Public Review Draft
Jorgensen Forge Corporation Property
Feasibility Study

Earle M. Jorgensen Company
Tukwila, Washington

for

Earle M. Jorgensen Company

January 16, 2026

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Ecology Agreed Order No. DE 14143
Earle M. Jorgensen Company
Tukwila, Washington

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Prepared for:

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Acronyms, Abbreviations, and Key Definitions

AFFF	aqueous film-forming foam
AO	Agreed Order No. DE 14143
AOC	areas of concern
ARARs	applicable or relevant and appropriate requirements
AS	air sparging
AST	above ground storage tank
bgs	below ground surface
CAAs	cleanup action alternatives
CAOs	cleanup action objectives
COC	contaminant of concern
CSM	Conceptual Site Model
CWA	Clean Water Act
DCA	disproportionate cost analysis
DCAP	Draft Cleanup Action Plan
DPE	dual phase extraction
ECs	engineering controls
Ecology	Washington State Department of Ecology
EMJ	Earle M. Jorgensen Company
EPA	United States Environmental Protection Agency
FS	Feasibility Study
GW	groundwater
IHS	indicator hazardous substance
ISCR	in-situ chemical reduction
ISCO	in-situ chemical oxidation
ISS	in-situ soil solidification/stabilization
LDW	Lower Duwamish Waterway
LNAPL	light non-aqueous phase liquid
MNA	monitored natural attenuation
MTCA	Model Toxics Control Act
NPDES	National Pollution Discharge Elimination System
O&M	operations and maintenance
OWS	oil-water separator
PCB	polychlorinated biphenyl
PCUL	preliminary cleanup level
PFAS	per- and polyfluoroalkyl substances
PFOS	perfluorooctanesulfonic acid

PRB	permeable reactive barrier
RCRA	Resource Conservation and Recovery Act
RCW	Revised Code of Washington
RI	Remedial Investigation
Site	Jorgensen Forge Corporation Property, located at 8531 East Marginal Way South in Tukwila, Washington
SVE	soil vapor extraction
SW	surface water
TPH	total petroleum hydrocarbon
TPH-G	total petroleum hydrocarbon quantified as gasoline
TPH-D	total petroleum hydrocarbon quantified as diesel
TPH-O	total petroleum hydrocarbon quantified as oil
UST	underground storage tank
WAC	Washington Administrative Code

UNITS

mg/kg	milligram per kilogram
µg/L	microgram per liter

Executive Summary

This Feasibility Study (FS) Report has been prepared on behalf of the Earle M. Jorgensen (EMJ) Company for the Jorgensen Forge Corporation Property (Site) under Agreed Order (AO) No. DE 14143, issued by the Washington State Department of Ecology (Ecology) and dated July 28, 2017 (Ecology, 2017). EMJ owned the Site from 1965 to 1992 and has voluntarily assumed responsibility for implementing FS activities at the Site pursuant to the AO under the Model Toxics Control Act (MTCA) and MTCA's implementing regulations.

This FS Report has been prepared under the oversight of Ecology. The purpose of this FS is to develop and evaluate cleanup action alternatives for addressing contamination identified at the Site and to select a preferred cleanup action. The FS uses information presented in the Agency Draft Remedial Investigation (RI) (Shannon & Wilson 2025). This FS was completed in accordance with the requirements of the Model Toxics Control Act (MTCA), Chapter 173-340 of the Washington Administrative Code (WAC), Ecology's guidance and checklist for preparing an FS (Ecology 2016) and Ecology's Guidance for Determining if Cleanup Actions uses Permanent Solutions to the Maximum Extent Practicable using Disproportionate Cost Analysis (Ecology 2025, Draft).

Historically, the Site was used for metals fabrication activities (forging, heat treating and machining) and associated use and storage of oil and fire-suppression materials, some of which resulted in soil and groundwater impacts. Contamination in soil is also present from the north adjacent property (Boeing Plant 2 Property) owned by The Boeing Company (Boeing) related to former electrical equipment with polychlorinated biphenyl (PCB)-containing oil. The Site is currently vacant and mostly paved with asphalt or concrete.

The primary contaminants of concern (COCs) at the Site include total petroleum hydrocarbons (TPH), polychlorinated biphenyls (PCBs) and perfluorooctanesulfonic acid (PFOS). The site is divided into eleven remedial areas with the following COCs and associated contaminated media.

- **Area 1 (Cutting Oil Contamination):** Soil and groundwater are impacted with diesel- and oil-range petroleum hydrocarbons (TPH-D and TPH-O). Cutting oil light non-aqueous phase liquid (LNAPL) is has impacted soil and on groundwater in this area.
- **Area 2 (Hydraulic Oil and Diesel Contamination):** Soil is impacted with TPH-D, TPH-O, and gasoline-range petroleum hydrocarbons (TPH-G). Groundwater is impacted with TPH-D and TPH-O. Hydraulic oil and diesel LNAPL have impacted soil and groundwater in this area.
- **Per- and Polyfluoroalkyl Substances (PFAS) Release Area:** Soil and groundwater are impacted with PFOS.
- **Area 3 (Former Gasoline Underground Storage Tanks):** Soil below the northernmost and center UST excavations and groundwater are impacted with TPH-G in the northernmost UST excavation.
- **Area 4 (Decommissioned Oil Storage Area):** Soil is impacted with TPH-G, TPH-D and TPH-O. Groundwater is impacted with TPH-D and TPH-O.
- **Shipping Area:** Soil and groundwater are impacted with TPH-G.
- **Storage Area (in the southwest corner of the Site):** Soil and groundwater are impacted with TPH-D, TPH-O, and PCBs.

- **Steam Clean Area:** Groundwater is impacted with TPH-D and TPH-O.
- **Northwest Corner:** Soil is impacted with TPH-G, TPH-D, and TPH-O. Groundwater is impacted with TPH-D.
- **Shoreline and Embayment:** Soil in the near shore area and groundwater at MW-39 are impacted with PCBs.
- **South of Boeing's Other Area 11 (OA-11):** Soil is impacted with PCBs.

Potential cleanup alternatives were evaluated based on MTCA general cleanup requirements, action- and media-specific requirements, and public concerns. Four alternatives were evaluated that included one or more of the following cleanup action elements with remedial area-specific implementation as appropriate for each portion of the Site: monitored natural attenuation (MNA); institutional controls; engineering controls, including capping; LNAPL recovery techniques, including dual phase extraction (DPE) and extraction from open excavations; in-situ remediation (air sparging/soil vapor extraction [AS/SVE], solidification/stabilization [ISS], permeable reactive barriers [PRB]); and excavation with off-site disposal.

A disproportionate cost analysis (DCA) was performed to determine the most effective and cost-efficient alternative for the Site using six criteria: protectiveness, permanence, long-term effectiveness, management of cleanup risks, implementability, and cost.

The results of this FS indicate the preferred alternative is Alternative 3, which consists of the following cleanup action elements:

- Areas 1 and 2: Targeted excavation for LNAPL recovery and ISS.
- Remaining remedial areas: Capping and MNA.
- Common elements to all remedial areas: Institutional and other engineering controls as needed.

The preferred alternative provides the highest benefit-to-cost ratio and ensures long-term protectiveness and compliance with MTCA. The preferred alternative is expected to reduce or eliminate risks to human health and the environment and future exposure. Groundwater will be monitored for a sufficient period of time following completion of cleanup activities to confirm cleanup effectiveness.

The proposed cleanup action will be detailed in a Draft Cleanup Action Plan (DCAP).

This Executive Summary should be used only in the context of the full report for which it is intended.

1.0 Introduction

This report presents the Feasibility Study (FS) completed for the Jorgensen Forge Corporation (Jorgensen Forge) property located at 8531 East Marginal Way South in Tukwila, Washington (Figure 1-1) on behalf of the Earle M. Jorgensen (EMJ) Company. EMJ completed an Agency Review Draft Remedial Investigation (RI) for the Site that defined the nature and extent of contamination requiring cleanup action (Shannon and Wilson, 2025). This FS has been completed in accordance with Agreed Order (AO) No. DE 14143, issued by the Washington State Department of Ecology (Ecology) and dated July 28, 2017 (Ecology, 2017).

1.1. REGULATORY FRAMEWORK

The Site is currently listed in Ecology's database of confirmed and suspected contaminated Sites under Facility/Site Number 2382 and Cleanup Site ID 3689. RI, FS, and preparation of the Draft Cleanup Action Plan (DCAP) are being completed under AO No. DE 14143.

The Lower Duwamish Waterway (LDW) Superfund Site borders the Site to the west. The United States Environmental Protection Agency (EPA) is overseeing the sediment investigation and remediation for the LDW Superfund Site. Ecology is responsible for overseeing investigation and remediation of upland areas that may discharge to the LDW to minimize recontamination of the sediments.

1.2. PURPOSE OF FEASIBILITY STUDY

This FS report was prepared to satisfy the requirements of the AO to develop and evaluate cleanup action alternatives for addressing contamination identified at the Site and to select a preferred cleanup action. This FS was completed in accordance with the requirements of the Model Toxics Control Act (MTCA) Cleanup Regulation, Chapter 173-340 of the Washington State Administrative Code (WAC), Ecology's guidance and checklist for preparing an FS (Ecology 2016), and Ecology's Guidance for Determining if Cleanup Actions uses Permanent Solutions to the Maximum Extent Practicable using Disproportionate Cost Analysis (Ecology 2025, Draft).

2.0 Site Background

General Site information including location and property description, land use history, and current and future land use assumptions for the Property are discussed in the subsections below.

2.1. LOCATION AND DESCRIPTION

The Site is located at 8531 East Marginal Way South in Tukwila, Washington (Figure 1-1). It is comprised of an approximately 20-acre parcel identified as King County tax parcel 0001600023. The Site is located on the east bank of the LDW at approximately LDW River Mile 3.6, between Slips 4 and 6. Slip 5 was historically located on the adjacent property to the south of the Site but was filled in between approximately 1936 and 1966. The Site is bordered to the north by Boeing Plant 2, owned by the Boeing Company (Boeing), to the south, by another Boeing-owned property, the Boeing Isaacson site, to the east by East Marginal Way South, beyond which lies the King County Airport, and to the west by the LDW.

A sheet pile/concrete panel bulkhead bounds the Site along the southwestern portion of the shoreline, while the remaining shoreline is sloped. Asphalt and concrete paving cover most of the Site, which is currently vacant as shown on Figure 2-1

2.2. HISTORICAL OPERATIONS AND LAND USE

The Site was first developed by Isaacson Iron Works for the U.S. Navy in 1942 during World War II to produce propeller shafts and other naval equipment. Between 1945 and 1965, Isaacson fabricated custom steel and aluminum parts on the Site; operations included forging, heat treating, and machining. Bethlehem Pacific owned the northwestern portion of the Site from 1949 until 1965 and operated a steel fabrication facility that was removed prior to the sale of the property. EMJ purchased the Site, including the Bethlehem Pacific property, in 1965. EMJ owned and operated the facility until 1992 when JFC acquired the property as part of a stock transaction. In 2016, Star Forge, LLC (Star Forge) took ownership of the Site following JFC’s bankruptcy. Star Forge operated the facility until it shut down operations in 2018.

From 1964 until 2018, operations at the Site remained relatively unchanged through different property purchases and owners (except the forge was shut down in 2015). The Site was a steel and aluminum forge and mill that produced custom steel and aluminum parts forged and machined to high precision specifications for various industrial clients.

Star Forge intends to sell the property and is pursuing Clean Closure under the State Dangerous Waste requirements. Events that occurred and information obtained during Star Forge’s Clean Closure process led Ecology to name Star Forge as a potentially liable person for the release of hazardous substances at the Site. On April 18, 2023, Star Forge entered into an Agreed Order (No. DE 21034) with Ecology (Ecology, 2023) to conduct an Interim Action at the Site to permanently close UST systems, decontaminate and/or remove concrete and asphalt slabs at the Dangerous Waste Management Units (DWMUs), and remove limited soil to facilitate paving. Star Forge completed its Clean Closure activities and Interim Actions in 2023 and 2024 along with demolition of the entire facility. Star Forge’s consultant issued a UST decommissioning and site assessment report (DH Environmental, Inc., 2024c) and a final dangerous waste clean closure report (DH Environmental, Inc., 2024a) in May 2024. An interim action completion report was issued in July 2024 (DH Environmental, Inc., 2024b).

Following demolition, unpaved areas within the former buildings and at the southwest corner of the Site were paved. Some portions of the Site remain unpaved.

A detailed account of historical Site activities can be found in the RI report (Shannon & Wilson 2025).

2.3. CURRENT AND FUTURE LAND USE

The Site currently consists of a fenced lot, the majority of which is paved with asphalt or concrete. The only significant features remaining at the site are a stormwater treatment system with an associated outfall to the LDW and four covered vaults associated with former press-pit operations.

Development plans for the property have not been determined, but future use is expected to remain industrial. According to counsel for the current property owner, Star Forge, “Development plans for the property have not been finalized, but the property is being marketed for future manufacturing, distribution, warehousing or similar use, consistent with zoning and adjacent Site use" (D. Quigley, email communication, May 7, 2025).

3.0 Summary of the Remedial Investigation

3.1. AREAS OF CONCERN AND INDICATOR HAZARDOUS SUBSTANCES

The RI identified eleven areas of concern (AOC) and associated indicator hazardous substances (IHSs) for impacted media within each area of the Site, as summarized below. The AOCs, which are subsequently referred to as "remedial areas" for the purposes of this FS, are shown on Figure 3-1. Detailed descriptions of each of the eleven areas and applicable Site history are provided in the RI (Shannon & Wilson 2025). IHSs are discussed in Section 4.3.1.

Area 1 (Cutting Oil Contamination): Area 1 encompasses much of the northeast quadrant of the Site, occupying an area of roughly 83,000 square feet. Cutting oil from former industrial operations has impacted soil and groundwater. Former vaults, tanks and piping which stored or conveyed cutting oil have been removed, decommissioned and/or capped. Prior remedial actions in this area have included light non-aqueous phase liquid (LNAPL) recovery via a well-based LNAPL recovery system.

- Soil and Groundwater: Diesel- and oil-range petroleum hydrocarbons (TPH-D and TPH-O).
- Cutting oil LNAPL present in soil and on groundwater.

Area 2 (Hydraulic Oil and Diesel Contamination): This AOC is located within the southeast quadrant of the Site, occupying an area of roughly 67,000 square feet. Hydraulic oil from a former oil-water separator (OWS), and diesel from former diesel underground storage tanks (USTs) and piping have impacted soil and groundwater. The OWS, USTs and associated vaults and piping were decommissioned and/or removed from the Site by Star Forge in 2023 under Ecology oversight. Prior remedial actions in this area have included LNAPL recovery via a well-based LNAPL recovery system.

- Soil: TPH-D, TPH-O, and gasoline-range petroleum hydrocarbons (TPH-G).
- Groundwater: TPH-D and TPH-O.
- Hydraulic oil and diesel LNAPL present in soil and on groundwater.

Per- and polyfluoroalkyl Substances (PFAS) Release Area: The PFAS Release Area is located within the footprint of Area 2, occupying an area of roughly 18,000 square feet. Releases of aqueous film-forming foam (AFFF) from fire suppression systems near the former 660-ton and/or 1,250-ton press pump rooms impacted soil and groundwater. Covered vaults associated with the presses are still present at the Site.

- Soil and Groundwater: Perfluorooctanesulfonic acid (PFOS).

