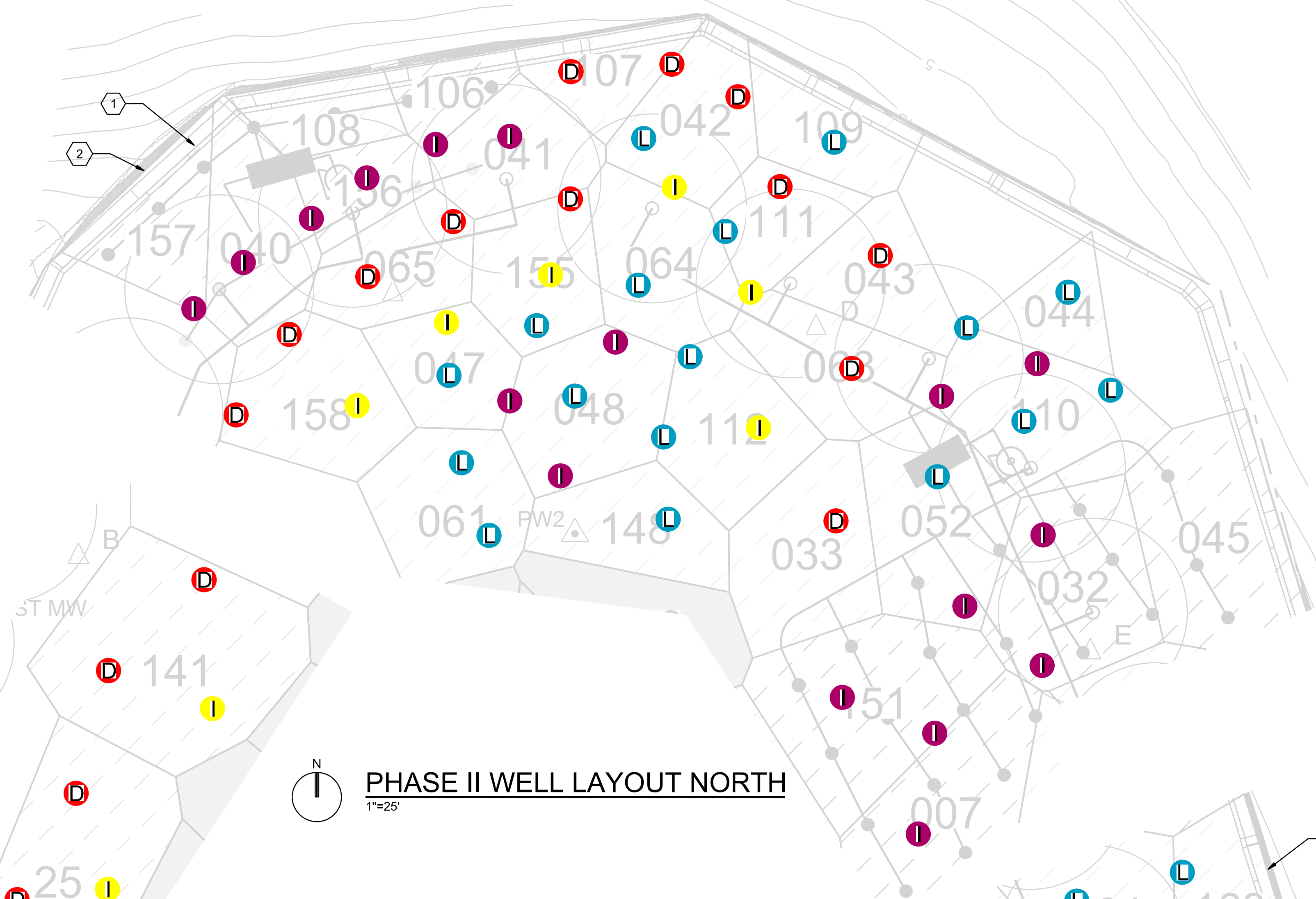
(1) NEW SHEET PILE WALL.

(2) EXST SHEET PILE WALL.

LEGEND

- EXST SHEET PILE WALL
- NEW SHEET PILE WALL (SHEET PILE AND CONCRETE)
- AIR SUPPLY LINE AND CONNECTIONS TO WELLS
- NEW EAB WELL AND INFLUENCE ZONE
  - WELL
  - INFLUENCE ZONE
- A NEW GW EXTRACTION WELL
- PW9 EXST PW WELL
- NEW EAB/INJECTION WELL
- NEW INJECTION WELL
- EXTRACTION WELL
- D PHASE II EXT WELL (SCREENED FULL SATURATED INTERVAL)
- L PHASE II EXT WELL (SCREENED 30-FT INTO SATURATED ZONE)
- I PHASE II INJ WELL NEST (TWO WELLS: SHALLOW/DEEP)
- I PHASE II INJ WELL (SCREENED 15-FT INTO SATURATED ZONE)
- 142 PHASE 1 ISS IMPLEMENTATION AREA
- 032 PHASE 1 NAPL RECOVERY
- 047 PHASE 2 INTERMEDIATE TECHNOLOGY IMPLEMENTATION AREA

0 25 50 75
1"=25'

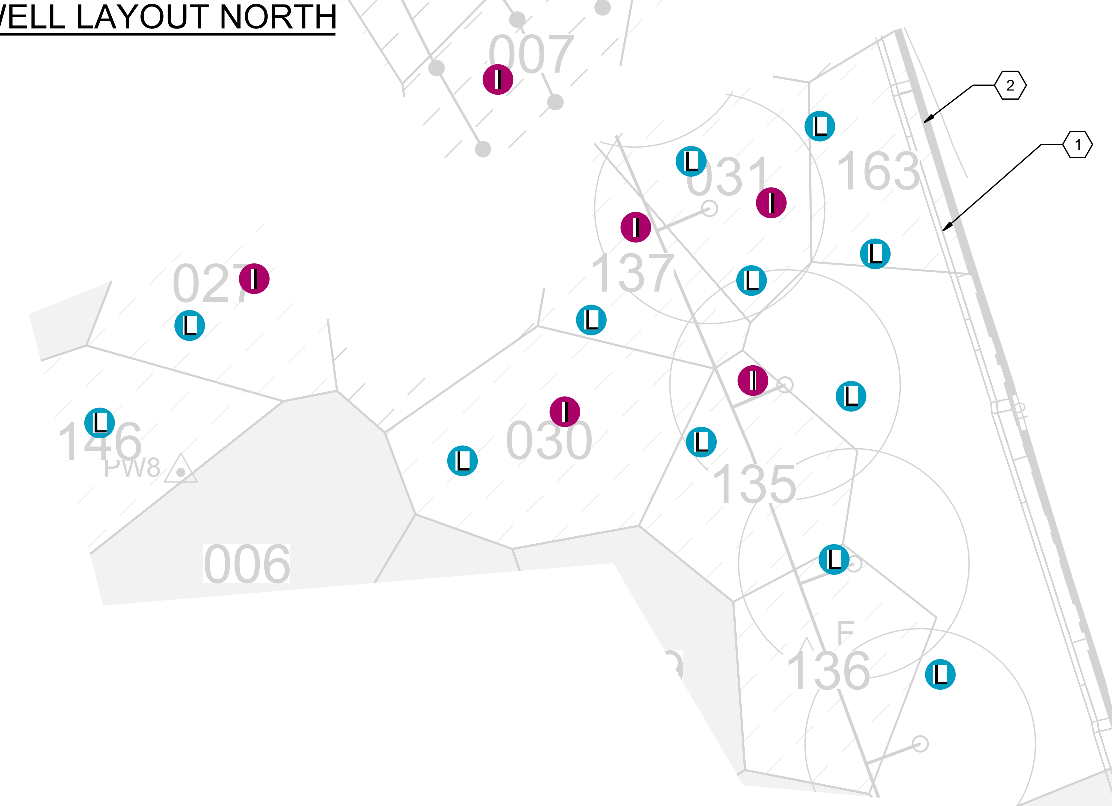


PHASE II WELL LAYOUT NORTH

1"=25'

PHASE II WELL LAYOUT WESTERN EXTENSION

1"=25'



PHASE II WELL LAYOUT – EASTERN EXTENSION

1"=25'

PRELIMINARY

NO.	DATE	REVISION	BY	APVD

DSGN BS | DR BCT | CHK KTS | APVD

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL®

ALTERNATIVE 7 PHASE 2 TREATMENT AREAS
THERMAL WELL SITE PLAN ENLARGEMENTS

1"=25'

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	OCTOBER 2015
PROJ	438527
DWG	700-C-110
SHEET	of

PRELIMINARY

1 2 3 4 5 6

GENERAL NOTES

1. EXISTING BASE MAP SHOWN SCREENED REPRESENTS CURRENT CONDITIONS. ACTUAL CONDITIONS WILL DEPEND ON GRADING AND REMOVALS DONE AS PART OF DEMOLITION. SEE DWG 101-CE-102 FOR DEMOLITION CHANGES.
2. SCHEMATIC LOCATIONS SHOWN

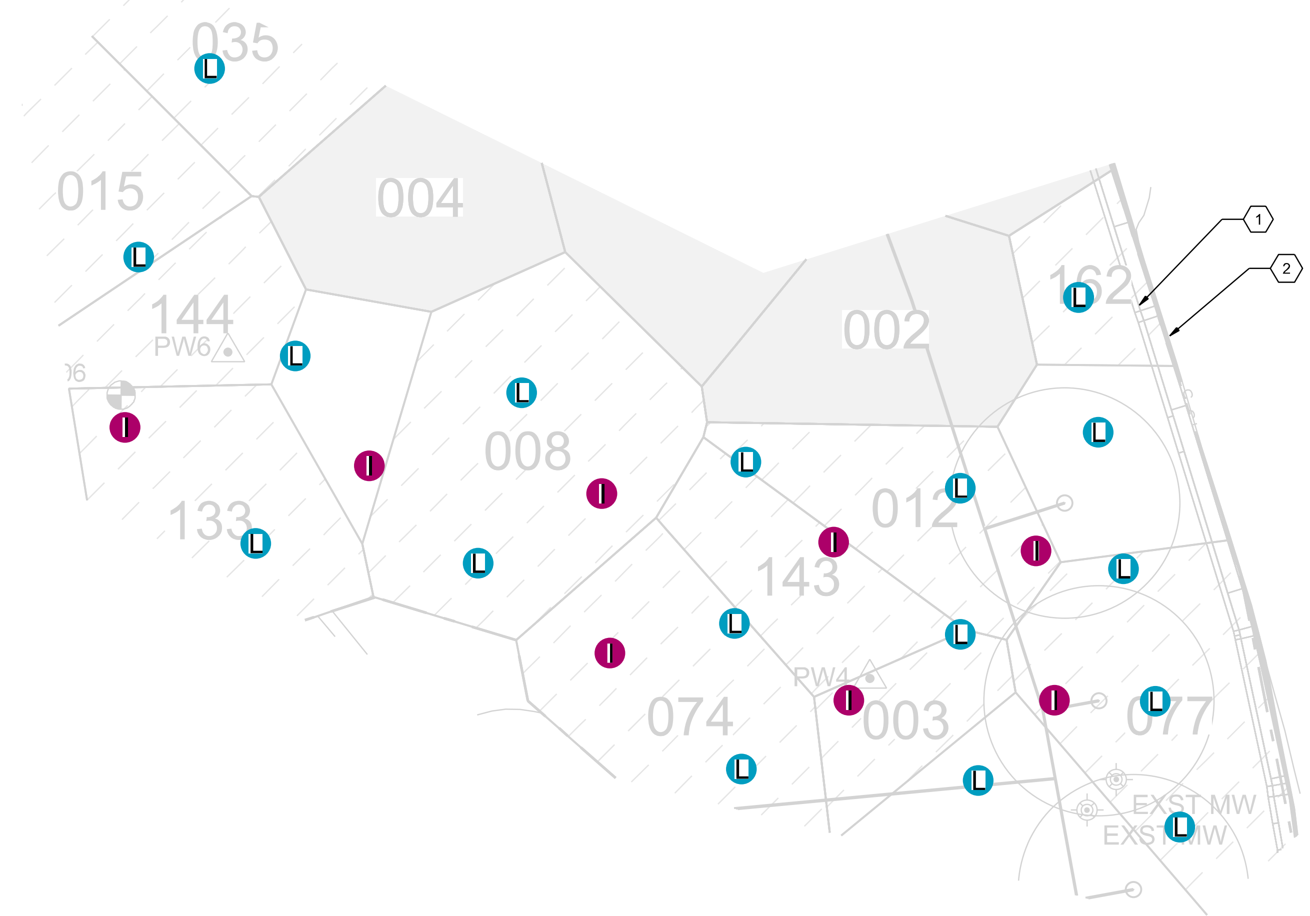
KEYNOTES

1. NEW SHEET PILE WALL.
2. EXST SHEET PILE WALL.

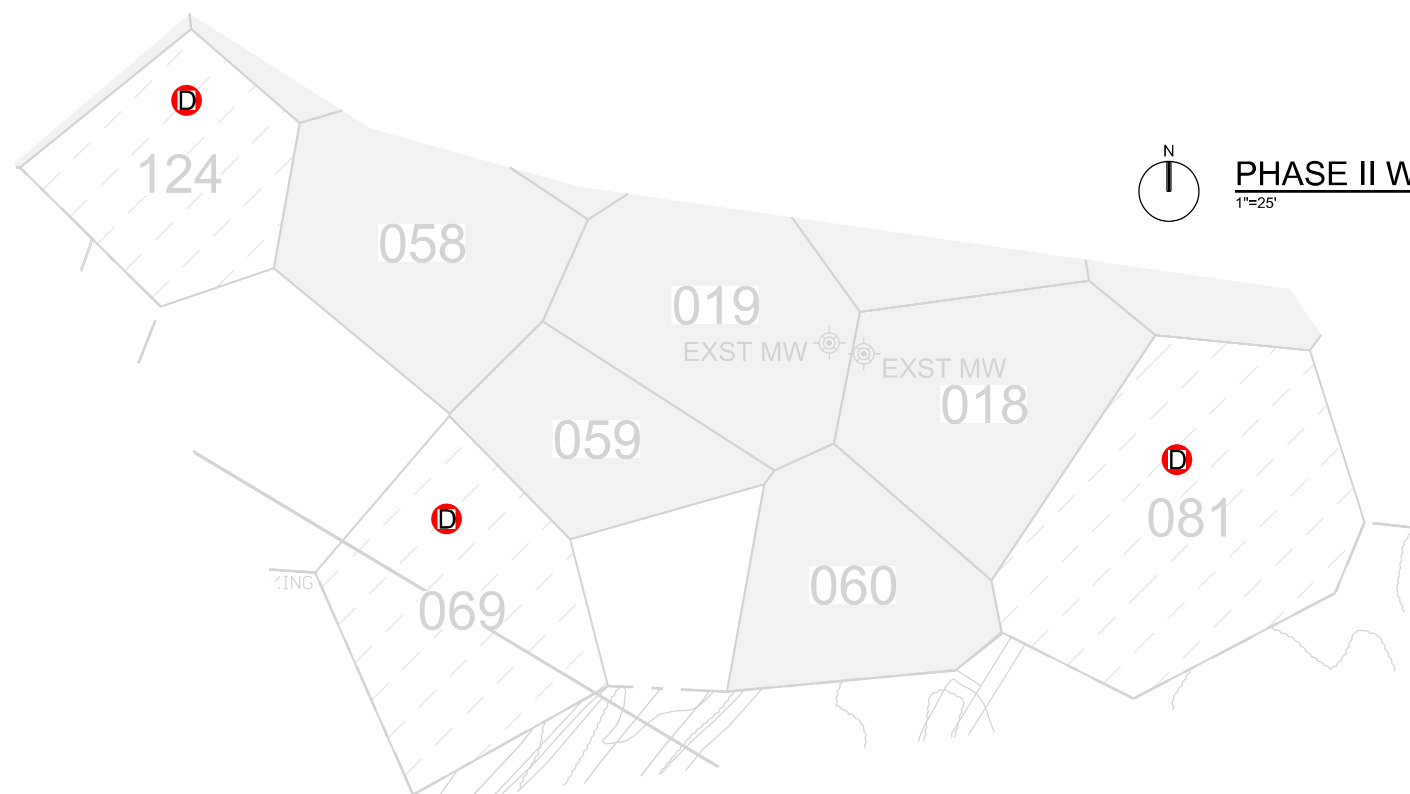
LEGEND

- EXST SHEET PILE WALL
- NEW SHEET PILE WALL (SHEET PILE AND CONCRETE)
- AIR SUPPLY LINE AND CONNECTIONS TO WELLS
- NEW EAB WELL AND INFLUENCE ZONE (WELL, INFLUENCE ZONE)
- A — NEW GW EXTRACTION WELL
- PW9 — EXST PW WELL
- NEW EAB/INJECTION WELL
- NEW INJECTION WELL
- EXTRACTION WELL
- PHASE II EXT WELL (SCREENED FULL SATURATED INTERVAL)
- PHASE II EXT WELL (SCREENED 30-FT INTO SATURATED ZONE)
- PHASE II INJ WELL NEST (TWO WELLS: SHALLOW/DEEP)
- PHASE II INJ WELL (SCREENED 15-FT INTO SATURATED ZONE)
- PHASE 1 ISS IMPLEMENTATION AREA
- 032 — PHASE 1 NAPL RECOVERY
- 047 — PHASE 2 INTERMEDIATE TECHNOLOGY IMPLEMENTATION AREA

0 25 50 75
1"=25'



PHASE II WELL LAYOUT – SOUTHEAST OF ISS
1"=25'



PHASE II WELL LAYOUTSOUTHWEST "ISLANDS"
1"=25'

PRELIMINARY

NO.	DATE	REVISION	BY	APVD

DSGN BS | DR BCT | CHK KTS | APVD

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

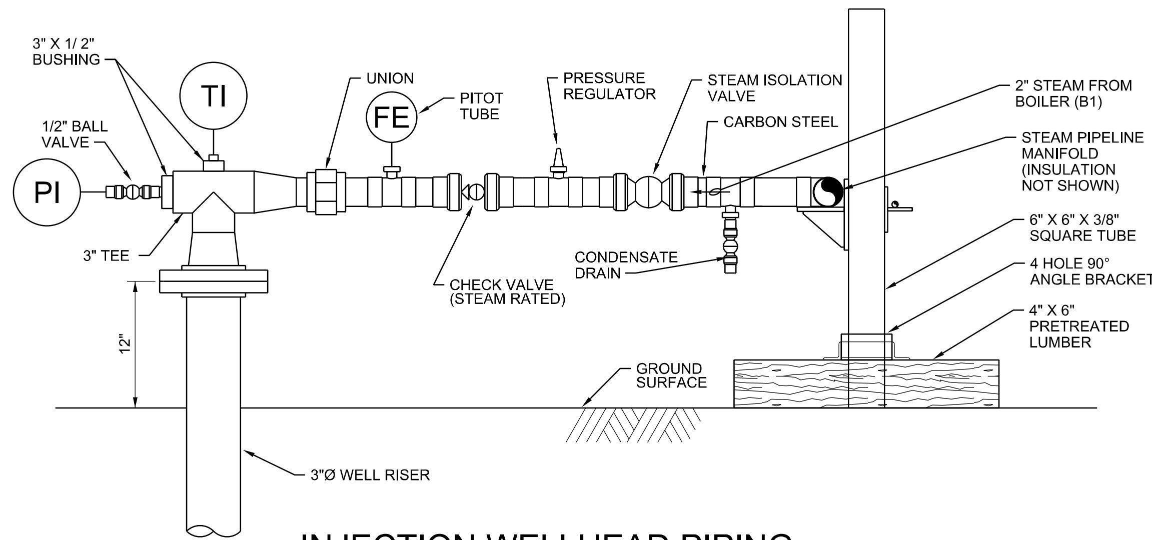
CH2MHILL

ALTERNATIVE 7 PHASE 2 TREATMENT AREAS
THERMAL WELL SITE PLAN ENLARGEMENTS

1"=25'
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	OCTOBER 2015
PROJ	438527
DWG	700-C-111
SHEET	of

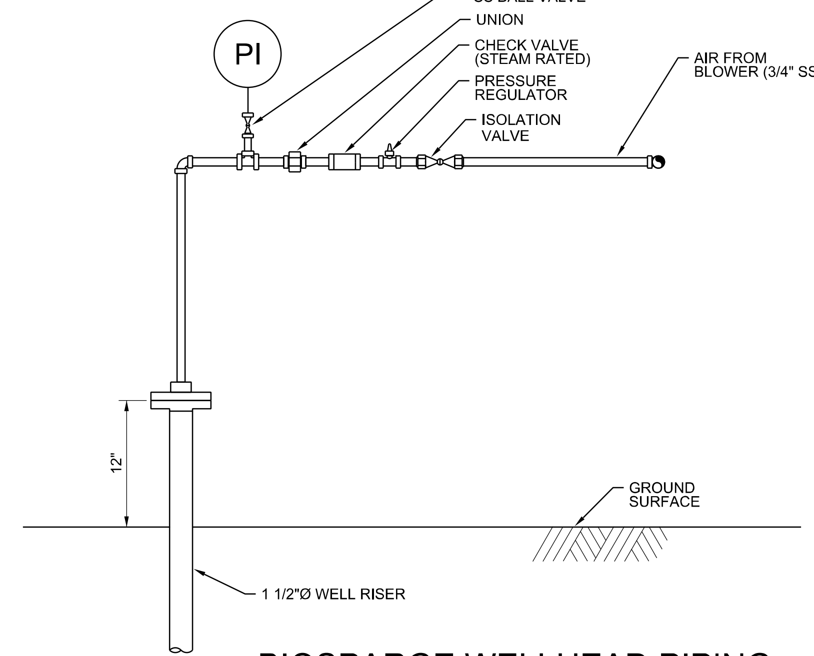
PRELIMINARY



INJECTION WELLHEAD PIPING

NTS

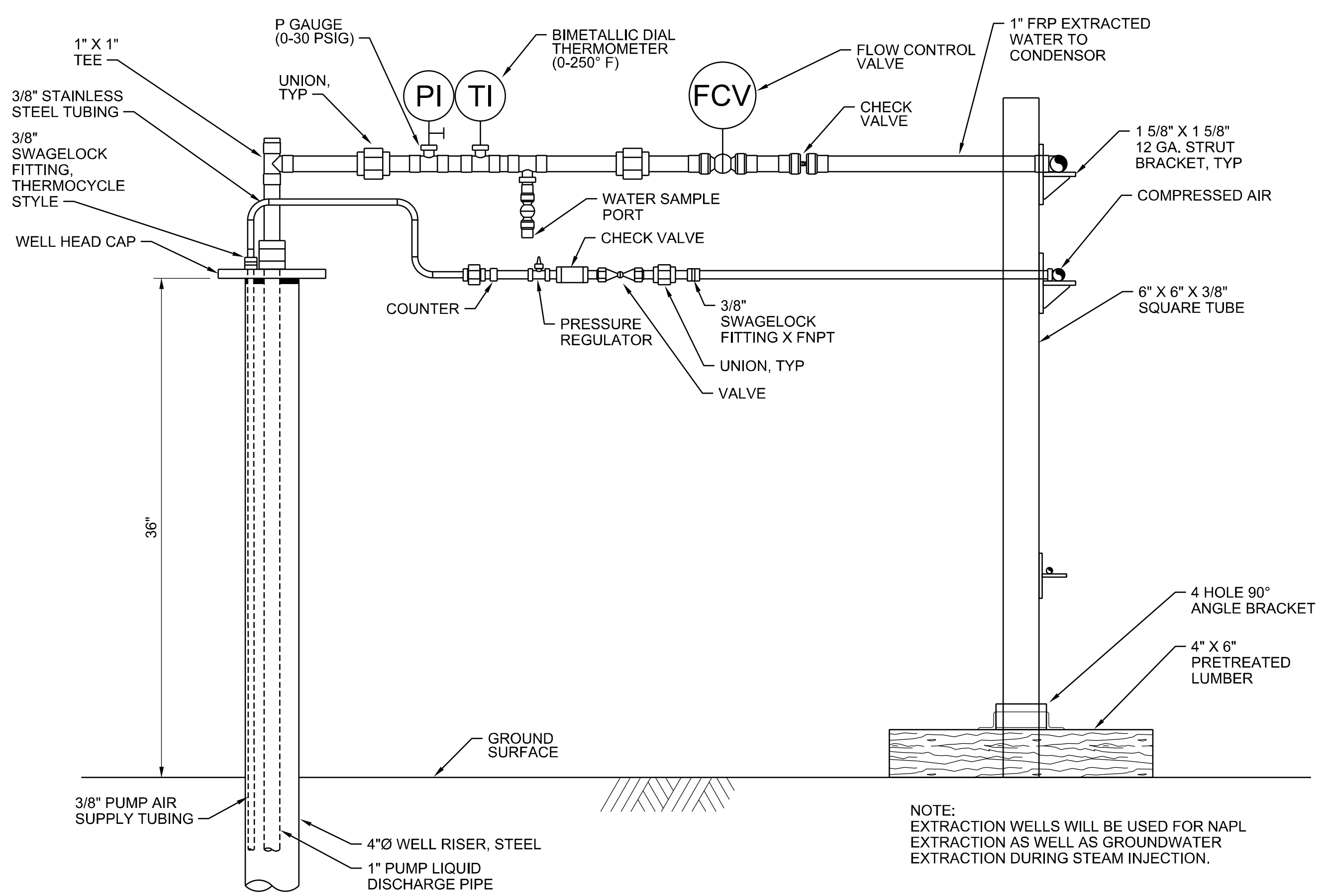
NOTE:
ONCE STEAM INJECTION IS COMPLETE, THESE WELLS MAY BE CONVERTED TO BIOSPARGING. STEAM PIPING AND THERMOCOUPLES CAN BE REMOVED.



BIOSPARGE WELLHEAD PIPING

NTS

NOTE:
THIS WELLHEAD IS ONLY USED IN AREAS WHERE NO STEAM INJECTION WELLS HAVE BEEN INSTALLED IN AREAS THAT RECEIVE ISCO TREATMENT, 1 1/2" Ø WELLS USED FOR ISCO WILL BE CONVERTED TO BIOSPARGING ONCE ISCO IS COMPLETE.



NOTE:
EXTRACTION WELLS WILL BE USED FOR NAPL EXTRACTION AS WELL AS GROUNDWATER EXTRACTION DURING STEAM INJECTION.

EXTRACTION WELLHEAD PIPING

NTS

NO.	DATE	REVISION	BY	APVD

DSGN C KATZEN | DR D SUNSERI | CHK KTS | APVD

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

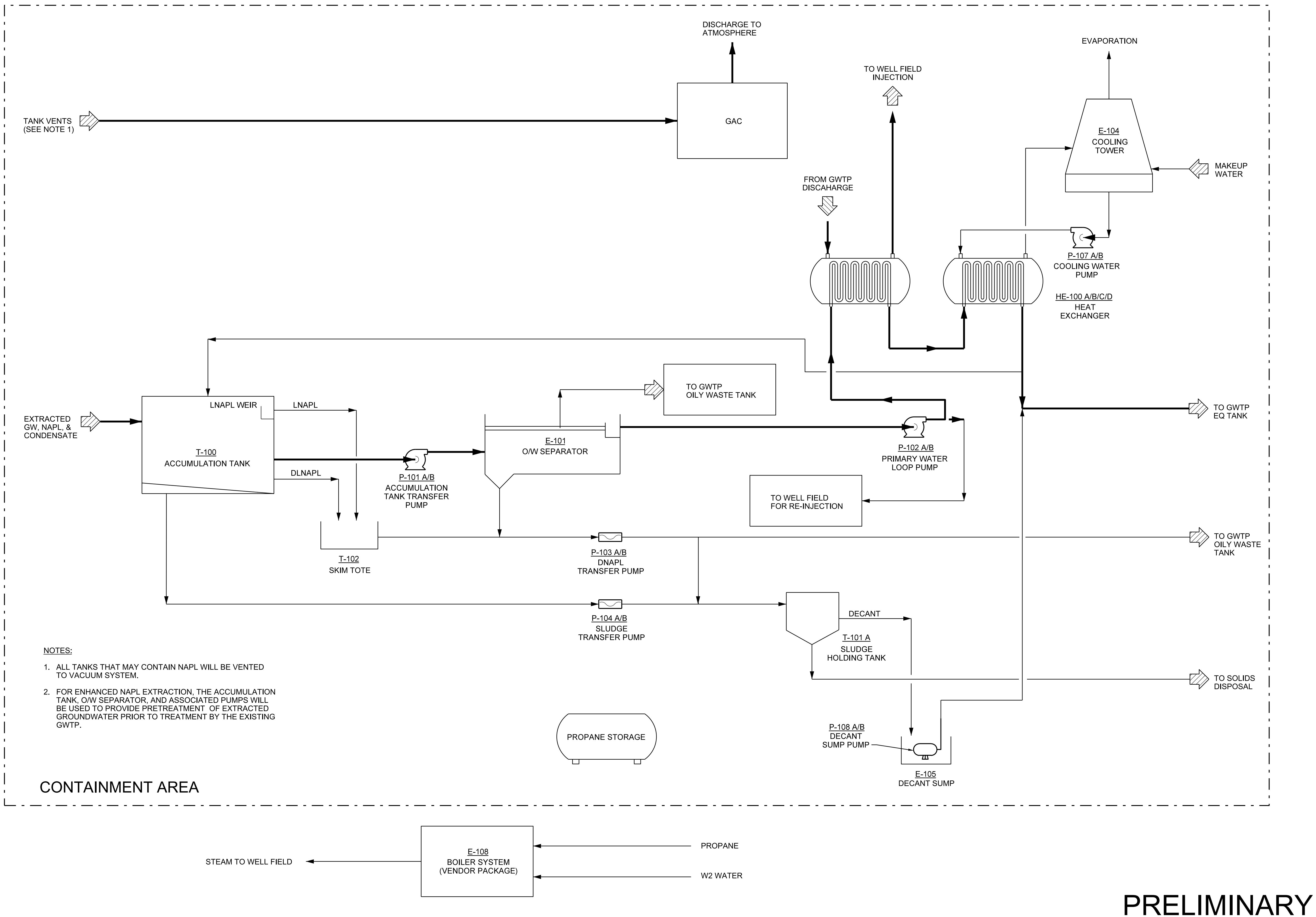
CH2MHILL®

ALTERNATIVE 7 PHASE 2 TREATMENT AREAS
THERMAL DETAILS
WELL HEAD & PIPE RACK DETAIL

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	OCTOBER 2015
PROJ	438527
DWG	700-C-112
SHEET	of

PRELIMINARY



CH2MHILL

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

ALTERNATIVE 7
PROCESS FLOW DIAGRAM

NO.	DATE	REVISION	BY	APVD
DSGN	DR	CHK	APVD	
	BS	VM	KS	

NTS
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.