Area 3 (Former Gasoline Underground Storage Tanks): This area is located near the eastern property boundary in the northeast quadrant of the Site, east of Areas 1, 2, and 4. Area 3 occupy an area of roughly 1,000 square feet. Three USTs containing gasoline were historically located in this area and removed in the early 1990s. Prior remedial action in this area included remedial excavation of soil and air sparging and soil vapor extraction (AS/SVE). Impacted soil and groundwater remain around the former northernmost UST and the center UST.

- Soil and Groundwater: TPH-G

Area 4 (Decommissioned Oil Storage Area): This area is located in the southeast quadrant of the Site and overlaps with the northeast portion of Area 2. Impacts within Area 4 are estimated to occupy approximately 15,000 square feet, although the southern boundary is not explicitly defined because of the LNAPL in Area 2. Releases from former heating oil and diesel fuel USTs and/or related oil recovery and storage equipment impacted soil and groundwater. USTs and associated piping were decommissioned and removed from the Site by Star Forge in 2023 under Ecology oversight.

- Soil: TPH-G, TPH-D and TPH-O.
- Groundwater: TPH-D and TPH-O.

Shipping Area: This area is located within the northeast quadrant of the Site and partially overlaps with Area 1. It occupies an area of approximately 2,000 square feet. Specific source(s) and release mechanisms are unclear for this area, but historic use included metals cleaning/testing and storage activities, where cleaning was reportedly done with petroleum-based solvents.

- Soil and Groundwater: TPH-G.

Storage Area: This area is located within the southwest corner of the Site, adjacent to the LDW and southern property boundary. It occupies an area of roughly 11,000 square feet. Former scrap bins, which were constructed partially below grade, were used to store metal scrap and debris in this area which was formerly unpaved. Scrap metal reportedly was contaminated with cutting fluids which was collected within a trench and vault system. Releases of cutting fluids in this area contaminated soil and groundwater.

- Soil and Groundwater: TPH-D, TPH-O, and polychlorinated biphenyls (PCBs).

Steam Clean Area: This area is located within the west-central portion of the Site, directly east of the shoreline and embayment area, occupying a roughly 6,000 square feet footprint. Former Site features in this area included a concrete reservoir and OWS associated with steam clean operations and a gasoline above ground storage tank (AST).

- Groundwater: TPH-D and TPH-O.

Northwest Corner: This area is located within the northwest corner of the Site, adjacent to the western boundary of the Site, adjacent to the LDW, and the northern property boundary between the Site and the Boeing Plant 2 Facility, near the Boeing's Area 2-66 sheet pile and known groundwater contamination. The area occupies roughly 14,000 square feet. Former Site features in this area included two buildings used for motor storage and used oil storage/diesel fueling, a diesel AST and a dangerous waste accumulation area.

- Soil: TPH-G, TPH-D, and TPH-O.
- Groundwater: TPH-D.

Shoreline and Embayment: This area is located along the western boundary of the Site, adjacent to the LDW and occupies roughly 111,000 square feet. A vertical sheet pile bulkhead and concrete panel wall separates most of this area from the LDW. Former site activities and/or features in this area were limited and included swarf (metal shavings) and slag storage, steam cleaning operations, and a metals processing melt bag house that collected dust classified as dangerous waste. Prior remedial actions completed in this area include remedial excavation of PCB- and metals-impacted soil in two discrete areas adjacent to the bulkhead.

- Soil and Groundwater: PCBs.

South of Boeing's Other Area 11 (OA-11): This area is located near the northwest corner of the Site, immediately adjacent to the northern property boundary between the Site and the Boeing Plant 2 Facility. It occupies roughly 2,000 square feet. PCB contamination in soil in this area has been attributed to historic releases of PCB-containing oil from transformers within a former Seattle City Light substation in OA-11 which was located approximately 12 feet north of the property boundary. Prior remedial actions completed in this area include a limited remedial excavation of PCB-contaminated soil by Boeing, which extended from the Boing Plant 2 Facility onto the Site.

- Soil: PCBs.

3.2. CONCEPTUAL SITE MODEL

The conceptual Site model (CSM) developed as part of the RI identified the primary sources and release mechanisms at the Site, which consisted of historic leaks and spills from industrial activities (oil storage areas including USTs, ASTs and associated piping, OWSs, AFFF--containing fire suppression systems, chemical storage/use areas and maintenance areas). Industrial operations at the Site are no longer active and the majority of historic Site infrastructure has been removed, thereby limiting any current or on-going primary sources to off-Site sources from which hazardous substances can migrate onto the Site via groundwater flow.

Historically, hazardous substances were released to the soil and groundwater, with subsequent releases to secondary media (soil vapor, stormwater and sediment). Secondary media have been considered as follows:

- Soil vapor: The soil vapor to indoor air pathway is not complete because no buildings exist at the Site. Potential future vapor intrusion risk was considered when developing the cleanup action alternatives and as part of the evaluation process for each alternative.
- Stormwater is largely managed by the existing stormwater collection and treatment system. Maintenance of existing system(s) and prevention of stormwater infiltration within limited pervious portions of the Site were considered when developing the cleanup action alternatives, and as part of the alternatives evaluation process.
- Sediment adjacent to the western side of the Site is being managed by the EPA as part of the LDW Superfund Site and is capped with reactive media. Contamination within the remedial areas appears to be relatively immobile and stable, and/or sufficiently separated from the shoreline that the risk to sediment is very low. For those reasons, sediment was not considered an exposure medium as part of this FS.

Current contamination transport mechanisms of concern at the Site consist of:

- Migration of contamination from off-Site sources to the Site via groundwater transport;
- Migration of contaminated groundwater on-site and potential migration off-site to the LDW, and to neighboring properties, primarily the Boeing Issacson property to the south;
- Stormwater infiltration within unpaved areas and subsequent mobilization/transport of contaminants from soil to groundwater;
- LNAPL dissolution or volatilization; and
- Volatilization of contaminants in soil and groundwater.

Current potential exposure pathways consist of human exposures primarily to future site workers as follows:

- Dermal contact with, and/or incidental ingestion of chemicals in soil (including LNAPL) at the Site. This pathway is largely incomplete due to existing pavement. However, portions of the Site are unpaved, and it could be a more significant exposure pathway in the future if soils on the Site were exposed.
- Inhalation of airborne particles (dust) generated from soil on the Site. This is also only a minor pathway because of the existing pavement which covers most of the Site.
- Dermal contact with or ingestion of chemicals in groundwater. This pathway is currently incomplete. Groundwater is currently not used for drinking water at or downgradient of the Site. Groundwater is non-potable as discussed below. Potential future pathways could include dermal contact of groundwater for construction workers.

Future exposure pathways considered as part of the FS based on likely future Site use include:

- Inhalation of air vapors emanating from contaminants in soil and/or groundwater (including LNAPL) via vapor intrusion into building(s) or outdoor features by Site workers.

Groundwater on the property and groundwater and surface water downgradient from the property are not a potential source of drinking water. Groundwater at and near the Site is non-potable (per the criteria in WAC 173-340-720) based on the Site groundwater's hydraulic connection with the non-potable saline LDW as documented in the RI. Ecology has concurred that the Site meets the requirements for non-potable groundwater (Ecology, 2018).

Potential off-property transport of chemicals in groundwater to surface water and sediment within the LDW, and associated exposure pathways to humans and ecological receptors, including direct contact or ingestion of benthic or aquatic species, was considered as part of this FS to derive cleanup standards (Section 4.3). However, as discussed above, groundwater contamination within the remedial areas adjacent to the LDW appears to pose a low risk to surface water and sediment, and residual risks would be mitigated via the upland cleanup actions proposed as part of this FS and the in-water reactive cap installed by EPA for the LDW Superfund Site.

Potential wildlife exposure to Site chemicals was considered for the industrial/commercial property scenario as part of the simplified Terrestrial Ecology Evaluation (TEE) performed as part of the RI (RI Section 6.4). This potential exposure pathway, while considered as part of this FS, is not a primary pathway driving cleanup because the other potential exposure pathways considered (described above) result in more stringent cleanup criteria for chemicals of concern.

Figure 3-2 presents a simplified CSM that highlights dominant sources, release and transport mechanisms and exposure pathways for receptors considered as part of this FS.

4.0 Basis for Cleanup Action

Cleanup action objectives (CAOs) formed the basis for evaluating and selecting remedial technologies and cleanup actions that will be successful at the Site. CAOs consist of location-, chemical- and medium-specific goals for protecting human health and the environment. CAOs are dependent on the chemicals and pathways that pose a risk to people and natural resources associated with a Site. Development of CAOs involves several steps, as described below and in the following sections:

- Identify laws and regulatory standards (potentially applicable or relevant and appropriate requirements and anticipated permits (ARARs) that set the framework and requirements for the development of cleanup standards and implementation of a cleanup action.
- Develop cleanup levels and points of compliance (cleanup standards) at which an acceptable risk level is attained; and
- Identify locations and media requiring cleanup based on selected cleanup standards.

4.1. POTENTIALLY APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Cleanup actions conducted under MTCA must comply with the state and federal laws that are legally applicable and those that Ecology determines are relevant and appropriate requirements WAC 173-340-710). These laws, implementing regulations, standards, limitations or other requirements are referred to as ARARs.

The ARARs identified for cleanup of the Site are listed in Table 4-1. The procedures, standards and other requirements specified in MTCA are the primary ARARs governing cleanup actions at the Site. Additional ARARs regulate specific components of the cleanup, including disposal of hazardous waste, management of extracted groundwater during construction, and worker safety during implementation.

MTCA cleanup actions conducted under an AO are generally exempt from the procedural requirements of many state and local permits. Typically, cleanup actions are exempt from the procedural requirements of the Washington State Clean Air Act, solid waste management, water pollution control, and local regulations. However, permits associated with two national programs that are administered by the State — the Clean Water Act (CWA) National Pollution Discharge Elimination System (NPDES) permits, and those permits required for treatment, storage or disposal of hazardous waste under the Resource, Conservation and Recovery Act (RCRA) — still apply, as do the federally required permits. Regardless of the permit exemptions, the cleanup actions must meet the substantive requirements of the subject regulations.

4.2. CLEANUP ACTION OBJECTIVES

The general objectives of the cleanup actions are to eliminate, reduce, or otherwise control to the extent practicable, unacceptable risks to human health and the environment posed by hazardous substances in impacted media at the Site in accordance with the MTCA cleanup regulation (Chapter 173-340 WAC) and other applicable regulatory requirements. The individual CAOs for the cleanup actions at the Site are specific to certain media and contaminants of concern, exposure routes, and receptors. The CAOs for the Site are based on an assumed industrial land use.

The media and exposure pathways of concern for the Site are identified in Section 3.2 and include potential human exposures to Site-related contaminants that are present in soil, groundwater and soil vapor. The CAOs for the Site consist of the following:

- Prevent people from contacting contaminants in soil (dermal contact, including incidental ingestion) and groundwater (dermal contact), including LNAPL.
- Prevent Site workers being exposed to contaminants resulting from soil vapor migrating to indoor air (inhalation of indoor air) if a future building is constructed in an area of the Site where there is a risk for vapor intrusion.
- Prevent stormwater from infiltrating at the Site and mobilizing contaminants in soil (which are or will be capped) to groundwater.

Groundwater is classified as non-potable as described in Section 3.2. Therefore, the CAOs do not include preventing use of groundwater as potable water. However, institutional controls will be included in the remedy that prohibit withdrawal of groundwater from the Site for potable and non-potable uses.

4.3. CLEANUP STANDARDS

Cleanup standards are used to develop cleanup actions that will achieve CAOs and lead to post-remedy conditions protective of human health and the environment. Cleanup standards consist of: (1) chemical concentrations (cleanup levels) in environmental media that are protective of human health and the environment; (2) locations where the cleanup levels must be met (i.e., point of compliance); and (3) additional regulatory requirements specified in applicable state and federal laws, which apply to a cleanup action because of the type of action and/or the location.

Proposed cleanup levels and screening levels developed as part of the RI are used as preliminary cleanup levels (PCULs) for Site media in this FS for IHS. The IHS selection process, preliminary cleanup levels, and points of compliance for soil and groundwater are described in subsequent sections.

4.3.1. Indicator Hazardous Substances

IHSs for the Site were selected in the RI in accordance with WAC 173-340-703 and were used to focus the evaluation of cleanup action alternatives. This process eliminates from consideration individual hazardous substances that contribute a small percentage of the overall threat to human health and the environment.

The IHSs identified in the RI report for each remedial area, as discussed in Section 3.1, were used in this FS. Remedial alternatives for the Site were developed based on the following IHSs, acknowledging that IHS occurrence is not Site-wide, but on an individual remedial area-basis:

TABLE I. IHS AND MEDIA

IHS	SOIL	GROUNDWATER
TPH-G	√	√
TPH-D	√	√
TPH-O	√	√
PCBs	√	√
PFOS	√	√

4.3.2. *Preliminary Cleanup Levels*

PCULs for soil and groundwater and the basis for each value are summarized as follows for Site IHSs.

TABLE II. IHS AND PCULS FOR EACH MEDIA OF CONCERN

IHS	SOIL PCUL (mg/kg)	BASIS FOR SOIL PCUL	GROUNDWATER PCUL (µg/L)	BASIS FOR GW PCUL
TPH-G	100	Protection of SW (weathered product)	1,000	Protection of SW (weathered product)
TPH-D[1]	2,000		500	
TPH-D + TPH-O[2]	2,000		500	
PCBs	5.5x10^-7	Protection of SW	7x10^-6	Protection of SW
PFOS	7.2x10^-4	Protection of SW	1.1	Protection of SW

Notes:

[1] The PCUL for TPH-D alone is applicable to the Northwest Corner AOC where only TPH-D is an IHS.

[2] The PCUL for TPH-D + TPH-O is applicable to AOCs 1, 2, 4, the Storage Area and the Steam Clean Area where both IHSs are present. TPH-D and TPH-O concentrations will be summed when evaluating compliance for these areas.

PCUL = preliminary cleanup level
SW = surface water (i.e., the LDW)
GW = groundwater
IHS = indicator hazardous substance
mg/kg = milligram per kilogram
µg/L = microgram per liter

4.3.3. *Points of Compliance*

The standard point of compliance for soil is throughout the Site. For the protection of human health via direct contact, the standard point of compliance for soil is from ground surface to 15 feet below ground surface (bgs). Cleanup action alternatives evaluated as part of this FS are not anticipated to meet the standard point of compliance across the Site, but instead use capping to prevent direct contact.

The standard point of compliance for groundwater is throughout the Site. MTCA allows use of a conditional point of compliance when it can be demonstrated that it is not practicable to meet cleanup levels throughout the Site within a reasonable restoration time frame (WAC 173-340-720[8][c]). This FS includes alternatives that are expected to meet groundwater cleanup levels at the conditional point of compliance defined at the property boundary.

4.3.4. Areas Requiring Cleanup

The areas requiring cleanup are those locations where the IHSs exceed PCULs. Figure 3-1 shows the approximate location of these areas. The Site is characterized in terms of eleven remedial areas. Remedial areas are identified for the Site based on the differences in types and concentrations of contamination in each area. It is not appropriate to select a single cleanup alternative that applies to the entire Site because of these differences. The eleven remedial areas and their characteristics are summarized in Section 3.1 and in the RI.

5.0 Identification and Screening of Remedial Technologies

A screening evaluation of potentially applicable remedial technologies for developing cleanup action alternatives in accordance with MTCA requirements, WAC 173-340-351 was performed for this FS. Sources of information used to develop the list of technologies include EPA publications and databases, text references, vendor information, and professional experience at similar sites.

The general categories of response actions identified for the Site include: no action, institutional controls, monitoring, containment, and in-situ and ex-situ treatment and/or removal. While many remedial technologies and specific process options were considered, demonstrated technologies which are commonly used for the IHSs and conditions at the Site were retained for cleanup action alternatives development. Examples of such technologies include physical, chemical, biological and thermal treatment. Specific process options retained within each of the technology categories include options such as MNA, AS/SVE, permeable reactive barriers (PRBs), dual phase extraction (DPE) and in-situ soil solidification/stabilization (ISS), among others.

The technology screening evaluation was performed for contaminants in soil and groundwater. The evaluation focuses on demonstrated technologies appropriate for the size, cleanup time frame, and conditions at the Site, and is presented in Tables 5-1 and 5-2 for soil and groundwater respectively.

6.0 Description of Cleanup Action Alternatives

This section describes the cleanup action alternatives (CAAs) using the remedial technologies retained in Section 5. The cleanup alternatives share several common elements. These common elements are not necessarily called out in the description detail for the individual alternatives. However, their costs are included in the total estimated cost for each alternative (Appendix A).

The following elements are common to each alternative:

- Monitoring. Conduct a monitoring program to evaluate attenuation and long-term stability of lower concentration dissolved contaminants outside the immediate area of active treatment, where applicable. Following active soil and/or groundwater treatment, groundwater monitoring would continue following treatment completion to evaluate treatment efficacy and long-term conditions associated with contaminants in groundwater.

- Institutional Controls. Each alternative will leave some contamination in place; therefore, institutional controls are required. Institutional controls will likely include use restrictions, engineering control requirements, operational and maintenance requirements, and financial assurances. Specific institutional controls for the cleanup action will be defined during future steps in the cleanup process.
- Engineering Controls. Each alternative will leave some contamination in place and maintenance of existing caps (and installation of caps where none exist) will be required to prevent transport of contaminants and direct-contact risk. Maintenance of existing stormwater collection infrastructure will be required associated with the widespread low-permeability capping at the Site. Maintenance of existing low-permeability caps and associated stormwater infrastructure is consistent with expected future Site use for industrial activities.

6.1. REMEDIAL AREAS WITH A SHARED CLEANUP ACTION (ALL ALTERNATIVES)

For each remedial area, the IHSs, affected media, and potential receptors were evaluated to identify cleanup actions which would meet the CAOs for the Site. Capping, in addition to the common elements discussed above, was identified as the most effective cleanup action to meet CAOs for eight of the eleven remedial areas (outlined below) based on that evaluation and was therefore included in all CAAs.

- Area 3 – Former Gasoline USTs
- Area 4 – Decommissioned Oil Storage Area
- Shipping Area
- Storage Area
- Steam Clean Area
- Northwest Corner
- Shoreline and Embayment
- Area South of Boeing AO-11

Capping will address the cleanup action objectives by preventing direct contact with remaining COCs and by reducing or eliminating stormwater infiltration which could potentially mobilize remaining COCs in these areas. The following sections of this FS will develop cleanup action alternatives with respect to the remaining remedial areas: Area 1, Area 2, and the PFAS Release Area.

Concentrations of diesel range organics, benzene, PCBs, CPAHs and CVOCs in groundwater have been detected sporadically above PCULs in the far northwest and southwest corners of the Site adjacent to the western property boundary. Groundwater COCs are relatively immobile with stable concentrations in these areas of the Site. Remediation of these COCs in groundwater along the western property boundary will be accomplished through capping (by eliminating transport via surface water infiltration) and monitored natural attenuation. Additionally, an engineered multi-layered cap was installed in these areas as part of the nearshore cleanup adjacent to the Site. This cap, which is augmented with granular activated carbon, would serve as a backstop to prevent Groundwater monitoring will continue to confirm the stability and natural degradation of COCs as part of the long-term monitoring for the Site (common to all elements of this FS). Potential remedial options will be evaluated should information indicate that the risk from remaining concentrations of COCs is changing particularly at the property boundary.

As part of the long-term monitoring for the Site (common to all elements of this FS), groundwater monitoring will continue to confirm the stability and natural degradation of COCs. Should information indicate that the risk from remaining concentrations of COCs, particularly at the property boundary, is changing, potential remedial options will be evaluated.

6.2. ALTERNATIVE 1: MNA (ALL REMEDIAL AREAS)

Alternative 1 includes addressing contamination using MNA for each remedial area and involves monitoring groundwater at the Site for the long term. A monitoring program would be implemented in accordance with established guidelines for MNA. Actions outlined in the monitoring plan would evaluate the effectiveness of natural attenuation on Site contaminants. The performance monitoring plan would identify monitoring wells to be used, groundwater sampling and analyses including quality control procedures, monitoring frequency, and metrics for evaluating MNA performance. The performance monitoring plan would also identify "triggers" for contingency remedial actions if, for instance, MNA is not successful within a certain timeframe, or if monitoring identifies changes in contaminant conditions which increase risks at the Site.

Groundwater monitoring would evaluate whether natural attenuation processes are performing as anticipated and will ultimately achieve cleanup levels. It is anticipated that select existing wells would be maintained and used for monitoring.

MNA alone likely does not meet the MTCA minimum requirements, at least for Areas 1 and 2 due to the anticipated extended restoration timeframe needed and measurable presence of LNAPL in soil and on groundwater. The MNA only alternative is only included as a baseline against which to compare other alternatives.

6.3. ALTERNATIVE 2: EXCAVATION FOR LNAPL RECOVERY & AS/SVE (AREA 1); DPE FOR LNAPL RECOVERY & AS/SVE (AREA 2)

Alternative 2 addresses contamination within Areas 1 and 2 using different LNAPL recovery techniques followed by AS/SVE of the groundwater plume as shown in Figure 6-1. Within Area 1, soil within the LNAPL plume would be excavated down to the top of the groundwater table to remove LNAPL-containing soils and to recover LNAPL on top of the water. In Area 2, Alternative 2 provides for DPE in wells to recover LNAPL within the LNAPL plume. In both Areas 1 and 2, AS/SVE would be used following LNAPL recovery efforts to treat the residual groundwater plume. Additionally, Alternative 2 includes installing and/or maintaining a low-permeability cap across the Site to prevent direct contact with contaminants in soil and groundwater and to prevent infiltration. MNA would be used in all other remedial areas where contaminant concentrations and potential risks to receptors are lower.

Additional details regarding Alternative 2 cleanup action elements are described below.

<u>Excavation and AS/SVE Area 1</u>

Alternative 2 addresses contamination in Area 1 via excavation and off-Site disposal of contaminated soil within the LNAPL plume, and also via LNAPL recovery within the open excavation. Excavation would be performed during the dry season, using standard erosion control measures and excavation equipment. The extent of LNAPL impacts in soil within Area 1 would be excavated to the top of the groundwater table, estimated to be approximately twelve (12) feet below ground surface (bgs). The excavation would be left open for a sufficient period (likely days) to allow LNAPL to collect, and be recovered using sumps, skimmers and pumping systems within the excavation. Excavated soil would be transported off-Site for disposal at a Subtitle D landfill. For the purposes of cost estimating, we have assumed the excavation can be sloped rather than shored, dewatering will not be required, and the top 5 feet of soil will be segregated on-Site and reused within the excavation as backfill. The overburden soil will be sampled and analyzed for COCs to confirm soil can be reused. Confirmation soil samples would be collected along the sidewalls of the excavation within the vadose zone to confirm contaminants were removed to concentrations at or below cleanup levels. Alternatively, remedial design investigative efforts may further delineate the extent of LNAPL prior to remedial construction for the purpose of defining the excavation area ahead of the DCAP process.

The excavated area would be backfilled with clean soil and an asphalt cap would be installed.

Dual Phase Extraction Area 2

A series of extraction wells would be installed within the LNAPL plume in Area 2 to remove recoverable LNAPL from the vadose zone and on top of groundwater. Removed LNAPL would be collected and recycled/disposed off-Site, while the extracted groundwater and soil vapor would be treated and discharged on Site. Groundwater discharge to the sewer would require authorization from King County and vapor discharge to ambient air would require authorization from the Puget Sound Clean Air Agency.

6.4. ALTERNATIVES 3 & 3B: TARGETED EXCAVATION FOR LNAPL RECOVERY AND ISS (AREAS 1 AND 2)

Alternative 3 addresses contamination within Areas 1 and 2 using targeted excavation for LNAPL recovery followed by ISS of the groundwater plume as shown in Figure 6-2. The most impacted portions of the LNAPL plumes would be excavated down to the top of the groundwater table to remove LNAPL-containing soils and to recover LNAPL on top of the water and from adjacent unsaturated soils. ISS would then be used to treat soils and residual groundwater plumes. Following ISS activities, all areas will be capped.

A variant of Alternative 3, Alternative 3B includes the elements of Alternative 3 plus a PRB near the western property boundary. Alternatives 3 and 3B are evaluated separately in this FS. Additional details regarding cleanup action elements for Alternatives 3 and 3B are described below.

Targeted Excavation for LNAPL Recovery

Excavation would be completed as described in Alternative 2, except with a smaller footprint within the Area 1 and Area 2 LNAPL plumes. The approximate footprint of the targeted excavation will be determined based on the estimated thirty-percent excess soils generated during ISS treatment as described below and shown conceptually in Figure 6-3. For cost estimating purposes, we assumed that PFOS-impacted soil removed from Area 2 will be disposed as hazardous waste (Subtitle C).

ISS

ISS would be completed using traditional excavator bucket mixing techniques down approximately 15 feet bgs. The intent of ISS is to solidify or stabilize remaining LNAPL and TPH-impacted soils to greatly reduce or eliminate contaminant leaching to groundwater. An excavator would be used to add and mix contaminated soil with a binding agent. Excess soil due to swelling during mixing, estimated at approximately 30 percent of the total mixed volume, will be removed and disposed off-Site as part of the ‘targeted excavation’ described above.

Treatability testing will be required to determine the admixtures that will be used to stabilize and solidify soil within the treatment zone. It is anticipated that a combination of portland cement, granular activated carbon, and potentially other treatment or stabilizing agents will be identified and tested to determine the appropriate mix for the Site.

Alternative 3B PRB

Alternative 3B includes a PRB with activated carbon to sequester potential PFAS (and/or metals which could potentially mobilize, at least temporarily as part of the ISS treatment process) which could migrate across the western property boundary. The PRB would be installed using direct-push or other drilling techniques and injection technology in temporary or permanent injection wells. The target treatment zone for the PRB would be across the saturated zone of potential PFAS impacts and would be determined following additional investigation at the remedial design phase.

6.5. ALTERNATIVES 4 & 4B: EXCAVATION FOR LNAPL RECOVERY & AS/SVE (AREAS 1 AND 2)

Alternative 4 is the same as Alternative 2 for Area 1 but applied to both Areas 1 and 2 as shown in Figure 6-3. For Areas 1 and 2, LNAPL-containing soils would be removed, and the excavations would be temporarily left open to recover LNAPL on top of the water. AS/SVE would be used following LNAPL recovery efforts to treat the residual groundwater plume.

As with Alternatives 3 and 3B, Alternative 4B is a variant of Alternative 4 which includes the elements of Alternative 4 plus a PRB with activated carbon to sequester potential PFAS near the western property boundary. Alternatives 4 and 4B are evaluated separately in this FS.

7.0 Cleanup Action Evaluation Criteria

This section describes MTCA evaluation criteria and analysis procedures for evaluating cleanup action alternatives.

7.1. MTCA EVALUATION CRITERIA

MTCA evaluation criteria used to evaluate the cleanup action alternatives are described in the following sections.

7.1.1. MTCA General Requirements

MTCA cleanup actions must comply with general requirements. Cleanup action alternatives that do not comply with the general requirements are not considered suitable alternatives under MTCA. As provided in WAC 173-340-360(3)(a), the ten general requirements for remedial actions are:

1. Protect human health and the environment, including likely vulnerable populations and overburdened communities.

2. Comply with the cleanup standards.
3. Comply with applicable state and federal laws.
4. Prevent or minimize present and future releases and migration of hazardous substances in the environment.
5. Provide resilience to climate change impacts that have a high likelihood of occurring and severely compromising the cleanup's long-term effectiveness.
6. Provide for compliance monitoring.
7. Not rely primarily on institutional controls and monitoring at a Site, or portion thereof, if it is technically possible to implement a more permanent cleanup action.
8. Not rely primarily on dilution and dispersion unless the incremental costs of any active remedial measures over the costs of dilution and dispersion grossly exceed the incremental degree of benefits of active remedial measures.
9. Ensure a reasonable restoration time frame.
10. Use permanent solutions to the maximum extent practicable.

7.1.2. Action Specific Requirements

When applicable, cleanup actions must use remediation levels, institutional controls, provide financial assurances, and provide for periodic reviews in accordance with the WAC.

7.1.3. Media Specific Requirements

7.1.3.1. SOIL

A soil cleanup must treat, remove, or contain contaminated soil located where a school or childcare center is located, and properties that qualify as a residential area based on current use or potential future use. The intent of this requirement is to clarify the more stringent soil cleanup standards required for sites with school, childcare, or residential use, and thus, the requirement does not apply at all sites such as this Site.

7.1.3.2. GROUNDWATER

A permanent groundwater cleanup must be implemented when such an action is practicable, or if Ecology determines that a permanent action is in the public interest. A non-permanent groundwater cleanup is permitted when the permanent conditions are not practicable. If the groundwater cleanup is nonpermanent, then the cleanup action must treat or remove the source of groundwater contamination at Sites where there are liquid wastes, areas contaminated with high concentrations of hazardous substances, highly mobile hazardous substances, or hazardous substances that cannot be reliably contained. The cleanup action also must contain contaminated groundwater to the maximum extent practicable to prevent lateral and vertical expansion of the groundwater volume affected by the hazardous substances and to prevent the migration of the hazardous substances.

7.1.4. Public Concerns and Tribal Rights and Interests

Ecology supervised cleanups must consider public concerns, including the concerns of likely vulnerable populations and overburdened communities, and tribal rights and interests when evaluating the cleanup alternatives. The Jorgensen Forge Site cleanup is an Ecology supervised cleanup.

7.2. MTCA DISPROPORTIONATE COST ANALYSIS

A disproportionate cost analysis (DCA) is performed to evaluate cleanup action alternatives that meet the MTCA minimum requirements. The DCA process compares the benefits and costs of the alternatives to identify which alternative has incremental costs that are not disproportionate to its incremental benefits, thereby defining the alternative that is permanent to the maximum extent practicable.