DATE	AUGUST 2015
PROJ	438527
DWG	700-C-113
SHEET	of

PRELIMINARY. NOT FOR CONSTRUCTION

Appendix C
Remedial Action Alternative Cost Estimates

Alternatives Cost Summary
Wyckoff/Eagle Harbor Soil and Groundwater OUs, Focused Feasibility Study

	Alternative 2	Alternative 4	Alternative 5	Alternative 6	Alternative 7
Pre-construction Activites	$879,000	$879,000	$879,000	$879,000	$879,000
Access Roads	$306,000	$306,000	$306,000	$306,000	$306,000
Concrete Demo	N/A	$2,324,000	$2,324,000	$2,324,000	$2,324,000
Debris Removal	N/A	$3,195,000	$3,195,000	$3,195,000	$3,195,000
Bulkhead Removal (Rock Soil Removal for Alt7X)	$8,764,000	$8,764,000	$8,764,000	$8,764,000	$8,764,000
Other Demo	$1,276,000	$2,832,000	$2,832,000	$2,832,000	$2,832,000
Storm Water Infiltration Trench	N/A	$214,000	$214,000	$214,000	$214,000
Sheet Pile Wall	$13,362,000	N/A	$13,362,000	$13,362,000	$13,362,000
Concrete Perimeter Wall	$11,363,000	$8,029,000	$11,363,000	$11,363,000	$11,363,000
Outfall	$3,294,000	$3,294,000	$3,294,000	$3,294,000	$3,294,000
Construction of Passive Drainage System	N/A	$1,306,000	$1,149,000	$1,149,000	$1,149,000
Wood Pile Mitigation	N/A	N/A	N/A	N/A	N/A
Site Cap	$4,100,000	$4,100,000	$4,100,000	$4,100,000	$4,100,000
COMMON ELEMENTS SUBTOTALS:	***$43,344,000***	***$35,243,000***	***$51,782,000***	***$51,782,000***	***$51,782,000***

REMEDIAL TECHNOLOGIES					
Alternative 2 - Hydraulic Containment	$1,462,000				
Alternative 4 - ISS Treatment		*$53,595,000*			
Alternative 5 - Thermal + Jet Grouting North Unit			$40,715,000		
Alternative 6 - Thermal + MTTD				$100,159,000	
Alternative 7 - Phase I					$30,336,491
Alternative 7 - Phase II					$7,379,846
Groundwater Treatment Plant Demolition	*$1,000,000*	*$1,000,000*	$1,000,000	$1,000,000	$1,000,000
Well Abandonment	*$0*	*$0*	$1,872,000	$1,948,000	$1,498,000
1st Year O&M of Passive Treatment System	*$0*	*$333,000*	$284,000	$284,000	$284,000
EPA O&M Costs During Remedial Action		$2,364,000	$7,092,000	$7,880,000	$11,820,000
REMEDIAL TECHNOLOGY SUBTOTALS:	***$2,462,000***	***$57,292,000***	***$50,963,000***	***$111,271,000***	***$52,318,337***

GWTP O&M Costs					
GWTP Operations	$52,015,000	$0	$0	$0	$0

100-yr O&M and Periodic Costs (non-discounted)					
Replace WTP Equipment/Piping	$600,000	$0	$0	$0	$0
Replace WTP Electrical/Mechanical	$12,000,000	$0	$0	$0	$0
Maintain Onsite Roads	$25,000	$25,000	$25,000	$25,000	$25,000
Passive Treatment System Operations	$0	$2,331,000	$5,112,000	$5,112,000	$5,112,000
EAB	$0	$0	$1,128,000	$940,000	$2,820,000
NAPL Recovery	$0	$0	$2,562,000	$2,562,000	$1,215,000
Thermal Operations	$0	$0	$37,455,000	$37,760,000	N/A*
Alt7 Phase II - Initial Year O&M	$0	$0	$0	$0	$4,031,000
Alt7 Phase II - Follow-on Years (4)	$0	$0	$0	$0	$6,724,000
	$12,625,000	**$2,356,000**	**$46,282,000**	**$46,399,000**	**$19,927,000**

*** Alt 7 thermal operations costs are included in Alt 7 Phase II Initial and Follow-on years (Lines 40 and 41, respectively)**

Long-Term EPA Reporting Costs (non-discounted)					
5-yr Reviews	$400,000	$400,000	$400,000	$400,000	$400,000
Final Completion Report	$150,000	$150,000	$150,000	$150,000	$150,000
	$550,000	**$550,000**	**$550,000**	**$550,000**	**$550,000**

	50%	**$166,500,000**	**$143,160,000**	**$224,370,000**	**$315,000,000**	**$186,870,000**
Non-Discounted Cost (2016)		**$111,000,000**	**$95,440,000**	**$149,580,000**	**$210,000,000**	**$124,580,000**
	-30%	**$77,700,000**	**$66,810,000**	**$104,710,000**	**$147,000,000**	**$87,210,000**
	50%	**$119,730,000**	**$140,610,000**	**$213,090,000**	**$296,550,000**	**$169,560,000**
Present Worth Cost		**$79,820,000**	**$93,740,000**	**$142,060,000**	**$197,700,000**	**$113,040,000**
	-30%	**$55,874,000**	**$65,618,000**	**$99,442,000**	**$138,390,000**	**$79,128,000**

Common Elements Subtotal	$43,344,000	$35,243,000	$51,782,000	$51,782,000	$51,782,000
Remedial Technology Subtotal	$2,462,000	$57,292,000	$50,963,000	$111,271,000	$52,318,337
Periodic Costs	$12,625,000	$2,356,000	$46,282,000	$46,399,000	$19,927,000
GWTP	$52,015,000	$0	$0	$0	$0

Alternate 2 - Hydraulic Containment
Wyckoff/Eagle Harbor Soil and Groundwater OUs, Focused Feasibility Study

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
CAPITAL COSTS					
GENERAL SITE ACTIVITIES					
Pre-construction Activites - Common Elements (2016)					
Permitting	1	LS	$20,000	$20,000	Excavation/Grading/Drilling/Ecological
Precon Submittals	1	LS	$54,000	$54,000	WP/H&SP/AHAs/Schedule
Mobilization/Demobilization	1	LS	$118,000	$118,000	
Community Relations	1	LS	$169,000	$169,000	
Site Preparation	1	LS	$52,000	$52,000	
Surveying - General	50	DY	$2,900	$145,000	
Project Management	6%		$558,000	$33,480	USEPA 540-R-00-002 Guidence Document
Construction Management	8%		$558,000	$44,640	USEPA 540-R-00-002 Guidence Document
Remedial Design	12%		$558,000	$66,960	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$703,000	$175,750	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$879,000**	
Access Roads (2016)					
Erosion Controls	1,500	LF	$10	$15,000	
Roadway Grading	1,955	CY	$50	$97,750	
P/D/P 3" Agg Base	725	TN	$10	$7,250	
P/D/P/Seal 4" AC Pavement	260	TN	$190	$49,400	
Erosion Control Matting	1,445	sy	$10	$14,450	
$515,000	8%		$183,850	$14,708	USEPA 540-R-00-002 Guidence Document
Construction Management	10%		$183,850	$18,385	USEPA 540-R-00-002 Guidence Document
Remedial Design	15%		$183,850	$27,578	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$244,521	$61,130	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$306,000**	
Rock/Soil/Bulkhead Removal (2016)					
Rock Removal	16,857	CY	$50	$842,850	
Excavate Behind Exist SP Wall	28,393	CY	$30	$851,790	
Bulkhead Removal	2,696	CY	$20	$53,920	
T&D Bulkhead Debris - Hazardous	2,022	TN	$1,000	$2,022,000	
T&D Bulkhead Debris - Non Haz	2,022	TN	$250	$505,500	
Backfill Existing Sheet Pile Wall	28,393	CY	$20	$567,860	
Crush Rock	16,857	CY	$10	$168,570	
Spread Crushed Material Onsite	16,857	CY	$20	$337,140	
Odor Control	12	WK	$9,700	$116,400	Allowance
Level C PPE Upgrade	1	LS	$425,895	$425,895	
Project Management	5%		$5,891,925	$294,596	USEPA 540-R-00-002 Guidence Document
Construction Management	6%		$5,891,925	$353,516	USEPA 540-R-00-002 Guidence Document
Remedial Design	8%		$5,891,925	$471,354	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$7,011,391	$1,752,848	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$8,764,000**	
Miscellaneous Demolition (2016)					
Remove/Dispose Asphalt	233	CY	$100	$23,300	HCSS Estimate
Remove/Dispose of Pilot Plant Pipe	1	LS	$20,000	$20,000	Engineer's Estimate
Remove/Dispose NW Beach SP	13,280	SF	$30	$398,400	HCSS Estimate
Remove/Dispose Tanks & Equip	1	LS	$119,000	$119,000	HCSS Estimate
Odor Control	4	WK	$9,700	$38,800	Allowance
Level C PPE Upgrade	1	LS	$210,850	$210,850	
Project Management	6%		$810,350	$48,621	USEPA 540-R-00-002 Guidence Document
Construction Management	8%		$810,350	$64,828	USEPA 540-R-00-002 Guidence Document
Remedial Design	12%		$810,350	$97,242	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$1,021,041	$255,260	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$1,276,000**	

Alternate 2 - Hydraulic Containment
Wyckoff/Eagle Harbor Soil and Groundwater OUs, Focused Feasibility Study

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
Install New Perimeter SP Wall, Non ISS (2017)					
P/D AZ50 Sheet Pile	3,700	TN	$1,900	$7,030,000	Vendor Quote
Unload Sheet Pile	169	LD	$2,300	$388,700	
Install Perimeter SP Wall (AZ50)	142,200	SF	$11	$1,564,200	
Project Management	5%		$8,982,900	$449,145	USEPA 540-R-00-002 Guidence Document
Construction Management	6%		$8,982,900	$538,974	USEPA 540-R-00-002 Guidence Document
Remedial Design	8%		$8,982,900	$718,632	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$10,689,651	$2,672,413	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$13,362,000**	
Non-ISS Concrete Perimeter Wall (2016)					
Excavation - Non-ISS Perimeter Wall	14,646	CY	$63	$922,698	
Install Concrete Plug	1,475	CY	$220	$324,500	
Odor Control	8	WK	$9,700	$77,600	Allowance
P/D/I Rebar	1,100	TN	$3,100	$3,410,000	
P/D/I Concrete	13,201	CY	$220	$2,904,220	
Project Management	5%		$7,639,018	$381,951	USEPA 540-R-00-002 Guidence Document
Construction Management	6%		$7,639,018	$458,341	USEPA 540-R-00-002 Guidence Document
Remedial Design	8%		$7,639,018	$611,121	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$9,090,431	$2,272,607.86	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$11,363,000**	
Construct Outfall (2017)					
P/D AZ36-700N Sheet Pile	90	TN	$1,700	$153,036	3,500 sf @ 51.8 lbs/ton
Unload Sheet Pile	5	LD	$2,100	$10,500	
Install Sheet Pile	3,500	SF	$10	$35,000	
Dewatering	20	DY	$800	$16,000	
HDD, Pipe, and Marine	1	LS	$1,500,000	$1,500,000	Vendor Quote
Onshore Construction	1	LS	$500,000	$500,000	
Project Management	5%		$2,214,536	$110,727	USEPA 540-R-00-002 Guidence Document
Construction Management	6%		$2,214,536	$132,872	USEPA 540-R-00-002 Guidence Document
Remedial Design	8%		$2,214,536	$177,163	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$2,635,298	$658,824	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$3,294,000**	
Final Site Cap (2018)					
Subgrade Preparation	39,150	SY	$3	$117,450	HCSS Estimate
P/D/P Embankment Fill	13,917	CY	$20	$278,340	HCSS Estimate
Geomembrane Cover	39,150	SY	$6.75	$264,263	Engineer's Estimate
Geomembrane Penetrations	13	EA	$500	$6,500	Engineer's Estimate
Cushion Geotextile	39,150	SY	$2.25	$88,088	Engineer's Estimate
P/D/P Granular Drain Mat'l	21,000	TN	$30	$630,000	HCSS Estimate
P/D/P Topsoil Layer	21,100	TN	$60	$1,266,000	HCSS Estimate
Survey	22	DY	$2,900	$63,800	HCSS Estimate
Restoration	13	AC	$3,200	$41,600	Engineer's Estimate
Project Management	5%		$2,756,040	$137,802	USEPA 540-R-00-002 Guidence Document
Construction Management	6%		$2,756,040	$165,362	USEPA 540-R-00-002 Guidence Document
Remedial Design	8%		$2,756,040	$220,483	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$3,279,688	$819,922	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$4,100,000**	

Alternate 2 - Hydraulic Containment
Wyckoff/Eagle Harbor Soil and Groundwater OUs, Focused Feasibility Study

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
REMEDIAL ACTION ALTERNATIVE					
Alternative 2 - Hydraulic Containment (Midpoint = 2018)					
Pre-construction Activities					
Precon Submittals - Driller	1	LS	$10,000	$10,000	
Mob/Demob - Driller	1	LS	$4,000	$4,000	Vendor Quote
Site Preparation	1	LS	$5,000	$5,000	Setup equip/mat'l laydown areas; erosion controls
Survey	15	Day	$2,900	$43,500	
			Subtotal:	**$62,500**	
Extraction System Installation					
Install New Extraction Wells	4	ea	$20,000	$80,000	Vendor Quote
Refurbish Existing Wells	9	ea	$2,300	$20,700	Vendor Quote
Well Surface Completions	4	ea	$1,800	$7,200	Vendor Quote
Install New Well Pumps	6	ea	$56,000	$336,000	Vendor Quote - Incl. valves, piping, flowmeter, pumps
Wellhead Infrastructure	6	ea	$10,000	$60,000	12'x8'x1' Vault, w/ sump
Trenching Excavation	350	cy	$12	$4,200	1.5' x 3' x 2100' trench
3" FRP Piping	2,100	LF	$22	$46,200	
FRP Valves, Fittings, Insulation	1	ls	$11,550	$11,550	Allowance: 25% of piping cost
Purchase/Deliver Bedding Sand	260	tn	$15	$3,900	6" below and 6" above pipe ==> 15"
Trench Backfill - sand/spoils	350	cy	$29	$10,150	6' lifts, by hand
I&C	4	ea	$5,000	$20,000	Allowance
Electrical (Power and I&C)	1	ls	$100,800	$100,800	Allowance: 30% of installed pump cost
GWTP Modifications	1	ls	$50,000	$50,000	Allowance for GWTP I&C modifications
			Subtotal:	**$750,700**	
Stormwater System					
P/D/I 5' dia x 10' deep	2	ea	$7,500	$15,000	RSMeans 33 49 13
Drainage Ditch	1,100	lf	$5	$5,500	Southern edge only
Trenching Excavation	150	cy	$15	$2,250	4'x2'x400' trench
P/D/I Stormwater Piping	400	lf	$22	$8,800	RSMeans 33 41 13.50
Trench Backfill - sand/spoils	130	cy	$30	$3,900	6' lifts, by hand
			Subtotal:	**$35,450**	
PROJECT MANAGEMENT	6%		$848,650	$50,919	Based on EPA 540-R-00-002
CONSTRUCTION MANAGEMENT	8%		$848,650	$67,892	Based on EPA 540-R-00-002
REMEDIAL DESIGN	12%		$848,650	$101,838	Based on EPA 540-R-00-002
CONSTRUCTION COMPLETION REPORT	1	LS	$100,000	$100,000	
			Subtotal:	**$320,649**	
CONTINGENCY (10% scope + 15% bid)	25%		$1,169,299	$292,325	Based on EPA 540-R-00-002
			TOTAL CAPITAL COSTS	**$1,462,000**	
Alternative 2 - GWTP Demolition					
GWTP Demolition	1	ls	$1,000,000	$1,000,000	Allowance
			Subtotal:	**$1,000,000**	
ALTERNATIVE 2 TOTAL CAPITAL COSTS				**$2,462,000**	
OPERATION & MAINTENANCE COSTS OF GWTP					
Operator(s)	3,120	hr	$80	$249,600	1.5 FTEs Operating GWTP
Electrical Usage	1	ls	$15,000	$15,000	Based on current Usage
Waste Disposal	1	ls	$25,000	$25,000	Allowance: NAPL and spent carbon disposal
Chemicals/Media	1	ls	$11,000	$11,000	Allowance
Maintenance	10%		$300,600	$30,060	Allowance
Quarterly GW Sampling	4	ea	$10,000	$40,000	
Annual GW Sampling	1	ls	$50,000	$50,000	
Undefined Scope Allowance	10%		$420,660	$42,066	
PROJECT MANAGEMENT	6%		$462,726	$27,764	Based on EPA 540-R-00-002
REPORTING	1		$25,000	$25,000	
TOTAL O&M COSTS				**$515,000**	

Alternate 2 - Hydraulic Containment
Wyckoff/Eagle Harbor Soil and Groundwater OUs, Focused Feasibility Study

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
PERIODIC COSTS					
Maintain Onsite Roads	1	ls	$25,000	$25,000	Allowance - regrade/repair onsite roads
Replace GWTP Piping/Equipment	1	ls	$200,000	$200,000	Allowance: Every 25 years
Replace GWTP Mechical/Electrical	1	ls	$4,000,000	$4,000,000	Allowance: Every 25 years
LONG-TERM EPA REPORTING COSTS					
5 Yr Reviews (last completed 2012)	1	ls	$20,000	$20,000	
Final Completion Report	1	ls	$150,000	$150,000	

PRESENT VALUE ANALYSIS ***Base YR 2014*** 1.4% Discount Rate — OMB - Discount Rates for Cost Effectiveness, Lease Purchase, and Related Analysis, 12/2013

Year	Cost Type	Cost	Discount Rate	Present Value	
0	Capital Costs	$22,588,000	1.00	$ 22,588,000	2016
0	Annual O&M Costs	$515,000	1.00	$ 515,000	2016
1	Capital Costs	$16,656,000	0.99	$ 16,426,036	2017
1	Annual O&M Costs	$515,000	0.99	$ 507,890	2017
1	5 Year Review (2017)	$20,000	0.99	$ 19,724	2017
2	Capital Costs	$5,562,000	0.97	$ 5,409,474	2018
2	Annual O&M Costs	$515,000	0.97	$ 500,877	2018
3	Annual O&M Costs	$515,000	0.96	$ 493,962	2019
4	Annual O&M Costs	$515,000	0.95	$ 487,142	2020
5	Annual O&M Costs	$515,000	0.93	$ 480,416	2021
6	Annual O&M Costs	$515,000	0.92	$ 473,783	2022
6	5 Year Review (2022)	$20,000	0.92	$ 18,399	2022
7	Annual O&M Costs	$515,000	0.91	$ 467,242	2023
8	Annual O&M Costs	$515,000	0.89	$ 460,791	2024
9	Annual O&M Costs	$515,000	0.88	$ 454,429	2025
10	Annual O&M Costs	$515,000	0.87	$ 448,154	2026
11	Annual O&M Costs	$515,000	0.86	$ 441,967	2027
11	5 Year Review (2027)	$20,000	0.86	$ 17,164	2027
12	Annual O&M Costs	$515,000	0.85	$ 435,865	2028
13	Annual O&M Costs	$515,000	0.83	$ 429,847	2029
14	Annual O&M Costs	$515,000	0.82	$ 423,912	2030
15	Annual O&M Costs	$515,000	0.81	$ 418,059	2031
16	Annual O&M Costs	$515,000	0.80	$ 412,287	2032
16	5 Year Review (2032)	$20,000	0.80	$ 16,011	2032
17	Annual O&M Costs	$515,000	0.79	$ 406,595	2033
18	Annual O&M Costs	$515,000	0.78	$ 400,981	2034
19	Annual O&M Costs	$515,000	0.77	$ 395,445	2035
20	Annual O&M Costs	$515,000	0.76	$ 389,985	2036
21	Annual O&M Costs	$515,000	0.75	$ 384,601	2037
21	5 Year Review (2037)	$20,000	0.75	$ 14,936	2037
22	Annual O&M Costs	$515,000	0.74	$ 379,291	2038
23	Annual O&M Costs	$515,000	0.73	$ 374,054	2039
23	Maintain Onsite Roads	$25,000	0.73	$ 18,158	2039
23	Replace GWTP Piping/Equipment	$200,000	0.73	$ 145,264	2039
23	Replace GWTP Mechical/Electrical	$4,000,000	0.73	$ 2,905,274	2040
24	Annual O&M Costs	$515,000	0.72	$ 368,890	2040
25	Annual O&M Costs	$515,000	0.71	$ 363,796	2041
26	Annual O&M Costs	$515,000	0.70	$ 358,774	2042
26	5 Year Review (2042)	$20,000	0.70	$ 13,933	2042
27	Annual O&M Costs	$515,000	0.69	$ 353,820	2043
28	Annual O&M Costs	$515,000	0.68	$ 348,935	2044
29	Annual O&M Costs	$515,000	0.67	$ 344,117	2045
30	Annual O&M Costs	$515,000	0.66	$ 339,366	2046
31	Annual O&M Costs	$515,000	0.65	$ 334,681	2047
31	5 Year Review (2047)	$20,000	0.65	$ 12,997	2047
32	Annual O&M Costs	$515,000	0.64	$ 330,060	2048
33	Annual O&M Costs	$515,000	0.63	$ 325,503	2049
34	Annual O&M Costs	$515,000	0.62	$ 321,009	2050
35	Annual O&M Costs	$515,000	0.61	$ 316,577	2051
36	Annual O&M Costs	$515,000	0.61	$ 312,206	2052
36	5 Year Review (2052)	$20,000	0.61	$ 12,124	2052
37	Annual O&M Costs	$515,000	0.60	$ 307,895	2053
38	Annual O&M Costs	$515,000	0.59	$ 303,644	2054
39	Annual O&M Costs	$515,000	0.58	$ 299,452	2055
40	Annual O&M Costs	$515,000	0.57	$ 295,317	2056
41	Annual O&M Costs	$515,000	0.57	$ 291,240	2057
41	5 Year Review (2057)	$20,000	0.57	$ 11,310	2057
42	Annual O&M Costs	$515,000	0.56	$ 287,219	2058

	Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)		NOTES	
43	Annual O&M Costs				$515,000	0.55	$ 283,253	2059
44	Annual O&M Costs				$515,000	0.54	$ 279,343	2060
45	Annual O&M Costs				$515,000	0.53	$ 275,486	2061
46	Annual O&M Costs				$515,000	0.53	$ 271,682	2062
46	5 Year Review (2062)				$20,000	0.53	$ 10,551	2062
47	Annual O&M Costs				$515,000	0.52	$ 267,931	2063
48	Annual O&M Costs				$515,000	0.51	$ 264,232	2064
48	Replace GWTP Piping/Equipment				$200,000	0.51	$ 102,614	2064
48	Replace GWTP Mechical/Electrical				$4,000,000	0.51	$ 2,052,287	2064
49	Annual O&M Costs				$515,000	0.51	$ 260,584	2065
50	Annual O&M Costs				$515,000	0.50	$ 256,986	2066
51	Annual O&M Costs				$515,000	0.49	$ 253,438	2067
51	5 Year Review (2067)				$20,000	0.49	$ 9,842	2067
52	Annual O&M Costs				$515,000	0.49	$ 249,939	2068
53	Annual O&M Costs				$515,000	0.48	$ 246,488	2069
54	Annual O&M Costs				$515,000	0.47	$ 243,085	2070
55	Annual O&M Costs				$515,000	0.47	$ 239,729	2071
56	Annual O&M Costs				$515,000	0.46	$ 236,419	2072
56	5 Year Review (2072)				$20,000	0.46	$ 9,181	2072
57	Annual O&M Costs				$515,000	0.45	$ 233,154	2073
58	Annual O&M Costs				$515,000	0.45	$ 229,935	2074
59	Annual O&M Costs				$515,000	0.44	$ 226,761	2075
60	Annual O&M Costs				$515,000	0.43	$ 223,630	2076
61	Annual O&M Costs				$515,000	0.43	$ 220,542	2077
61	5 Year Review (2077)				$20,000	0.43	$ 8,565	2077
62	Annual O&M Costs				$515,000	0.42	$ 217,497	2078
63	Annual O&M Costs				$515,000	0.42	$ 214,494	2079
64	Annual O&M Costs				$515,000	0.41	$ 211,533	2080
65	Annual O&M Costs				$515,000	0.41	$ 208,612	2081
66	Annual O&M Costs				$515,000	0.40	$ 205,732	2082
66	5 Year Review (2082)				$20,000	0.40	$ 7,990	2082
67	Annual O&M Costs				$515,000	0.39	$ 202,892	2083
68	Annual O&M Costs				$515,000	0.39	$ 200,090	2084
69	Annual O&M Costs				$515,000	0.38	$ 197,328	2085
70	Annual O&M Costs				$515,000	0.38	$ 194,603	2086
71	Annual O&M Costs				$515,000	0.37	$ 191,917	2087
71	5 Year Review (2087)				$20,000	0.37	$ 7,453	2087
72	Annual O&M Costs				$515,000	0.37	$ 189,267	2088
73	Annual O&M Costs				$515,000	0.36	$ 186,654	2089
73	Replace GWTP Piping/Equipment				$200,000	0.36	$ 72,487	2091
73	Replace GWTP Mechical/Electrical				$4,000,000	0.36	$ 1,449,737	2091
74	Annual O&M Costs				$515,000	0.36	$ 184,077	2090
75	Annual O&M Costs				$515,000	0.35	$ 181,535	2091
76	Annual O&M Costs				$515,000	0.35	$ 179,029	2092
76	5 Year Review (2092)				$20,000	0.35	$ 6,953	2092
77	Annual O&M Costs				$515,000	0.34	$ 176,557	2093
78	Annual O&M Costs				$515,000	0.34	$ 174,119	2094
79	Annual O&M Costs				$515,000	0.33	$ 171,715	2095
80	Annual O&M Costs				$515,000	0.33	$ 169,344	2096
81	Annual O&M Costs				$515,000	0.32	$ 167,006	2097
81	5 Year Review (2097)				$20,000	0.32	$ 6,486	2097
82	Annual O&M Costs				$515,000	0.32	$ 164,701	2098
83	Annual O&M Costs				$515,000	0.32	$ 162,427	2099
84	Annual O&M Costs				$515,000	0.31	$ 160,184	2100
85	Annual O&M Costs				$515,000	0.31	$ 157,972	2101
86	Annual O&M Costs				$515,000	0.30	$ 155,791	2102
86	5 Year Review (2102)				$20,000	0.30	$ 6,050	2102
87	Annual O&M Costs				$515,000	0.30	$ 153,640	2103
88	Annual O&M Costs				$515,000	0.29	$ 151,519	2104
89	Annual O&M Costs				$515,000	0.29	$ 149,427	2105
90	Annual O&M Costs				$515,000	0.29	$ 147,364	2106
91	Annual O&M Costs				$515,000	0.28	$ 145,329	2107
91	5 Year Review (2107)				$20,000	0.28	$ 5,644	2107
92	Annual O&M Costs				$515,000	0.28	$ 143,323	2108
93	Annual O&M Costs				$515,000	0.27	$ 141,344	2109
94	Annual O&M Costs				$515,000	0.27	$ 139,393	2110
95	Annual O&M Costs				$515,000	0.27	$ 137,468	2111
96	Annual O&M Costs				$515,000	0.26	$ 135,570	2112
96	5 Year Review (2112)				$20,000	0.26	$ 5,265	2112
97	Annual O&M Costs				$515,000	0.26	$ 133,698	2113
98	Annual O&M Costs				$515,000	0.26	$ 131,852	2114
99	Annual O&M Costs				$515,000	0.25	$ 130,032	2115
100	Annual O&M Costs				$515,000	0.25	$ 128,237	2117
100	GWTP Demolition				$1,000,000	0.25	$ 249,003	2117
100	Final Completion Report				$150,000	0.25	$ 37,350	2117
TOTAL VALUE ANALYSIS					**$111,000,000**		**$79,820,000**	

Item Description	Qty	Units	Unit Cost ($)	Total Cost	($)	NOTES

This construction cost estimate is not an offer for construction and/or project execution. The construction cost estimate for this Design is an Association for the Advancement of Cost Engineering (AACE) Class 4 estimate and is assumed to represent the actual total installed cost. The estimate above is considered control-level cost estimating, suitable for use in project budgeting and planning. This estimate has been prepared with partial design and engineering calculations. The level of accuracy for the class of estimate defines the upper and lower ranges of the cost estimate. It is based upon the level of design detail and uncertainty associate with that level of detail. For a Class 4 estimate, the accuracy range is +50% to -30%.   It would appear prudent that internal budget allowances account for the highest cost indicated by this range as well as other site specific allowances. The cost estimate has been prepared for guidance in project evaluation and implementation from the information available at the time of the estimate.   The final costs of the project will depend on actual labor and material costs, competitive market conditions, implementation schedule, and other variable factors. As a result, the final project costs will vary from the estimates presented herein. Because of this, project feasibility and funding needs must be carefully reviewed prior to making specific financial decisions to help ensure proper project evaluation and adequate funding.

Alternate 4 - ISS
Wyckoff/Eagle Harbor Soil and Groundwater OUs, Focused Feasibility Study

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
CAPITAL COSTS					
GENERAL SITE ACTIVITIES					
Pre-construction Activites - Common Elements (2016)					
Permitting	1	LS	$20,000	$20,000	Excavation/Grading/Drilling/Ecological
Precon Submittals	1	LS	$54,000	$54,000	WP/H&SP/AHAs/Schedule
Mobilization/Demobilization	1	LS	$118,000	$118,000	
Community Relations	1	LS	$169,000	$169,000	
Site Preparation	1	LS	$52,000	$52,000	WP/H&SP/AHAs/Schedule
Surveying - General	50	DY	$2,900	$145,000	
Project Management	6%		$558,000	$33,480	USEPA 540-R-00-002 Guidence Document
Construction Management	8%		$558,000	$44,640	USEPA 540-R-00-002 Guidence Document
Remedial Design	12%		$558,000	$66,960	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$703,080	$175,770	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$879,000**	
Access Roads (2016)					
Erosion Controls	1,500	LF	$10	$15,000	
Roadway Grading	1,955	CY	$50	$97,750	
P/D/P 3" Agg Base	725	TN	$10	$7,250	
P/D/P/Seal 4" AC Pavement	260	TN	$190	$49,400	
Erosion Control Matting	1,445	sy	$10	$14,450	
Project Management	8%		$183,850	$14,708	USEPA 540-R-00-002 Guidence Document
Construction Management	10%		$183,850	$18,385	USEPA 540-R-00-002 Guidence Document
Remedial Design	15%		$183,850	$27,578	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$244,521	$61,130	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$306,000**	
Demolition - Concrete Structures (2016)					
Surface Decontamination	7,200	SY	$10.00	$72,000	
Concrete Demolition - Easy	2,010	CY	$40.00	$80,400	
Concrete Demolition - Difficult	6,020	CY	$70.00	$421,400	
Concrete Crushing	8,030	CY	$70.00	$562,100	
Spread Crushed Concrete Oniste	8,030	CY	$20.00	$160,600	
Recycle Rebar	650	TN	-$290.00	-$188,500	
Odor Control	12	WK	$9,700	$116,400	Allowance
Level C PPE Upgrade	1	LS	$250,900	$250,900	Allowance
Project Management	6%		$1,475,300	$88,518	USEPA 540-R-00-002 Guidence Document
Construction Management	8%		$1,475,300	$118,024	USEPA 540-R-00-002 Guidence Document
Remedial Design	12%		$1,475,300	$177,036	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$1,858,878	$464,720	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$2,324,000**	
Debris Removal - Site Wide (2016)					
Excavation/Debris Removal (5-ft)	66,578	CY	$10	$665,780	
Odor Control	12	WK	$9,700	$116,400	
Backfill - Site Wide	66,578	CY	$2	$133,156	
T&D Debris - Hazardous	900	TN	$1,000	$900,000	
Level C PPE Upgrade	1	LS	$332,890	$332,890	Allowance
Project Management	5%		$2,148,226	$107,411	USEPA 540-R-00-002 Guidence Document
Construction Management	6%		$2,148,226	$128,894	USEPA 540-R-00-002 Guidence Document
Remedial Design	8%		$2,148,226	$171,858	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$2,556,389	$639,097	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$3,195,000**	

Alternate 4 - ISS
Wyckoff/Eagle Harbor Soil and Groundwater OUs, Focused Feasibility Study

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
Rock/Soil/Bulkhead Removal (2016)					
Rock Removal	16,857	CY	$50	$842,850	
Excavate Behind Exist SP Wall	28,393	CY	$30	$851,790	
Bulkhead Removal	2,696	CY	$20	$53,920	
T&D Bulkhead Debris - Hazardous	2,022	TN	$1,000	$2,022,000	$0.30/lb incineration + haul to SLC
T&D Bulkhead Debris - Non Haz	2,022	TN	$250	$505,500	$0.30/lb incineration + haul to SLC
Backfill Existing Sheet Pile Wall	28,393	CY	$20	$567,860	
Crush Rock	16,857	CY	$10	$168,570	
Spread Crushed Material Onsite	16,857	CY	$20	$337,140	
Odor Control	12	WK	$9,700	$116,400	Allowance
Level C PPE Upgrade	1	LS	$425,895	$425,895	Allowance
Project Management	5%		$5,891,925	$294,596	USEPA 540-R-00-002 Guidence Document
Construction Management	6%		$5,891,925	$353,516	USEPA 540-R-00-002 Guidence Document
Remedial Design	8%		$5,891,925	$471,354	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$7,011,391	$1,752,848	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$8,764,000**	
Miscellaneous Demolition (2016)					
Remove/Dispose Asphalt	233	CY	$100	$23,300	HCSS Estimate
Remove/Dispose of Pilot Plant Pipe	1	LS	$20,000	$20,000	Engineer's Estimate
Remove/Dispose Pilot Plant SP	24,300	SF	$30	$729,000	Engineer's Estimate
Remove/Dispose NW Beach SP	13,280	SF	$30	$398,400	HCSS Estimate
Remove/Dispose Tanks & Equip	1	LS	$119,000	$119,000	HCSS Estimate
Odor Control	4	WK	$9,700	$38,800	Allowance
Level C PPE Upgrade	1	LS	$575,350	$575,350	Allowance
Project Management	5%		$1,903,850	$95,193	USEPA 540-R-00-002 Guidence Document
Construction Management	6%		$1,903,850	$114,231	USEPA 540-R-00-002 Guidence Document
Remedial Design	8%		$1,903,850	$152,308	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$2,265,582	$566,395	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$2,832,000**	
Storm Water Infiltration Trench (2016)					
Excavation	2,800	CY	$17	$47,600	
P/D Drain Gravel	4,536	TN	$24	$108,864	
Spread Drain Gravel	6,400	TN	$9	$57,600	
Project Management	8%		$214,064	$17,125	USEPA 540-R-00-002 Guidence Document
Construction Management	10%		$214,064	$21,406	USEPA 540-R-00-002 Guidence Document
Construction Management	15%		$214,064	$32,110	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$284,705	$71,176	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$214,000**	
Construct Outfall (2017)					
P/D AZ36-700N Sheet Pile	90	TN	$1,700	$153,036	
Unload Sheet Pile	5	LD	$2,100	$10,500	
Install Sheet Pile	3,500	SF	$10	$35,000	
Dewatering	20	DY	$800	$16,000	
HDD, Pipe, and Marine	1	LS	$1,500,000	$1,500,000	Vendor Quote
Onshore Construction	1	LS	$500,000	$500,000	
Project Management	5%		$2,214,536	$110,727	USEPA 540-R-00-002 Guidence Document
Construction Management	6%		$2,214,536	$132,872	USEPA 540-R-00-002 Guidence Document
Remedial Design	8%		$2,214,536	$177,163	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$2,635,298	$658,824	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$3,294,000**	

Alternate 4 - ISS
Wyckoff/Eagle Harbor Soil and Groundwater OUs, Focused Feasibility Study

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
ISS Passive Drainage System (2017)					
MH Excavations, ISS PWT	1,500	CY	$38	$57,000	
P/D Treatment Manholes	15	EA	$24,000	$360,000	
Install Treatment MH	15	EA	$4,000	$60,000	
Install Contech GAC Storm Filters	1	LS	$15,000	$15,000	
Install Hydraulic Collection Wells	15	EA	$6,000	$90,000	
Install Discharge Lines	15	EA	$9,000	$135,000	
Backfill Manholes	1,500	CY	$30	$45,000	
Repair Cap	1,000	SY	$67	$67,000	
Project Management	6%		$829,000	$49,740	USEPA 540-R-00-002 Guidence Document
Construction Management	8%		$829,000	$66,320	USEPA 540-R-00-002 Guidence Document
Remedial Design	12%		$829,000	$99,480	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$1,044,540	$261,135	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$1,306,000**	
ISS Concrete Perimeter Wall (2017)					
Excavation - ISS Perimeter Wall	10,007	CY	$35	$350,245	
Install Concrete Plug	1,475	CY	$220	$324,500	
P/D/I Rebar	930	TN	$3,060	$2,845,800	
P/D/P Concrete	8,532	CY	$220	$1,877,040	
Project Management	5%		$5,397,585	$269,879	USEPA 540-R-00-002 Guidence Document
Construction Management	6%		$5,397,585	$323,855	USEPA 540-R-00-002 Guidence Document
Remedial Design	8%		$5,397,585	$431,807	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$6,423,126	$1,605,782	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$8,029,000**	
Final Site Cap (2018)					
Subgrade Preparation	39,150	SY	$3.00	$117,450	HCSS Estimate
P/D/P Embankment Fill	13,917	CY	$20	$278,340	HCSS Estimate
Geomembrane Cover	39,150	SY	$6.75	$264,263	Engineer's Estimate
Geomembrane Penetrations	13	EA	$500	$6,500	Engineer's Estimate
Cushion Geotextile	39,150	SY	$2.25	$88,088	Engineer's Estimate
P/D/P Granular Drain Mat'l	21,000	TN	$30.00	$630,000	HCSS Estimate
P/D/P Topsoil Layer	21,100	TN	$60.00	$1,266,000	HCSS Estimate
Survey	22	DY	$2,900.00	$63,800	HCSS Estimate
Restoration	13	AC	$3,200.00	$41,600	Engineer's Estimate
Project Management	5%		$2,756,040	$137,802	USEPA 540-R-00-002 Guidence Document
Construction Management	6%		$2,756,040	$165,362	USEPA 540-R-00-002 Guidence Document
Remedial Design	8%		$2,756,040	$220,483	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$3,279,688	$819,922	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$4,100,000**	

Alternate 4 - ISS
Wyckoff/Eagle Harbor Soil and Groundwater OUs, Focused Feasibility Study

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
REMEDIAL ACTION ALTERNATIVE					
Alternative 4 - ISS (Midpoint = 2017)					
Pre-construction Activities (ISS Subcontractor)					
Permitting	1	LS	$10,000	$10,000	Allowance
Precon Submittals	1	LS	$50,000	$50,000	
Site Preparation	1	LS	$50,000	$50,000	Erosion Controls, Staging/Stockpile Areas
Survey (Throughout Project)	50	DY	$2,900	$145,000	
			Subtotal:	**$255,000**	
MOBILIZATION					
Equipment Costs (Transportation)					
ISS Crane	2	ea	$60,000	$120,000	Engineer's Estimate
Jet Grout Rig - Casa Grande C-7	1	ea	$25,000	$25,000	Engineer's Estimate
Drilling Attachment	2	ea	$38,000	$76,000	Engineer's Estimate
Grout Pump, Hose, Washout Tank	1	ea	$28,000	$28,000	Engineer's Estimate
Storage Silo (Pig)	1	ea	$3,200	$3,200	Engineer's Estimate
Batch Plan and Silo(s)	1	ea	$34,500	$34,500	Engineer's Estimate
Crane Mats	3	ea	$3,200	$9,600	Engineer's Estimate
Crew Truck	3	ea	$1,500	$4,500	Engineer's Estimate
Tool Truck	1	ea	$1,500	$1,500	Engineer's Estimate
Project Trailer and Generator	2	ea	$4,000	$8,000	Engineer's Estimate
Forklift	1	ea	$2,000	$2,000	Engineer's Estimate
Manlift	1	ea	$2,000	$2,000	Engineer's Estimate
Excavator, CAT 336D	1	ea	$2,500	$2,500	Engineer's Estimate
Excavator, CAT 345D	1	ea	$2,500	$2,500	Engineer's Estimate
Loader, CAT 966H	1	ea	$2,000	$2,000	Engineer's Estimate
Bulldozer, CAT D6K LGP	1	ea	$2,000	$2,000	Engineer's Estimate
Equipment Costs (4 week Mob)					
ISS Rig - Manitowoc/Attachment	4	wk	$21,100	$84,400	Engineer's Estimate
Jet Grout Rig	4	wk	$15,000	$60,000	Engineer's Estimate
Batch Plant and Silo(s)	4	wk	$3,900	$15,600	Engineer's Estimate
Grout Pumping System/Metering	4	wk	$3,000	$12,000	Engineer's Estimate
Hose, Connectors, Whip Checks	4	wk	$1,600	$6,400	Engineer's Estimate
Wash Down Tank	4	wk	$1,500	$6,000	Engineer's Estimate
Drill Tools	4	wk	$2,500	$10,000	Engineer's Estimate

Alternate 4 - ISS
Wyckoff/Eagle Harbor Soil and Groundwater OUs, Focused Feasibility Study

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
Horizontal Storage Silo (Pig)	4	wk	$750	$3,000	Engineer's Estimate
Forklift, CAT 1255 12k#	4	wk	$3,500	$14,000	Engineer's Estimate
Manlift, 60-ft	4	wk	$2,000	$8,000	Engineer's Estimate
Excavator, CAT 336D	4	wk	$6,000	$24,000	Engineer's Estimate
Excavator, CAT 345D	4	wk	$7,100	$28,400	Engineer's Estimate
Loader, CAT 966H	4	wk	$4,000	$16,000	Engineer's Estimate
Bulldozer, CAT D6K LGP	4	wk	$3,500	$14,000	Engineer's Estimate
Crew Truck	12	wk	$1,200	$14,400	Engineer's Estimate
Tool Truck	4	wk	$1,100	$4,400	Engineer's Estimate
Subcontractors					
Electrical	1	LS	$15,000	$15,000	Engineer's Estimate
Welders	1	LS	$25,000	$25,000	Engineer's Estimate
Personnel (based on 5-day week, 50 hrs/wk)					
Batch Plan Operator	4	wk	$5,000	$20,000	Engineer's Estimate
Crane Operator	8	wk	$5,500	$44,000	Engineer's Estimate
Equipment Operator	8	wk	$4,950	$39,600	Engineer's Estimate
Jet Grout Superintendent	4	wk	$6,600	$26,400	Engineer's Estimate
Jet Grout Operator	4	wk	$5,000	$20,000	Engineer's Estimate
ISS Attachment Operator	8	wk	$4,950	$39,600	Engineer's Estimate
Labor, Foreman	4	wk	$3,850	$15,400	Engineer's Estimate
Labor, General	8	wk	$3,575	$28,600	Engineer's Estimate
ISS Superintendent	4	wk	$6,600	$26,400	Engineer's Estimate
QA/QC Manager	8	wk	$6,875	$55,000	Engineer's Estimate
Safety Manager	4	wk	$6,875	$27,500	Engineer's Estimate
Miscellaneous					
Derrick/barge/tug, 2 days+tug+plus fuel	1	ls	$100,000	$100,000	Allowance
Mob/Demob Derrick/Barge/tug	1	ls	$100,000	$100,000	Allowance
Per Diem	448	day	$129	$57,792	Standard Per Diem Rate = Washington
			Subtotal:	**$1,284,192**	
Install Monitoring Wells (2016)					
Mob/Demob	1	ls	$5,000	$5,000	Vendor Quote
Install MW - Alt 4	20	ea	$15,750	$315,000	70-ft bgs
Develop Wells - Alt 4	20	ea	$1,600	$32,000	Engineer's Estimate
		Subtotal:		**$352,000**	
SITE WIDE EXCAVATION (7-FT)					
Equipment					
Excavator, CAT345D	18	wk	$7,100	$127,800	Engineer's Estimate
Loader, CAT 966H	18	wk	$4,000	$72,000	Engineer's Estimate
Water Truck	4	wk	$2,500	$10,000	Engineer's Estimate
Crew Truck	18	wk	$1,200	$21,600	Engineer's Estimate
Personnel (60 hr/wk)					
Equipment Operator	36	wk	$6,300	$226,800	Engineer's Estimate
Water Truck Driver	4	wk	$5,600	$22,400	Engineer's Estimate
Labor, Foreman	18	wk	$4,900	$88,200	Engineer's Estimate
Labor, General	36	wk	$4,550	$163,800	Engineer's Estimate
Miscellaneous					
Stockpile Management	52	wk	$350	$18,200	Engineer's Estimate
Per Diems	126	day	$129	$16,254	Standard Per Diem Rate = Washington
			Subtotal:	**$767,054**	
AUGER MIX ISS					
Equipment					
ISS Rig - Manitowoc/Attacment	160	wk	$21,100	$3,376,000	Engineer's Estimate
Batch Plant and Silo(s)	80	wk	$3,900	$312,000	Engineer's Estimate
Grout Pumping System/Metering	160	wk	$3,000	$480,000	Engineer's Estimate
Hose, Connectors, Whip Checks	160	wk	$1,600	$256,000	Engineer's Estimate
Wash Down Tank	80	wk	$1,500	$120,000	Engineer's Estimate
Drill Tools	160	wk	$2,500	$400,000	Engineer's Estimate
Horizontal Storage Silo (Pig)	160	wk	$750	$120,000	Engineer's Estimate
Teeth replacement/Tooth Packets	160	wk	$750	$120,000	Engineer's Estimate
Forklift, CAT TL1255 12k#	80	wk	$3,500	$280,000	Engineer's Estimate
Manlift	80	wk	$2,000	$160,000	Engineer's Estimate
Excavator, CAT336D	80	wk	$6,000	$480,000	Engineer's Estimate

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
Excavator, CAT345D	80	wk	$7,100	$568,000	Engineer's Estimate
Generator, 350 kW	80	wk	$5,000	$400,000	Engineer's Estimate
Generator Fuel	64,000	gal	$4	$256,000	Engineer's Estimate
Crew Truck	240	wk	$1,200	$288,000	Engineer's Estimate
Tool Truck	80	wk	$1,100	$88,000	Engineer's Estimate
Subcontractors					
Electrical	1	ls	$15,000	$15,000	Engineer's Estimate
Welders	1	ls	$25,000	$25,000	Engineer's Estimate
Personnel (70 hrs/wk)					
Batch Plant Operator	80	wk	$9,000	$720,000	Engineer's Estimate
Crane Operator	160	wk	$9,000	$1,440,000	Engineer's Estimate
Equipment Operator	160	wk	$8,100	$1,296,000	Engineer's Estimate
ISS Attachment Operator	160	wk	$8,100	$1,296,000	Engineer's Estimate
Labor, Foreman	80	wk	$6,300	$504,000	Engineer's Estimate
Labor, General	160	wk	$5,850	$936,000	Engineer's Estimate
ISS Superintendent	80	wk	$10,800	$864,000	Engineer's Estimate
QA/QC Manager	160	wk	$11,250	$1,800,000	Engineer's Estimate
Safety Manager	80	wk	$11,250	$900,000	Engineer's Estimate
Materials					
P/D Portland Cement	58,170	tn	$125	$7,271,250	Engineer's Estimate
P/D Bentonite	2,705	tn	$325	$879,125	Engineer's Estimate
Miscellaneous					
Per Diems	7,840	day	$129	$1,011,360	Standard Per Diem Rate = Washington
			Subtotal:	**$26,661,735**	
JET GROUT ISS					
Equipment					
Jet Grout Rig	31	wk	$15,000	$465,000	Engineer's Estimate
Hose, Connectors, Whip Checks	31	wk	$1,600	$49,600	Engineer's Estimate
Wash Down Tank	31	wk	$1,500	$46,500	Engineer's Estimate
Excavator, CAT 336D	31	wk	$6,000	$186,000	Engineer's Estimate
Crew Truck	31	wk	$1,200	$37,200	Engineer's Estimate
Personnel (70 hrs/wk)					
Jet Grout Operator	31	wk	$9,000	$279,000	Engineer's Estimate
Equipment Operator	31	wk	$8,100	$251,100	Engineer's Estimate
Labor, Foreman	31	wk	$6,300	$195,300	Engineer's Estimate
Labor, General	31	wk	$5,850	$181,350	Engineer's Estimate
Jet Grout Superintendent	31	wk	$10,800	$334,800	Engineer's Estimate
QA/QC Manager	31	wk	$11,250	$348,750	Engineer's Estimate
Safety Manager	31	wk	$11,250	$348,750	Engineer's Estimate
Materials					
P/D Portland Cement	1,300	tn	$125	$162,500	Engineer's Estimate
P/D Bentonite	65	tn	$325	$21,125	Engineer's Estimate
Miscellaneous					
Per Diems	1,519	day	$129	$195,951	Standard Per Diem Rate = Washington
			Subtotal:	**$3,102,926**	
EX-SITU SOIL MIXING AND PLACEMENT					
Equipment					
Excavator, CAT 336D	25	wk	$6,000	$150,000	Engineer's Estimate
Loader, CAT 966H	25	wk	$4,000	$100,000	Engineer's Estimate
Bulldozer, CAT D6K LGP	25	wk	$3,500	$87,500	Engineer's Estimate
Water Truck	25	wk	$2,500	$62,500	Engineer's Estimate
Personnel (70 hrs/wk)					
Equipment Operator	50	wk	$8,100	$405,000	Engineer's Estimate
Water Truck Driver	25	wk	$7,200	$180,000	Engineer's Estimate
Labor, Foreman	25	wk	$6,300	$157,500	Engineer's Estimate
Labor, General	50	wk	$5,850	$292,500	Engineer's Estimate
Materials					
P/D Portland Cement	14,600	TN	$125	$1,825,000	Engineer's Estimate
P/D Bentonite	730	TN	$325	$237,250	Engineer's Estimate
Miscellaneous					
Per Diems	175	day	$129	$22,575	Standard Per Diem Rate = Washington
			Subtotal:	**$3,519,825**	

Alternate 4 - ISS
Wyckoff/Eagle Harbor Soil and Groundwater OUs, Focused Feasibility Study

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
DEMOBILIZATION					
Equipment Costs (Transportation)					
ISS Crane	2	ea	$30,000	$60,000	Engineer's Estimate
Jet Grout Rig - Casa Grande C-7	1	ea	$12,500	$12,500	Engineer's Estimate
Drilling Attachment	2	ea	$19,000	$38,000	Engineer's Estimate
Grout Pump, Hose, Washout Tank	1	ea	$14,000	$14,000	Engineer's Estimate
Storage Silo (Pig)	1	ea	$1,600	$1,600	Engineer's Estimate
Batch Plan and Silo(s)	1	ea	$17,250	$17,250	Engineer's Estimate
Crane Mats	3	ea	$1,600	$4,800	Engineer's Estimate
Crew Truck	3	ea	$750	$2,250	Engineer's Estimate
Tool Truck	1	ea	$750	$750	Engineer's Estimate
Project Trailer and Generator	2	ea	$2,000	$4,000	Engineer's Estimate
Forklift, CAT TL1255 12k#	1	ea	$1,000	$1,000	Engineer's Estimate
Manlift	1	ea	$1,000	$1,000	Engineer's Estimate
Excavator, CAT336D	1	ea	$1,250	$1,250	Engineer's Estimate
Excavator, CAT345D	1	ea	$1,250	$1,250	Engineer's Estimate
Loader, CAT 966H	1	ea	$1,000	$1,000	Engineer's Estimate
Bulldozer, CAT D6K LGP	1	ea	$1,000	$1,000	Engineer's Estimate
Equipment Costs (2 week demob)					
ISS Rig - Manitowoc/Attachment	2	wk	$21,100	$42,200	Engineer's Estimate
Jet Grout Rig - CasaGrande C-7	2	wk	$15,000	$30,000	Engineer's Estimate
Batch Plant and Silo(s)	2	wk	$3,900	$7,800	Engineer's Estimate
Grout Pumping System/Metering	2	wk	$3,000	$6,000	Engineer's Estimate
Hose, Connectors, Whip Checks	2	wk	$1,600	$3,200	Engineer's Estimate
Wash Down Tank	2	wk	$1,500	$3,000	Engineer's Estimate
Drill Tools	2	wk	$2,500	$5,000	Engineer's Estimate
Horizontal Storage Silo (Pig)	2	wk	$750	$1,500	Engineer's Estimate
Forklift, CAT TL1255 12k#	2	wk	$3,500	$7,000	Engineer's Estimate
Manlift	2	wk	$2,000	$4,000	Engineer's Estimate
Excavator, CAT 336D	2	wk	$3,600	$7,200	Engineer's Estimate
Excavator, CAT 345D	2	wk	$7,100	$14,200	Engineer's Estimate
Loader, CAT 966H	2	wk	$4,000	$8,000	Engineer's Estimate
Bulldozer, CAT D6K LGP	2	wk	$3,500	$7,000	Engineer's Estimate
Crew Trucks	6	wk	$1,200	$7,200	Engineer's Estimate
Tool Truck	2	wk	$1,100	$2,200	Engineer's Estimate
Personnel (50 hr/wk)					
Batch Plan Operator	2	wk	$5,000	$10,000	Engineer's Estimate
Crane Operator	4	wk	$5,500	$22,000	Engineer's Estimate
Equipment Operator	4	wk	$4,950	$19,800	Engineer's Estimate
Jet Grout Superintendent	2	wk	$6,875	$13,750	Engineer's Estimate
Jet Grout Operator	2	wk	$5,000	$10,000	Engineer's Estimate
ISS Attachment Operator	4	wk	$4,950	$19,800	Engineer's Estimate
Labor, General	4	wk	$3,575	$14,300	Engineer's Estimate
Labor, Foreman	2	wk	$3,850	$7,700	Engineer's Estimate
ISS Superintendent	2	wk	$6,600	$13,200	Engineer's Estimate
QA/QC Manager	4	wk	$6,875	$27,500	Engineer's Estimate
Safety Manager	2	wk	$6,875	$13,750	Engineer's Estimate
Miscellaneous					
Derrick/barge/tug, 2 days+tug+plus fuel	1	ls	$50,000	$50,000	Allowance
Mob/Demob Derrick/Barge/tug	1	ls	$50,000	$50,000	Allowance
Per Diems	224	day	$129	$28,896	Standard Per Diem Rate = Washington
			Subtotal:	**$617,846**	
PROJECT MANAGEMENT	5%		$36,560,578	$1,828,029	Based on EPA 540-R-00-002
CONSTRUCTION MANAGEMENT	6%		$36,560,578	$2,193,635	Based on EPA 540-R-00-002
REMEDIAL DESIGN	6%		$36,560,578	$2,193,635	Based on EPA 540-R-00-002
CONSTRUCTION COMPLETION REPORT	1	LS	$100,000	$100,000	
			Subtotal:	**$6,315,298**	
CONTINGENCY (10% scope + 15% bid)	25%		$42,875,876	$10,718,969	Based on EPA 540-R-00-002
			TOTAL CAPITAL COSTS FOR ISS:	**$53,595,000**	

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
Alternative 4 - GWTP Demolition					
GWTP Demolition	1	ls	$1,000,000	$1,000,000	Allowance
			Subtotal:	**$1,000,000**	
ALTERNATIVE 4 TOTAL CAPITAL COSTS				**$54,595,000**	
ANNUAL OPERATION & MAINTENANCE COSTS OF GWTP (through 2018)					
Operator(s)	4,160	hr	$80	$332,800	2 FTEs Operating GWTP
Electrical Usage	1	ls	$60,000	$60,000	Current usage is $4k/mo to pump 65 gpm, scaled up to pump 140 gpm
Waste Disposal	1	ls	$100,000	$100,000	Allowance: NAPL and spent carbon disposal
Chemicals/Media	1	ls	$20,000	$20,000	Allowance
Maintenance	10%		$512,800	$51,280	Allowance
Quarterly GW Sampling	4	ea	$10,000	$40,000	
Annual GW Sampling	1	ls	$50,000	$50,000	
Undefined Scope Allowance	10%		$654,080	$65,408	
PROJECT MANAGEMENT	6%		$719,488	$43,169	Based on EPA 540-R-00-002
REPORTING	1		$25,000	$25,000	
TOTAL ANNUAL O&M COSTS OF GWTP (YR0 thru YR3)				**$788,000**	
OPERATION & MAINTENANCE COSTS OF PASSIVE TREATMENT SYSTEM (YR2020 thru YR2026)					
Operator(s)	1,040	hr	$80	$83,200	0.5 FTEs
Maintenance	10%		$83,200	$8,320	Allowance
GAC Filled Storm Filter Changeout	420	ea	$200	$84,000	Quarterly changeout/recycle
T&D of Spent GAC Filters	40	drum	$400	$16,000	1 drum/manhole/event
Quarterly GW Sampling	4	ea	$10,000	$40,000	
Annual GW Sampling	1	ls	$50,000	$50,000	
Undefined Scope Allowance	10%		$84,000	$8,400	
PROJECT MANAGEMENT	8%		$289,920	$23,194	Based on EPA 540-R-00-002
CONSTRUCTION MANAGEMENT	10%		$198,400	$19,840	Based on EPA 540-R-00-002
TOTAL O&M COSTS				**$333,000**	
PERIODIC COSTS					
Maintain Onsite Roads	1	ls	$25,000	$25,000	Allowance - regrade/repair onsite roads
Long Term EPA Reporting Costs					
5 Yr Reviews (last completed 2012)	1	ls	$20,000	$20,000	
Final Completion Report	1	ls	$150,000	$150,000	

PRESENT VALUE ANALYSIS ***Base YR*** ***2014*** 1.4% Discount Rate — OMB - Discount Rates for Cost Effectiveness, Lease Purchase, and Related Analysis, 12/2013

Year	Cost Type	Cost	Discount Rate	Present Value
0	Capital Costs	$18,514,000	1.00	$ 18,514,000
0	Annual O&M Costs	$788,000	1.00	$ 788,000
1	Capital Costs	$66,224,000	0.99	$ 65,309,665
1	5-yr Review (2017)	$20,000	0.99	$ 19,724
1	Annual O&M Costs	$788,000	0.99	$ 777,120
2	Capital Costs	$4,100,000	0.97	$ 3,987,567
2	Annual O&M Costs	$788,000	0.97	$ 766,391
3	Capital Cost - Passive Drainage Shakedown Period	$333,000	0.96	$ 319,397
4	Annual O&M Costs	$333,000	0.95	$ 314,987
5	Annual O&M Costs	$333,000	0.93	$ 310,638
6	Annual O&M Costs	$333,000	0.92	$ 306,349
6	5 Year Review (2022)	$20,000	0.92	$ 18,399
7	Annual O&M Costs	$333,000	0.91	$ 302,119

	Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)		NOTES
8	Annual O&M Costs				$333,000	0.89	$ 297,948
9	GWTP Demolition				$1,000,000	0.88	$ 882,386
9	Annual O&M Costs				$333,000	0.88	$ 293,834
10	Annual O&M Costs				$333,000	0.87	$ 289,778
11	5 Year Review (2027)				$20,000	0.86	$ 17,164
16	5 Year Review (2032)				$20,000	0.80	$ 16,011
21	5 Year Review (2037)				$20,000	0.75	$ 14,936
23	Maintain Onsite Roads				$25,000	0.73	$ 18,158
26	5 Year Review (2042)				$20,000	0.70	$ 13,933
31	5 Year Review (2047)				$20,000	0.65	$ 12,997
36	5 Year Review (2052)				$20,000	0.61	$ 12,124
41	5 Year Review (2057)				$20,000	0.57	$ 11,310
46	5 Year Review (2062)				$20,000	0.53	$ 10,551
51	5 Year Review (2067)				$20,000	0.49	$ 9,842
56	5 Year Review (2072)				$20,000	0.46	$ 9,181
61	5 Year Review (2077)				$20,000	0.43	$ 8,565
66	5 Year Review (2082)				$20,000	0.40	$ 7,990
71	5 Year Review (2087)				$20,000	0.37	$ 7,453
76	5 Year Review (2092)				$20,000	0.35	$ 6,953
81	5 Year Review (2097)				$20,000	0.32	$ 6,486
86	5 Year Review (2102)				$20,000	0.30	$ 6,050
91	5 Year Review (2107)				$20,000	0.28	$ 5,644
96	5 Year Review (2112)				$20,000	0.26	$ 5,265
100	Final Completion Report (2116)				$150,000	0.25	$ 37,350
TOTAL VALUE ANALYSIS					**$95,440,000**		**$93,740,000**

This construction cost estimate is not an offer for construction and/or project execution. The construction cost estimate for this Design is an Association for the Advancement of Cost Engineering (AACE) Class 4 estimate and is assumed to represent the actual total installed cost. The estimate above is considered control-level cost estimating, suitable for use in project budgeting and planning. This estimate has been prepared with partial design and engineering calculations. The level of accuracy for the class of estimate defines the upper and lower ranges of the cost estimate. It is based upon the level of design detail and uncertainty associate with that level of detail. For a Class 4 estimate, the accuracy range is +50% to -30%. It would appear prudent that internal budget allowances account for the highest cost indicated by this range as well as other site specific allowances. The cost estimate has been prepared for guidance in project evaluation and implementation from the information available at the time of the estimate. The final costs of the project will depend on actual labor and material costs, competitive market conditions, implementation schedule, and other variable factors. As a result, the final project costs will vary from the estimates presented herein. Because of this, project feasibility and funding needs must be carefully reviewed prior to making specific financial decisions to help ensure proper project evaluation and adequate funding.