7.2.1. DCA Benefit Criteria

The environmental benefits for the alternatives are evaluated based on six criteria in WAC 173-340-360(5)(d):

1. **Protectiveness** – The is criterion considers the degree to which the alternative protects human health and the environment, including likely vulnerable populations and overburdened communities. It requires consideration of the degree to which the alternative reduces existing risks; the cleanup timeframe; the on-Site and off-Site risks remaining after implementing the alternative; and the improvement of the overall environmental quality.
2. **Permanence** – This criterion requires consideration of the degree to which the alternative permanently reduces the toxicity, mobility or volume of hazardous substances, including the adequacy of the alternative in destroying the hazardous substances, the reduction or elimination of hazardous substance releases and sources of releases, the degree of irreversibility of waste treatment process, and the characteristics and quantity of treatment residuals generated.
3. **Long-term effectiveness** – This criterion considers the degree of certainty that the alternative will be successful, the reliability of the alternative during the period of time hazardous substances are expected to remain on-Site at concentrations that exceed cleanup levels, the magnitude of residual risk with the alternative in place, the resilience of the alternative to climate change impacts, and the effectiveness of controls required to manage treatment residues or remaining wastes. The following types of cleanup action components, in descending order, are used as a guide in assessing the relative degree of long-term effectiveness (WAC 173-340-360[5][d][iii][B]):
    - Reuse or recycling;
    - Destruction or detoxification;
    - Immobilization or solidification;
    - On-Site or off-Site disposal in an engineered, lined and monitored facility;
    - On-Site isolation or containment with attendant engineering controls (ECs); and
    - Institutional controls and monitoring.
4. **Management of implementation risks** – This criterion evaluates risks to human health and the environment, including likely vulnerable populations and overburdened communities, associated with the alternative during construction and implementation, and the effectiveness of the alternative to manage such risks. Risks can occur from worker or public exposure to contaminants, other releases of contaminants to the environment, and physical hazards created by construction and related materials management.
5. **Technical and administrative implementability** – This criterion assesses the ability to implement the alternative, including consideration of technical difficulty regardless of cost; the availability of

necessary off-Site facilities, services, and materials; administrative and regulatory requirements; scheduling; project size and complexity; monitoring requirements; access for construction operations and monitoring; and integration with existing facility operations.

6. **Costs** – This criterion considers costs of remedial actions necessary to implement the alternative, including both construction and post-construction costs. Construction costs include design, permitting, construction, waste management, compliance monitoring, construction management, establishment of institutional controls, quality assurance and quality control; and regulatory oversight. Post-construction costs include operation and maintenance activities necessary to maintain the effectiveness of the cleanup, waste management and disposal, replacement or repair of equipment, permit renewal, compliance monitoring, maintaining institutional controls, financial assurances, periodic reviews, postconstruction management, and regulatory oversight. Future post-construction costs are discounted using present worth analysis by estimating future costs using constant-year dollars and discounting future costs using the current U.S. Treasury real interest rate for bonds of comparable maturity to the period of analysis (up to 30 years).

7.2.2. DCA Scoring

The DCA scoring process compares the relative overall benefit and cost of the cleanup alternatives to identify the alternative that is permanent to the maximum extent practicable; and then that alternative is selected as the preferred remedy. The benefits of each alternative are evaluated based on the MTCA DCA criteria discussed above, other than cost. Each criterion is given a score between 1 and 10, with 1 being the lowest score and 10 being the highest. For each alternative, the individual criterion scores are then equally weighted (20 percent each) unless there is a compelling reason not to.

The total weighted benefit scores are compared to the estimated cost to implement the alternative, including the cost of construction, the net present value of any long-term expenses, and agency oversight costs that are recoverable from the responsible parties. Long-term costs cover operation and maintenance, monitoring, equipment replacement and institutional controls.

A benefit-to-cost ratio is calculated for each alternative by dividing its total weighted benefit score by its total cost.

7.2.3. Determination of Permanence to the Maximum Extent Practicable

Under MTCA, preference is given to cleanup actions that use permanent solutions to the maximum extent practicable. Permanent remedies require no additional action to meet cleanup standards per the definition in MTCA. A practicable cleanup action is designed, constructed and implemented in a reliable, cost-effective manner. A cleanup action is not considered practicable if the incremental costs are disproportionate to the incremental benefits when compared to lower-cost alternatives.

The MTCA DCA analysis for this FS uses a relative benefit-to-cost ratio to compare the alternatives and determine whether incremental cost increases are disproportionate to respective incremental increases in benefits. To calculate the relative benefit-to-cost ratio for each alternative, the total weighted benefit score was divided by the total cost. Alternatives with incremental benefits that are disproportionately small in comparison to the incremental cost produce lower relative benefit/cost ratios.

8.0 Evaluation of Cleanup Action Alternatives

This section summarizes the evaluation results for cleanup action alternatives developed using a quantitative approach as prescribed in MTCA 173-340-350 and -360. The degree to which each cleanup action alternative uses permanent solutions to the maximum extent practicable was determined using a disproportionate cost analysis of the alternatives as described in Section 7.2. Alternatives were evaluated against weighted benefit criteria, scored on a scale from 1 (lowest score) to 10 (highest score) and summed to develop a total weighted relative benefit score for the alternative. A discussion of the scoring considerations for each criterion and the cost of each alternative is presented in the sections that follow.

Four alternatives (with two sub-alternatives 3B and 4B) were evaluated for the Site as summarized in Tables 8-1 through 8-3. Each of the cleanup action alternatives meet the MTCA requirements except Alternative 1 (MNA only).

8.1. PROTECTIVENESS

Alternative 1 (MNA) is not protective of human health and the environment because it leaves considerable LNAPL in place and has an unnecessarily long restoration timeframe. Alternative 1 scored the lowest in protectiveness for this reason.

Alternative 2 scored the second lowest for protectiveness due to the low confidence in successfully recovering LNAPL in Area 2 using DPE techniques, particularly given the unfavorable LNAPL recovery data provided in the RI. Alternatives 3 and 4 scored the same for protectiveness based on the assumed effectiveness of both these alternatives to remove LNAPL and treat the remaining groundwater plumes in Areas 1 and 2. Sub-alternatives 3B and 4B similarly scored the same for protectiveness, both with slightly higher scores than their respective primary alternatives due to the added protection provided by the PRB at the western property boundary at containing future PFOS (and/or metals mobilized as part of the ISS treatment process [Alternative 3B]) transport in groundwater.

8.2. PERMANENCE

Alternative 1 (MNA) scores the lowest on permanence for similar reasons to those discussed above for protectiveness. Alternative 2, 3 and 3B were scored the same for permanence because these will each remove significant portions of the LNAPL plumes, particularly in Area 1 where impacts are the greatest. Alternatives 4 and 4B score the highest because the most LNAPL is removed and disposed off-Site although relocated to a landfill.

8.3. LONG-TERM EFFECTIVENESS

Alternative 1 (MNA) is not expected to be effective over the long term based on the volume of LNAPL present in Areas 1 and 2. The remaining alternatives are generally effective over the long term, with scores ranging from 5 for Alternative 2 (due to uncertainties with implementing DPE) to a score of 9 for Alternative 4B. Sub-alternatives 3B and 4B scored slightly higher than their respective primary alternatives (as with protectiveness) because of the added protection/effectiveness over the long term of having a PRB at the western property boundary to capture potential PFOS migration in groundwater.

8.4. MANAGEMENT OF IMPLEMENTATION RISKS

Alternatives 1 and 2 score relatively low for management of implementation risks due to the risks of leaving significant volumes of LNAPL in place over the long implementation period for these alternatives. Alternatives 3 and 3B scored the highest, although only slightly higher than Alternatives 4 and 4B, because of the more targeted excavation extents which pose risks to workers and the public (during soil transport) during the implementation phase.

8.5. TECHNICAL AND ADMINISTRATIVE IMPLEMENTABILITY

Each alternative ranked the same in terms of technical and administrative implementability, except Alternative 1 which ranked the highest due to the ease of implementing an MNA remedy. In general, the scale and components of Alternatives 2 through 4B are considered similar from a technical and administrative standpoint as each use standard equipment and widely used remediation techniques which will be straightforward to implement, albeit on a moderately large scale given the size of the Site and Areas 1 and 2 in particular. The implementation timeframe for construction is expected to be somewhat similar across each alternative (except Alternative 1). Accordingly, disruption to future business operations at the Site was not a differentiator in terms of scoring.

8.6. COST

Estimated implementation costs for the alternatives including contingency ranged from $1,290,000 (Alternative 1) to $14,380,000 (Alternative 4B). Contingency costs were assigned as a percentage of the total estimated base cost for each alternative. Contingency for each alternative was determined based on the relative complexity and associated uncertainties regarding implementation or effectiveness for that alternative.

Costs for each of the alternatives are summarized in Table 8-3. Detailed cost estimates are presented in Appendix A.

9.0 Disproportionate Cost Analysis

A relative benefit-to-cost ratio is used to compare the cleanup action alternatives to determine whether costs are disproportionate to benefits.

Table 8-3 presents the total weighted relative benefit score for each alternative calculated using the raw scores and respective weighting factor for each criterion. The costs for each alternative are also provided in Table 8-3. The benefits, costs, and relative benefit-to-cost ratio are presented graphically in Figure 9-1.

The total weighted relative benefit scores for the alternatives range from 3.20 (Alternative 1) to 7.60 (Alternative 4B) as shown in Table 8-3 and Figure 9-1. Under MTCA, costs must be considered when selecting the alternative that is permanent to the maximum extent practicable and costs are considered disproportionate to benefits if the incremental costs of the alternative over that of a lower cost alternative exceed the incremental degree of benefits achieved by the alternative over that of lower cost alternative. Graphically, this concept is illustrated in Figure 9-1. Based on Figure 9-1, and the relative benefit ranking of remedial cost ranking presented in Table 8-3, Alternative 3 has the highest benefit-to-cost ratio.

10.0 Preferred Cleanup Action Alternative

The preferred alternative has the highest benefit per unit cost and is determined to be permanent to the maximum extent practicable in accordance with MTCA. The preferred alternative is Alternative 3, which consists of the following cleanup action elements:

- **Areas 1 and 2:** Targeted excavation for LNAPL recovery and ISS.
- **Remaining remedial areas:** capping and MNA.
- **Common Elements to all remedial areas:** institutional and other engineering controls as needed.

Post-remedy performance monitoring will be completed to evaluate remedy performance and will include an evaluation of vapor intrusion risks, any vapor mitigation requirements for future building(s) at the Site, and the need for any related environmental covenants. The final cleanup action for the Site will be presented in the DCAP and developed in more detail in an Engineering Design Report.

The preferred alternative was selected based on results of the DCA that comparatively evaluates the relative benefit and cost of each alternative. The preferred alternative has the highest benefit-to-cost ratio and therefore is considered permanent to the maximum extent practicable. The alternative provides the optimum balance between cost, benefit and certainty of long-term performance while meeting the threshold and other requirements for cleanup actions set forth in MTCA. The preferred alternative will:

- Protect human health and the environment by removing LNAPL to the extent practicable from the Site where present (Areas 1 and 2), treating the most contaminated groundwater to mitigate a future vapor intrusion risk (Areas 1 and 2), and managing contaminants in other remedial areas with lower contaminant concentrations using MNA, institutional and engineering controls.
- Protect future workers from exposure to contaminants in shallow soil on Site by maintaining the existing paved surfaces, installing new paved surfaces where none exist and implementing institutional controls that restrict access to contaminants left in place following cleanup.
- Provide for groundwater monitoring to ensure that groundwater continues to meet cleanup levels at the point of compliance.

11.0 Limitations and Guidelines for Use

GeoEngineers, Inc. (GeoEngineers) has prepared this report for the exclusive use by Earle M. Jorgensen Company, its authorized agents, and regulatory agencies for the Jorgensen Forge Corporation Property located in Tukwila, Washington. No other party may rely on the product of our services unless GeoEngineers agree in advance and in writing to such reliance. Within the limitations of scope, schedule, and budget, GeoEngineers' services have been executed in accordance with generally accepted environmental science practices in this area at the time this report was prepared. No warranty or other conditions, express or implied, should be understood.

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Please refer to the Appendix B titled “Report Limitations and Guidelines for Use” for additional information pertaining to use of this report.

12.0 References

Ecology 2016. “Feasibility Study Checklist,” Washington State Department of Ecology, Toxics Cleanup Program, Publication Number 17-09-007, May 2016.

Ecology 2017. “Agreed Order No. DE 14143 in the matter of remedial action by Earle M. Jorgensen Company: Washington State Department of Ecology,” signed July 28, 2017.

Ecology 2018. “Ecology Comments on the Draft Remedial Investigation Work Plan, Jorgensen Forge Corporation Property, Tukwila, Washington, dated October 25, 2017 for: Jorgensen Forge Corp Site, 8531 East Marginal Way South, Tukwila, WA 98106, Facility/Site No. 2382, Cleanup Site ID No. 3689, Agreed Order No. 14143,” Washington State Department of Ecology Toxics Cleanup Program letter, dated July 13, 2018.

Ecology 2025. “Guidance for Determining if a Cleanup Action used Permanent Solutions to the Maximum Extent Practicable using Disproportionate Cost Analysis,” Washington State Department of Ecology, Toxics Cleanup Program, Publication Number 25-09-059, Draft for Public Comment, February 2025.

Shannon & Wilson 2025. Draft for Public Comment Remedial Investigation Report, Jorgensen Forge Corporation Property, Tukwila, Washington, Ecology Agreed Order No. DE 14143 dated March 10, 2025.

Tables

Table 4-1

Potential and Applicable Laws and Relevant and Appropriate Requirements (ARARs) Governing Cleanup

Jorgensen Forge Corporation Property

Tukwila, Washington

Authorizing Statute and Implementing Regulation	Citation	Procedural/Substantive Requirements	Description and Applicability
Federal ARARs			
Archaeological Resources Protection Act	16 USC § 470aa et seq. 43 CFR Part 7	Prohibits the unauthorized disturbance of archaeological resources on public or Indian lands. Archaeological resources are "any material remains of past human life and activities which are of archaeological interest," including pottery, baskets, tools, and human skeletal remains. The unauthorized removal of archaeological resources from public or Indian lands is prohibited without a permit, and any archaeological investigations at a site must be conducted by a professional archeologist.	Potentially applicable to a site where response actions involve disturbance/ alteration of the ground and/or site terrain. Appropriate measures will be taken to evaluate the presence of cultural resources. If a potential for an existence of cultural resources exists then appropriate measures will be taken during excavation activities and appropriate tribal members will be contacted in the event that an artifact is encountered.
American Indian Religious Freedom Act	42 USC § 1996 et seq	The American Indian Religious Freedom Act and implementing regulations are intended to protect Native American religious, ceremonial, and burial sites, and the free practice of religions by Native American groups. The requirements of this Act must be followed if sacred sites graves are discovered in the course of ground-disturbing activities.	
Native American Graves Protection and Repatriation Act	25 USC § 3001 et seq 43 CFR Part 10	Intended to protect Native American graves from desecration through the removal and trafficking of human remains and "cultural items" including funerary and sacred objects. The requirements of this Act must be followed when graves are discovered or ground-disturbing activities encounter Native American burial sites.	
Clean Air Act (CAA), National Ambient Air Quality Standards	42 USC 7401 et seq. 40 CFR Part 50	Provides air quality standards for six criteria pollutants, including particulate matter, to protect public health and welfare.	Applicable for cleanup action construction activities that may create fugitive dust or other regulated emissions.
Hazardous Materials Transportation Act	49 USC 5101 et seq. 49 CFR Parts 107, 171-177	Regulates the transportation of hazardous materials.	Applicable to the site if offsite disposal is included in the cleanup action.
Occupational Safety and Health Act (OSHA)	29 CFR Part 1904 29 CFR Part 1910 29 CFR Part 1926	Specifies minimum requirements to maintain worker health and safety during hazardous waste operations, including training and construction safety requirements.	Applicable to construction phases of a cleanup. Construction activities will be conducted in accordance with the requirements of OSHA.
Resource Conservation and Recovery Act (RCRA), Identification and Management of Hazardous Wastes	40 CFR Part 261 et seq.	Specifies how to determine whether a solid waste is considered hazardous (whether listed or based on characteristic) and how to manage hazardous wastes.	Applicable. Washington State is authorized for RCRA.
State ARARs			
Model Toxics Control Act (MTCA) Cleanup Regulation	Chapter 70A.305 RCW Chapter 173-340 WAC	MTCA regulations are the primary regulations governing cleanup actions.	Applicable. Cleanup actions conducted by Ecology under MTCA are exempt from the procedural requirements of most state and local laws/permits; however, must meet substantive requirements of the laws/permits.
State Environmental Policy Act (SEPA)	Chapter 43.21C RCW Chapter 173-802 WAC Chapter 197-11 WAC	Prior to taking any action on a proposal, agencies must follow specific procedures to ensure that appropriate consideration has been given to the environment. The severity of potential environmental impacts associated with a project determines whether an Environmental Impact Statement is required.	Applicable. A SEPA checklist is required prior to cleanup action construction activities.
MTCA, Site Cleanup and Monitoring	WAC 173-340-400 through 173-340-440	Provides requirements for implementation of the cleanup action, compliance monitoring, periodic review, interim action and institutional controls.	Applicable.
Washington Clean Air Act	Chapter 70A.15 RCW Chapter 173-400 WAC	Requires all sources of air contaminants to meet emission standards for visible, particulate, fugitive, odors, and hazardous air emissions. Requires use of reasonably available control technology.	Substantive requirements are applicable for cleanup actions at the site that may create fugitive dust or other regulated air emissions.