Alternate 5 - Thermal and Jet Grouting
Wyckoff/Eagle Harbor Soil and Groundwater OUs, Focused Feasibility Study

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
CAPITAL COSTS					
GENERAL SITE ACTIVITIES					
Pre-construction Activities - Common Elements (2016)					
Permitting	1	LS	$20,000	$20,000	Excavation/Grading/Drilling/Ecological
Precon Submittals	1	LS	$54,000	$54,000	WP/H&SP/AHAs/Schedule
Mobilization/Demobilization	1	LS	$118,000	$118,000	
Community Relations	1	LS	$169,000	$169,000	
Site Preparation	1	LS	$52,000	$52,000	WP/H&SP/AHAs/Schedule
Surveying - General	50	DY	$2,900	$145,000	
Project Management	6%		$558,000	$33,480	USEPA 540-R-00-002 Guidance Document
Construction Management	8%		$558,000	$44,640	USEPA 540-R-00-002 Guidance Document
Remedial Design	12%		$558,000	$66,960	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$703,080	$175,770	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$879,000**	
Access Roads (2016)					
Erosion Controls	1,500	LF	$10	$15,000	
Roadway Grading	1,955	CY	$50	$97,750	
P/D/P 3" Agg Base	725	TN	$10	$7,250	
P/D/P/Seal 4" AC Pavement	260	TN	$190	$49,400	
Erosion Control Matting	1,445	sy	$10	$14,450	
Project Management	8%		$183,850	$14,708	USEPA 540-R-00-002 Guidance Document
Construction Management	10%		$183,850	$18,385	USEPA 540-R-00-002 Guidance Document
Remedial Design	15%		$183,850	$27,578	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$244,521	$61,130	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$306,000**	
Demolition - Concrete Structures (2016)					
Surface Decontamination	7,200	SY	$10.00	$72,000	
Concrete Demolition - Easy	2,010	CY	$40.00	$80,400	
Concrete Demolition - Difficult	6,020	CY	$70.00	$421,400	
Concrete Crushing	8,030	CY	$70.00	$562,100	
Spread Crushed Concrete Oniste	8,030	CY	$20.00	$160,600	
Recycle Rebar	650	TN	-$290.00	-$188,500	
Odor Control	12	WK	$9,700	$116,400	Allowance
Level C PPE Upgrade	1	LS	$250,900	$250,900	Allowance
Project Management	6%		$1,475,300	$88,518	USEPA 540-R-00-002 Guidance Document
Construction Management	8%		$1,475,300	$118,024	USEPA 540-R-00-002 Guidance Document
Remedial Design	12%		$1,475,300	$177,036	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$1,858,878	$464,720	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$2,324,000**	
Debris Removal - Site Wide (2016)					
Excavation/Debris Removal (5-ft)	66,578	CY	$10	$665,780	
Odor Control	12	WK	$9,700	$116,400	
Backfill - Site Wide	66,578	CY	$2	$133,156	
T&D Debris - Hazardous	900	TN	$1,000	$900,000	
Level C PPE Upgrade	1	LS	$332,890	$332,890	Allowance
Project Management	5%		$2,148,226	$107,411	USEPA 540-R-00-002 Guidance Document
Construction Management	6%		$2,148,226	$128,894	USEPA 540-R-00-002 Guidance Document
Remedial Design	8%		$2,148,226	$171,858	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$2,556,389	$639,097	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$3,195,000**	

Alternate 5 - Thermal and Jet Grouting
Wyckoff/Eagle Harbor Soil and Groundwater OUs, Focused Feasibility Study

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
Rock/Soil/Bulkhead Removal (2016)					
Rock Removal	16,857	CY	$50	$842,850	
Excavate Behind Exist SP Wall	28,393	CY	$30	$851,790	
Bulkhead Removal	2,696	CY	$20	$53,920	
T&D Bulkhead Debris - Hazardous	2,022	TN	$1,000	$2,022,000	
T&D Bulkhead Debris - Non Haz	2,022	TN	$250	$505,500	
Backfill Existing Sheet Pile Wall	28,393	CY	$20	$567,860	
Crush Rock	16,857	CY	$10	$168,570	
Spread Crushed Material Onsite	16,857	CY	$20	$337,140	
Odor Control	12	WK	$9,700	$116,400	Allowance
Level C PPE Upgrade	1	LS	$425,895	$425,895	Allowance
Project Management	5%		$5,891,925	$294,596	USEPA 540-R-00-002 Guidance Document
Construction Management	6%		$5,891,925	$353,516	USEPA 540-R-00-002 Guidance Document
Remedial Design	8%		$5,891,925	$471,354	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$7,011,391	$1,752,848	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$8,764,000**	
Miscellaneous Demolition (2016)					
Remove/Dispose Asphalt	233	CY	$100	$23,300	HCSS Estimate
Remove/Dispose of Pilot Plant Pipe	1	LS	$20,000	$20,000	Engineer's Estimate
Remove/Dispose Pilot Plant SP	24,300	SF	$30	$729,000	Engineer's Estimate
Remove/Dispose NW Beach SP	13,280	SF	$30	$398,400	HCSS Estimate
Remove/Dispose Tanks & Equip	1	LS	$119,000	$119,000	HCSS Estimate
Odor Control	4	WK	$9,700	$38,800	Allowance
Level C PPE Upgrade	1	LS	$575,350	$575,350	Allowance
Project Management	5%		$1,903,850	$95,193	USEPA 540-R-00-002 Guidance Document
Construction Management	6%		$1,903,850	$114,231	USEPA 540-R-00-002 Guidance Document
Remedial Design	8%		$1,903,850	$152,308	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$2,265,582	$566,395	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$2,832,000**	
Storm Water Infiltration Trench (2016)					
Excavation	2,800	CY	$17	$47,600	
P/D Drain Gravel	4,536	TN	$24	$108,864	
Spread Drain Gravel	6,400	TN	$9	$57,600	
Project Management	8%		$214,064	$17,125	USEPA 540-R-00-002 Guidance Document
Construction Management	10%		$214,064	$21,406	USEPA 540-R-00-002 Guidance Document
Remedial Design	15%		$214,064	$32,110	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$284,705	$71,176	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$214,000**	
Install New Perimeter SP Wall, Non ISS (2017)					
P/D AZ50 Sheet Pile	3,700	TN	$1,900	$7,030,000	Vendor Quote
Unload Sheet Pile	169	LD	$2,300	$388,700	
Install Perimeter SP Wall (AZ50)	142,200	SF	$11	$1,564,200	
Project Management	5%		$8,982,900	$449,145	USEPA 540-R-00-002 Guidance Document
Construction Management	6%		$8,982,900	$538,974	USEPA 540-R-00-002 Guidance Document
Remedial Design	8%		$8,982,900	$718,632	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$10,689,651	$2,672,413	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$13,362,000**	

Alternate 5 - Thermal and Jet Grouting
Wyckoff/Eagle Harbor Soil and Groundwater OUs, Focused Feasibility Study

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
Non-ISS Concrete Perimeter Wall (2026)					
Excavation - Non-ISS Perimeter Wall	14,646	CY	$63	$922,698	
Install Concrete Plug	1,475	CY	$220	$324,500	
Odor Control	8	WK	$9,700	$77,600	Allowance
P/D/I Rebar	1,100	TN	$3,100	$3,410,000	
P/D/I Concrete	13,201	CY	$220	$2,904,220	
Project Management	5%		$7,639,018	$381,951	USEPA 540-R-00-002 Guidance Document
Construction Management	6%		$7,639,018	$458,341	USEPA 540-R-00-002 Guidance Document
Remedial Design	8%		$7,639,018	$611,121	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$9,090,431	$2,272,608	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$11,363,000**	
Construct Outfall (2017)					
P/D AZ36-700N Sheet Pile	90	TN	$1,700	$153,036	
Unload Sheet Pile	5	LD	$2,100	$10,500	
Install Sheet Pile	3,500	SF	$10	$35,000	
Dewatering	20	DY	$800	$16,000	
HDD, Pipe, and Marine	1	LS	$1,500,000	$1,500,000	Vendor Quote
Onshore Construction	1	LS	$500,000	$500,000	
Project Management	5%		$2,214,536	$110,727	USEPA 540-R-00-002 Guidance Document
Construction Management	6%		$2,214,536	$132,872	USEPA 540-R-00-002 Guidance Document
Remedial Design	8%		$2,214,536	$177,163	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$2,635,298	$658,824	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$3,294,000**	
Final Site Cap (2026)					
Subgrade Preparation	39,150	SY	$3.00	$117,450	HCSS Estimate
P/D/P Embankment Fill	13,917	CY	$20.00	$278,340	HCSS Estimate
Geomembrane Cover	39,150	SY	$6.75	$264,263	Engineer's Estimate
Geomembrane Penetrations	13	EA	$500	$6,500	Engineer's Estimate
Cushion Geotextile	39,150	SY	$2.25	$88,088	Engineer's Estimate
P/D/P Granular Drain Mat'l	21,000	TN	$30.00	$630,000	HCSS Estimate
P/D/P Topsoil Layer	21,100	TN	$60.00	$1,266,000	HCSS Estimate
Survey	22	DY	$2,900.00	$63,800	HCSS Estimate
Restoration	13	AC	$3,200.00	$41,600	Engineer's Estimate
Project Management	5%		$2,756,040	$137,802	USEPA 540-R-00-002 Guidance Document
Construction Management	6%		$2,756,040	$165,362	USEPA 540-R-00-002 Guidance Document
Remedial Design	8%		$2,756,040	$220,483	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$3,279,688	$819,922	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$4,100,000**	
Non-ISS Passive Drainage System (2026)					
MH Excavations, Non-ISS PWT	1,500	CY	$35	$52,500	
P/D/I Manholes & Bases	10	EA	$17,000	$170,000	
Install Manholes & Bases	10	EA	$0	$0	
Install Contech GAC Storm Filters	1	LS	$15,000	$15,000	
Discharge Line Penetration/Install	10	EA	$6,900	$69,000	
Backfill Manholes	1,500	CY	$31	$46,500	
Excavate French Drains	4,750	CY	$18	$85,500	
P/D/I 12", Slotted HDPE	2,000	LF	$55	$110,000	
Backfill French Drains	4,750	CY	$24	$114,000	
Repair Cap	1,000	SY	$67	$67,000	
Project Management	6%		$729,500	$43,770	USEPA 540-R-00-002 Guidance Document
Construction Management	8%		$729,500	$58,360	USEPA 540-R-00-002 Guidance Document
Remedial Design	12%		$729,500	$87,540	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$919,170	$229,793	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$1,149,000**	

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
Alternative 5 - North Unit Jet Grouting					
Pre-construction Activities					
Permitting	1	LS	$10,000	$10,000	Allowance
Precon Submittals	1	LS	$50,000	$50,000	
Site Preparation	1	LS	$25,000	$25,000	
			Subtotal:	**$85,000**	
MOBILIZATION					
Equipment Costs (Transportation)					
Jet Grout Rig - Casa Grande C-7	1	ea	$25,000	$25,000	Engineer's Estimate
Grout Pump, Hose, Washout Tank	1	ea	$28,000	$28,000	Engineer's Estimate
Storage Silo (Pig)	1	ea	$3,200	$3,200	Engineer's Estimate
Batch Plan and Silo(s)	1	ea	$34,500	$34,500	Engineer's Estimate
Crane Mats	1	ea	$3,200	$3,200	Engineer's Estimate
Crew Truck	1	ea	$1,500	$1,500	Engineer's Estimate
Tool Truck	1	ea	$1,500	$1,500	Engineer's Estimate
Project Trailer and Generator	1	ea	$4,000	$4,000	Engineer's Estimate
Forklift, CAT 1255 12k#	1	ea	$2,000	$2,000	Engineer's Estimate
Excavator, CAT 336D	1	ea	$2,500	$2,500	Engineer's Estimate
Equipment Costs (2 week Mob)					
Jet Grout Rig	2	wk	$15,000	$30,000	Engineer's Estimate
Batch Plant and Silo(s)	2	wk	$3,900	$7,800	Engineer's Estimate
Grout Pumping System/Metering	2	wk	$3,000	$6,000	Engineer's Estimate
Hose, Connectors, Whip Checks	2	wk	$1,600	$3,200	Engineer's Estimate
Wash Down Tank	2	wk	$1,500	$3,000	Engineer's Estimate
Horizontal Storage Silo (Pig)	2	wk	$750	$1,500	Engineer's Estimate
Forklift, CAT 1255 12k#	2	wk	$3,500	$7,000	Engineer's Estimate
Excavator, CAT 336D	2	wk	$6,000	$12,000	Engineer's Estimate
Crew Truck	2	wk	$1,200	$2,400	Engineer's Estimate
Tool Truck	2	wk	$1,100	$2,200	Engineer's Estimate
Subcontractors					
Electrical	1	LS	$15,000	$15,000	Engineer's Estimate
Welders	1	LS	$25,000	$25,000	Engineer's Estimate
Personnel (50 hrs/wk)					
Batch Plan Operator	2	wk	$5,000	$10,000	Engineer's Estimate
Equipment Operator	2	wk	$4,950	$9,900	Engineer's Estimate
Jet Grout Superintendent	2	wk	$6,600	$13,200	Engineer's Estimate
Jet Grout Operator	2	wk	$5,000	$10,000	Engineer's Estimate
Labor, General	2	wk	$3,850	$7,700	Engineer's Estimate
Labor, Foreman	2	wk	$3,575	$7,150	Engineer's Estimate
QA/QC Manager	2	wk	$6,875	$13,750	Engineer's Estimate
Safety Manager	2	wk	$6,875	$13,750	Engineer's Estimate
Miscellaneous					
Per Diem	112	day	$129	$14,448	Standard Per Diem Rate = Washington
			Subtotal:	**$320,398**	
JET GROUTING NORTH UNIT					
Equipment					
Jet Grout Rig	31	wk	$15,000	$465,000	Engineer's Estimate
Hose, Connectors, Whip Checks	31	wk	$1,600	$49,600	Engineer's Estimate
Wash Down Tank	31	wk	$1,500	$46,500	Engineer's Estimate
Excavator, CAT 336D L	31	wk	$6,000	$186,000	Engineer's Estimate
Forklift, CAT 1255 12k#	31	wk	$3,500	$108,500	Engineer's Estimate
Crew Truck	31	wk	$1,200	$37,200	Engineer's Estimate
Batch Plant and Silo(s)	31	wk	$3,900	$120,900	Engineer's Estimate
Wash Down Tank	31	wk	$1,500	$46,500	Engineer's Estimate
Horizontal Storage Silo (Pig)	31	wk	$750	$23,250	Engineer's Estimate
Generator, 350 kW	31	wk	$5,000	$155,000	Engineer's Estimate
Generator Fuel	24,800	gal	$4	$99,200	Engineer's Estimate
Tool Truck	31	wk	$1,100	$34,100	Engineer's Estimate

Alternate 5 - Thermal and Jet Grouting
Wyckoff/Eagle Harbor Soil and Groundwater OUs, Focused Feasibility Study

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
Personnel (60 hrs/wk)					
Jet Grout Operator	31	wk	$7,000	$217,000	Engineer's Estimate
Equipment Operator	31	wk	$6,300	$195,300	Engineer's Estimate
Batch Plan Operator	31	wk	$7,000	$217,000	Engineer's Estimate
Labor, Foreman	31	wk	$4,900	$151,900	Engineer's Estimate
Labor, General	31	wk	$4,550	$141,050	Engineer's Estimate
Jet Grout Superintendent	31	wk	$8,400	$260,400	Engineer's Estimate
QA/QC Manager	31	wk	$8,750	$271,250	Engineer's Estimate
Safety Manager	31	wk	$8,750	$271,250	Engineer's Estimate
Materials					
P/D Portland Cement	1,300	tn	$125	$162,500	Engineer's Estimate
P/D Bentonite	65	tn	$325	$21,125	Engineer's Estimate
Miscellaneous					
Per Diems	1,736	day	$129	$223,944	Standard Per Diem Rate = Washington
			Subtotal:	**$3,504,469**	
DEMOBILIZATION					
Equipment Costs (Transportation)					
Jet Grout Rig - Casa Grande C-7	1	ea	$12,500	$12,500	Engineer's Estimate
Grout Pump, Hose, Washout Tank	1	ea	$14,000	$14,000	Engineer's Estimate
Storage Silo (Pig)	1	ea	$1,600	$1,600	Engineer's Estimate
Batch Plan and Silo(s)	1	ea	$17,250	$17,250	Engineer's Estimate
Crane Mats	1	ea	$1,600	$1,600	Engineer's Estimate
Crew Truck	1	ea	$750	$750	Engineer's Estimate
Tool Truck	1	ea	$750	$750	Engineer's Estimate
Project Trailer and Generator	1	ea	$2,000	$2,000	Engineer's Estimate
Forklift	1	ea	$1,000	$1,000	Engineer's Estimate
Excavator, CAT 336D	1	ea	$1,250	$1,250	Engineer's Estimate
Equipment Costs (1 week Demob)					
Jet Grout Rig	1	wk	$15,000	$15,000	Engineer's Estimate
Batch Plant and Silo(s)	1	wk	$3,900	$3,900	Engineer's Estimate
Grout Pumping System/Metering	1	wk	$3,000	$3,000	Engineer's Estimate
Hose, Connectors, Whip Checks	1	wk	$1,600	$1,600	Engineer's Estimate
Wash Down Tank	1	wk	$750	$750	Engineer's Estimate
Horizontal Storage Silo (Pig)	1	wk	$750	$750	Engineer's Estimate
Forklift, CAT 1255 12k#	1	wk	$3,500	$3,500	Engineer's Estimate
Excavator, CAT 336D	1	wk	$6,000	$6,000	Engineer's Estimate
Crew Truck	1	wk	$1,200	$1,200	Engineer's Estimate
Tool Truck	1	wk	$1,100	$1,100	Engineer's Estimate
Personnel (50 hrs/wk)					
Batch Plan Operator	1	wk	$5,000	$5,000	Engineer's Estimate
Equipment Operator	1	wk	$4,950	$4,950	Engineer's Estimate
Jet Grout Superintendent	1	wk	$6,875	$6,875	Engineer's Estimate
Jet Grout Operator	1	wk	$5,000	$5,000	Engineer's Estimate
Labor, General	1	wk	$3,575	$3,575	Engineer's Estimate
Labor, Foreman	1	wk	$3,850	$3,850	Engineer's Estimate
QA/QC Manager	1	wk	$6,875	$6,875	Engineer's Estimate
Safety Manager	1	wk	$6,875	$6,875	Engineer's Estimate
Miscellaneous					
Per Diem	56	day	$129	$7,224	Standard Per Diem Rate = Washington
			Subtotal:	**$139,724**	
PROJECT MANAGEMENT	5%		$4,049,591	$202,480	Based on EPA 540-R-00-002
CONSTRUCTION MANAGEMENT	6%		$4,049,591	$242,975	Based on EPA 540-R-00-002
REMEDIAL DESIGN	6%		$4,049,591	$242,975	Based on EPA 540-R-00-002
CONSTRUCTION COMPLETION REPORT	1	LS	$100,000	$100,000	
			Subtotal:	**$788,430**	
CONTINGENCY (10% scope + 15% bid)	25%		$4,838,021	$1,209,505	Based on EPA 540-R-00-002
TOTAL CAPITAL COSTS JET GROUTING:				**$6,048,000**	**(Rounded)**

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
Alternative 5 - Thermal (Midpoint 2018)					
Pre-construction Activities					
Permitting	1	LS	$10,000	$10,000	Allowance
Precon Submittals	1	LS	$50,000	$50,000	
Site Preparation	1	LS	$50,000	$50,000	
			Subtotal:	**$110,000**	
Mob/Demob					
P/D AZ36-700N Sheet Pile	2,509	TN	$1,600	$4,014,400	Vendor Quote
Unload Sheet Pile	114	LD	$1,200	$136,800	Engineer's Estimate
Install AZ36-700N Sheet Pile	145,043	SF	$10	$1,450,430	Engineer's Estimate
Install Dewatering Wells	27	ea	$25,000	$675,000	Engineer's Estimate
Dewatering Well Completions	27	ea	$350	$9,450	Engineer's Estimate
Install Steam Injection Wells	172	ea	$15,000	$2,580,000	Engineer's Estimate
Injection Well Completions	172	ea	$450	$77,400	Engineer's Estimate
Steam Injection Well Piping/System	1	ls	$460,000	$460,000	Engineer's Estimate
Install Extraction Wells	147	ea	$5,700	$837,900	Engineer's Estimate
Extraction Well Completions	147	ea	$450	$66,150	Engineer's Estimate
Install Extraction Well Head System	49	ea	$2,500	$122,500	Engineer's Estimate
Allowance to Relocate Well Heads	197	ea	$1,500	$295,500	Engineer's Estimate
Install Biosparge Wells	31	ea	$5,000	$155,000	Engineer's Estimate
Biosparge Well Completions	31	ea	$350	$10,850	Engineer's Estimate
Install Biosparge Wellhead and Header Piping/Valves	31	ea	$2,500	$77,500	Engineer's Estimate
Install Thermocouple Borings	201	ea	$2,800	$562,800	Engineer's Estimate
Purchase Thermocouples	589	ea	$1,500	$883,500	Engineer's Estimate
Install Thermocouples	7,068	ft	$25	$176,700	Engineer's Estimate
Thermocouple Completions	201	ea	$350	$70,350	Engineer's Estimate
Install Vapor Collection Layer	8,985	tn	$20	$179,700	Engineer's Estimate
Install Vapor Collection Piping	462	ft	$25	$11,550	Engineer's Estimate
Install Select Fill Below Vapor Cap	6,739	tn	$25	$168,475	Engineer's Estimate
Temp Geomembrane over VC	28,881	sy	$7	$202,167	Engineer's Estimate
Temp VC Pipe Penetrations	84	ea	$500	$42,000	Engineer's Estimate
Install Cushion Geotextile	28,881	sy	$2	$57,762	Engineer's Estimate
Install Fill Above VC (18")	20,217	tn	$25	$505,425	Engineer's Estimate
Surface Top Coarse (6")	6,739	tn	$25	$168,475	Engineer's Estimate
Steam Supply Header Materials	8,550	ft	$45	$384,750	Engineer's Estimate
Allowance for Steam Valves/I&C	1	ls	$75,000	$75,000	Engineer's Estimate
Air Supply Piping Header	10,645	ft	$20	$212,900	Engineer's Estimate
Vapor Extraction Piping	8,550	ft	$55	$470,250	Engineer's Estimate
Extracted Water Piping	10,645	ft	$20	$212,900	Engineer's Estimate
Install Air/Vapor/Extraction Piping	38,390	ft	$7	$268,730	Engineer's Estimate
Installation of 6' Pipe Rack	940	ea	$400	$376,000	Engineer's Estimate
Installation of 15' Pipe Rack	127	ea	$750	$95,250	Engineer's Estimate
Allowance for Extraction Valves/I&C	1	ls	$100,000	$100,000	Engineer's Estimate
Corrosion Protection for wells	377	ls	$500	$188,500	Engineer's Estimate
			Subtotal:	**$16,382,064**	
Vapor and GW Treatment System					
Site Preparation	1	ls	$30,000	$30,000	Engineer's Estimate
Concrete Slab on Grade	1,400	cy	$350	$490,000	Engineer's Estimate
Secondary Containment Walls	13	CY	$350	$4,550	Engineer's Estimate
P/D Diesel Generators	2	ea	$600,000	$1,200,000	Engineer's Estimate
P/D Direct Contact Condenser	1	ea	$415,000	$415,000	Engineer's Estimate
P/D VLS, LRVP, Therm-OX Package	1	ea	$100,000	$100,000	Engineer's Estimate
P/D Solids Dewater Screw Conveyor	2	ea	$135,000	$270,000	Engineer's Estimate
P/D Cooling Tower	1	ea	$41,000	$41,000	Engineer's Estimate
Cooling Water Chemical/Makeup Treatment Systems	1	ls	$150,000	$150,000	Allowance
P/D Heat Exchanger H-1	2	ea	$11,500	$23,000	Engineer's Estimate
P/D Heat Exchanger H-2	2	ea	$15,000	$30,000	Engineer's Estimate
P/D Accumulation Tank	1	ea	$97,000	$97,000	Engineer's Estimate
P/D Oil/Water Separator	1	ea	$310,000	$310,000	Engineer's Estimate
P/D Solids NAPL Holding Tank	1	ea	$92,000	$92,000	Engineer's Estimate
P/D Air Compressor	1	ea	$11,000	$11,000	Engineer's Estimate
P/D Pumps	20	ea	$10,000	$200,000	Engineer's Estimate
P/D DAF	1	ea	$357,000	$357,000	Engineer's Estimate
P/D Walnut Filter	1	ea	$300,000	$300,000	Engineer's Estimate

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
Equipment Installation (15% of equipment cost)	1	ls	$400,000	$400,000	Allowance
Process Piping (5% of equip cost)	1	ls	$132,000	$132,000	Allowance
I&C (15% of equipment cost)	1	ls	$400,000	$400,000	Allowance
Electrical (20% of equipment cost)	1	ls	$530,000	$530,000	Allowance
Solids Handling Rain Shelter	1,000	sf	$100	$100,000	Allowance
Electrical/I&C Building (30% of cost)	1,000	sf	$200	$200,000	Allowance
			Subtotal:	**$5,882,550**	
Boiler Propane System					
Site Preparation	1	ls	$15,000	$15,000	Engineer's Estimate
Concrete Slab on Grade	125	cy	$350	$43,750	Engineer's Estimate
Install Propane Tank	1	ls	$30,000	$30,000	Allowance
Install Vaporizer	1	ls	$30,000	$30,000	Allowance
Setup Boiler System	1	ls	$75,000	$75,000	Allowance
Monthly Rental of Boiler System	60	mo	$17,500	$1,050,000	Nationwide Boiler Quote. Includes softener and feed water pump.
			Subtotal:	**$1,243,750**	
PROJECT MANAGEMENT	5%		$23,618,364	$1,180,918	Based on EPA 540-R-00-002
CONSTRUCTION MANAGEMENT	6%		$23,618,364	$1,417,102	Based on EPA 540-R-00-002
REMEDIAL DESIGN	6%		$23,618,364	$1,417,102	Based on EPA 540-R-00-002
CONSTRUCTION COMPLETION REPORT	1	LS	$100,000	$100,000	
			Subtotal:	**$4,115,122**	
CONTINGENCY (10% scope + 15% bid)	25%		$27,733,486	$6,933,371	Based on EPA 540-R-00-002
			TOTAL COST THERMAL:	**$34,667,000**	**(Rounded)**
Alternative 5 - Well Abandonment and GWTP Demolition					
Well Abandonment (2025)					
Driller Mobilization/Demob	1	ls	$5,000	$5,000	Vendor Quote
Abandon 2-in Wells	195	ea	$1,300	$253,500	Vendor Quote
Abandon 4-in Wells	357	ea	$2,550	$910,350	Vendor Quote
PROJECT MANAGEMENT	6%		$1,168,850	$70,131	Based on EPA 540-R-00-002
CONSTRUCTION MANAGEMENT	8%		$1,168,850	$93,508	Based on EPA 540-R-00-002
REMEDIAL DESIGN	12%		$1,168,850	$140,262	Based on EPA 540-R-00-002
CONSTRUCTION COMPLETION REPORT	1	LS	$25,000	$25,000	
CONTINGENCY (10% scope + 15% bid)	25%		$1,497,751	$374,438	Based on EPA 540-R-00-002
			Subtotal:	**$1,872,000**	**(Rounded)**
GWTP Demolition	1	ls	$1,000,000	$1,000,000	Allowance
			Subtotal:	**$1,000,000**	
TOTAL COST REMEDIAL ACTION				**$43,587,000**	