Authorizing Statute and Implementing Regulation	Citation	Procedural/Substantive Requirements	Description and Applicability
State ARARs (continued)			
Puget Sound Clean Air Agency (PSCAA)	Regulation 1	Provides regulation for the visible emissions of fugitive dust and reasonable precautions that should be employed to minimize these emissions. Provides regulation for discharge of emissions from dual-phase extraction, soil vapor extraction and related treatments which require vapor discharge to atmosphere.	Substantive requirements are applicable for any cleanup actions at the site that may create fugitive dust or other regulated air emissions. Requirements are also applicable for vapor treatment systems which may be needed.
Hazardous Waste Management Act, Dangerous Waste Regulations	Chapter 70A.300 RCW Chapter 173-303 WAC	Governs handling and disposition of dangerous waste, including identification, accumulation, storage, transport, treatment, and disposal.	Substantive requirements are applicable for handling, storage, and disposal of hazardous waste. These requirements will apply if dangerous wastes are generated during the cleanup action.
Solid Waste Handling Standards	Chapter 70A.95 RCW Chapter 173-350 WAC.	The solid waste requirements are applicable to cleanup action alternatives that consist of off-site disposal of solid non-hazardous wastes and contaminated media.	Applicable. For off site disposal activities, waste materials will be sent to facilities licensed and permitted to accept the specific waste material and documentation will be obtained of such disposition.
Water Quality	Water Pollution Control Act (RCW 90.48); Underground Injection Control (UIC; Chapter 173-218 WAC)	Specifies requirements to protect water quality and prevent the pollution of surface and underground waters of the State of Washington.	Substantive requirements are applicable for protection of water quality during cleanup actions at the site. UIC requirements will be met if cleanup action requires in-situ injection of amendments.
Washington Industrial Safety and Health Act (WISHA)	Chapter 49.17 RCW Chapter 296-62 WAC Chapter 296-843 WAC	Specifies minimum requirements to maintain worker health and safety during hazardous waste operations, including training and construction safety requirements.	Applicable to construction phases of the cleanup action. Construction activities will be conducted in accordance with the requirements of WISHA.
City ARARs			
City of Tukwila Noise Ordinance	Tukwila Municipal Code Chapter 8.22	Establishes noise levels and standards.	Potentially applicable depending on cleanup action activities and equipment selected. Construction activities will be limited to normal working hours, to the extent possible, to minimize noise impacts.
City of Tukwila Stormwater Management Program	Tukwila Municipal Code Chapter 14.30	Provides the necessary measures for regulation of development activities that could affect stormwater and non-stormwater discharges to the stormwater drainage system and establishes methods for controlling the introduction of pollutants into the stormwater drainage system to comply with the requirements of the National Pollutant Discharge Elimination Systems (NPDES) permit process.	Potentially applicable during cleanup action construction activities.
City of Tukwila Site Grading Permit	Tukwila Municipal Code Chapter 16.54.050	Establishes requirements for sitework activities (excavation, grading, paving, etc.) to support cleanup action.	Potentially applicable to support cleanup action activities.
City of Tukwila Right-of-Way Use Permit	Tukwila Municipal Code Chapter 11.08	Establishes requirements for traffic control and truck haul routes.	Applicable. A City of Tukwila Street Use Permit will be needed for traffic control and truck haul routes.
City of Tukwila Electrical Permit	Tukwila Building and Construction Code Chapter 16.04.010 and Article 80.3 of the National Electric Code	Establishes requirements for electrical installations to support cleanup action activities.	Potentially applicable to support cleanup action activities. All electrical installations to be weatherized per National Electrical Manufacturers Association 4 standards.

Notes:

ARAR = Applicable or Relevant and Appropriate Requirement

CFR = Code of Federal Regulations

RCW = Revised Code of Washington

WAC = Washington Administrative Code

UIC = Underground Injection Control

USC = United States Code

Table 5-1

Soil Remedial Technologies Screening

Jorgensen Forge Corporation Property

Tukwila, Washington

Remedial Technology Identification						Relative Cost of Remedial Technology			
General Response Action	**Type of Remedial Technology**	**Process Option**	**Description of Remedial Technology**	**Implementability of Remedial Technology**	**Effectiveness of Remedial Technology**	**Capital**	**O&M**	**Summary of Screening**	**Technology Retained (Yes/No)**
No Action	No Action	None	No institutional controls or treatment.	Not effective for protecting human health and environment.	Implementable but not acceptable to the general public or government agencies.	None	None	Used as a baseline for comparison.	Yes
Monitoring	MNA	Natural Attenuation	Monitoring of natural processes that degrade contaminants in soil and groundwater. Requires monitoring over time and a contingency plan if expected processes do not occur.	Implementable; requires long term monitoring and thus has a longer restoration timeframe than other remedial technologies.	Effective in combination with other technologies.	Low	Low	Applicable in combination with other technologies.	Yes
Institutional Controls (ICs)	Governmental/ Property Controls	Environmental Covenant	Legal restrictions associated with future land use and activities (e.g., development, construction, etc.); may also be used to specify long-term maintenance requirements of remediation systems.	Technically implementable. Specific legal requirements and authority would need to be met.	Not effective for remediating contaminants. Can be effective at reducing risks and maintaining integrity of a remedy.	Low	Low	Applicable and/or required in combination with other technologies.	Yes
		Land Use Restrictions, Material Management Plans/ Requirements	Restrictions on activities such as excavation to prevent physical damage to components of the cleanup alternative (e.g., caps) and/or exposure to hazardous substances that remain in-place. Implement soil management plans/requirements to properly manage contaminated soils in an event that it is necessary to disturb/excavate (e.g., utility work, development etc.).	Technically implementable but administratively more difficult.	Not effective for remediating contaminants. Enforcement would be required for restrictions to be effective.	Low	Low	Applicable and/or required in combination with other technologies.	Yes
	Informational Devices	State registries of contaminated sites, Public notices, Deed notices, Fact sheets and/or Advisories	Informational tools provide information or notification with regard to a remedy or residual contamination at a site. The informational devices provide a means to inform property owners and tenants regarding Site issues and/or planned activities.	Placing information concerning the Site through recorded notices, Site Registries, or other notification methods is relatively easy to implement.	While informational tool provide relatively high visibility to attempt to control Site activities, limited enforcement capability exists within these controls to ensure that requested actions are taking place.	Low	Low	Applicable in combination with other technologies.	Yes
	Access Restrictions	Warning Signs and Fencing	Placement of fencing and warning signs to prevent access and inform the public regarding health risks.	Technically implementable.	Not effective for remediating contaminants. Effective in minimizing human exposure to contaminated media by preventing access.	Low	Low	May not be effective due to current/future site use.	Yes

Remedial Technology Identification						Relative Cost of Remedial Technology			
General Response Action	Type of Remedial Technology	Process Option	Description of Remedial Technology	Implementability of Remedial Technology	Effectiveness of Remedial Technology	Capital	O&M	Summary of Screening	Technology Retained (Yes/No)
Containment/ Capping	Low-Permeability Cap with Drainage Controls	Asphalt and/or Concrete Cap	Surface capping includes engineered low-permeability caps which are designed to prevent infiltration, gas migration, and direct contact; and soil, pavement or building caps which prevent direct contact and also provide drainage controls to prevent infiltration.	Technically implementable.	Effective for preventing exposure to hazardous substances that remain in-place, erosion of source material, and reducing stormwater infiltration and contaminant migration.	Low to Moderate	Low	Applicable in combination with other technologies.	Yes
	Permeable Cap	Permeable Soil Cover	Install and/or maintain existing 6-feet thick (conditional point of compliance) soil cover over contaminated soil. Can be vegetated at the surface based on future site use. Primary function of the cover is to prevent/minimize exposure to hazardous substances that remain in-place. Not effective at reducing stormwater infiltration.	Technically implementable. Implementability and applicability depends on current and future site uses. Requires disposal of material removed to facilitate placement of cover.	Effective for preventing exposure to hazardous substances that remain in-place and erosion of source material. Not effective at reducing stormwater infiltration and contaminant migration.	Low	Low	Not effective given site characteristics and future planned usage.	No
In-Situ Treatment	Biological Treatment	Enhanced Bioremediation	The activity of naturally occurring microbes is stimulated by circulating water-based solutions through contaminated soil to enhance degradation of organic contaminants. Nutrients, oxygen, or other amendments may be used to enhance bioremediation and contaminant desorption from subsurface materials.	Technically implementable. Requires network of injection wells to deliver water-based solutions through the contaminated soil. May require multiple rounds of injection to achieve desired outcome.	Can be effective for treating TPH. Effectiveness may be limited by presence of fine-grained soils and may result in the vertical migration of contaminants through the soil column.	Moderate	Moderate	Estimated timeframe for cleanup would be very long, despite potential effectiveness for portions of the site.	No
		Bioventing	Oxygen is delivered to contaminated unsaturated soil by forced air movement (either extraction or injection of air) to increase oxygen concentrations and stimulate biodegradation.	Technically implementable. Requires network of injection wells to deliver oxygen through the contaminated soil. May require permanent support compound to house blowers and piping to connect to bioventing wells.	Can be effective for treating TPH. Injection of oxygen may cause build up of contaminants in soil vapor which may potentially migrate into indoor air.	Low to Moderate	Moderate	Estimated timeframe for cleanup would be very long, despite potential effectiveness for portions of the site. Could pose vapor intrusion risk for future building(s).	No
	Physical Treatment	Soil Vapor Extraction (SVE)	Vacuum is applied through extraction pipes screened within unsaturated zone soil to create a pressure/concentration gradient, which induces gas-phase volatile organics to diffuse through soil to extraction wells.	Technically implementable. Requires network of piping to SVE wells and treatment compound containing blowers and vapor collection/treatment systems. Requires treatment of collected vapors before permitted discharge to atmosphere.	Effective for treating volatile fraction of TPH. Effectiveness may be limited by presence of fine-grained soils.	Moderate	Moderate	Applicable in combination with other technologies.	Yes
	Physical Treatment	Soil Flushing	The extraction of contaminants from soil with aqueous solution accomplished by passing fluid through in-place soils using an injection or infiltration process. Extraction fluids must be recovered from underlying groundwater.	Technically implementable, but would require significant safety components to prevent exacerbating groundwater contamination. Regulatory concerns over potential to wash contaminants beyond fluid capture zones and introduction of surfactants in to the subsurface would make permitting difficult.	Effective for more soluble chemicals. Presence of fine-grained soils and debris limits effectiveness.	High	Moderate	High cost and uncertainty relative to other remedial technologies.	No
	Chemical Treatment	In-Situ Stabilization (ISS)	ISS is accomplished by injecting solutions of chemical reagents with contaminated media to physically bond or enclose the contaminant mass (solidification), or to induce chemical reactions between the stabilizing agent and contaminants to reduce their mobility (stabilization).	Solidification and stabilization processes can result in an increase in volume. Treatability testing is required.	Effective for stabilizing NAPL.	Moderate	Low	Applicable in combination with other technologies.	Yes

Remedial Technology Identification			Description of Remedial Technology	Implementability of Remedial Technology	Effectiveness of Remedial Technology	Relative Cost of Remedial Technology		Summary of Screening	Technology Retained (Yes/No)
General Response Action	Type of Remedial Technology	Process Option				Capital	O&M		
In-Situ Treatment (continued)	Thermal Treatment	Vitrification	Electrodes for applying head are used to melt contaminated soil and sludges producing glass and crystalline structures with very low leaching characteristics.	Technically implementable. Organic and inorganic off-gassing must be controlled.	Not generally considered effective for Site contaminants.	High	Moderate	High cost and uncertainty relative to other remedial technologies.	No
		Thermal Conduction Heating (TCH)	Electrically-powered heaters are installed to heat contaminated soil to target treatment temperatures. The increased temperature volatilizes VOCs, allowing removal by vapor extraction methods from vapor extraction points (SVE wells).	Technically implementable. Requires network of piping to SVE wells and treatment compound containing vapor collection/treatment systems. Also requires network of heating elements wired to a power source. Existing utility infrastructure and buildings would need to be considered in placement of TCH system.	Common in-situ source control technology for saturated and unsaturated soil.	High	Low	High cost and uncertainty relative to other remedial technologies.	No
	Thermal Treatment (continued)	Electrical Resistive Heating (ERH)	Electrical current is generated between electrodes installed in subsurface, which gradually raises the ground temperature. The increased temperature volatilizes lighter hydrocarbons, allowing removal by vapor extraction methods.	Technically implementable. Requires network of piping to SVE wells and treatment compound containing vapor collection/treatment systems. Also requires network of electrodes wired to a power source. Existing utility infrastructure and buildings would need to be considered in placement of ERH system.	Resistance heating tends to target saturated zones and can incidentally treat select soil types in a mixture of lithologies. Therefore, ERH has a lower relative certainty of effectiveness given the nature of the unsaturated zone at the Site.	High	Low	High cost and uncertainty relative to other remedial technologies.	No
		Steam Enhanced Extraction (SEE)	Installation of a series of steam injection wells in the contaminated soil areas. Steam is generated in an on-site boiler and injected through the wells, which raises the temperature of the soil. Similar to the application of ERH, contaminants are extracted by vapor extraction methods.	Technically implementable. Requires network of piping of steam injections points and compound to house the boiler. Existing utility infrastructure and buildings would need to be considered in placement of SEE system.	Site lithology may limit the distribution of steam in the subsurface and effectiveness. Condensation of injected steam results in additional water that must be extracted and treated.	High	Low	High cost and uncertainty relative to other remedial technologies.	No
Removal	Soil Excavation and Off-Site Disposal	Excavation and Landfill	Removal of contaminated soil using common excavation techniques. Disposal of contaminated soil at an off-site, permitted landfill. May require treatment of contaminated soil at landfill facility prior to disposal.	Technically implementable where accessibility allows for excavation.	Effective for all site contaminants and commonly used remedy. Less effective for contamination extending to depths greater than 20 feet without extensive shoring systems.	High	Low	Applicable for specific applications and/or in combination with other technologies.	Yes
	Soil Excavation, Ex-Situ Treatment and Off-Site Disposal/On Site Reuse	Solidification/ Stabilization (S/S)	Removal of impacted soil using common excavation techniques. Contaminants are physically bound or enclosed within a stabilized mass using cementitious reagents (cement, lime, etc.) or surface adsorption/chemical reagents.	Requires sufficient space on site to set up temporary treatment plant and treat/process excavated material prior to disposal. S/S processes may result in an increase in the overall volume of material for off-site disposal/on-site reuse. Additionally S/S processes increases density which increases disposal costs.	Stabilization is a common and effective technology for NAPL.	High	Low	Applicable for specific applications and/or in combination with other technologies.	Yes
		Soil Washing	Removal of impacted soil using common excavation techniques. Wash soil with water-based surfactants, detergents, acids, etc., to remove chemicals from soil particles. Treat or dispose of high chemical concentration residuals fluids.	Technically implementable. Require sufficient space on site to set up temporary treatment plant and treat/process excavated material prior to disposal/reuse. Require treatment of residual fluids.	Effective for more soluble chemicals. Presence of fine-grained soils and debris limits effectiveness.	High	Moderate	High cost and uncertainty relative to other remedial technologies. High degree of difficulty to implement given Site current and future use.	No