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
OPERATION & MAINTENANCE COSTS OF GWTP (through 2024)					
Annual O&M					
Operator(s)	4,160	hr	$80	$332,800	2 FTEs Operating GWTP
Electrical Usage	1	ls	$60,000	$60,000	Current usage is $4k/mo to pump 65 gpm, scaled up to pump 140 gpm
Waste Disposal	1	ls	$100,000	$100,000	Allowance: NAPL and spent carbon disposal
Chemicals/Media	1	ls	$20,000	$20,000	Allowance
Maintenance	10%		$512,800	$51,280	Allowance
Quarterly GW Sampling	4	ea	$10,000	$40,000	
Annual GW Sampling	1	ls	$50,000	$50,000	
Undefined Scope Allowance	10%		$654,080	$65,408	
PROJECT MANAGEMENT	6%		$719,488	$43,169	Based on EPA 540-R-00-002
REPORTING	1		$25,000	$25,000	
TOTAL O&M COSTS - GWTP				**$788,000**	

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
OPERATION & MAINTENANCE COSTS OF NAPL RECOVERY (20219 through 2021)					
Annual O&M					
Disposal - NAPL Waste	47,000	gal	$7	$329,000	Vendor Quote; 140,000-gal over 3 yrs
Transportation - NAPL Waste	22	load	$6,400	$140,800	Vendor Quote
Well field Analysis&Sampling Team	1,040	hr	$80	$83,200	Engineer's Estimate
Laboratory Analysis	260	ls	$300	$78,000	Engineer's Estimate
PPE Allowance	1,040	hr	$15	$15,600	Allowance
Maintenance	10%		$646,600	$64,660	Allowance
Undefined Scope Allowance	10%		$711,260	$71,126	
PROJECT MANAGEMENT	6%		$782,386	$46,943	
REPORTING	1		$25,000	$25,000	
TOTAL ANNUAL O&M COSTS - NAPL RECOVERY				**$854,000**	
OPERATION & MAINTENANCE COSTS OF EAB (2021 through 2026)					
EAB					
Operator(s)	1,040	hr	$80	$83,200	1/2 yr running EAB System
Supervisor	208	hr	$100	$20,800	20% of operator time
Electrical	1	ls	$16,000	$16,000	Engineer's Estimate
Nutrient Chemicals/Media	1	ls	$11,000	$11,000	
System Maintenance	5%		$131,000	$6,550	Allowance
Undefined Scope Allowance	10%		$137,550	$13,755	
PROJECT MANAGEMENT	8%		$151,305	$12,104	Based on EPA 540-R-00-002
REPORTING	1		$25,000	$25,000	
TOTAL ANNUAL O&M COSTS - EAB RECOVERY				**$188,000**	
OPERATION & MAINTENANCE COSTS OF THERMAL (2019 through 2024)					
Annual O&M					
Operator(s)	16,640	hr	$80	$1,331,200	8 FTEs running system 24/7
Supervisor	4,160	hr	$100	$416,000	2 FTE
Electrical Usage	1	ls	$103,385	$103,385	Current usage is $4k/mo to pump 65 gpm, scaled up to pump 140 gpm
Diesel Generator	12	mo	$20,600	$247,200	5150 gal/mo @ $4/gal
Propane	12	mo	$266,600	$3,199,200	86,000-gal/mo@$3.10/gal
Disposal - NAPL Waste	13,000	gal	$7	$91,000	Vendor Quote; 14,000-gal/yr
Transportation - NAPL Waste	6	load	$6,400	$38,400	Vendor Quote
Disposal - Naphthalene Waste	264	tn	$660	$174,240	Engineer's Estimate
Transportation - Naphthalene Waste	12	ld	$1,360	$16,320	22 tn/load => 16 hrs/load haul time
Waste Disposal - Carbon/Filter Media	1	ls	$86,000	$86,000	Allowance
Well field Analysis&Sampling Team	1,040	hr	$80	$83,200	Engineer's Estimate
Laboratory Analysis	260	ls	$300	$78,000	Engineer's Estimate
PPE Allowance	16,640	hr	$0.75	$12,480	Allowance - hard hats, boots, work gloves, safety glasses, Tyvek and other consumables
Maintenance	10%		$5,876,625	$587,663	Allowance
Undefined Scope Allowance	10%		$6,464,288	$646,429	
PROJECT MANAGEMENT	5%		$7,110,716	$355,536	
REPORTING	1		$25,000	$25,000	
TOTAL ANNUAL O&M COSTS - THERMAL				**$7,491,000**	

Alternate 5 - Thermal and Jet Grouting
Wyckoff/Eagle Harbor Soil and Groundwater OUs, Focused Feasibility Study

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
OPERATION & MAINTENANCE COSTS OF PASSIVE GROUNDWATER TREATMENT SYSTEM (2025 through 2035)					
Operator(s)	520	hr	$80	$41,600	0.25 FTEs
Maintenance	10%		$41,600	$4,160	Allowance
Quarterly GW Sampling	4	ea	$10,000	$40,000	
Annual GW Sampling	1	ls	$50,000	$50,000	
Contech GAC Filled Storm Filter Change	280	ea	$200	$56,000	Quarterly change out/recycle
T&D of Spent GAC Filters	40	drum	$400	$16,000	1 drum/manhole/event
Undefined Scope Allowance	10%		$191,760	$19,176	
PROJECT MANAGEMENT	8%		$226,936	$18,155	Based on EPA 540-R-00-002
CONSTRUCTION MANAGEMENT	15%		$91,176	$13,676	Based on EPA 540-R-00-002
REPORTING	1	ls	$25,000	$25,000	
TOTAL O&M COSTS - PASSIVE WATER TREATMENT SYSTEM:				**$284,000**	
PERIODIC COSTS					
Maintain Onsite Roads	1	ls	$25,000	$25,000	Allowance - regrade/repair onsite roads
Long Term EPA Reporting Costs					
5 Yr Reviews (last completed 2012)	1	ls	$20,000	$20,000	
Final Completion Report	1	ls	$150,000	$150,000	

PRESENT VALUE ANALYSIS 1.4% Discount Rate — OMB - Discount Rates for Cost Effectiveness, Lease Purchase, and Related Analysis, 12/2013

Year	Cost Type	Cost	Discount Rate	Present Value
0	Capital Costs (2016)	$18,514,000	1.00	$ 18,514,000
0	Capital Costs (2016)	$6,048,000	1.00	$ 6,048,000
0	Capital Costs - GWTP O&M	$788,000	1.00	$ 788,000
1	Capital Costs (2017)	$28,019,000	0.99	$ 27,632,150
1	Capital Costs - GWTP O&M	$788,000	0.99	$ 777,120
1	5 Year Review (2017)	$20,000	0.99	$ 19,724
2	Capital Costs Thermal (midpoint 2018)	$34,667,000	0.97	$ 33,716,334
2	Capital Costs - GWTP O&M	$788,000	0.97	$ 766,391
3	Capital Costs - GWTP O&M/NAPL Recovery	$1,642,000	0.96	$ 1,574,923
4	Capital Costs - GWTP O&M/NAPL Recovery/Thermal	$9,133,000	0.95	$ 8,638,963
5	Capital Costs - GWTP O&M/NAPL Recovery/Thermal/EAB	$9,321,000	0.93	$ 8,695,063
6	Capital Costs - GWTP O&M/Thermal/EAB	$8,467,000	0.92	$ 7,789,361
6	5 Year Review (2022)	$20,000	0.92	$ 18,399
7	Capital Costs - GWTP O&M/Thermal/EAB	$8,467,000	0.91	$ 7,681,816
8	Capital Costs - GWTP O&M/Thermal/EAB	$8,467,000	0.89	$ 7,575,755
9	Capital Costs (Passive GWT System)	$1,149,000	0.88	$ 1,013,861
9	Periodic Cost - Well Abandonment	$1,872,000	0.88	$ 1,651,826
9	Capital Cost - PGWT Shakedown/EAB	$472,000	0.88	$ 416,486
10	Capital Cost - PGWT Shakedown/EAB	$472,000	0.87	$ 410,736
10	Capital Costs (Final Cap)	$4,100,000	0.87	$ 3,567,831
11	Annual O&M Costs	$284,000	0.86	$ 243,725
11	5 Year Review (2027)	$20,000	0.86	$ 17,164
12	Annual O&M Costs	$284,000	0.85	$ 240,360
13	Annual O&M Costs	$284,000	0.83	$ 237,042
14	Annual O&M Costs	$284,000	0.82	$ 233,769
15	Annual O&M Costs	$284,000	0.81	$ 230,541
15	Periodic Cost - GWTP Demolition	$1,000,000	0.81	$ 811,766
16	Annual O&M Costs	$284,000	0.80	$ 227,358
16	5 Year Review (2032)	$20,000	0.80	$ 16,011
17	Annual O&M Costs	$284,000	0.79	$ 224,219
18	Annual O&M Costs	$284,000	0.78	$ 221,124
19	Annual O&M Costs	$284,000	0.77	$ 218,071
20	Annual O&M Costs	$284,000	0.76	$ 215,060
21	Annual O&M Costs	$284,000	0.75	$ 212,091
21	5 Year Review (2037)	$20,000	0.75	$ 14,936
22	Annual O&M Costs	$284,000	0.74	$ 209,162
23	Capital Costs (Road Maintenance)	$25,000	0.73	$ 18,158
23	Annual O&M Costs	$284,000	0.73	$ 206,274
24	Annual O&M Costs	$284,000	0.72	$ 203,426
25	Annual O&M Costs	$284,000	0.71	$ 200,618
26	Annual O&M Costs	$284,000	0.70	$ 197,848

Alternate 5 - Thermal and Jet Grouting
Wyckoff/Eagle Harbor Soil and Groundwater OUs, Focused Feasibility Study

	Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)				NOTES
26	5 Year Review (2042)				$20,000	0.70	$	13,933	
27	Annual O&M Costs				$284,000	0.69	$	195,116	
31	5 Year Review (2047)				$20,000	0.65	$	12,997	
36	5 Year Review (2052)				$20,000	0.61	$	12,124	
41	5 Year Review (2057)				$20,000	0.57	$	11,310	
46	5 Year Review (2062)				$20,000	0.53	$	10,551	
51	5 Year Review (2067)				$20,000	0.49	$	9,842	
56	5 Year Review (2072)				$20,000	0.46	$	9,181	
61	5 Year Review (2077)				$20,000	0.43	$	8,565	
66	5 Year Review (2082)				$20,000	0.40	$	7,990	
71	5 Year Review (2087)				$20,000	0.37	$	7,453	
76	5 Year Review (2092)				$20,000	0.35	$	6,953	
81	5 Year Review (2097)				$20,000	0.32	$	6,486	
86	5 Year Review (2102)				$20,000	0.30	$	6,050	
91	5 Year Review (2107)				$20,000	0.28	$	5,644	
96	5 Year Review (2112)				$20,000	0.26	$	5,265	
100	Final Completion Report (2116)				$150,000	0.25	$	37,350	
TOTAL VALUE ANALYSIS					**$149,580,000**			**$142,060,000**	

This construction cost estimate is not an offer for construction and/or project execution. The construction cost estimate for this Design is an Association for the Advancement of Cost Engineering (AACE) Class 4 estimate and is assumed to represent the actual total installed cost. The estimate above is considered control-level cost estimating, suitable for use in project budgeting and planning. This estimate has been prepared with partial design and engineering calculations. The level of accuracy for the class of estimate defines the upper and lower ranges of the cost estimate. It is based upon the level of design detail and uncertainty associate with that level of detail. For a Class 4 estimate, the accuracy range is +50% to -30%. It would appear prudent that internal budget allowances account for the highest cost indicated by this range as well as other site specific allowances. The cost estimate has been prepared for guidance in project evaluation and implementation from the information available at the time of the estimate. The final costs of the project will depend on actual labor and material costs, competitive market conditions, implementation schedule, and other variable factors. As a result, the final project costs will vary from the estimates presented herein. Because of this, project feasibility and funding needs must be carefully reviewed prior to making specific financial decisions to help ensure proper project evaluation and adequate funding.

Alternate 6 - MTTD and Thermal
Wyckoff/Eagle Harbor Soil and Groundwater OUs, Focused Feasibility Study

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
CAPITAL COSTS					
GENERAL SITE ACTIVITIES					
Pre-construction Activites - Common Elements (2016)					
Permitting	1	LS	$20,000	$20,000	Excavation/Grading/Drilling/Ecological
Precon Submittals	1	LS	$54,000	$54,000	WP/H&SP/AHAs/Schedule
Mobilization/Demobilization	1	LS	$118,000	$118,000	
Community Relations	1	LS	$169,000	$169,000	
Site Preparation	1	LS	$52,000	$52,000	WP/H&SP/AHAs/Schedule
Surveying - General	50	DY	$2,900	$145,000	
Project Management	6%		$558,000	$33,480	USEPA 540-R-00-002 Guidence Document
Construction Management	8%		$558,000	$44,640	USEPA 540-R-00-002 Guidence Document
Remedial Design	12%		$558,000	$66,960	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$703,080	$175,770	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$879,000**	
Access Roads (2016)					
Erosion Controls	1,500	LF	$10	$15,000	
Roadway Grading	1,955	CY	$50	$97,750	
P/D/P 3" Agg Base	725	TN	$10	$7,250	
P/D/P/Seal 4" AC Pavement	260	TN	$190	$49,400	
Erosion Control Matting	1,445	sy	$10	$14,450	
Project Management	8%		$183,850	$14,708	USEPA 540-R-00-002 Guidence Document
Construction Management	10%		$183,850	$18,385	USEPA 540-R-00-002 Guidence Document
Remedial Design	15%		$183,850	$27,578	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$244,521	$61,130	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$306,000**	
Demolition - Concrete Structures (2016)					
Surface Decontamination	7,200	SY	$10.00	$72,000	
Concrete Demolition - Easy	2,010	CY	$40.00	$80,400	
Concrete Demolition - Difficult	6,020	CY	$70.00	$421,400	
Concrete Crushing	8,030	CY	$70.00	$562,100	
Spread Crushed Concrete Oniste	8,030	CY	$20.00	$160,600	
Recycle Rebar	650	TN	-$290.00	-$188,500	
Odor Control	12	WK	$9,700	$116,400	Allowance
Level C PPE Upgrade	1	LS	$250,900	$250,900	Allowance
Project Management	6%		$1,475,300	$88,518	USEPA 540-R-00-002 Guidence Document
Construction Management	8%		$1,475,300	$118,024	USEPA 540-R-00-002 Guidence Document
Remedial Design	12%		$1,475,300	$177,036	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$1,858,878	$464,720	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$2,324,000**	
Debris Removal - Site Wide (2016)					
Excavation/Debris Removal (5-ft)	66,578	CY	$10	$665,780	
Odor Control	12	WK	$9,700	$116,400	
Backfill - Site Wide	66,578	CY	$2	$133,156	
T&D Debris - Hazardous	900	TN	$1,000	$900,000	
Level C PPE Upgrade	1	LS	$332,890	$332,890	Allowance
Project Management	5%		$2,148,226	$107,411	USEPA 540-R-00-002 Guidence Document
Construction Management	6%		$2,148,226	$128,894	USEPA 540-R-00-002 Guidence Document
Remedial Design	8%		$2,148,226	$171,858	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$2,556,389	$639,097	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$3,195,000**	

Alternate 6 - MTTD and Thermal
Wyckoff/Eagle Harbor Soil and Groundwater OUs, Focused Feasibility Study

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
Rock/Soil/Bulkhead Removal (2016)					
Rock Removal	16,857	CY	$50	$842,850	
Excavate Behind Exist SP Wall	28,393	CY	$30	$851,790	
Bulkhead Removal	2,696	CY	$20	$53,920	
T&D Bulkhead Debris - Hazardous	2,022	TN	$1,000	$2,022,000	
T&D Bulkhead Debris - Non Haz	2,022	TN	$250	$505,500	
Backfill Existing Sheet Pile Wall	28,393	CY	$20	$567,860	
Crush Rock	16,857	CY	$10	$168,570	
Spread Crushed Material Onsite	16,857	CY	$20	$337,140	
Odor Control	12	WK	$9,700	$116,400	Allowance
Level C PPE Upgrade	1	LS	$425,895	$425,895	Allowance
Project Management	5%		$5,891,925	$294,596	USEPA 540-R-00-002 Guidence Document
Construction Management	6%		$5,891,925	$353,516	USEPA 540-R-00-002 Guidence Document
Remedial Design	8%		$5,891,925	$471,354	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$7,011,391	$1,752,848	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$8,764,000**	
Miscellaneous Demolition (2016)					
Remove/Dispose Asphalt	233	CY	$100	$23,300	HCSS Estimate
Remove/Dispose of Pilot Plant Pipe	1	LS	$20,000	$20,000	Engineer's Estimate
Remove/Dispose Pilot Plant SP	24,300	SF	$30	$729,000	Engineer's Estimate
Remove/Dispose NW Beach SP	13,280	SF	$30	$398,400	HCSS Estimate
Remove/Dispose Tanks & Equip	1	LS	$119,000	$119,000	HCSS Estimate
Odor Control	4	WK	$9,700	$38,800	Allowance
Level C PPE Upgrade	1	LS	$575,350	$575,350	Allowance
Project Management	5%		$1,903,850	$95,193	USEPA 540-R-00-002 Guidence Document
Construction Management	6%		$1,903,850	$114,231	USEPA 540-R-00-002 Guidence Document
Remedial Design	8%		$1,903,850	$152,308	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$2,265,582	$566,395	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$2,832,000**	
Storm Water Infiltration Trench (2016)					
Excavation	2,800	CY	$17	$47,600	
P/D Drain Gravel	4,536	TN	$24	$108,864	
Spread Drain Gravel	6,400	TN	$9	$57,600	
Project Management	8%		$214,064	$17,125	USEPA 540-R-00-002 Guidence Document
Construction Management	10%		$214,064	$21,406	USEPA 540-R-00-002 Guidence Document
Remedial Design	15%		$214,064	$32,110	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$284,705	$71,176	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$214,000**	
Install New Perimeter SP Wall, Non ISS (2017)					
P/D AZ50 Sheet Pile	3,700	TN	$1,900	$7,030,000	Vendor Quote
Unload Sheet Pile	169	LD	$2,300	$388,700	
Install Perimeter SP Wall (AZ50)	142,200	SF	$11	$1,564,200	
Project Management	5%		$8,982,900	$449,145	USEPA 540-R-00-002 Guidence Document
Construction Management	6%		$8,982,900	$538,974	USEPA 540-R-00-002 Guidence Document
Remedial Design	8%		$8,982,900	$718,632	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$10,689,651	$2,672,413	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$13,362,000**	
Construct Outfall (2017)					
P/D AZ36-700N Sheet Pile	90	TN	$1,700	$153,036	HCSS Estimate
Unload Sheet Pile	5	LD	$2,100	$10,500	HCSS Estimate
Install Sheet Pile	3,500	SF	$10	$35,000	HCSS Estimate
Dewatering	20	DY	$800	$16,000	HCSS Estimate
HDD, Pipe, and Marine	1	LS	$1,500,000	$1,500,000	Vendor Quote
Onshore Construction	1	LS	$500,000	$500,000	HCSS Estimate

Alternate 6 - MTTD and Thermal
Wyckoff/Eagle Harbor Soil and Groundwater OUs, Focused Feasibility Study

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
Project Management	5%		$2,214,536	$110,727	USEPA 540-R-00-002 Guidence Document
Construction Management	6%		$2,214,536	$132,872	USEPA 540-R-00-002 Guidence Document
Remedial Design	8%		$2,214,536	$177,163	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$2,635,298	$658,824	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$3,294,000**	
Non-ISS Passive Drainage System (2025)					
MH Excavations, Non-ISS PWT	1,500	CY	$35	$52,500	
P/D/I Manholes & Bases	10	EA	$17,000	$170,000	
Install Manholes & Bases	10	EA	$0	$0	
Install Contech GAC Storm Filters	1	LS	$15,000	$15,000	
Discharge Line Penetration/Install	10	EA	$6,900	$69,000	
Backfill Manholes	1,500	CY	$31	$46,500	
Excavate French Drains	4,750	CY	$18	$85,500	
P/D/I 12", Slotted HDPE	2,000	LF	$55	$110,000	
Backfill French Drains	4,750	CY	$24	$114,000	
Repair Cap	1,000	SY	$67	$67,000	
Project Management	6%		$729,500	$43,770	USEPA 540-R-00-002 Guidence Document
Construction Management	8%		$729,500	$58,360	USEPA 540-R-00-002 Guidence Document
Remedial Design	12%		$729,500	$87,540	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$919,170	$229,793	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$1,149,000**	
Final Site Cap (2028)					
Subgrade Preparation	39,150	SY	$3.00	$117,450	HCSS Estimate
P/D/P Embankment Fill	13,917	CY	$20	$278,340	HCSS Estimate
Geomembrane Cover	39,150	SY	$6.75	$264,263	Engineer's Estimate
Geomembrane Penetrations	13	EA	$500	$6,500	Engineer's Estimate
Cushion Geotextile	39,150	SY	$2.25	$88,088	Engineer's Estimate
P/D/P Granular Drain Mat'l	21,000	TN	$30	$630,000	HCSS Estimate
P/D/P Topsoil Layer	21,100	TN	$60	$1,266,000	HCSS Estimate
Survey	22	DY	$2,900	$63,800	HCSS Estimate
Restoration	13	AC	$3,200.00	$41,600	Engineer's Estimate
Project Management	5%		$2,756,040	$137,802	USEPA 540-R-00-002 Guidence Document
Construction Management	6%		$2,756,040	$165,362	USEPA 540-R-00-002 Guidence Document
Remedial Design	8%		$2,756,040	$220,483	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$3,279,688	$819,922	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$4,100,000**	
Non-ISS Concrete Perimeter Wall (2028)					
Excavation - Non-ISS Perimeter Wall	14,646	CY	$63	$922,698	
Install Concrete Plug	1,475	CY	$220	$324,500	
Odor Control	8	WK	$9,700	$77,600	Allowance
P/D/I Rebar	1,100	TN	$3,100	$3,410,000	
P/D/I Concrete	13,201	CY	$220	$2,904,220	
Project Management	5%		$7,639,018	$381,951	USEPA 540-R-00-002 Guidence Document
Construction Management	6%		$7,639,018	$458,341	USEPA 540-R-00-002 Guidence Document
Remedial Design	8%		$7,639,018	$611,121	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$9,090,431	$2,272,608	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$11,363,000**	

Alternate 6 - MTTD and Thermal
Wyckoff/Eagle Harbor Soil and Groundwater OUs, Focused Feasibility Study

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
REMEDIAL ACTION ALTERNATIVE					
Alternative 6 - Thermal (Midpoint 2019)					
Pre-construction Activities					
Permitting	1	LS	$10,000	$10,000	Allowance
Precon Submittals	1	LS	$50,000	$50,000	
Site Preparation	1	LS	$50,000	$50,000	
			Subtotal:	**$110,000**	
Mob/Demob					
P/D AZ36-700N Sheet Pile	4,331	TN	$1,600	$6,929,600	Vendor Quote
Unload Sheet Pile	114	LD	$1,200	$136,800	Engineer's Estimate
Install AZ36-700N Sheet Pile	189,255	SF	$10	$1,892,550	Engineer's Estimate
Install Dewatering Wells	27	ea	$25,000	$675,000	Engineer's Estimate
Dewatering Well Completions	27	ea	$350	$9,450	Engineer's Estimate
Install Steam Injection Wells	183	ea	$15,000	$2,745,000	Engineer's Estimate
Injection Well Completions	183	ea	$450	$82,350	Engineer's Estimate
Steam Injection Well Piping/System	1	ls	$460,000	$460,000	Engineer's Estimate
Install Extraction Wells	147	ea	$5,700	$837,900	Engineer's Estimate
Extraction Well Completions	147	ea	$450	$66,150	Engineer's Estimate
Install Extraction Well Head System	49	ea	$2,500	$122,500	Engineer's Estimate
Allowance to Relocate Well Heads	220	ea	$1,500	$330,000	Engineer's Estimate
Install Biosparge Wells	31	ea	$5,000	$155,000	Engineer's Estimate
Biosparge Well Completions	31	ea	$350	$10,850	Engineer's Estimate
Install Biosparge Wellhead and Header Piping/Valves	31	ea	$2,500	$77,500	Engineer's Estimate
Install Thermocouple Borings	238	ea	$2,800	$666,400	Engineer's Estimate
Purchase Thermocouples	589	ea	$1,500	$883,500	Engineer's Estimate
Install Thermocouples	7,068	ft	$25	$176,700	Engineer's Estimate
Thermocouple Completions	238	ea	$350	$83,300	Engineer's Estimate
Install Vapor Collection Layer	8,168	tn	$20	$163,360	Engineer's Estimate
Install Vapor Collection Piping	3,420	ft	$25	$85,500	Engineer's Estimate
Install Select Fill Below Vapor Cap	6,126	tn	$25	$153,150	Engineer's Estimate
Temp Geomembrane over VC	26,255	SY	$7	$183,785	Engineer's Estimate
Temp VC Pipe Penetrations	76	ea	$500	$38,000	Engineer's Estimate
Install Cushion Geotextile	26,255	SY	$2	$52,510	Engineer's Estimate
Install Fill Above VC (18")	18,379	tn	$25	$459,475	Engineer's Estimate
Surface Top Coarse (6")	6,126	tn	$25	$153,150	Engineer's Estimate
Steam Supply Header Materials	10,645	ft	$45	$479,025	Engineer's Estimate
Allowance for Steam Valves/I&C	1	ls	$75,000	$75,000	Engineer's Estimate
Air Supply Piping Header	10,645	ft	$20	$212,900	Engineer's Estimate
Vapor Extraction Piping	10,645	ft	$55	$585,475	Engineer's Estimate
Extracted Water Piping	10,645	ft	$20	$212,900	Engineer's Estimate
Install Air/Vapor/Extraction Piping	42,580	ft	$7	$298,060	Engineer's Estimate
Installation of 6' Pipe Rack	940	ea	$400	$376,000	Engineer's Estimate
Installation of 15' Pipe Rack	127	ea	$750	$95,250	Engineer's Estimate
Allowance for Extraction Valves/I&C	1	ls	$100,000	$100,000	Engineer's Estimate
Corrosion Protection for wells	388	ls	$500	$194,000	Engineer's Estimate
			Subtotal:	**$20,258,090**	
Vapor and GW Treatment System					
Site Preparation	1	ls	$30,000	$30,000	Engineer's Estimate
Concrete Slab on Grade	1,400	cy	$350	$490,000	Engineer's Estimate
Secondary Containment Walls	13	CY	$350	$4,550	Engineer's Estimate
P/D Diesel Generators	2	ea	$600,000	$1,200,000	Engineer's Estimate
P/D Direct Contact Condenser	1	ea	$415,000	$415,000	Engineer's Estimate
P/D VLS, LRVP, Therm-OX Package	1	ea	$100,000	$100,000	Engineer's Estimate
P/D Solids Dewater Screw Conveyor	2	ea	$135,000	$270,000	Engineer's Estimate
P/D Cooling Tower	1	ea	$41,000	$41,000	Engineer's Estimate
Cooling Water Chemical/Makeup Treatment Systems	1	ls	$150,000	$150,000	Allowance
P/D Heat Exchanger H-1	2	ea	$11,500	$23,000	Engineer's Estimate
P/D Heat Exchanger H-2	2	ea	$15,000	$30,000	Engineer's Estimate
P/D Accumulation Tank	1	ea	$97,000	$97,000	Engineer's Estimate
P/D Oil/Water Separator	1	ea	$310,000	$310,000	Engineer's Estimate
P/D Solids NAPL Holding Tank	1	ea	$92,000	$92,000	Engineer's Estimate
P/D Air Compressor	1	ea	$11,000	$11,000	Engineer's Estimate
P/D Pumps	20	ea	$10,000	$200,000	Engineer's Estimate
P/D DAF	1	ea	$357,000	$357,000	Engineer's Estimate
P/D Walnut Filter	1	ea	$300,000	$300,000	Engineer's Estimate
Equipment Installation (15% of equipment cost)	1	ls	$400,000	$400,000	Allowance