Remedial Technology Identification			Description of Remedial Technology	Implementability of Remedial Technology	Effectiveness of Remedial Technology	Relative Cost of Remedial Technology		Summary of Screening	Technology Retained (Yes/No)
General Response Action	Type of Remedial Technology	Process Option				Capital	O&M		
Removal (continued)	Soil Excavation, Ex-Situ Treatment and Off-Site Disposal/On Site Reuse	Incineration	Removed soil is heated above approximately 1,600 degrees Fahrenheit to volatilize and combust organic contaminants. Incinerator off-gas is treated in an air pollution control system.	Potentially difficult to implement. Limited space for on-site treatment system and staging. Specific feed size and material handling requirements may impact implement ability. Suitable off-site facility not currently identified.	Proven effective treatment for organics.	High	High	High cost and difficult to implement relative to other remedial technologies.	No
		Bioremediation	Biodegradation of contaminants in removed soil is enhanced through modification of the material for microbial growth. Treatment is conducted in landfarm arrangement, aboveground reactor, or in treatment cells (biopiles).	Difficult to implement. Landfarming option may require use of a large amount of space, depending on quantity of excavated material. Slurry and biopile treatment require reactor or treatment cell construction. Leachate and off-gas require collection and treatment. Addition of additives may increase total bulk volume of treated material.	Proven effective treatment for organics.	Moderate to High	Moderate to High	Long restoration timeframe and uncertainty in implementation due to future Site use relative to other remedial technologies.	No

Notes:

O&M = Operations and Maintenance; SVE = Soil Vapor Extraction; ISS = In-Situ Stabilization; TCH = Thermal Conduction Heating; TPH = total petroleum hydrocarbons

ERH = Electrical Resistive Heating; SEE = Steam Enhanced Extraction; S/S = Solidification/Stabilization; VOC = Volatile Organic Compound

Shading indicates remedial technology not retained for cleanup action evaluation.

Table 5-2

Groundwater Remedial Technologies Screening

Jorgensen Forge Corporation Property

Tukwila, Washington

Remedial Technology Identification						Relative Cost of Remedial Technology			
General Response Action	Type of Remedial Technology	Process Option	Description of Remedial Technology	Implementability of Remedial Technology	Effectiveness of Remedial Technology	Capital	O&M	Summary of Screening	Technology Retained (Yes/No)
No Action	No Action	None	No institutional controls or treatment.	Not effective for protecting human health and environment.	Implementable but not acceptable to the general public or government agencies.	None	None	Used as a baseline for comparison.	Yes
Institutional Controls (ICs)	Governmental/ Property Controls	Environmental Covenant	Legal restrictions associated with future land use and activities (e.g., development, construction, etc.); may also be used to specify long-term maintenance requirements of remediation systems.	Technically implementable. Specific legal requirements and authority would need to be met.	Not effective for remediating contaminants. Can be effective at reducing risks and maintaining integrity of a remedy.	Low	Low	Applicable in combination with other technologies.	Yes
		Groundwater Use Restrictions, Material Management Plans/ Requirements	Restrictions on groundwater extraction and use and/or exposure of humans and environment to hazardous substances present in groundwater. Implement groundwater management plans/requirements so that contaminated groundwater is managed properly in an event that it is necessary to remove groundwater (e.g., utility work, etc.).	Technically implementable but administratively more difficult.	Not effective for remediating contaminants. Enforcement would be required for restrictions to be effective.	Low	Low	Applicable in combination with other technologies.	Yes
	Informational Devices	State registries of contaminated sites, Public notices, Deed notices, Fact sheets and/or Advisories	Informational tools provide information or notification with regard to a remedy or residual contamination at a site. The informational devices provide a means to inform property owners and tenants regarding Site issues and/or planned activities.	Placing information concerning the Site through recorded notices, Site Registries, or other notification methods is relatively easy to implement.	While Informational ICs provide relatively high visibility to attempt to control Site activities, limited enforcement capability exists within these controls to ensure that requested actions are taking place.	Low	Low	Applicable in combination with other technologies.	Yes
Monitoring	Monitored Natural Attenuation (MNA)	Natural Attenuation	Monitoring of naturally occurring physical, chemical and biological processes that reduce the mass, toxicity, mobility, volume, or concentration of contaminants in groundwater. Involves monitoring over time to confirm that natural processes are occurring to reduce risk associated with contaminant concentrations. A contingency plan is needed if the expected processes do not occur.	Technically implementable but requires long-term monitoring. Cleanup time frame may be longer than other remedial technologies. Source to groundwater generally requires treatment such as removal, containment or stabilization.	Effectiveness is dependent on site conditions and time frame for implementation. Not effective in preventing contaminant migration and/or exposure.	Low	Low	Applicable in combination with other technologies. The most applicable technology for portions of the Site where contaminants pose low risks to receptors under current and anticipated future site use(s) due to long remediation timeframe.	Yes

Remedial Technology Identification			Description of Remedial Technology	Implementability of Remedial Technology	Effectiveness of Remedial Technology	Relative Cost of Remedial Technology		Summary of Screening	Technology Retained (Yes/No)
General Response Action	Type of Remedial Technology	Process Option				Capital	O&M		
Containment	Physical Groundwater Barrier	Low-Permeability Vertical Barrier	Construction of a low-permeability vertical barrier such as driven steel sheet piles, soil-bentonite or cement-bentonite wall to restrict groundwater flow and contaminant migration in the downgradient direction. Barrier can be installed down to the nearest aquitard to provide full containment, or installed at a partial depth to direct groundwater deeper. Groundwater extraction may be required to achieve containment under some scenarios. Long-term monitoring of containment structure required.	Technically implementable but requires long-term monitoring. Cleanup time frame longer than other remedial technologies but shorter compared to MNA. Source to groundwater generally requires treatment such as removal, containment or stabilization.	Established technology effective for reducing mobility of contaminants. Effective for containing impacted groundwater or directing groundwater away from a source. However, does not provide treatment of contaminants. Effectiveness likely to increase if implemented to encapsulate the entire source area such that upgradient groundwater flows around the source area thereby minimizing contaminant mobility.	Moderate	Moderate	Not expected to be a viable option given contamination location/mobility and nearness to the LDW.	No
	Hydraulic Groundwater Barrier	Groundwater Pumping	Groundwater pumping to establish a hydraulic capture zone and restrict groundwater flow and contaminant migration in the downgradient direction. May be used in conjunction with a physical barrier to achieve full containment.	Technically implementable using standard groundwater extraction methods. The need to treat extracted groundwater to acceptable levels to allow discharge will reduce the implementability.	Potentially effective for hydraulic control of impacted groundwater. May be implemented to increase effectiveness of physical barrier technologies. Requires continuous long-term operation to achieve effective containment and maintenance of treatment components to prevent discharge of contaminated groundwater.	Moderate	High	Not expected to be a viable option given contamination location/mobility and nearness to the LDW.	No

Remedial Technology Identification			Description of Remedial Technology	Implementability of Remedial Technology	Effectiveness of Remedial Technology	Relative Cost of Remedial Technology		Summary of Screening	Technology Retained (Yes/No)
General Response Action	Type of Remedial Technology	Process Option				Capital	O&M		
In-Situ Treatment	Biological Treatment	Enhanced Aerobic Bioremediation	Injection of a oxygen-releasing compounds and microbes into the contaminated zone to enhance degradation of contaminants in groundwater through metabolic reactions.	Technically implementable. This method relies on advection and dispersion to distribute reagents in groundwater to effectively address contamination. Treatability testing is required.	Effective for low concentrations of TPH. Common in-situ source control technology for groundwater.	Moderate	Low	Applicable, most likely in combination w/ other technologies. However, estimated long restoration timeframe compared to other similar technologies.	No
	Physical Treatment	Air Sparging (AS)/ Soil Vapor Extraction (SVE)	Sparging injects air into saturated zone body to volatilize contaminants which are then removed by Soil Vapor Extraction (SVE). Requires treatment of collected vapors before discharge to atmosphere.	Technically implementable. Requires network of piping to AS/SVE wells and treatment compound containing blowers and vapor collection/ treatment systems. Existing utility infrastructure and buildings would limit placement of AS/SVE system.	Effective for treating volatile TPH. Common in-situ source control technology for saturated and unsaturated soil. Current/future land use considerations may reduce long term effectiveness and may require modifications to the system during redevelopment.	Moderate	Moderate	Applicable, most likely in combination w/ other technologies.	Yes
	Chemical Treatment	In-Situ Chemical Oxidation (ISCO)	ISCO is accomplished by injecting solutions of chemical oxidation reagents with contaminated media. The reagents chemically oxidizes and destroys contaminants.	Technically implementable. This method relies on advection and dispersion to distribute reagents in groundwater to effectively address contamination. Treatability testing is required.	The groundwater is already anaerobic and there are no volatiles in the LNAPL plume, which would render this technology ineffective.	Moderate	Low	Not expected to be a viable option given groundwater conditions.	No
		In-Situ Chemical Reduction (ISCR)	ISCR is accomplished by injecting solutions of chemical reagents into the contaminated zone to convert hazardous compounds to nonhazardous or less toxic compounds that are more stable, less mobile, or inert.	Technically implementable. This method relies on advection and dispersion to distribute reagents in groundwater to effectively address contamination. Treatability testing is required.	Generally not considered effective for treating NAPL and dissolved phase TPH plumes.	Moderate	Low	Not expected to be a viable option given groundwater conditions.	No
		Permeable Reactive Barrier (PRB)	PRBs are walls containing reactive media that are installed across the path of contaminated groundwater flow to intercept and treat contaminated groundwater. The barrier allows water to pass through while the media remove the contaminants by precipitation, degradation, adsorption, or ion exchange. PRB wall can be installed by excavating a trench (continuous or funnel/gate) or by injection method.	Technically implementable where accessibility allows for placement of reactive barrier.	Effective treatment configuration under proper hydrogeologic conditions that direct Site groundwater through PRB. Effectiveness relies on selecting an effective reactive treatment component.	Moderate	Moderate	Applicable, most likely in combination w/ other technologies.	Yes

Remedial Technology Identification			Description of Remedial Technology	Implementability of Remedial Technology	Effectiveness of Remedial Technology	Relative Cost of Remedial Technology		Summary of Screening	Technology Retained (Yes/No)
General Response Action	Type of Remedial Technology	Process Option				Capital	O&M		
Ex-Situ Treatment	Pump and Treat	Adsorption	Extracted groundwater is treated by passing extracted groundwater through a fixed bed of adsorption media (e.g. activated alumina, activated carbon). As contaminated water is passed through the adsorption media, contaminants are adsorbed. When adsorption sites become filled, the column must be regenerated or disposed of and replaced with new media.	Technically implementable. Long treatment time frame. Permitting may be required for discharge of treated water. May need to be combined with pre- and post-treatment steps. Treatment byproducts (e.g., spent carbon) require management. Systems using this technology generally require skilled operators.	Effectiveness of adsorption treatment process is sensitive to a variety of untreated water contaminants and characteristics. Competition for adsorption sites could reduce the effectiveness of adsorption because other constituents may be preferentially adsorbed, resulting in a need for more frequent bed regeneration or replacement. Current/future land use considerations may reduce long term effectiveness and may require modifications to the system during future property redevelopment.	High	High	High cost and difficult to implement relative to other remedial technologies.	No
		Air Sparging	Similar to in-situ treatment, air is passed through the water column to enhance volatilization of organic contaminants. Vapor is captured by collection systems.	Technically implementable. Long treatment timeframe. Permitting may be required for discharge of treated water.	Effective for treating volatile TPH. Current/future land use considerations may reduce long term effectiveness and may require modifications to the system during future property redevelopment.	High	High	High cost and difficult to implement in this configuration relative to other remedial technologies. Retained when used in combination with AS/SVE in-situ (See above).	No
		Dual Phase Extraction	DPE is a technology that uses a vacuum system to remove contaminated groundwater and soil vapor. DPE systems typically use a vacuum pump and a blower to extract liquid and gaseous phases from extraction wells. Requires treatment of extracted liquids and vapor prior to disposal.	Technically implementable where the groundwater contamination is shallow.	Effectiveness of DPE relies on continuous, long-term operation. Initial startup and installation, and long-term operation, maintenance, treatment and disposal of extracted groundwater and vapor would have a high cost. Likely not effective/implementable on a site-wide basis especially in areas with deeper groundwater contamination.	High	High	Applicable, most likely in combination w/ other technologies.	Yes
	Groundwater Recirculation	Groundwater Recirculation	Groundwater is typically extracted from the distal end of a contaminated plume, treated with chemical or biological agents and then reinjected up-gradient to provide a clean front of groundwater and to introduce treatment media to the plume.	Technically implementable. Locations of extraction and injection wells, treatment facilities, and conveyance piping are a logistical constraint.	Effective at treating COCs and has built-in flexibility to deliver multiple treatment agents in reaction to system performance.	High	High	High cost and difficult to implement relative to other remedial technologies.	No

Notes:

O&M = Operations and Maintenance; AS = Air Sparging; SVE= Soil Vapor Extraction; ISCO = In-Situ Chemical; ISCR = In-Situ Chemical Reduction; PRB = Permeable Reactive Barrier; TPH = total petroleum hydrocarbons

Shading indicates remedial technology not retained for cleanup action evaluation.