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
Process Piping (5% of equip cost)	1	ls	$132,000	$132,000	Allowance
I&C (15% of equipment cost)	1	ls	$400,000	$400,000	Allowance
Electrical (20% of equipment cost)	1	ls	$530,000	$530,000	Allowance
Solids Handling Rain Shelter	600	sf	$200	$120,000	Allowance
Electrical/I&C Building (30% of cost)	1	ls	$36,000	$36,000	Allowance
			Subtotal:	**$5,738,550**	
Boiler Propane System					
Site Preparation	1	ls	$15,000	$15,000	Engineer's Estimate
Concrete Slab on Grade	125	cy	$350	$43,750	Engineer's Estimate
Install Propane Tank	1	ls	$30,000	$30,000	Allowance
Install Vaporizor	1	ls	$30,000	$30,000	Allowance
Setup Boiler System	1	ls	$75,000	$75,000	Allowance
Monthly Rental of Boiler System	60	mo	$17,500	$1,050,000	Nationwide Boiler Quote. Includes softener and feedwater pump.
			Subtotal:	**$1,243,750**	
PROJECT MANAGEMENT	5%		$27,350,390	$1,367,520	Based on EPA 540-R-00-002
CONSTRUCTION MANAGEMENT	6%		$27,350,390	$1,641,023	Based on EPA 540-R-00-002
REMEDIAL DESIGN	6%		$27,350,390	$1,641,023	Based on EPA 540-R-00-002
CONSTRUCTION COMPLETION REPORT	1	LS	$100,000	$100,000	
			Subtotal:	**$4,749,566**	
CONTINGENCY (10% scope + 15% bid)	25%		$32,099,956	$8,024,989	Based on EPA 540-R-00-002
TOTAL CAPITAL COSTS - THERMAL:				**$40,125,000**	
Alternative 6 - MTTD (Midpoint 2018)					
Sheet Pile, Whalers, and Struts					
P/D AZ50 Sheet Pile	3,186	TN	$1,900	$6,053,400	Vendor Quote
P/D AZ36-700N Sheet Pile	1,148	TN	$1,600	$1,836,800	Vendor Quote
P/D Whalers	302	TN	$1,400	$422,800	Vendor Quote
P/D Struts	500	TN	$1,500	$750,000	Vendor Quote
Unload Sheet Pile, Whalers, struts	241	LD	$2,300	$554,300	Engineer's Estimate
Install AZ50 Sheet Pile	123,000	SF	$20	$2,460,000	HCSS Estimate
Install AZ36-700N Sheet Pile	66,349	SF	$20	$1,326,980	HCSS Estimate
P/D Controlled Density Fill (CDF)	2,110	cy	$220	$464,200	HCSS Estimate
Derrick barge, 2 days+tug+plus fuel	1	ls	$100,000	$100,000	Engineer's Estimate
Demobilize GC Derrick Barge+tug	1	ls	$100,000	$100,000	Engineer's Estimate
Demobilize MTTD Equipment	1	ls	$96,000	$96,000	Engineer's Estimate
Holding Cell (124' x 120')					
P/D/P Ecology Blocks	200	ea	$400	$80,000	Vendor Quote
Subgrade Preparation	1,500	sy	$3	$4,500	HCSS Estimate
Geotextile	1,600	sy	$7	$10,800	Engineer's Estimate
P/D/P Structural Fill (6")	230	cy	$20	$4,600	HCSS Estimate
P/D/P Agg Base (3")	115	cy	$10	$1,150	HCSS Estimate
P/D/P/Seal AC Pavement	230	ton	$190	$43,700	HCSS Estimate
Material Handling Building (100' x 300')					
Sprung Structure (or similar)	30,000	sf	$40	$1,200,000	Enclosed/Insulated Metal Frame Structure
Subgrade Preparation	3,111	sy	$3	$9,333	HCSS Estimate
P/D/P Geotextile	2,700	sy	$7	$18,225	Engineer's Estimate
P/D/P Structural Fill (6")	450	cy	$35	$15,750	HCSS Estimate
P/D/P Agg Base (3")	225	cy	$25	$5,625	HCSS Estimate
P/D/P/Seal AC Pavement	450	ton	$90	$40,500	HCSS Estimate
Perimeter Foundation	170	cy	$350	$59,500	HCSS Estimate
Interior Lighting	1	ls	$20,000	$20,000	Allowance
Construct Dump Ramp	40	ea	$400	$16,000	Ecology Blocks
Weather Station	1	ls	$4,000	$4,000	Allowance
Building Protection	300	ea	$400	$120,000	Ecology Blocks
MHB Operating Costs	12	mo	$78,500	$942,000	2 operators, Loader, skid steer, mixer/tiller
Sheet Pile Cell Excavation	12	mo	$135,000	$1,620,000	Long reach excavator/clamshell; two off road haul trucks; dozer; H2O truck; four operators
Propane Tank					
Subgrade Preparation	284	sy	$3	$853	
P/D/P Structural Fill (6")	35	cy	$35	$1,225	HCSS Estimate
P/D/P Agg Base (3")	15	cy	$25	$375	HCSS Estimate
P/D/P Ecology Blocks	40	ea	$400	$16,000	
P/D/I Propane Piping - SS	50	lf	$50	$2,500	1" line, fittings
Trench - HDPE Pipe	75	cy	$6	$420	2'x2'x500' trench
Trench - Backfill (by hand)	75	cy	$59	$4,425	2'x2'x500' trench
P/D/I Propane Piping - HDPE	500	lf	$2	$1,000	2" line
Generator MTTD					

Alternate 6 - MTTD and Thermal
Wyckoff/Eagle Harbor Soil and Groundwater OUs, Focused Feasibility Study

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
750kW Generators - Rental	28	mo	$13,500	$378,000	Vendor Quote
20-30kW Generators - Rental	56	mo	$1,050	$58,800	Vendor Quote-Bldg; wheel wash; extraction wells (2)
Parralling Gear and Cables	1	ls	$70,000	$70,000	Vendor Quote
Adder for 65 dBA @ 23' (non-refund)	1	ls	$50,000	$50,000	Vendor Quote
16k-gal Diesel Tank	1	ea	$75,000.00	$75,000	Budgetary Quote from Western Global
Buried/armored cable	400	lf	$13	$5,000	
Fuel Consumption					
Propane for MTTD	3,017,600	gal	$1.70	$5,129,920	
Diesel for MTTD	450,000	gal	$4	$1,800,000	Engineer's Estimate
Diesel for Building Gensets	42,048	gal	$4	$168,192	Engineer's Estimate
Diesel for Wheel Wash Genset	20,160	gal	$4	$80,640	Engineer's Estimate
Diesel for Extraction Well Gensets	14,400	gal	$4	$57,600	Engineer's Estimate
Decon Pad					
Decon Trailer	14	mo	$5,000	$70,000	Engineer's Estimate
Powered Wheel Wash	14	mo	$2,700	$37,800	Engineer's Estimate
Excavation for Buried Wheel Wash	10	cy	$15	$150	
Water Supply Connection	1	ls	$5,000	$5,000	Engineer's Estimate
P/D/P Concrete Ramp	12	cy	$350	$4,200	HCSS Estimate
P/D/I Chain-link Fencing	1,000	lf	$5	$5,000	HCSS Estimate
Road Along Beach Soil Stockpile					
Subgrade Preparation	267	sf	$3	$800	
P/D/P Geotextile	2,700	sy	$7	$18,900	
P/D/P Crushed Gravel	890	cy	$35	$31,150	
Maintenance (2 yrs)	200	cy	$35	$7,000	
Delineators, flexible	1	ls	$1,000	$1,000	
Excavate Storm Water Trench	555	cy	$6	$3,108	
P/D Vaults	3	ea	$1,200	$3,600	4' dia x 4' deep precast storm drain
P/D Pumps	3	ea	$350	$1,050	1/2 hp submersible RSMeans
Install Vaults w/ Pumps	3	ea	$3,000	$9,000	Set vault, backfill, piping connections
Fractionation Tanks MTTD and Decon Pad					
22k-gal, trailer mount tanks rental	32	mo	$15,000	$480,000	Based on vendor quote (verbal) - 2 tanks
Subgrade Preparation	244	sy	$3	$733	
P/D/P Crushed Gravel	30	cy	$35	$1,050	
Tank Piping	1	ls	$2,500	$2,500	Allowance
Excavate Water Supply Line Trench	1,800	lf	$15	$27,000	300'x3'x2'
Dust Control and Wheel Wash Supply Tank					
Trailer Mounted Fractionation Tank	16	mo	$15,000	$240,000	Based on vendor quote (verbal)
P/D Flocculant	5	totes	$1,600	$8,000	
Subgrade Preparation	125	sy	$3	$375	
P/D/P Crushed Gravel	14	cy	$35	$490	
Water Supply Connection	200	lf	$50	$10,000	
Water Truck Fill Stand Pipe	1	ls	$5,000.00	$5,000	
Fire Hose for Dust Suppresion	16	ea	$175	$2,800	50-ft sections
Soils and Water Analysis (3-day TAT)					
PAH and PCB SIM Soil	1,640	ea	$475	$779,000	Engineer's Estimate
MTTD Feed Soil	410	ea	$475	$194,750	Engineer's Estimate
Water Analysis	100	ea	$475	$47,500	
Sampling Tech	2,496	hrs	$75	$187,200	1 FTE for 1.2 yrs
Data Validation	500	hrs	$120	$60,000	
Test Burn	1	ls	$50,000	$50,000	Allowance
Stockpile Management	12	mo	$55,800	$669,600	1 Loader/Oper, 12 hrs/day
Water Supply Well					
Trenching Excavation	350	cy	$6	$2,100	6-in HDPE, buried
P/D/I Conveyance Piping	1,600	lf	$2.50	$4,000	6-in HDPE, buried
P/D Bedding Sand	300	tn	$15	$4,500	
Trench - Backfill (by hand)	175	cy	$58	$10,150	

Alternate 6 - MTTD and Thermal
Wyckoff/Eagle Harbor Soil and Groundwater OUs, Focused Feasibility Study

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
MTTD Operations					
Treatment Costs	131,000	tn	$70	$9,170,000	Includes equipment costs
Miscellaneous Equip Costs	12	mo	$7,500	$90,000	radial stacker
MTTD Footprint (110'x100')					
Subgrage Preparation	1,333	sy	$3	$4,000	
P/D/P Geotextile	1,450	sy	$7	$9,788	Engineer's Estimate
P/D/P Crushed Gravel	200	cy	$35	$7,000	
P/D/P Agg Base	135	cy	$25	$3,375	HCSS Estimate
P/D/P/Seal AC Pavement	200	ton	$90	$18,000	HCSS Estimate
Treated Soil Stockpile					
P/D/P Ecology Blocks	400	ea	$400	$160,000	
Subgrade Preparation	4,444	sy	$3	$13,333	
P/D/P Geotextile	40,000	sy	$7	$270,000	Engineer's Estimate
P/D/P Crushed Gravel	1,110	cy	$35	$38,850	
P/D/P Agg Base	370	cy	$25	$9,250	HCSS Estimate
P/D/P/Seal AC Pavement	750	ton	$90	$67,500	HCSS Estimate
P/D/I Chain Link Fence	400	lf	$29	$11,600	10' O.C., 6' high, 9 ga. wire, set in concrete
Operating Cost	12	mo	$98,000	$1,176,000	1 Loader/oper; 2 haul trucks/oper.; H2O truck; for 1 yr, 12 hrs/day
Granular Activated Carbon					
Pickup Plenum Inside Bldg	1	ls	$10,000	$10,000	
P/D/I GAC Units	6	ea	$40,000	$240,000	20' x 8' x 8' GAC Siemens containers w/ 20,000# GAC/each
GAC Changeouts	200,000	lbs	$1.20	$240,000	Engineer's Estimate
Hoses	1	ls	$10,000	$10,000	Allowance
P/D/I Blower, Motor, Control Skid	1	ls	$50,000	$50,000	
Odor Control Foam					
Odor Control Foam	1	ls	$100,000	$100,000	Allowance
			Subtotal:	**$40,963,316**	
PROJECT MANAGEMENT	5%		$40,963,316	$2,048,166	Based on EPA 540-R-00-002
CONSTRUCTION MANAGEMENT	6%		$40,963,316	$2,457,799	Based on EPA 540-R-00-002
REMEDIAL DESIGN	6%		$40,963,316	$2,457,799	Based on EPA 540-R-00-002
CONSTRUCTION COMPLETION REPORT	1	LS	$100,000	$100,000	
			Subtotal:	**$7,063,764**	
CONTINGENCY (10% scope + 15% bid)	25%		$48,027,080	$12,006,770	Based on EPA 540-R-00-002
			TOTAL CAPITAL COSTS -MTTD:	**$60,034,000**	

Alternative 5 - Well Abandonment and GWTP Demolition

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
Well Abandonment (2025)					
Driller Mobilization/Demob	1	ls	$5,000	$5,000	Vendor Quote
Abandon 2-in Wells	232	ea	$1,300	$301,600	Vendor Quote
Abandon 4-in Wells	357	ea	$2,550	$910,350	Vendor Quote
PROJECT MANAGEMENT	6%		$1,216,950	$73,017	Based on EPA 540-R-00-002
CONSTRUCTION MANAGEMENT	8%		$1,216,950	$97,356	Based on EPA 540-R-00-002
REMEDIAL DESIGN	12%		$1,216,950	$146,034	Based on EPA 540-R-00-002
CONSTRUCTION COMPLETION REPORT	1	LS	$25,000	$25,000	
CONTINGENCY (10% scope + 15% bid)	25%		$1,558,357	$389,589	Based on EPA 540-R-00-002
			Subtotal:	**$1,948,000**	**(Rounded)**
GWTP Demolition	1	ls	$1,000,000	$1,000,000	Allowance
			Subtotal:	**$1,000,000**	

TOTAL COST REMEDIAL ACTION	**$103,107,000**

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
OPERATION & MAINTENANCE COSTS OF GWTP (through 2024)					
Annual O&M					
Operator(s)	4,160	hr	$80	$332,800	2 FTEs Operating GWTP
Electrical Usage	1	ls	$60,000	$60,000	Current usage is $4k/mo to pump 65 gpm, scaled up to pump 140 gpm
Waste Disposal	1	ls	$100,000	$100,000	Allowance: NAPL and spent carbon disposal
Chemicals/Media	1	ls	$20,000	$20,000	Allowance
Maintenance	10%		$512,800	$51,280	Allowance
Quarterly GW Sampling	4	ea	$10,000	$40,000	
Annual GW Sampling	1	ls	$50,000	$50,000	
Undefined Scope Allowance	10%		$654,080	$65,408	
PROJECT MANAGEMENT	6%		$719,488	$43,169	Based on EPA 540-R-00-002
REPORTING	1		$25,000	$25,000	
TOTAL O&M COSTS GWTP				**$788,000**	
OPERATION & MAINTENANCE COSTS OF NAPL RECOVERY (20219 through 2021)					
Annual O&M					
Disposal - NAPL Waste	47,000	gal	$7	$329,000	Vendor Quote; 140,000-gal over 3 yrs
Transportation - NAPL Waste	22	ld	$6,400	$140,800	Vendor Quote
Well field Analysis&Sampling Team	1,040	hr	$80	$83,200	Engineer's Estimate
Laboratory Analysis	260	ls	$300	$78,000	Engineer's Estimate
PPE Allowance	1,040	hr	$15	$15,600	Allowance
Maintenance	10%		$646,600	$64,660	Allowance
Undefined Scope Allowance	10%		$711,260	$71,126	
PROJECT MANAGEMENT	6%		$782,386	$46,943	
REPORTING	1		$25,000	$25,000	
TOTAL ANNUAL O&M COSTS - NAPL RECOVERY				**$854,000**	
OPERATION & MAINTENANCE COSTS OF EAB (2021 through 2026)					
EAB					
Operator(s)	1,040	hr	$80	$83,200	1/2 yr running EAB System
Supervisor	208	hr	$100	$20,800	20% of operator time
Electrical	1	ls	$16,000	$16,000	Engineer's Estimate
Nutrient Chemicals/Media	1	ls	$11,000	$11,000	
System Maintenance	5%		$131,000	$6,550	Allowance
Undefined Scope Allowance	10%		$137,550	$13,755	
PROJECT MANAGEMENT	8%		$151,305	$12,104	Based on EPA 540-R-00-002
REPORTING	1		$25,000	$25,000	
TOTAL ANNUAL O&M COSTS - EAB RECOVERY				**$188,000**	
OPERATION & MAINTENANCE COSTS OF THERMAL (2019 through 2023)					
Annual O&M					
Operator(s)	16,640	hr	$80	$1,331,200	8 FTEs running system 24/7
Supervisor	4,160	hr	$100	$416,000	2 FTE
Electrical Usage	1	ls	$103,385	$103,385	Current usage is $4k/mo to pump 65 gpm, scaled up to pump 140 gpm
Diesel Generator	12	mo	$20,600	$247,200	5150 gal/mo @ $4/gal
Propane	12	mo	$266,600	$3,199,200	86,000-gal/mo@$3.10/gal
Disposal - NAPL Waste	14,000	gal	$7	$98,000	Vendor Quote; 14,000-gal/yr
Transportation - NAPL Waste	13	ld	$6,400	$83,200	Vendor Quote
Disposal - Naphthalene Waste	258	tn	$660	$170,360	Engineer's Estimate
Transportation - Naphthalene Waste	12	ld	$1,360	$16,320	22 tn/load => 16 hrs/load haul time
Waste Disposal - Carbon/Filter Media	1	ls	$86,000	$86,000	Allowance
Well field Analysis&Sampling Team	1,040	hr	$80	$83,200	Engineer's Estimate
Laboratory Analysis	260	ls	$300	$78,000	Engineer's Estimate
PPE Allowance	16,640	hr	$0.75	$12,480	Allowance - hard hats, boots, work gloves, safety glasses, Tyvek and other consumables
Maintenance	10%		$5,924,545	$592,455	Allowance
Undefined Scope Allowance	10%		$6,517,000	$651,700	

Alternate 6 - MTTD and Thermal
Wyckoff/Eagle Harbor Soil and Groundwater OUs, Focused Feasibility Study

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
PROJECT MANAGEMENT	5%		$7,168,700	$358,435	
REPORTING	1		$25,000	$25,000	
TOTAL ANNUAL O&M COSTS - THERMAL				**$7,552,000**	
OPERATION & MAINTENANCE COSTS OF PASSIVE GROUNDWATER TREATMENT SYSTEM (2026 through 2035)					
Operator(s)	520	hr	$80	$41,600	0.25 FTE
Maintenance	10%		$41,600	$4,160	Allowance
Quarterly GW Sampling	4	ea	$10,000	$40,000	
Annual GW Sampling	1	ls	$50,000	$50,000	
Contech GAC Filled Storm Filter Change	280	ea	$200	$56,000	Quarterly change out/recycle
T&D of Spent GAC Filters	40	drum	$400	$16,000	1 drum/manhole/event
Undefined Scope Allowance	10%		$191,760	$19,176	
PROJECT MANAGEMENT	8%		$226,936	$18,155	Based on EPA 540-R-00-002
CONSTRUCTION MANAGEMENT	15%		$91,176	$13,676	Based on EPA 540-R-00-002
REPORTING	1	ls	$25,000	$25,000	
TOTAL O&M COSTS PASSIVE GWT				**$284,000**	
PERIODIC COSTS					
Maintain Onsite Roads	1	ls	$25,000	$25,000	Allowance - re-grade/repair onsite roads
LONG TERM EPA REPORTING COSTS					
5 Yr Reviews (last completed 2012)	1	ls	$20,000	$20,000	
Final Completion Report	1	ls	$150,000	$150,000	

PRESENT VALUE ANALYSIS 1.4% Discount Rate — OMB - Discount Rates for Cost Effectiveness, Lease Purchase, and Related Analysis, 12/2013

Year	Cost Type	Cost	Discount Rate	Present Value
0	Capital Costs (2016)	$18,514,000	1.00	$ 18,514,000
0	Capital Costs - GWTP O&M	$788,000	1.00	$ 788,000
1	Capital Costs (2017)	$16,656,000	0.99	$ 16,426,036
1	Capital Costs - GWTP O&M	$788,000	0.99	$ 777,120
1	5 Year Review (2017)	$20,000	0.99	$ 19,724
2	Capital Costs MTTD (midpoint 2018)	$60,034,000	0.97	$ 58,387,700
2	Capital Costs - GWTP O&M	$788,000	0.97	$ 766,391
3	Capital Costs Thermal (midpoint 2019)	$40,125,000	0.96	$ 38,485,859
3	Capital Costs - GWTP O&M	$788,000	0.96	$ 755,810
4	Capital Costs - GWTP O&M/NAPL	$1,642,000	0.95	$ 1,553,178
5	Capital Costs - GWTP O&M/NAPL/Thermal	$9,194,000	0.93	$ 8,576,591
6	Capital Costs - GWTP O&M/NAPL/Thermal/EAB	$9,382,000	0.92	$ 8,631,131
6	5 Year Review (2022)	$20,000	0.92	$ 18,399
7	Capital Costs - GWTP O&M/Thermal/EAB	$8,528,000	0.91	$ 7,737,159
8	Capital Costs - GWTP O&M/Thermal/EAB	$8,528,000	0.89	$ 7,630,334
9	Capital Costs (Passive GWT System)	$1,149,000	0.88	$ 1,013,861
9	Capital Costs - GWTP O&M/Thermal/EAB	$8,528,000	0.88	$ 7,524,984
10	Annual O&M Costs	$472,000	0.87	$ 410,736
11	Annual O&M Costs	$284,000	0.86	$ 243,725
11	5 Year Review (2027)	$20,000	0.86	$ 17,164
12	Periodic Cost - Well Abandonment	$1,948,000	0.85	$ 1,648,669
12	Capital Costs (Final Cap + Concrete Perimeter Wall)	$15,463,000	0.85	$ 13,086,946
12	Annual O&M Costs	$284,000	0.85	$ 240,360
13	Annual O&M Costs	$284,000	0.83	$ 237,042
14	Annual O&M Costs	$284,000	0.82	$ 233,769
15	Annual O&M Costs	$284,000	0.81	$ 230,541
16	Annual O&M Costs	$284,000	0.80	$ 227,358
16	5 Year Review (2032)	$20,000	0.80	$ 16,011
17	Annual O&M Costs	$284,000	0.79	$ 224,219
18	Periodic Cost - GWTP Demolition	$1,000,000	0.78	$ 778,604
18	Annual O&M Costs	$284,000	0.78	$ 221,124
19	Annual O&M Costs	$284,000	0.77	$ 218,071
20	Annual O&M Costs	$284,000	0.76	$ 215,060
21	Annual O&M Costs	$284,000	0.75	$ 212,091
21	Annual O&M Costs	$284,000	0.75	$ 212,091
21	5 Year Review (2037)	$20,000	0.75	$ 14,936
22	Annual O&M Costs	$284,000	0.74	$ 209,162

Alternate 6 - MTTD and Thermal
Wyckoff/Eagle Harbor Soil and Groundwater OUs, Focused Feasibility Study

	Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)			NOTES
23	Maintain Onsite Roads				$25,000	0.73	$	18,158
23	Annual O&M Costs				$284,000	0.73	$	206,274
24	Annual O&M Costs				$284,000	0.72	$	203,426
25	Annual O&M Costs				$284,000	0.71	$	200,618
26	Annual O&M Costs				$284,000	0.70	$	197,848
26	5 Year Review (2042)				$20,000	0.70	$	13,933
27	Annual O&M Costs				$284,000	0.69	$	195,116
31	5 Year Review (2047)				$20,000	0.65	$	12,997
36	5 Year Review (2052)				$20,000	0.61	$	12,124
41	5 Year Review (2057)				$20,000	0.57	$	11,310
46	5 Year Review (2062)				$20,000	0.53	$	10,551
51	5 Year Review (2067)				$20,000	0.49	$	9,842
56	5 Year Review (2072)				$20,000	0.46	$	9,181
61	5 Year Review (2077)				$20,000	0.43	$	8,565
66	5 Year Review (2082)				$20,000	0.40	$	7,990
71	5 Year Review (2087)				$20,000	0.37	$	7,453
76	5 Year Review (2092)				$20,000	0.35	$	6,953
81	5 Year Review (2097)				$20,000	0.32	$	6,486
86	5 Year Review (2102)				$20,000	0.30	$	6,050
91	5 Year Review (2107)				$20,000	0.28	$	5,644
96	5 Year Review (2112)				$20,000	0.26	$	5,265
100	Final Completion Report (2116)				$150,000	0.25	$	37,350
TOTAL VALUE ANALYSIS					**$210,000,000**		**$197,700,000**	

This construction cost estimate is not an offer for construction and/or project execution. The construction cost estimate for this Design is an Association for the Advancement of Cost Engineering (AACE) Class 4 estimate and is assumed to represent the actual total installed cost. The estimate above is considered control-level cost estimating, suitable for use in project budgeting and planning. This estimate has been prepared with partial design and engineering calculations. The level of accuracy for the class of estimate defines the upper and lower ranges of the cost estimate. It is based upon the level of design detail and uncertainty associate with that level of detail. For a Class 4 estimate, the accuracy range is +50% to -30%. It would appear prudent that internal budget allowances account for the highest cost indicated by this range as well as other site specific allowances. The cost estimate has been prepared for guidance in project evaluation and implementation from the information available at the time of the estimate. The final costs of the project will depend on actual labor and material costs, competitive market conditions, implementation schedule, and other variable factors. As a result, the final project costs will vary from the estimates presented herein. Because of this, project feasibility and funding needs must be carefully reviewed prior to making specific financial decisions to help ensure proper project evaluation and adequate funding.

Alternate 7 - ISS and Thermal
Wyckoff/Eagle Harbor Soil and Groundwater OUs, Focused Feasibility Study

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
CAPITAL COSTS					
GENERAL SITE ACTIVITIES					
Pre-construction Activities - Common Elements (2017)					
Permitting	1	LS	$20,000	$20,000	Excavation/Grading/Drilling/Ecological
Precon Submittals	1	LS	$54,000	$54,000	WP/H&SP/AHAs/Schedule
Mobilization/Demobilization	1	LS	$118,000	$118,000	
Community Relations	1	LS	$169,000	$169,000	
Site Preparation	1	LS	$52,000	$52,000	WP/H&SP/AHAs/Schedule
Surveying - General	50	DY	$2,900	$145,000	
Project Management	6%		$558,000	$33,480	USEPA 540-R-00-002 Guidance Document
Construction Management	8%		$558,000	$44,640	USEPA 540-R-00-002 Guidance Document
Remedial Design	12%		$558,000	$66,960	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$703,080	$175,770	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$879,000**	
Access Roads (2017)					
Erosion Controls	1,500	LF	$10	$15,000	
Roadway Grading	1,955	CY	$50	$97,750	
P/D/P 3" Agg Base	725	TN	$10	$7,250	
P/D/P/Seal 4" AC Pavement	260	TN	$190	$49,400	
Erosion Control Matting	1,445	sy	$10	$14,450	
Project Management	8%		$183,850	$14,708	USEPA 540-R-00-002 Guidance Document
Construction Management	10%		$183,850	$18,385	USEPA 540-R-00-002 Guidance Document
Remedial Design	15%		$183,850	$27,578	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$244,521	$61,130	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$306,000**	
Demolition - Concrete Structures (2018)					
Surface Decontamination	7,200	SY	$10.00	$72,000	
Concrete Demolition - Easy	2,010	CY	$40.00	$80,400	
Concrete Demolition - Difficult	6,020	CY	$70.00	$421,400	
Concrete Crushing	8,030	CY	$70.00	$562,100	
Spread Crushed Concrete Oniste	8,030	CY	$20.00	$160,600	
Recycle Rebar	650	TN	-$290.00	-$188,500	
Odor Control	12	WK	$9,700	$116,400	Allowance
Level C PPE Upgrade	1	LS	$250,900	$250,900	Allowance
Project Management	6%		$1,475,300	$88,518	USEPA 540-R-00-002 Guidance Document
Construction Management	8%		$1,475,300	$118,024	USEPA 540-R-00-002 Guidance Document
Remedial Design	12%		$1,475,300	$177,036	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$1,858,878	$464,720	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$2,324,000**	
Debris Removal - Site Wide (2018)					
Excavation/Debris Removal (5-ft)	66,578	CY	$10	$665,780	
Odor Control	12	WK	$9,700	$116,400	
Backfill - Site Wide	66,578	CY	$2	$133,156	
T&D Debris - Hazardous	900	TN	$1,000	$900,000	
Level C PPE Upgrade	1	LS	$332,890.00	$332,890	Allowance
Project Management	5%		$2,148,226	$107,411	USEPA 540-R-00-002 Guidance Document
Construction Management	6%		$2,148,226	$128,894	USEPA 540-R-00-002 Guidance Document
Remedial Design	8%		$2,148,226	$171,858	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$2,556,389	$639,097	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$3,195,000**	

Alternate 7 - ISS and Thermal
Wyckoff/Eagle Harbor Soil and Groundwater OUs, Focused Feasibility Study

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
Rock/Soil/Bulkhead Removal (2018)					
Rock Removal	16,857	CY	$50	$842,850	
Excavate Behind Exist SP Wall	28,393	CY	$30	$851,790	
Bulkhead Removal	2,696	CY	$20	$53,920	
T&D Bulkhead Debris - Hazardous	2,022	TN	$1,000	$2,022,000	
T&D Bulkhead Debris - Non Haz	2,022	TN	$250	$505,500	
Backfill Existing Sheet Pile Wall	28,393	CY	$20	$567,860	
Crush Rock	16,857	CY	$10	$168,570	
Spread Crushed Material Onsite	16,857	CY	$20	$337,140	
Odor Control	12	WK	$9,700	$116,400	Allowance
Level C PPE Upgrade	1	LS	$425,895	$425,895	Allowance
Project Management	5%		$5,891,925	$294,596	USEPA 540-R-00-002 Guidance Document
Construction Management	6%		$5,891,925	$353,516	USEPA 540-R-00-002 Guidance Document
Remedial Design	8%		$5,891,925	$471,354	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$7,011,391	$1,752,848	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$8,764,000**	
Miscellaneous Demolition (2018)					
Remove/Dispose Asphalt	233	CY	$100	$23,300	HCSS Estimate
Remove/Dispose of Pilot Plant Pipe	1	LS	$20,000	$20,000	Engineer's Estimate
Remove/Dispose Pilot Plant SP	24,300	SF	$30	$729,000	Engineer's Estimate
Remove/Dispose NW Beach SP	13,280	SF	$30	$398,400	HCSS Estimate
Remove/Dispose Tanks & Equip	1	LS	$119,000	$119,000	HCSS Estimate
Odor Control	4	WK	$9,700	$38,800	Allowance
Level C PPE Upgrade	1	LS	$575,350	$575,350	Allowance
Project Management	5%		$1,903,850	$95,193	USEPA 540-R-00-002 Guidance Document
Construction Management	6%		$1,903,850	$114,231	USEPA 540-R-00-002 Guidance Document
Remedial Design	8%		$1,903,850	$152,308	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$2,265,582	$566,395	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$2,832,000**	
Storm Water Infiltration Trench (2021)					
Excavation	2,800	CY	$17	$47,600	
P/D Drain Gravel	4,536	TN	$24	$108,864	
Spread Drain Gravel	6,400	TN	$9	$57,600	
Project Management	8%		$214,064	$17,125	USEPA 540-R-00-002 Guidance Document
Construction Management	10%		$214,064	$21,406	USEPA 540-R-00-002 Guidance Document
Remedial Design	15%		$214,064	$32,110	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$284,705	$71,176	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$214,000**	
Non-ISS New Perimeter Sheet Pile Wall (2019)					
P/D AZ50 Sheet Pile	3,700	TN	$1,900	$7,030,000	Vendor Quote
Unload Sheet Pile	169	LD	$2,300	$388,700	
Install Perimeter SP Wall (AZ50)	142,200	SF	$11	$1,564,200	
Project Management	5%		$8,982,900	$449,145	USEPA 540-R-00-002 Guidance Document
Construction Management	6%		$8,982,900	$538,974	USEPA 540-R-00-002 Guidance Document
Remedial Design	8%		$8,982,900	$718,632	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$10,689,651	$2,672,413	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$13,362,000**	
Non-ISS Concrete Perimeter Wall (2019)					
Excavation - Non-ISS Perimeter Wall	14,646	CY	$63	$922,698	
Install Concrete Plug	1,475	CY	$220	$324,500	
Odor Control	8	WK	$9,700	$77,600	Allowance
P/D/I Rebar	1,100	TN	$3,100	$3,410,000	
P/D/I Concrete	13,201	CY	$220	$2,904,220	

Alternate 7 - ISS and Thermal
Wyckoff/Eagle Harbor Soil and Groundwater OUs, Focused Feasibility Study

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
Project Management	5%		$7,639,018	$381,951	USEPA 540-R-00-002 Guidance Document
Construction Management	6%		$7,639,018	$458,341	USEPA 540-R-00-002 Guidance Document
Remedial Design	8%		$7,639,018	$611,121	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$9,090,431	$2,272,608	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$11,363,000**	
Construct Outfall (2027)					
P/D AZ36-700N Sheet Pile	90	TN	$1,700	$153,036	
Unload Sheet Pile	5	LD	$2,100	$10,500	
Install Sheet Pile	3,500	SF	$10	$35,000	
Dewatering	20	DY	$800	$16,000	
HDD, Pipe, and Marine	1	LS	$1,500,000	$1,500,000	Vendor Quote
Onshore Construction	1	LS	$500,000	$500,000	
Project Management	5%		$2,214,536	$110,727	USEPA 540-R-00-002 Guidance Document
Construction Management	6%		$2,214,536	$132,872	USEPA 540-R-00-002 Guidance Document
Remedial Design	8%		$2,214,536	$177,163	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$2,635,298	$658,824	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$3,294,000**	
Final Site Cap (2034)					
Subgrade Preparation	39,150	SY	$3.00	$117,450	HCSS Estimate
P/D/P Embankment Fill	13,917	CY	$20.00	$278,340	HCSS Estimate
Geomembrane Cover	39,150	SY	$6.75	$264,263	Engineer's Estimate
Geomembrane Penetrations	13	EA	$500	$6,500	Engineer's Estimate
Cushion Geotextile	39,150	SY	$2.25	$88,088	Engineer's Estimate
P/D/P Granular Drain Mat'l	21,000	TN	$30.00	$630,000	HCSS Estimate
P/D/P Topsoil Layer	21,100	TN	$60.00	$1,266,000	HCSS Estimate
Survey	22	DY	$2,900.00	$63,800	HCSS Estimate
Restoration	13	AC	$3,200.00	$41,600	Engineer's Estimate
Project Management	5%		$2,756,040	$137,802	USEPA 540-R-00-002 Guidance Document
Construction Management	6%		$2,756,040	$165,362	USEPA 540-R-00-002 Guidance Document
Remedial Design	8%		$2,756,040	$220,483	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$3,279,688	$819,922	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$4,100,000**	
Non-ISS Passive Drainage System (2022)					
MH Excavations, Non-ISS PWT	1,500	CY	$35	$52,500	
P/D/I Manholes & Bases	10	EA	$17,000	$170,000	
Install Contech GAC Storm Filters	1	LS	$15,000	$15,000	
Discharge Line Penetration/Install	10	EA	$6,900	$69,000	
Backfill Manholes	1,500	CY	$31	$46,500	
Excavate French Drains	4,750	CY	$18	$85,500	
P/D/I 12", Slotted HDPE	2,000	LF	$55	$110,000	
Backfill French Drains	4,750	CY	$24	$114,000	
Repair Cap	1,000	SY	$67	$67,000	
Project Management	6%		$729,500	$43,770	USEPA 540-R-00-002 Guidance Document
Construction Management	8%		$729,500	$58,360	USEPA 540-R-00-002 Guidance Document
Remedial Design	12%		$729,500	$87,540	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$919,170	$229,793	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$1,149,000**	

Alternate 7 - ISS and Thermal
Wyckoff/Eagle Harbor Soil and Groundwater OUs, Focused Feasibility Study

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
REMEDIAL ACTION ALTERNATIVE					
Alternative 7 - ISS EXPANDED CORE					
Pre-construction Activities (ISS Subcontractor)					
Permitting	1	LS	$10,000	$10,000	Allowance
Precon Submittals	1	LS	$50,000	$50,000	
Site Preparation	1	LS	$50,000	$50,000	Erosion Controls, Staging/Stockpile Areas
Survey (Throughout Project)	50	DY	$2,900	$145,000	
			Subtotal:	**$255,000**	
MOBILIZATION					
Equipment Costs (Transportation)					
ISS Crane	1	ea	$60,000	$60,000	Engineer's Estimate
Drilling Attachment	1	ea	$38,000	$38,000	Engineer's Estimate
Grout Pump, Hose, Washout Tank	1	ea	$28,000	$28,000	Engineer's Estimate
Storage Silo (Pig)	1	ea	$3,200	$3,200	Engineer's Estimate
Batch Plan and Silo(s)	1	ea	$34,500	$34,500	Engineer's Estimate
Crane Mats	2	ea	$3,200	$6,400	Engineer's Estimate
Crew Truck	2	ea	$1,500	$3,000	Engineer's Estimate
Tool Truck	1	ea	$1,500	$1,500	Engineer's Estimate
Project Trailer and Generator	2	ea	$4,000	$8,000	Engineer's Estimate
Forklift	1	ea	$2,000	$2,000	Engineer's Estimate
Manlift	1	ea	$2,000	$2,000	Engineer's Estimate
Excavator, CAT 336D	1	ea	$2,500	$2,500	Engineer's Estimate
Excavator, CAT 345D	1	ea	$2,500	$2,500	Engineer's Estimate
Loader, CAT 966H	1	ea	$2,000	$2,000	Engineer's Estimate
Bulldozer, CAT D6K LGP	1	ea	$2,000	$2,000	Engineer's Estimate
Equipment Costs (4 week Mob)					
ISS Rig - Manitowoc/Attachment	4	wk	$21,100	$84,400	Engineer's Estimate
Batch Plant and Silo(s)	4	wk	$3,900	$15,600	Engineer's Estimate
Grout Pumping System/Metering	4	wk	$3,000	$12,000	Engineer's Estimate
Hose, Connectors, Whip Checks	4	wk	$1,600	$6,400	Engineer's Estimate
Wash Down Tank	4	wk	$1,500	$6,000	Engineer's Estimate
Drill Tools	4	wk	$2,500	$10,000	Engineer's Estimate
Horizontal Storage Silo (Pig)	4	wk	$750	$3,000	Engineer's Estimate
Forklift, CAT 1255 12k#	4	wk	$3,500	$14,000	Engineer's Estimate
Manlift, 60-ft	4	wk	$2,000	$8,000	Engineer's Estimate
Excavator, CAT 336D	4	wk	$6,000	$24,000	Engineer's Estimate
Excavator, CAT 345D	4	wk	$7,100	$28,400	Engineer's Estimate
Loader, CAT 966H	4	wk	$4,000	$16,000	Engineer's Estimate
Bulldozer, CAT D6K LGP	4	wk	$3,500	$14,000	Engineer's Estimate
Crew Truck	8	wk	$1,200	$9,600	Engineer's Estimate
Tool Truck	4	wk	$1,100	$4,400	Engineer's Estimate
Subcontractors					
Electrical	1	LS	$15,000	$15,000	Engineer's Estimate
Welders	1	LS	$25,000	$25,000	Engineer's Estimate
Personnel (50 hr/wk)					
Batch Plan Operator	4	wk	$5,000	$20,000	Engineer's Estimate
Crane Operator	4	wk	$5,500	$22,000	Engineer's Estimate
Equipment Operator	8	wk	$4,950	$39,600	Engineer's Estimate
ISS Attachment Operator	4	wk	$4,950	$19,800	Engineer's Estimate
Labor, Foreman	4	wk	$3,850	$15,400	Engineer's Estimate
Labor, General	8	wk	$3,575	$28,600	Engineer's Estimate
ISS Superintendent	4	wk	$6,600	$26,400	Engineer's Estimate
QA/QC Manager	4	wk	$6,875	$27,500	Engineer's Estimate
Safety Manager	4	wk	$6,875	$27,500	Engineer's Estimate
Miscellaneous					
Derrick/barge/tug, 2 days+tug+plus fuel	1	ls	$100,000	$100,000	Allowance
Mob/Demob Derrick/Barge/tug	1	ls	$100,000	$100,000	Allowance
Crane Mat Purchase	30	ea	$2,500	$75,000	Engineer's Estimate
Miscellaneous Tools and Supplies	1	ls	$12,500	$12,500	Engineer's Estimate
Per Diem	308	day	$129	$39,732	Standard Per Diem Rate = Washington
			Subtotal:	**$1,045,432**	

Alternate 7 - ISS and Thermal
Wyckoff/Eagle Harbor Soil and Groundwater OUs, Focused Feasibility Study

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
Install Monitoring Wells (2016)					
Mob/Demob	1	ls	$5,000	$5,000	Vendor Quote
Install MW - Alt 4	20	ea	$15,750	$315,000	70-ft bgs
Develop Wells - Alt 4	20	ea	$1,600	$32,000	Engineer's Estimate
			Subtotal:	**$352,000**	
CORE AREA EXCAVATION (7-FT)					
Equipment					
Excavator, CAT345D	9	wk	$7,100	$63,900	Engineer's Estimate
Loader, CAT 966H	9	wk	$4,000	$36,000	Engineer's Estimate
Water Truck	2	wk	$2,500	$5,000	Engineer's Estimate
Crew Truck	9	wk	$1,200	$10,800	Engineer's Estimate
Personnel (70 hr/wk)					
Equipment Operator	18	wk	$8,100	$145,800	Engineer's Estimate
Water Truck Driver	2	wk	$7,200	$14,400	Engineer's Estimate
Labor, Foreman	9	wk	$6,300	$56,700	Engineer's Estimate
Labor, General	18	wk	$5,850	$105,300	Engineer's Estimate
Miscellaneous					
Stockpile Management	52	wk	$350	$18,200	Engineer's Estimate
Per Diems	331	day	$129	$42,699	Standard Per Diem Rate = Washington
			Subtotal:	**$498,799**	
AUGER MIX ISS (7 days/week)					
Equipment					
ISS Rig - Manitowoc/Attacment	68	wk	$21,100	$1,434,800	Engineer's Estimate
Batch Plant and Silo(s)	68	wk	$3,900	$265,200	Engineer's Estimate
Grout Pumping System/Metering	68	wk	$3,000	$204,000	Engineer's Estimate
Hose, Connectors, Whip Checks	68	wk	$1,600	$108,800	Engineer's Estimate
Wash Down Tank	68	wk	$1,500	$102,000	Engineer's Estimate
Drill Tools	68	wk	$2,500	$170,000	Engineer's Estimate
Horizontal Storage Silo (Pig)	68	wk	$750	$51,000	Engineer's Estimate
Teeth replacement/Tooth Packets	68	wk	$750	$51,000	Engineer's Estimate
Forklift, CAT TL1255 12k#	68	wk	$3,500	$238,000	Engineer's Estimate
Manlift	68	wk	$2,000	$136,000	Engineer's Estimate
Excavator, CAT345D	68	wk	$7,100	$482,800	Engineer's Estimate
Generator, 350 kW	68	wk	$5,000	$340,000	Engineer's Estimate
Generator Fuel	76,160	gal	$4	$304,640	Engineer's Estimate
Crew Truck	136	wk	$1,200	$163,200	Engineer's Estimate
Tool Truck	68	wk	$1,100	$74,800	Engineer's Estimate
Subcontractors					
Electrical	1	ls	$15,000	$15,000	Engineer's Estimate
Welders	1	ls	$25,000	$25,000	Engineer's Estimate
Personnel (70 hr/wk)					
Batch Plant Operator	68	wk	$9,000	$612,000	Engineer's Estimate
Crane Operator	68	wk	$9,000	$612,000	Engineer's Estimate
Equipment Operator	68	wk	$8,100	$550,800	Engineer's Estimate
ISS Attachment Operator	68	wk	$8,100	$550,800	Engineer's Estimate
Labor, Foreman	68	wk	$6,300	$428,400	Engineer's Estimate
Labor, General	136	wk	$5,850	$795,600	Engineer's Estimate
ISS Superintendent	68	wk	$10,800	$734,400	Engineer's Estimate
QA/QC Manager	68	wk	$11,250	$765,000	Engineer's Estimate
Safety Manager	68	wk	$11,250	$765,000	Engineer's Estimate
Materials					
P/D Portland Cement	25,338	tn	$125	$3,167,227	Engineer's Estimate
P/D Bentonite	1,267	tn	$325	$411,739	Engineer's Estimate
Miscellaneous					
Per Diems	4,760	day	$129	$614,040	Standard Per Diem Rate = Washington
			Subtotal:	**$14,173,246**	
EX-SITU SOIL MIXING AND PLACEMENT					
Equipment					
Excavator, CAT 336D	12	wk	$6,000	$72,000	Engineer's Estimate
Loader, CAT 966H	12	wk	$4,000	$48,000	Engineer's Estimate
Bulldozer, CAT D6K LGP	12	wk	$3,500	$42,000	Engineer's Estimate
Water Truck	12	wk	$2,500	$30,000	Engineer's Estimate

Alternate 7 - ISS and Thermal
Wyckoff/Eagle Harbor Soil and Groundwater OUs, Focused Feasibility Study

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
Personnel (70 hrs/wk)					
Equipment Operator	24	wk	$8,100	$194,400	Engineer's Estimate
Water Truck Driver	12	wk	$7,200	$86,400	Engineer's Estimate
Labor, Foreman	12	wk	$6,300	$75,600	Engineer's Estimate
Labor, General	24	wk	$5,850	$140,400	Engineer's Estimate
Materials					
P/D Portland Cement	5,847	TN	$125	$730,898	Engineer's Estimate
P/D Bentonite	292	TN	$325	$95,017	Engineer's Estimate
Miscellaneous					
Per Diems	504	day	$129	$65,016	Standard Per Diem Rate = Washington
			Subtotal:	**$1,579,731**	
DEMOBILIZATION (5-days/week)					
Equipment Costs (Transportation)					
ISS Crane	1	ea	$30,000	$30,000	Engineer's Estimate
Drilling Attachment	1	ea	$19,000	$19,000	Engineer's Estimate
Grout Pump, Hose, Washout Tank	1	ea	$14,000	$14,000	Engineer's Estimate
Storage Silo (Pig)	1	ea	$1,600	$1,600	Engineer's Estimate
Batch Plan and Silo(s)	1	ea	$17,250	$17,250	Engineer's Estimate
Crane Mats	2	ea	$1,600	$3,200	Engineer's Estimate
Crew Truck	2	ea	$750	$1,500	Engineer's Estimate
Tool Truck	1	ea	$750	$750	Engineer's Estimate
Project Trailer and Generator	2	ea	$2,000	$4,000	Engineer's Estimate
Forklift, CAT TL1255 12k#	1	ea	$1,000	$1,000	Engineer's Estimate
Manlift	1	ea	$1,000	$1,000	Engineer's Estimate
Excavator, CAT336D	1	ea	$1,250	$1,250	Engineer's Estimate
Excavator, CAT345D	1	ea	$1,250	$1,250	Engineer's Estimate
Loader, CAT 966H	1	ea	$1,000	$1,000	Engineer's Estimate
Bulldozer, CAT D6K LGP	1	ea	$1,000	$1,000	Engineer's Estimate
Equipment Costs (2 week demob)					
ISS Rig - Manitowoc/Attachment	2	wk	$21,100	$42,200	Engineer's Estimate
Batch Plant and Silo(s)	2	wk	$3,900	$7,800	Engineer's Estimate
Grout Pumping System/Metering	2	wk	$3,000	$6,000	Engineer's Estimate
Hose, Connectors, Whip Checks	2	wk	$1,600	$3,200	Engineer's Estimate
Wash Down Tank	2	wk	$1,500	$3,000	Engineer's Estimate
Drill Tools	2	wk	$2,500	$5,000	Engineer's Estimate
Horizontal Storage Silo (Pig)	2	wk	$750	$1,500	Engineer's Estimate
Forklift, CAT TL1255 12k#	2	wk	$3,500	$7,000	Engineer's Estimate
Manlift	2	wk	$2,000	$4,000	Engineer's Estimate
Excavator, CAT 336D	2	wk	$6,000	$12,000	Engineer's Estimate
Excavator, CAT 345D	2	wk	$7,100	$14,200	Engineer's Estimate
Loader, CAT 966H	2	wk	$4,000	$8,000	Engineer's Estimate
Bulldozer, CAT D6K LGP	2	wk	$3,500	$7,000	Engineer's Estimate
Crew Trucks	4	wk	$1,200	$4,800	Engineer's Estimate
Tool Truck	2	wk	$1,100	$2,200	Engineer's Estimate
Personnel (50 hrs/wk)					
Batch Plan Operator	2	wk	$5,000	$10,000	Engineer's Estimate
Crane Operator	2	wk	$5,500	$11,000	Engineer's Estimate
Equipment Operator	4	wk	$4,950	$19,800	Engineer's Estimate
ISS Attachment Operator	2	wk	$4,950	$9,900	Engineer's Estimate
Labor, General	4	wk	$3,575	$14,300	Engineer's Estimate
Labor, Foreman	2	wk	$3,850	$7,700	Engineer's Estimate
ISS Superintendent	2	wk	$6,600	$13,200	Engineer's Estimate
QA/QC Manager	2	wk	$6,875	$13,750	Engineer's Estimate
Safety Manager	2	wk	$6,875	$13,750	Engineer's Estimate
Miscellaneous					
Derrick/barge/tug, 2 days+tug+plus fuel	1	ls	$50,000	$50,000	Allowance
Mob/Demob Derrick/Barge/tug	1	ls	$50,000	$50,000	Allowance
Per Diems	196	day	$129	$25,284	Standard Per Diem Rate = Washington
			Subtotal:	**$464,384**	

Alternate 7 - ISS and Thermal
Wyckoff/Eagle Harbor Soil and Groundwater OUs, Focused Feasibility Study

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
PROJECT MANAGEMENT	5%		$18,368,592	$918,430	Based on EPA 540-R-00-002
CONSTRUCTION MANAGEMENT	6%		$18,368,592	$1,102,116	Based on EPA 540-R-00-002
REMEDIAL DESIGN	6%		$18,368,592	$1,102,116	Based on EPA 540-R-00-002
CONSTRUCTION COMPLETION REPORT	1	LS	$100,000	$100,000	
			Subtotal:	**$3,222,661**	
CONTINGENCY (10% scope + 15% bid)	25%		$21,591,253	$5,397,813	Based on EPA 540-R-00-002
TOTAL CAPITAL COSTS FOR ISS				**$26,989,000**	
Alternative 7 - EAB NAPL Recovery and Thermal (2018&2019)					
Pre-construction Activities - Phase I					
Permitting	1	LS	$10,000	$10,000	Allowance
Precon Submittals	1	LS	$50,000	$50,000	
Mobilization	-	LS	$100,000	$0	Engineer's Estimate
Site Preparation	1	LS	$50,000	$50,000	
NAPL Recovery - Phase I					
Install Injection Wells Phase I	8	ea	$15,000	$120,000	Engineer's Estimate
Injection Well Completions Phase I	8	ea	$450	$3,600	Engineer's Estimate
Water Re-Injection Well Piping/System	1	ls	$12,360	$12,360	Engineer's Estimate
Install Extraction Wells Phase I	30	ea	$5,700	$171,000	Engineer's Estimate
Extraction Well Completions Phase I	30	ea	$450	$13,500	Engineer's Estimate
Install Extraction Well Head System I	30	ea	$8,950	$268,500	Engineer's Estimate
Allowance for Extraction Valves/I&C Phase I	1	ls	$20,408	$20,408	Engineer's Estimate
Corrosion Protection for wells Phase I	30	ls	$500	$15,000	Engineer's Estimate
PROJECT MANAGEMENT	6%		$734,368	$44,062	Based on EPA 540-R-00-002
CONSTRUCTION MANAGEMENT	8%		$734,368	$58,749	Based on EPA 540-R-00-002
REMEDIAL DESIGN	12%		$734,368	$88,124	Based on EPA 540-R-00-002
CONSTRUCTION COMPLETION REPORT	1	LS	$20,000	$20,000	
CONTINGENCY (10% scope + 15% bid)	25%		$945,304	$236,326	Based on EPA 540-R-00-002
			Subtotal:	**$1,181,630**	
Extraction System Installation- Phase I					
Install New Extraction Wells	6	ea	$20,000	$120,000	Vendor Quote
Refurbish Existing Wells	2	ea	$2,300	$4,600	Vendor Quote
Well Surface Completions	6	ea	$1,000	$6,000	Vendor Quote
Install New Well Pumps	6	ea	$56,000	$336,000	Vendor Quote - Incl. valves, piping, flowmeter, pumps
Wellhead Infrastructure	6	ea	$10,000	$60,000	12'x8'x1' Vault, w/ sump
Pipe Rack and Fittings	1	ls	$10,000	$10,000	Allowance
3" FRP Piping	2,100	LF	$22	$46,200	
FRP Valves, Fittings, Insulation	1	ls	$11,550	$11,550	Allowance: 25% of piping cost
I&C	6	ea	$5,000	$30,000	Allowance
Electrical (Power and I&C)	1	ls	$100,800	$100,800	Allowance: 30% of installed pump cost
GWTP Modifications	1	ls	$50,000	$50,000	Allowance for GWTP I&C modifications
PROJECT MANAGEMENT	6%		$775,150	$46,509	Based on EPA 540-R-00-002
CONSTRUCTION MANAGEMENT	8%		$775,150	$62,012	Based on EPA 540-R-00-002
REMEDIAL DESIGN	12%		$775,150	$93,018	Based on EPA 540-R-00-002
CONSTRUCTION COMPLETION REPORT	1	LS	$20,000	$20,000	
CONTINGENCY (10% scope + 15% bid)	25%		$996,689	$249,172	Based on EPA 540-R-00-002
			Subtotal Phase I GW Extraction:	**$1,245,861**	
EAB - Phase I					
Install Biosparge Wells	27	ea	$5,000	$135,000	Engineer's Estimate
Biosparge Well Completions	27	ea	$350	$9,450	Engineer's Estimate
Install Biosparge Wellhead and Header Piping/Valves	27	ea	$625	$16,875	Engineer's Estimate
Air Supply Piping Header EAB	1,600	ft	$10	$16,000	Engineer's Estimate
Installation of 6' Pipe Rack	620	ea	$400	$248,000	Engineer's Estimate
Installation of 15' Pipe Rack	84	ea	$750	$63,000	Engineer's Estimate
P/D Air Compressor	1	ea	$50,000	$50,000	Engineer's Estimate

Alternate 7 - ISS and Thermal
Wyckoff/Eagle Harbor Soil and Groundwater OUs, Focused Feasibility Study

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
PROJECT MANAGEMENT	8%		$538,325	$43,066	Based on EPA 540-R-00-002
CONSTRUCTION MANAGEMENT	10%		$538,325	$53,833	Based on EPA 540-R-00-002
REMEDIAL DESIGN	15%		$538,325	$80,749	Based on EPA 540-R-00-002
CONSTRUCTION COMPLETION REPORT	1	LS	$20,000	$20,000	
CONTINGENCY (10% scope + 15% bid)	25%		$735,972	$183,993	Based on EPA 540-R-00-002
			Subtotal Phase I EAB:	**$920,000**	
			Subtotal for Phase I:	**$3,347,491**	
Thermal Enhanced NAPL Recovery - Phase II					
Install Injection Wells Phase II	39	ea	$15,000	$585,000	Engineer's Estimate
Injection Well Completions Phase II	39	ea	$450	$17,550	Engineer's Estimate
Thermal Injection Well Piping/System	1	ls	$120,510	$120,510	Engineer's Estimate
Install Extraction Wells Phase II	67	ea	$5,700	$381,900	
Extraction Well Completions Phase II	67	ea	$450	$30,150	
Install Extraction Well Head System II	67	ea	$4,250	$284,750	
Install Thermocouple Borings	97	ea	$2,800	$271,600	Engineer's Estimate
Purchase Thermocouple Strings	97	ea	$1,500	$145,500	Engineer's Estimate
Thermocouple Completions	97	ea	$350	$33,950	Engineer's Estimate
Surface Top Coarse (6")	2,966	tn	$10	$29,660	Engineer's Estimate
Steam Supply Header Materials	2,336	ft	$45	$105,135	Engineer's Estimate
Allowance for Steam Valves/I&C	1	ls	$21,027	$21,027	Engineer's Estimate
Air Supply Piping - GW Pumps Phase II	4,719	ft	$10	$47,195	Engineer's Estimate
Extracted Water Piping Phase II	4,719	ft	$20	$94,389	Engineer's Estimate
Allowance for Extraction Valves/I&C Phase II	1	ls	$45,578	$45,578	Engineer's Estimate
Corrosion Protection for wells Phase II	106		$500	$53,000	Engineer's Estimate
GW Treatment System Upgrades - Phase II					
Site Preparation	1	ls	$30,000	$30,000	Engineer's Estimate
Concrete Slab on Grade	700	cy	$350	$245,000	Engineer's Estimate
Secondary Containment Walls	6.5	CY	$350	$2,275	Engineer's Estimate
P/D Diesel Generators	1	ea	$600,000	$600,000	Engineer's Estimate
P/D Cooling Tower	1	ea	$20,500	$20,500	Engineer's Estimate
Cooling Water Chemical/Makeup Treatment Systems	0.25	ls	$150,000	$37,500	Allowance
P/D Heat Exchanger H-1	4	ea	$11,500	$46,000	Engineer's Estimate
P/D Accumulation Tank	1	ea	$97,000	$97,000	Engineer's Estimate
P/D Oil/Water Separator	1	ea	$155,000	$155,000	Engineer's Estimate
P/D Solids NAPL Holding Tank	1	ea	$92,000	$92,000	Engineer's Estimate
P/D Air Compressor	1	ea	$11,000	$11,000	Engineer's Estimate
P/D Pumps	6	ea	$10,000	$60,000	Engineer's Estimate
Equipment Installation (15% of equipment cost)	1	ls	$167,850	$167,850	Allowance
Process Piping (5% of equip cost)	1	ls	$55,950	$55,950	Allowance
I&C (15% of equipment cost)	1	ls	$167,850	$167,850	Allowance
Electrical (20% of equipment cost)	1	ls	$223,800	$223,800	Allowance
Solids Handling Rain Shelter	600	sf	$200	$120,000	Allowance
Electrical/I&C Building	1	ls	$36,000	$36,000	Allowance
Boiler Propane System- Phase II					
Site Preparation	1	ls	$15,000	$15,000	Engineer's Estimate
Concrete Slab on Grade	50	cy	$350	$17,500	Engineer's Estimate
Install Propane Tank	1	ls	$30,000	$30,000	Allowance
Install Vaporizer	1	ls	$30,000	$30,000	Allowance
Setup Boiler System	1	ls	$75,000	$75,000	Allowance
Steam Generator Purchase	1	ea	$291,895	$291,895	Nationwide Boiler Quote. Includes softener and feed
PROJECT MANAGEMENT	5%		$4,894,014	$244,701	Based on EPA 540-R-00-002
CONSTRUCTION MANAGEMENT	6%		$4,894,014	$293,641	Based on EPA 540-R-00-002
REMEDIAL DESIGN	8%		$4,894,014	$391,521	Based on EPA 540-R-00-002
CONSTRUCTION COMPLETION REPORT	1	LS	$80,000	$80,000	
			Subtotal Boiler System Phase II:	**$5,903,877**	
CONTINGENCY (10% scope + 15% bid)	25%		$5,903,877	$1,475,969	Based on EPA 540-R-00-002
			Subtotal for Phase II Thermal Enhancement:	**$7,379,846**	

Alternate 7 - ISS and Thermal
Wyckoff/Eagle Harbor Soil and Groundwater OUs, Focused Feasibility Study

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
Alternative 7 - Well Abandonment and GWTP Demolition					
Well Abandonment (2023)					
Driller Mobilization/Demob	1	ls	$5,000	$5,000	Vendor Quote
Abandon 2-in Wells	195	ea	$1,300	$253,500	Vendor Quote
Abandon 4-in Wells	357	ea	$2,550	$910,350	Vendor Quote
PROJECT MANAGEMENT	6%		$1,168,850	$70,131	Based on EPA 540-R-00-002
CONSTRUCTION MANAGEMENT	8%		$1,168,850	$93,508	Based on EPA 540-R-00-002
REMEDIAL DESIGN	12%		$1,168,850	$140,262	Based on EPA 540-R-00-002
REPORTING	1	ls	$25,000	$25,000	
			Subtotal:	**$1,498,000**	
GWTP Demolition (2033)	1	ls	$1,000,000	$1,000,000	Allowance
			Subtotal:	**$1,000,000**	