Table 6-1

Cleanup Action Alternatives Concepts

Jorgensen Forge Corporation Property

Tukwila, Washington

Remedial Approach		Alternative Applicability					
		Alt. 1	**Alt. 2**	**Alt. 3**	**Alt. 3B**	**Alt. 4**	**Alt. 4B**
Common Elements for All Alternatives	Monitored Natural Attenuation	All Remedial Areas	All Remedial Areas	All Remedial Areas	All Remedial Areas	All Remedial Areas	All Remedial Areas
	Institutional Controls	All Remedial Areas	All Remedial Areas	All Remedial Areas	All Remedial Areas	All Remedial Areas	All Remedial Areas
	Engineering Controls (Capping)	All Remedial Areas	All Remedial Areas	All Remedial Areas	All Remedial Areas	All Remedial Areas	All Remedial Areas
LNAPL Recovery	Dual Phase Extraction	--	Area 2	--	--	--	--
	Recovery from Open Excavation	--	Area 1	Areas 1 & 2	Areas 1 & 2	Areas 1 & 2	Areas 1 & 2
Soil Treatment with Residual LNAPL Encapsulation or Removal	In-situ Solidification/Stabilization	--	--	Areas 1 & 2	Areas 1 & 2	--	--
	Excavation within LNAPL Footprint and Off-Site Disposal	--	Area 1	--	--	Areas 1 & 2	Areas 1 & 2
	Targeted Excavation within LNAPL Footprint and Off-Site Disposal	--	--	Areas 1 & 2	Areas 1 & 2	--	--
Groundwater Treatment	Air Sparging/Soil-vapor Extraction	--	Areas 1 & 2	--	--	Areas 1 & 2	Areas 1 & 2
	Permeable Reactive Barrier	--	--	--	PFAS Release Area	--	PFAS Release Area

Notes:

-- = Remedial approach not included in alternative

Alt. = alternative

LNAPL = light non-aqueous phase liquid

PFAS = per- and polyfluoroalkyl substances

Table 8-1

MTCA Requirements: Evaluation of Alternatives

Jorgensen Forge Corporation Property
Tukwila, Washington

MTCA Cleanup Action Requirements		Alternative 1: MNA (all remedial areas)	Alternative 2: Excavation with LNAPL Recovery & AS/SVE (Area 1); DPE for LNAPL Recovery & AS/SVE (Area 2)	Alternative 3: Targeted Excavation for LNAPL Recovery & ISS (Areas 1 & 2)	Alternative 3B: Alternative 3 + PRB (PFAS Release Area)	Alternative 4: Excavation with LNAPL Recovery & AS/SVE (Areas 1 & 2)	Alternative 4B: Alternative 4 + PRB (PFAS Release Area)
General Criteria							
Protection of Human Health and the Environment		No	Yes	Yes	Yes	Yes	Yes
Compliance With Cleanup Standards		No	Yes	Yes	Yes	Yes	Yes
Compliance With Applicable State and Federal Regulations		Yes	Yes	Yes	Yes	Yes	Yes
Prevent or Minimize Present and Future Releases and Migration of Hazardous Substances in the Environment		No	Yes	Yes	Yes	Yes	Yes
Provide Resilience to Climate Change Impacts		No	Yes	Yes	Yes	Yes	Yes
Provision for Compliance Monitoring		Yes	Yes	Yes	Yes	Yes	Yes
Not Rely Primarily on Institutional Controls and Monitoring at a Site if More Action is Feasible		No	Yes	Yes	Yes	Yes	Yes
Not Rely Primarily on Dilution and Dispersion unless costs are disproportionate to benefits		See DCA Analysis					
Reasonable Restoration Time Frame		See DCA Analysis					
Permanent Solutions to the Maximum Extent Practicable		See DCA Analysis					
Action-Specific Criteria							
Use Remediation Levels in Accordance with WAC		Yes	Yes	Yes	Yes	Yes	Yes
Use Institutional Controls in Accordance with WAC		Yes	Yes	Yes	Yes	Yes	Yes
Provide for Financial Assurances in Accordance with WAC		Yes	Yes	Yes	Yes	Yes	Yes
Provide for Periodic Reviews in Accordance with WAC		Yes	Yes	Yes	Yes	Yes	Yes
Compliance with MTCA Media-Specific Criteria							
Soil	Treat, remove, or contain contaminated soil on schools, childcare facilities and residential properties (based on current or future site use).	Not Applicable: The site is not a school, childcare facility or residential property under current use, and is unlikely to be in the future due to surrounding site use and zoning. Therefore, this criteria is not applicable.					
Groundwater	Achieve CULS at the standard POC without further remedial action required if practicable OR treat or remove source(s) where there are liquid wastes, high concentrations or highly mobile hazardous substances, or hazardous substances that cannot be reliably contained and contain contaminated groundwater to the maximum extent practicable.	No	See DCA Analysis				
Public Concerns and Tribal Rights and Interests							
Consideration for Public Concerns and Tribal Rights and Interests		Yes	Yes	Yes	Yes	Yes	Yes

Notes:

AS/SVE = air-sparge/soil-vapor extraction; CUL = cleanup level; DPE = dual phase extraction; MNA = monitored natural attenuation

MTCA = Model Toxics Control Act; LNAPL = light non-aqueous phase liquid; POC = point of compliance; PRB = permeable reactive barrier; WAC = Washington Administrative Code

Table 8-2

Disproportionate Cost Analysis: Relative Benefit Evaluation of Alternatives

Jorgensen Forge Corporation Property

Tukwila, Washington

Evaluation Criteria	Criteria Description	Alternative 1: MNA (all remedial areas)	Alternative 2: Excavation with LNAPL Recovery & AS/SVE (Area 1); DPE for LNAPL Recovery & AS/SVE (Area 2)	Alternative 3: Targeted Excavation for LNAPL Recovery & ISS (Areas 1 & 2)	Alternative 3B: Alternative 3 + PRB (PFAS Release Area)	Alternative 4: Excavation with LNAPL Recovery & AS/SVE (Areas 1 & 2)	Alternative 4B: Alternative 4 + PRB (PFAS Release Area)
Restoration Time Frame		Soil: >50 years	Soil: >30 years	Soil: >30 years	Soil: >30 years	Soil: >30 years	Soil: >30 years
The restoration time frame is the period of time needed for a cleanup action to achieve cleanup levels at the point of compliance. Reasonable restoration timeframe evaluation considers the following factors: potential risks to receptors, practicability of shorter restoration timeframe, long-term effectiveness of alternative, current and future site use, ability to control and monitor plume, availability of alternative water supplies, toxicity of hazardous substances, documented natural attenuation processes and public concerns and tribal rights and interests.		Relies on natural attenuation of COCs in soil and groundwater for remediation, and thus a long restoration timeframe is expected.	Improved restoration timeframe for groundwater versus Alt 1. due to active LNAPL recovery. Soil and groundwater contamination in other remedial areas are as described in Alt 2. Soil and groundwater contamination in other remedial areas, except where co-located with treatment in Areas 1 & 2 (ex. PFAS Release Area) will be treated using MNA and capping, and thus a medium-long restoration timeframe is expected - particularly for COCs which are resistant to degradation such as PCBs.	LNAPL recovery and encapsulation using excavation and ISS is expected to quickly treat soil in Areas 1 and 2. AS/SVE of the remaining dissolved phase plumes in these areas should similarly address groundwater within a reasonable restoration timeframe. Soil and groundwater contamination in other remedial areas are as described in Alt 2.	Same as Alternative 3. Existing data suggests PFAS in groundwater is not migrating across the southern property boundary.	Restoration timeframe for soil and groundwater in Areas 1 and 2 is expected to be similar to Alt 3. Soil and groundwater contamination in other remedial areas are as described in Alt 2.	Same rationale as Alternative 3B.
Relative Benefits Ranking (Scored from 1-lowest to 10-highest).							
Protectiveness	Overall protectiveness of human health and the environment including the degree to which existing risks are reduced, time required to reduce risk at the facility and attain cleanup standards, on-site and off-site risks resulting from implementing the alternative, and improvement of the overall environmental quality.	**Score = 1** Relies on natural attenuation of COCs in soil and groundwater; restoration timeframe is expected to be long, with only incremental degredation of LNAPL over time.	**Score = 6** More protective than Alt 1. due to active LNAPL recovery.	**Score = 8** More protective than Alt 2. due to the additional LNAPL recovery and encapsulation in Areas 1 & 2.	**Score = 9** Same as Alternative 3, with slight increase in protectiveness due to PRB which could capture PFAS and dissolved metals under future Site conditions.	**Score = 8** Similar protectiveness to Alt. 3 because of the LNAPL removal and/or encapsulation in either alternative.	**Score = 9** Same rationale as Alternative 3B.
Permanence	The degree to which the alternative permanently reduces the toxicity, mobility or volume of hazardous substances, including the adequacy of the alternative in destroying the hazardous substances, the reduction or elimination of hazardous substance releases and sources of releases, the degree of irreversibility of waste treatment process, and the characteristics and quantity of treatment residuals generated.	**Score = 1** Relies on natural attenuation of COCs in soil and groundwater for remediation, which will be permanent where attenuation is occuring, however over a long restoration timeframe.	**Score = 7** Removes more LNAPL in Area 1 than Alt . 1 which increases permanence.	**Score = 7** Similar to Alternative 2, although with more certainty of LNAPL removal in Area 2. ISS provides additional protection for areas with residual LNAPL.	**Score = 7** Same as Alternative 3	**Score = 8** Increased permanence over Alt 3. due to more complete LNAPL removal off-Site.	**Score = 8** Same as Alternative 4

Evaluation Criteria	Criteria Description	Alternative 1: MNA (all remedial areas)	Alternative 2: Excavation with LNAPL Recovery & AS/SVE (Area 1); DPE for LNAPL Recovery & AS/SVE (Area 2)	Alternative 3: Targeted Excavation for LNAPL Recovery & ISS (Areas 1 & 2)	Alternative 3B: Alternative 3 + PRB (PFAS Release Area)	Alternative 4: Excavation with LNAPL Recovery & AS/SVE (Areas 1 & 2)	Alternative 4B: Alternative 4 + PRB (PFAS Release Area)
Effectiveness over the Long Term	Includes the degree of certainty that the alternative will be successful, the reliability of the alternative during the period of time hazardous substances are expected to remain on-site at concentrations that exceed cleanup levels, the magnitude of residual risk with the alternative in place, and the effectiveness of controls required to manage treatment residuals or remaining wastes.	**Score = 1** Relies on natural attenuation of COCs in soil and groundwater for remediation which is not expected to be successful within a reasonable restoration timeframe.	**Score = 5** More effective than MNA alone because LNAPL will be removed, although uncertainties in implementing DPE reduce overall effectiveness score.	**Score = 7** Targeted excavations for 'open pit' LNAPL recovery are expected to be very effective, and ISS will immobilize remaining LNAPL, including residual LNAPL.	**Score = 8** Same as Alternative 3	**Score = 8** Excavation within the LNAPL footprints in Areas 1 & 2 is expected to be very effective. Scoring is slightly higher than Alt. 3 because more LNAPL will be removed and disposed off-Site.	**Score = 9** Same as Alternative 4
Management of Implementation Risks	The risk to human health and the environment associated with the alternative during construction and implementation, and the effectiveness of measures that will be taken to manage such risks.	**Score = 4** Low score because LNAPL is left in place, which increases risk at the Site.	**Score = 4** Same score as Alt. 1 due to the expected long timeframe for LNAPL to be in place in Area 2.	**Score = 7** Higher score than Alternative 4 due to more limited excavation which reduced implementation risks.	**Score = 7** Same as Alternative 3	**Score = 6** Slightly lower score than Alt. 3 due to larger excavation which increases implementation timeframe and risks to workers and the public.	**Score = 6** Same as Alternative 4
Technical and Administrative Implementability	Ability to be implemented including consideration of whether the alternative is technically possible, availability of necessary off-site facilities, services and materials, administrative and regulatory requirements, scheduling, size, complexity, monitoring requirements, access for construction operations and monitoring, and integration with existing facility operations and other current or potential remedial actions.	**Score = 9** High score due to ease of technical and administrative implementation for MNA program.	**Score = 6** Moderate score due to use of common technologies and current Site use which improves access and implementation timeframe.	**Score = 6** Same as Alternative 2.	**Score = 6** Same as Alternative 2.	**Score = 6** Same as Alternative 2.	**Score = 6** Same as Alternative 2.

Notes:

AS/SVE = air-sparge/soil-vapor extraction; COC = contaminant of concern; CUL = cleanup level; DPE = dual phase extraction

MNA = monitored natural attenuation; MTCA = Model Toxics Control Act; LNAPL = non-aqueous phase liquid

PCB = polychlorinated biphenyl; PRB = permeable reactive barrier

Table 8-3

Summary of MTCA Evaluation and Ranking of Cleanup Action Alternatives

Jorgensen Forge Corporation Property

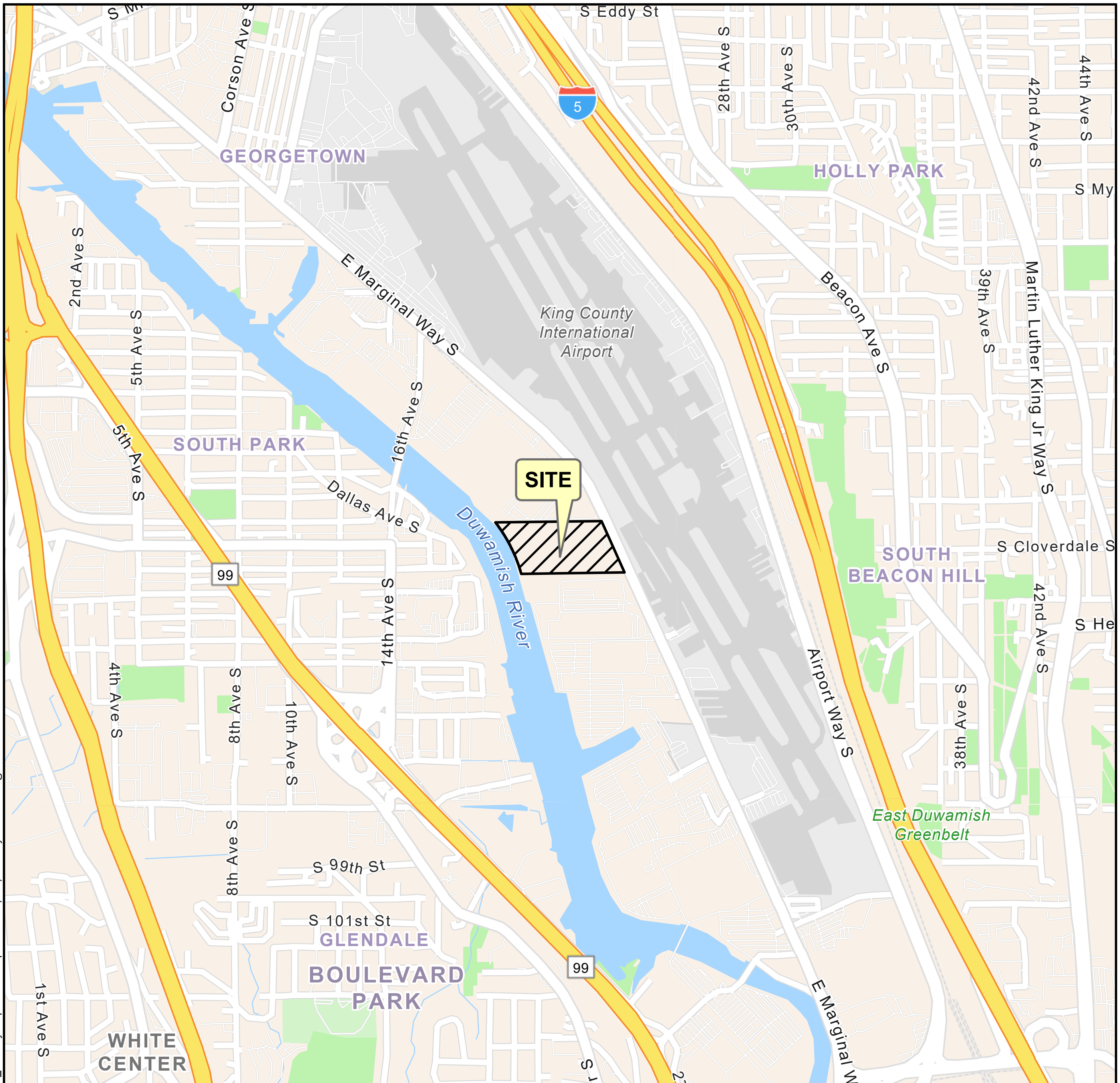
Tukwila, Washington

Remedial Alternative	Criteria Weight Fraction	Alternative 1	Alternative 2	Alternative 3	Alternative 3B	Alternative 4	Alternative 4B
		MNA (all remedial areas)	Excavation with LNAPL Recovery & AS/SVE (Area 1); DPE for LNAPL Recovery & AS/SVE (Area 2)	Targeted Excavation for LNAPL Recovery & ISS (Areas 1 & 2)	Alternative 3 + PRB (PFAS Release Area)	Excavation with LNAPL Recovery & AS/SVE (Areas 1 & 2)	Alternative 4 + PRB (PFAS Release Area)
Relative Benefits Ranking							
Protectiveness	20%	1	6	8	9	8	9
Permanence	20%	1	7	7	7	8	8
Effectiveness over the Long Term	20%	1	5	7	8	8	9
Management of Implementation Risks	20%	4	4	7	7	6	6
Technical and Administrative Implementability	20%	9	6	6	6	6	6
Overall Weighted Benefit Score	**100%**	**3.20**	**5.60**	**7.00**	**7.40**	**7.20**	**7.60**
Disproportionate Cost Analysis							
Remedy Permanent to Maximum Extent Practicable		No	Yes	Yes	Yes	Yes	Yes
Potential Base Remedy Costs for Feasibility Purposes (rounded to nearest thousand)[1]		$1,170,000	$7,860,000	$9,030,000	$10,060,000	$9,610,000	$10,650,000
Contingency		10%	30%	30%	30%	35%	35%
Potential Base Remedy Costs with Contingency for Feasibility Purposes		$1,290,000	$10,220,000	$11,740,000	$13,080,000	$12,980,000	$14,380,000
Relative Benefit Ranking to Remedial Cost (Benefit/$1M)		2.48	0.55	0.60	0.57	0.55	0.53
Costs Disproportionate to Incremental Benefits		No	No	No	Yes	Yes	Yes
Overall Alternative Ranking		**Not applicable; does not meet MTCA**	**3**	**1**	**2**	**4**	**5**

Notes:

[1] Estimated costs are at the FS level, with a range of +50% and -30%, not including contingency. See Appendix A.