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
OPERATION & MAINTENANCE COSTS OF GWTP (2018 - 2033: Phase I and Phase II					
Annual O&M					
Operator(s)	4,160	hr	$80	$332,800	2 FTEs Operating GWTP
Electrical Usage	1	ls	$60,000	$60,000	Current usage is $4k/mo to pump 65 gpm, scaled up
Waste Disposal	1	ls	$100,000	$100,000	Allowance: NAPL and spent carbon disposal
Chemicals/Media	1	ls	$20,000	$20,000	Allowance
Maintenance	10%		$512,800	$51,280	Allowance
Quarterly GW Sampling	4	ea	$10,000	$40,000	
Annual GW Sampling	1	ls	$50,000	$50,000	
Contech GAC Filled Storm Filter Change out	-	ea	$200	$0	Annual change out/recycle of 7 filters in 10 MHs
Undefined Scope Allowance	10%		$654,080	$65,408	
PROJECT MANAGEMENT	6%		$719,488	$43,169	Based on EPA 540-R-00-002
REPORTING	1		$25,000	$25,000	
TOTAL O&M COSTS - GWTP				**$788,000**	

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
OPERATION & MAINTENANCE COSTS OF NAPL RECOVERY (2018 through 2022) - Phase I					
Annual O&M					
Operator(s)	1,040	hr	$80	$83,200	1/2 yr running EAB System
Supervisor	208	hr	$100	$20,800	20% of operator time
Disposal - NAPL Waste	4,000	gal	$7	$28,000	Vendor Quote; 20,000-gal over 5 yrs
Transportation - NAPL Waste	2	load	$6,400	$12,800	Vendor Quote
GWTP Chemicals/Media	-	ls	$20,000	$0	
Well field Analysis&Sampling Team	260	hr	$80	$20,800	Engineer's Estimate
Laboratory Analysis	40	ls	$300	$12,000	Engineer's Estimate
PPE Allowance	1,040	hr	$15	$15,600	Allowance
Maintenance	10%		$89,200	$8,920	Allowance
Undefined Scope Allowance	10%		$98,120	$9,812	
PROJECT MANAGEMENT	6%		$107,932	$6,476	
REPORTING	1		$25,000	$25,000	
TOTAL ANNUAL O&M COSTS - NAPL RECOVERY				**$243,000**	

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
OPERATION & MAINTENANCE COSTS OF EAB (2018 through 2032) - Phase I & Phase II					
EAB					
Operator(s)	1,040	hr	$80	$83,200	1/2 yr running EAB System
Supervisor	208	hr	$100	$20,800	20% of operator time
Electrical	1	ls	$16,000	$16,000	Engineer's Estimate
Nutrient Chemicals/Media	1	ls	$11,000	$11,000	
System Maintenance	5%		$131,000	$6,550	Allowance
Undefined Scope Allowance	10%		$137,550	$13,755	

Alternate 7 - ISS and Thermal
Wyckoff/Eagle Harbor Soil and Groundwater OUs, Focused Feasibility Study

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
PROJECT MANAGEMENT	8%		$151,305	$12,104	Based on EPA 540-R-00-002
REPORTING	1		$25,000	$25,000	
TOTAL ANNUAL O&M COSTS - EAB RECOVERY				**$188,000**	
OPERATION & MAINTENANCE COSTS OF PHASE II (Initial 1 year of operation, 2028)					
Annual O&M					
Operator(s)	6,240	hr	$80	$499,200	3 FTEs running system 24/7
Supervisor	2,080	hr	$100	$208,000	1 FTE
Electrical Usage	1	ls	$103,385	$103,385	Current usage is $4k/mo to pump 65 gpm, scaled up
Diesel Generator	12	mo	$10,300	$123,600	5150 gal/mo @ $4/gal
Propane	12	mo	$155,000	$1,860,000	50,000 gal/month @ $1.70/gal
Disposal - NAPL Waste	22,000	gal	$7	$154,000	Vendor Quote; 14,000-gal/yr
Transportation - NAPL Waste	11	load	$6,400	$70,400	Vendor Quote
Waste Disposal - Carbon/Filter Media	1	ls	$43,000	$43,000	Allowance
Well field Analysis&Sampling Team	520	hr	$80	$41,600	Engineer's Estimate
Laboratory Analysis	130	ls	$300	$39,000	Engineer's Estimate
PPE Allowance	6,240	hr	$0.75	$4,680	Allowance - hard hats, boots, work gloves, safety
Maintenance	10%		$3,174,865	$317,487	Allowance
Undefined Scope Allowance	10%		$3,492,352	$349,235	
PROJECT MANAGEMENT	5%		$3,841,587	$192,079	
REPORTING	1		$25,000	$25,000	
TOTAL ANNUAL O&M COSTS - INITIAL Phase II				**$4,031,000**	
OPERATION & MAINTENANCE COSTS OF PHASE II (Additional 4 years of operation, 2029 through 2032)					
Annual O&M					
Operator(s)	4,160	hr	$80	$332,800	2 FTE
Supervisor	520	hr	$100	$52,000	0.5 FTE
Electrical Usage	1.0	ls	$103,385	$103,385	Current usage is $4k/mo to pump 65 gpm, scaled up
Diesel Generator	12	mo	$10,300	$123,600	5150 gal/mo @ $4/gal
Propane	12	mo	$30,600	$367,200	18,000-gal/mo@$1.7/gal
Disposal - NAPL Waste	12,000	gal	$7	$84,000	Vendor Quote; 12,000-gal/yr
Transportation - NAPL Waste	6	load	$6,400	$38,400	Vendor Quote
Waste Disposal - Carbon/Filter Media	2	ls	$43,000	$86,000	Allowance
Well field Analysis&Sampling Team	520	hr	$80	$41,600	Engineer's Estimate
Laboratory Analysis	130	ls	$300	$39,000	Engineer's Estimate
Boiler-specific Maintenance	1	ls	14,595	$14,595	5% of purchase price for annual maint.
PPE Allowance	2,080	hr	$0.75	$1,560	Allowance - hard hats, boots, work gloves, safety
Maintenance	10%		$1,284,140	$128,414	Allowance
Undefined Scope Allowance	10%		$1,412,554	$141,255	
PROJECT MANAGEMENT	5%		$1,553,809	$77,690	
REPORTING	1		$50,000	$50,000	
TOTAL ANNUAL O&M COSTS - Phase II				**$1,681,000**	
O&M COSTS OF PASSIVE GROUNDWATER TREATMENT SYSTEM (2023 through 2026) - Phase I (2032 - 2050) - Phase II					
Operator(s)	520	hr	$80	$41,600	0.25 FTEs
Maintenance	10%		$41,600	$4,160	Allowance
Quarterly GW Sampling	4	ea	$10,000	$40,000	
Annual GW Sampling	1	ls	$50,000	$50,000	
Contech GAC Filled Storm Filter Change out	280	ea	$200	$56,000	Quarterly change out/recycle
T&D of Spent GAC Filters	40	drum	$400	$16,000	1 drum/manhole/event
Undefined Scope Allowance	10%		$191,760	$19,176	

Alternate 7 - ISS and Thermal
Wyckoff/Eagle Harbor Soil and Groundwater OUs, Focused Feasibility Study

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
PROJECT MANAGEMENT	8%		$226,936	$18,155	Based on EPA 540-R-00-002
CONSTRUCTION MANAGEMENT	15%		$91,176	$13,676	Based on EPA 540-R-00-002
REPORTING	1	ls	$25,000	$25,000	
TOTAL O&M COSTS - PASSIVE WATER TREATMENT SYSTEM:				**$284,000**	
PERIODIC COSTS					
Maintain Onsite Roads (2039)	1	ls	$25,000	$25,000	Allowance - regrade/repair onsite roads
LONG TERM EPA MONITORING					
5 Yr Reviews (last completed 2012)	1	ls	$20,000	$20,000	
Final Completion Report	1	ls	$150,000	$150,000	

PRESENT VALUE ANALYSIS 1.4% Discount Rate Purchase, and Related Analysis, 12/2013

Year	Cost Type	Cost	Discount Rate	Present Value
0	Annual O&M Costs	$0	1.00	$ -
1	Capital Costs (2017) - Common Elements	$1,185,000	0.99	$ 1,168,639
1	Capital Costs (2017) - Phase I Groundwater Extraction	$1,245,861	0.99	$ 1,228,660
1	Capital Costs (2017) - NAPL Recovery	$1,181,630	0.99	$ 1,165,315
1	Capital Costs (2017) - EAB	$920,000	0.99	$ 907,298
1	5 Year Review (2017)	$20,000	0.99	$ 19,724
2	Capital Costs (2018) - Common Elements	$17,115,000	0.97	$ 16,645,659
2	Annual Costs GWTP/NAPL Recovery/EAB	$1,219,000	0.97	$ 1,185,572
3	Capital Costs (2019) - Common Elements	$24,725,000	0.96	$ 23,714,962
3	Annual Costs GWTP/NAPL Recovery/EAB	$1,219,000	0.96	$ 1,169,203
4	Capital Costs (2020) - Remedial Action	$13,494,500	0.95	$ 12,764,534
4	Annual Costs GWTP/NAPL Recovery/EAB	$1,219,000	0.95	$ 1,153,060
5	Capital Costs (2021) - Remedial Action	$13,708,500	0.93	$ 12,787,927
5	Annual Costs GWTP/NAPL Recovery/EAB	$1,219,000	0.93	$ 1,137,140
6	Capital Costs (2022) - Passive Drainage System	$1,149,000	0.92	$ 1,057,042
6	Annual Costs GWTP/NAPL Recovery/EAB	$1,219,000	0.92	$ 1,121,440
6	5 Year Review (2022)	$20,000	0.92	$ 18,399
7	Annual Costs GWTP/EAB	$976,000	0.91	$ 885,491
7	Periodic Cost (2023)	$1,498,000	0.91	$ 1,359,083
8	Annual Costs GWTP/EAB	$976,000	0.89	$ 873,265
9	Annual Costs GWTP/EAB	$976,000	0.88	$ 861,208
10	Annual Costs GWTP/EAB	$976,000	0.87	$ 849,318
11	Construction Costs (2027) - Common Elements	$3,294,000	0.86	$ 2,826,872
11	Construction Costs (2027) - Phase II	$7,379,846	0.86	$ 6,333,296
11	Annual Costs GWTP/EAB	$976,000	0.86	$ 837,592
11	5 Year Review (2027)	$20,000	0.86	$ 17,164
12	Annual Costs GWTP/EAB	$5,007,000	0.85	$ 4,237,621
13	Annual Costs GWTP/EAB/Phase II	$2,657,000	0.83	$ 2,217,676
14	Annual Costs GWTP/EAB/Phase II	$2,657,000	0.82	$ 2,187,057
15	Annual Costs GWTP/EAB/Phase II	$2,657,000	0.81	$ 2,156,861
16	AnnualCosts GWTP/EAB/Phase II/Passive Drainage Treatment	$2,941,000	0.80	$ 2,354,441
16	5 Year Review (2032)	$20,000	0.80	$ 16,011
17	Annual O&M Costs	$284,000	0.79	$ 224,219
17	Periodic Cost (2033)	$1,000,000	0.79	$ 789,505
18	Capital Costs (2034) - Common Elements	$4,100,000	0.78	$ 3,192,278
18	Annual O&M Costs	$284,000	0.78	$ 221,124
19	Annual O&M Costs	$284,000	0.77	$ 218,071
20	Annual O&M Costs	$284,000	0.76	$ 215,060
21	Annual O&M Costs	$284,000	0.75	$ 212,091
21	5 Year Review (2037)	$20,000	0.75	$ 14,936
22	Annual O&M Costs	$284,000	0.74	$ 209,162
23	Annual O&M Costs	$284,000	0.73	$ 206,274
24	Annual O&M Costs	$284,000	0.72	$ 203,426
25	Annual O&M Costs	$284,000	0.71	$ 200,618
25	Capital Costs (Road Maintenance)	$25,000	0.71	$ 17,660
26	Annual O&M Costs	$284,000	0.70	$ 197,848
26	5 Year Review (2042)	$20,000	0.70	$ 13,933

Alternate 7 - ISS and Thermal
Wyckoff/Eagle Harbor Soil and Groundwater OUs, Focused Feasibility Study

	Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)			NOTES
27	Annual O&M Costs				$284,000	0.69	$	195,116
28	Annual O&M Costs				$284,000	0.68	$	192,422
29	Annual O&M Costs				$284,000	0.67	$	189,766
30	Annual O&M Costs				$284,000	0.66	$	187,146
31	Annual O&M Costs				$284,000	0.65	$	184,562
31	5 Year Review (2047)				$20,000	0.65	$	12,997
32	Annual O&M Costs				$284,000	0.64	$	182,014
33	Annual O&M Costs				$284,000	0.63	$	179,501
34	Annual O&M Costs				$284,000	0.62	$	177,022
35	Annual O&M Costs				$0	0.61	$	-
36	Annual O&M Costs				$0	0.61	$	-
36	5 Year Review (2052)				$20,000	0.61	$	12,124
37	Annual O&M Costs				$0	0.60	$	-
38	Annual O&M Costs				$0	0.59	$	-
39	Annual O&M Costs				$0	0.58	$	-
40	Annual O&M Costs				$0	0.57	$	-
41	Annual O&M Costs				$0	0.57	$	-
41	5 Year Review (2057)				$20,000	0.57	$	11,310
42	Annual O&M Costs				$0	0.56	$	-
43	Annual O&M Costs				$0	0.55	$	-
44	Annual O&M Costs				$0	0.54	$	-
45	Annual O&M Costs				$0	0.53	$	-
46	Annual O&M Costs				$0	0.53	$	-
46	5 Year Review (2062)				$20,000	0.53	$	10,551
47	Annual O&M Costs				$0	0.52	$	-
48	Annual O&M Costs				$0	0.51	$	-
49	Annual O&M Costs				$0	0.51	$	-
50	Annual O&M Costs				$0	0.50	$	-
51	Annual O&M Costs				$0	0.49	$	-
51	5 Year Review (2067)				$20,000	0.49	$	9,842
52	Annual O&M Costs				$0	0.49	$	-
53	Annual O&M Costs				$0	0.48	$	-
54	Annual O&M Costs				$0	0.47	$	-
55	Annual O&M Costs				$0	0.47	$	-
56	Annual O&M Costs				$0	0.46	$	-
56	5 Year Review (2072)				$20,000	0.46	$	9,181
57	Annual O&M Costs				$0	0.45	$	-
58	Annual O&M Costs				$0	0.45	$	-
59	Annual O&M Costs				$0	0.44	$	-
60	Annual O&M Costs				$0	0.43	$	-
61	Annual O&M Costs				$0	0.43	$	-
61	5 Year Review (2077)				$20,000	0.43	$	8,565
62	Annual O&M Costs				$0	0.42	$	-
63	Annual O&M Costs				$0	0.42	$	-
64	Annual O&M Costs				$0	0.41	$	-
65	Annual O&M Costs				$0	0.41	$	-
66	Annual O&M Costs				$0	0.40	$	-
66	5 Year Review (2082)				$20,000	0.40	$	7,990
67	Annual O&M Costs				$0	0.39	$	-
68	Annual O&M Costs				$0	0.39	$	-
69	Annual O&M Costs				$0	0.38	$	-
70	Annual O&M Costs				$0	0.38	$	-
71	Annual O&M Costs				$0	0.37	$	-
71	5 Year Review (2087)				$20,000	0.37	$	7,453
72	Annual O&M Costs				$0	0.37	$	-
73	Annual O&M Costs				$0	0.36	$	-
74	Annual O&M Costs				$0	0.36	$	-
75	Annual O&M Costs				$0	0.35	$	-
76	Annual O&M Costs				$0	0.35	$	-
76	5 Year Review (2092)				$20,000	0.35	$	6,953
77	Annual O&M Costs				$0	0.34	$	-
78	Annual O&M Costs				$0	0.34	$	-
79	Annual O&M Costs				$0	0.33	$	-
80	Annual O&M Costs				$0	0.33	$	-
81	Annual O&M Costs				$0	0.32	$	-
81	5 Year Review (2097)				$20,000	0.32	$	6,486
82	Annual O&M Costs				$0	0.32	$	-
83	Annual O&M Costs				$0	0.32	$	-
84	Annual O&M Costs				$0	0.31	$	-

	Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)			NOTES
85	Annual O&M Costs				$0	0.31	$	-
86	Annual O&M Costs				$0	0.30	$	-
86	5 Year Review (2102)				$20,000	0.30	$	6,050
87	Annual O&M Costs				$0	0.30	$	-
88	Annual O&M Costs				$0	0.29	$	-
89	Annual O&M Costs				$0	0.29	$	-
90	Annual O&M Costs				$0	0.29	$	-
91	Annual O&M Costs				$0	0.28	$	-
91	5 Year Review (2107)				$20,000	0.28	$	5,644
92	Annual O&M Costs				$0	0.28	$	-
93	Annual O&M Costs				$0	0.27	$	-
94	Annual O&M Costs				$0	0.27	$	-
95	Annual O&M Costs				$0	0.27	$	-
96	Annual O&M Costs				$0	0.26	$	-
96	5 Year Review (2112)				$20,000	0.26	$	5,265
97	Annual O&M Costs				$0	0.26	$	-
98	Annual O&M Costs				$0	0.26	$	-
99	Annual O&M Costs				$0	0.25	$	-
100	Final Completion Report (2116)				$150,000	0.25	$	37,350
TOTAL VALUE ANALYSIS					**$124,580,000**			**$113,040,000**

This construction cost estimate is not an offer for construction and/or project execution. The construction cost estimate for this Design is an Association for the Advancement of Cost Engineering (AACE) Class 4 estimate and is assumed to represent the actual total installed cost. The estimate above is considered control-level cost estimating, suitable for use in project budgeting and planning. This estimate has been prepared with partial design and engineering calculations. The level of accuracy for the class of estimate defines the upper and lower ranges of the cost estimate. It is based upon the level of design detail and uncertainty associate with that level of detail. For a Class 4 estimate, the accuracy range is +50% to -30%. It would appear prudent that internal budget allowances account for the highest cost indicated by this range as well as other site specific allowances. The cost estimate has been prepared for guidance in project evaluation and implementation from the information available at the time of the estimate. The final costs of the project will depend on actual labor and material costs, competitive market conditions, implementation schedule, and other variable factors. As a result, the final project costs will vary from the estimates presented herein. Because of this, project feasibility and funding needs must be carefully reviewed prior to making specific financial decisions to help ensure proper project evaluation and adequate funding.

Appendix D
Wyckoff NAPL Composition

TABLE D-1
Upper Aquifer Production Well NAPL SVOC Analysis Results
Wyckoff /Eagle Harbor Groundwater Operable Unit
Bainbridge Island, WA

Well ID :		RPW1	RPW1	RPW2	RPW2	RPW4	RPW5	RPW6	RPW6	PW8	PW9
Screen Elevation :		5 to 38	5 to 38	5 to 55	5 to 55	5 to 49.4	5 to 54	4.1 to 35.6	4.1 to 35.6	5 to 48	4 to 34
Compartment Number :		1B/2/3	1B/2/3	1B/2/3	1B/2/3	1B/2/3	1B/2/3	1B/2/3	1B/2/3	1B/2/3	1B/2/3
CH2M HILL SampleID :		RPW1-0514-L	RPW1-0514-D	RPW2-0514-L	RPW2-0514-D	RPW4-0514-L	RPW5-0514-D	RPW6-0514-D	FD1-0514	PW8-0514-D	PW9-0514-D
CLP SampleID :		14174100	14174101	14174106	14174107	14174102	14174103	14174104	14174105	14174108	14174109
Date Collected :		5/1/2014	5/1/2014	5/2/2014	5/2/2014	5/1/2014	5/1/2014	5/1/2014	5/1/2014	5/2/2014	5/2/2014
Sample Type :		N	N	N	N	N	N	N	FD	N	N
Analyte	**Units**										
SVOC-Total PAH [a]											
Total PAHs	ug/L	206,785	320,705	215,420	304,405	223,330	287,770	258,425	243,655	245,820	320,940
Total LPAHs	ug/L	174,340	271,690	188,780	254,370	201,370	230,440	208,980	196,750	198,810	278,170
Total HPAHs	ug/L	32,445	49,015	26,640	50,035	21,960	57,330	49,445	46,905	47,010	42,770
SVOC-Low Molecular Weight PAHs											
9H-Fluorene	mg/Kg	16,000	26,000	14,000	24,000	12,000	26,000	25,000	24,000	21,000	25,000
Acenaphthene	mg/Kg	19,000	27,000	20,000	28,000	21,000	30,000	27,000	26,000	26,000	30,000
Acenaphthylene	mg/Kg	540	590	580	670	770	640	680	650	610	570
Anthracene	mg/Kg	5,800	7,100	5,200	7,700	4,600	7,800	7,300	7,100	6,200	7,600
Naphthalene	mg/Kg	100,000	140,000	120,000	140,000	140,000	110,000	92,000	86,000	99,000	150,000
Phenanthrene	mg/Kg	33,000	71,000	29,000	54,000	23,000	56,000	57,000	53,000	46,000	65,000
SVOC-Other Creosote Related											
9H-Carbazole	mg/Kg	1,600	3,200	810	2,500	600	2,900	1,900	1,900	2,100	3,000
Dibenzofuran	mg/Kg	13,000	23,000	13,000	20,000	12,000	21,000	20,000	20,000	18,000	24,000
Naphthalene, 1-methyl-	mg/Kg	20,000	21,000	28,000	25,000	35,000	23,000	22,000	21,000	22,000	30,000
Naphthalene, 2-methyl-	mg/Kg	35,000	41,000	46,000	48,000	60,000	35,000	29,000	29,000	33,000	58,000
SVOC-High Molecular Weight PAHs											
Benzo(a)anthracene	mg/Kg	2,600	3,800	2,000	4,600	1,700	5,000	4,100	3,900	4,100	2,900
Benzo(a)pyrene	mg/Kg	810	900	760	1,300	710	1,500	1,200	1,100	1,300	720
Benzo(g,h,i)perylene	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
Benzo[b]Fluoranthene	mg/Kg	1,300	1,300	1,000	2,200	930	2,400	1,800	1,700	2,100	930
Benzo[k]fluoranthene	mg/Kg	460	640	560	1,000	500	1,100	840	830	920	530
Chrysene	mg/Kg	1,900	2,700	1,500	3,200	1,400	3,400	2,800	2,700	2,900	2,000
Dibenzo[a,h]anthracene	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
Indeno(1,2,3-cd)pyrene	mg/Kg	450 U	450 U	480 U	490 U	480 U	470	470 U	450 U	460 U	460 U
Fluoranthene	mg/Kg	15,000	24,000	12,000	22,000	9,600	26,000	23,000	22,000	21,000	21,000
Pyrene	mg/Kg	9,700	15,000	8,100	15,000	6,400	17,000	15,000	14,000	14,000	14,000
SVOC-Other											
Pentachlorophenol	mg/Kg	1,600	450 U	480 U	490 U	1,900	460 U	470 U	450 U	460 U	460 U
1,1'-Biphenyl	mg/Kg	5,200	7,800	6,000	8,100	7,500	7,500	7,500	7,300	7,100	10,000
1,2,4,5-Tetrachlorobenzene	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
1,2,4-Trichlorobenzene	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
2,3,4,6-Tetrachlorophenol	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
2,4,5-Trichlorophenol	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
2,4,6-Trichlorophenol	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
2,4-Dichlorophenol	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
2,4-Dimethylphenol	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
2,4-Dinitrophenol	mg/Kg	1,800 UJ	1,800 UJ	1,900 UJ	1,900 UJ	1,900 UJ	1,800 UJ	1,900 UJ	1,800 UJ	1,900 UJ	1,800 UJ
2,4-Dinitrotoluene	mg/Kg	910 U	890 U	960 U	970 U	950 U	920 U	940 U	900 U	930 U	920 U
2,6-Dinitrotoluene	mg/Kg	910 U	890 U	960 U	970 U	950 U	920 U	940 U	900 U	930 U	920 U
2-Chloronaphthalene	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
2-Chlorophenol	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
2-Nitroaniline	mg/Kg	910 U	890 U	960 U	970 U	950 U	920 U	940 U	900 U	930 U	920 U
2-Nitrophenol	mg/Kg	910 U	890 U	960 U	970 U	950 U	920 U	940 U	900 U	930 U	920 U
3,3'-Dichlorobenzidine	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
3-Nitroaniline	mg/Kg	910 U	890 U	960 U	970 U	950 U	920 U	940 U	900 U	930 U	920 U
4,6-Dinitro-2-methylphenol	mg/Kg	910 UJ	890 UJ	960 UJ	970 UJ	950 UJ	920 UJ	940 UJ	900 UJ	930 UJ	920 UJ
4-Bromophenyl-Phenylether	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
4-Chloro-3-methylphenol	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
4-Chloroaniline	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U

TABLE D-1

Upper Aquifer Production Well NAPL SVOC Analysis Results

Wyckoff /Eagle Harbor Groundwater Operable Unit

Bainbridge Island, WA

Well ID :		RPW1	RPW1	RPW2	RPW2	RPW4	RPW5	RPW6	RPW6	PW8	PW9
Screen Elevation :		5 to 38	5 to 38	5 to 55	5 to 55	5 to 49.4	5 to 54	4.1 to 35.6	4.1 to 35.6	5 to 48	4 to 34
Compartment Number :		1B/2/3	1B/2/3	1B/2/3	1B/2/3	1B/2/3	1B/2/3	1B/2/3	1B/2/3	1B/2/3	1B/2/3
CH2M HILL SampleID :		RPW1-0514-L	RPW1-0514-D	RPW2-0514-L	RPW2-0514-D	RPW4-0514-L	RPW5-0514-D	RPW6-0514-D	FD1-0514	PW8-0514-D	PW9-0514-D
CLP SampleID :		14174100	14174101	14174106	14174107	14174102	14174103	14174104	14174105	14174108	14174109
Date Collected :		5/1/2014	5/1/2014	5/2/2014	5/2/2014	5/1/2014	5/1/2014	5/1/2014	5/1/2014	5/2/2014	5/2/2014
Sample Type :		N	N	N	N	N	N	N	FD	N	N
Analyte	**Units**										
4-Chlorophenyl-Phenylether	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
4-Methylphenol	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
4-Nitroaniline	mg/Kg	910 U	890 U	960 U	970 U	950 U	920 U	940 U	900 U	930 U	920 U
4-Nitrophenol	mg/Kg	910 U	890 U	960 U	970 U	950 U	920 U	940 U	900 U	930 U	920 U
Atrazine	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
Benzaldehyde	mg/Kg	910 UJ	890 UJ	960 UJ	970 UJ	950 UJ	920 UJ	940 UJ	900 UJ	930 UJ	920 UJ
bis(2-Chloroethyl)ether	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
Bis(2-Chloroisopropyl)ether	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
Bis(2-ethylhexyl) phthalate	mg/Kg	910 U	890 U	960 U	970 U	950 U	920 U	940 U	900 U	930 U	920 U
Butylbenzylphthalate	mg/Kg	910 U	890 U	960 U	970 U	950 U	920 U	940 U	900 U	930 U	920 U
Caffeine	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
Caprolactam	mg/Kg	910 UJ	890 UJ	960 UJ	970 UJ	950 UJ	920 UJ	940 UJ	900 UJ	930 UJ	920 UJ
Diethyl phthalate	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
Dimethylphthalate	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
Di-n-Butylphthalate	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
Di-n-octylphthalate	mg/Kg	910 U	890 U	960 U	970 U	950 U	920 U	940 U	900 U	930 U	920 U
Ethanone, 1-phenyl-	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
Hexachlorobenzene	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
Hexachlorobutadiene	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
Hexachlorocyclopentadiene	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
Hexachloroethane	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
Isophorone	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
Methane, bis(2-chloroethoxy)-	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
Nitrobenzene	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
N-Nitrosodimethylamine	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
N-Nitrosodinpropylamine	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
n-Nitrosodiphenylamine	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
Phenol	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
Phenol, 2-methyl-	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U

Notes:

[a] Total PAH, Total LPAH, and Total HPAR are calculated results using detected constituents and 1/2 reporting limit for non-detect constituents.

mg/kg = milligrams per kilogram

U - The analyte was not detected at or above the reported value.

J - The identification of the analyte is acceptable; however the reported value is an estimate.

N = normal sample

FD = field duplicate

TABLE D-2

Production Well NAPL VOC Analysis Results

Wyckoff /Eagle Harbor Groundwater Operable Unit Upper Aquifer Results

Bainbridge Island, WA

	Well ID :	RPW1	RPW1	RPW2	RPW2	RPW4	RPW5	RPW6	RPW6	PW8	PW9
	Screen Elevation :	5 to 38	5 to 38	5 to 55	5 to 55	5 to 49.4	5 to 54	4.1 to 35.6	4.1 to 35.6	5 to 48	4 to 34
	Compartment Number :	1B/2/3	1B/2/3	1B/2/3	1B/2/3	1B/2/3	1B/2/3	1B/2/3	1B/2/3	1B/2/3	1B/2/3
	CH2M HILL SampleID :	RPW1-0514-L	RPW1-0514-D	RPW2-0514-L	RPW2-0514-D	RPW4-0514-L	RPW5-0514-D	RPW6-0514-D	FD1-0514	PW8-0514-D	PW9-0514-D
	CLP SampleID :	14174100	14174101	14174106	14174107	14174102	14174103	14174104	14174105	14174108	14174109
	Date Collected :	5/1/2014	5/1/2014	5/2/2014	5/2/2014	5/1/2014	5/1/2014	5/1/2014	5/1/2014	5/2/2014	5/2/2014
	Sample Type :	N	N	N	N	N	N	N	FD	N	N
Analyte	**Units**										
BTEX											
Benzene	mg/kg	48 U	36 U	46 U	40 U	47 U	48 U	46 U	42 U	44 U	44
Ethylbenzene	mg/kg	440	380	1,300	740	430	480	280	280	590	1,300
MP-Xylene	mg/kg	1,000	800	2,400	860	1,400	530	450	430	680	2,800
o-Xylene	mg/kg	490	350	1,100	590	720	360	250	240	440	1,200
Toluene	mg/kg	71	180	160	180	47 U	130	46 U	42 U	74	630

Notes:

mg/kg = milligrams per kilogram

U - The analyte was not detected at or above the reported value.