Figures



N

0 2,000

Feet

Vicinity Map

Jorgensen Forge Corporation Property
Tukwila, Washington

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Figure 1-1

Source(s):
- ESRI

Coordinate System: NAD 1983 UTM Zone 10N

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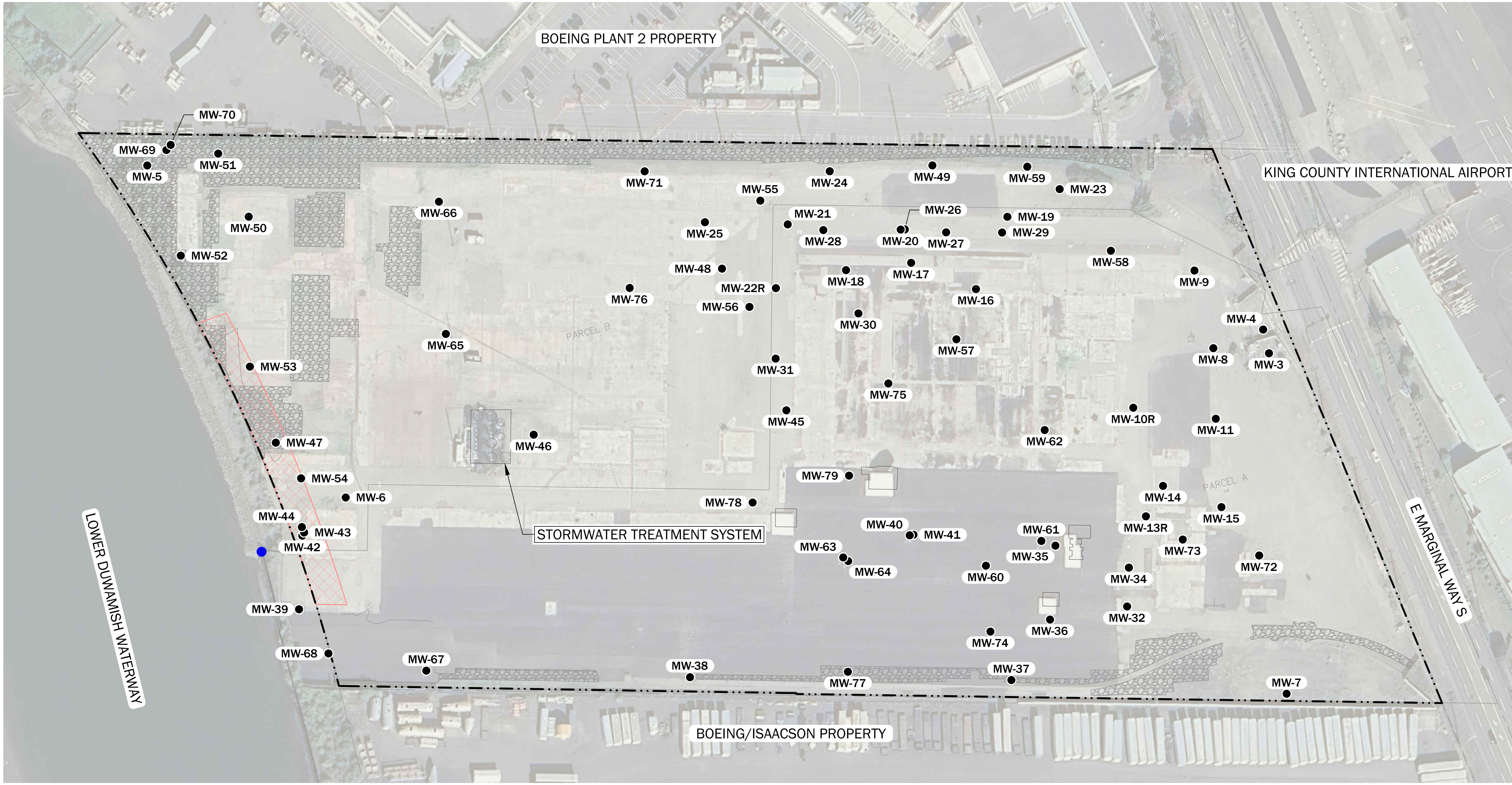

Legend

- Parcel Boundary
- Property Fence
- Monitoring Well Location
- Outfall Location
- Approximate Property Boundary
- Unpaved Surface
- Bulkhead Area
- Press Pit Vaults

0 120
Feet

N

Source(s):
- Basemap from Shannon & Wilson Remedial Investigation Report, dated September 13, 2024
- Aerial from Microsoft Bing Images

Coordinate System: WA State Plane, North Zone, NAD83, US Foot

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Site Plan

Jorgensen Forge Corporation Property
Tukwila, Washington

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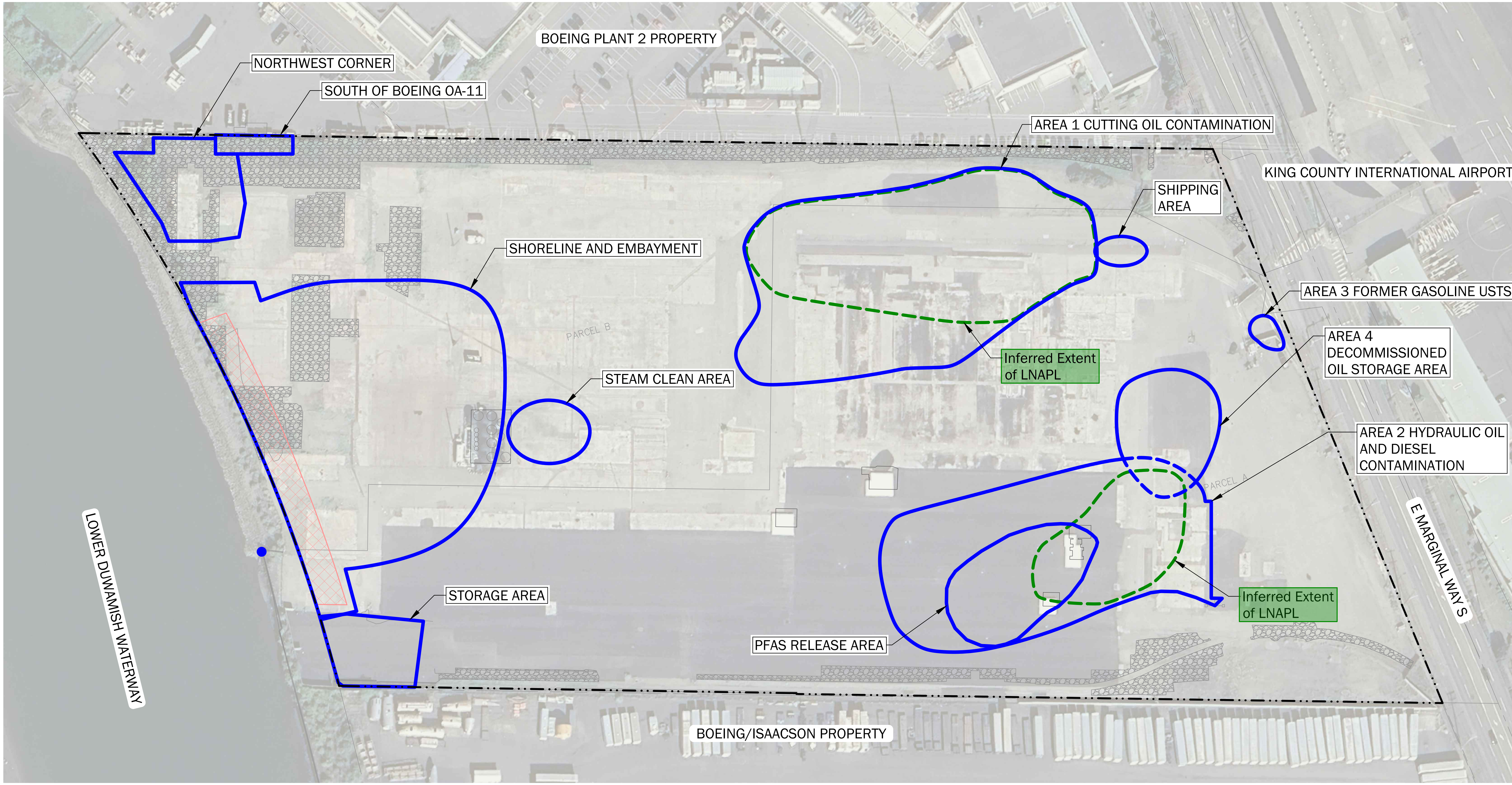
Figure 2-1



Note(s):

1. PFAS = per-and-polyfluoroalkyl substances; LNAPL = light non-aqueous phase liquid; UST = underground storage tank

Source(s):

- Basemap from Shannon & Wilson Remedial Investigation Report, dated September 13, 2024
- Aerial from Microsoft Bing Images

Coordinate System: WA State Plane, North Zone, NAD83, US Foot

Legend

- Parcel Boundary
- Property Fence
- Outfall Location
- Approximate Property Boundary
- Estimated Extent of LNAPL in Soil and Groundwater
- Remedial Areas
- Estimated Extent of Remedial Area
- Unpaved Surface
- Bulkhead Area

N

0 120

Feet

Areas Requiring Cleanup

Jorgensen Forge Corporation Property
Tukwila, Washington

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Figure 3-1

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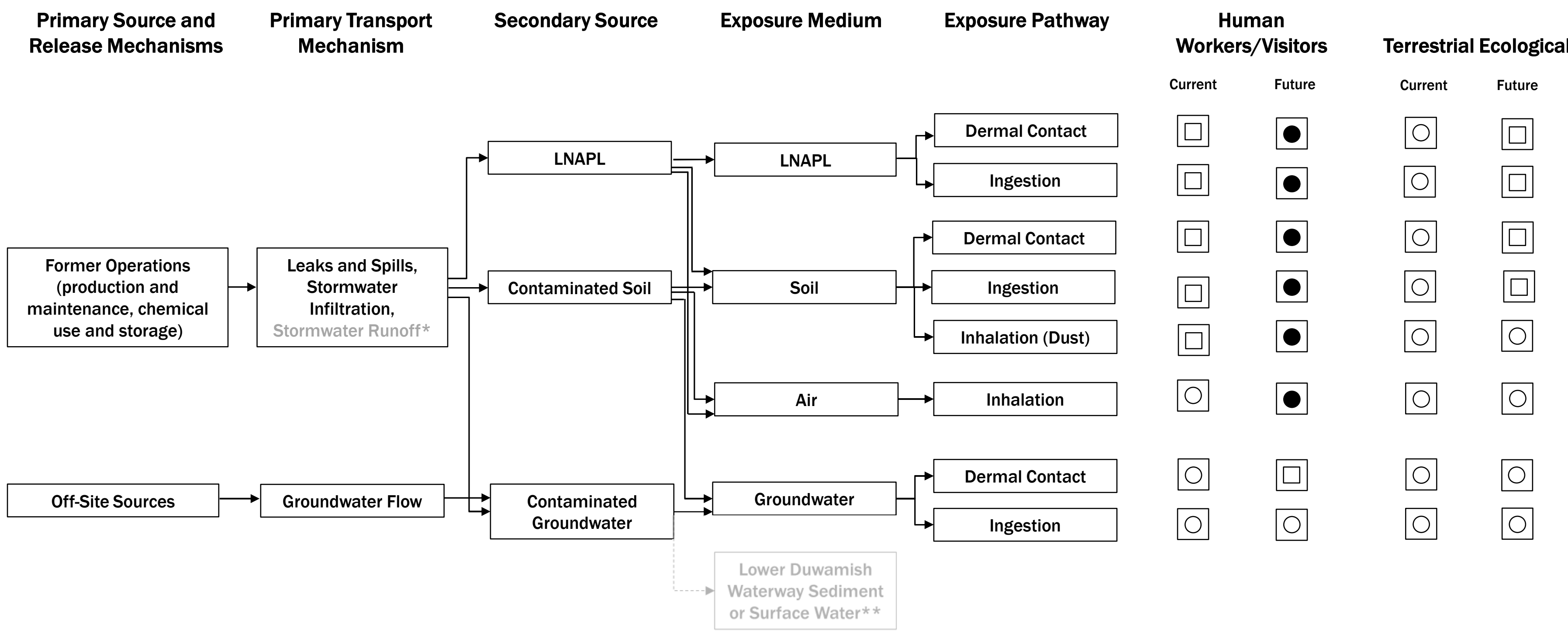

*Stormwater runoff is routed to the stormwater treatment system and is thus not an active transport mechanism for Site contamination.

**Groundwater contamination appears to pose a low risk to surface water and sediment. However, potential exposure pathways to humans and ecological receptors including direct contact, or ingestion of benthic or aquatic species were considered to derive cleanup standards as discussed in Sections 3.2 and 4.3.2. Residual risks will be addressed via on-property soil, groundwater and LNAPL cleanup actions. An in-water reactive cap will be installed by EPA to address current sediment contamination as part of the LDW Superfund Site cleanup.

Legend

● Complete Exposure Pathway

○ Incomplete Exposure Pathway

□ Complete but Minor/Unlikely Exposure Pathway

Conceptual Site Model

Jorgensen Forge Corporation Property
Tukwila, Washington

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Figure 3-2

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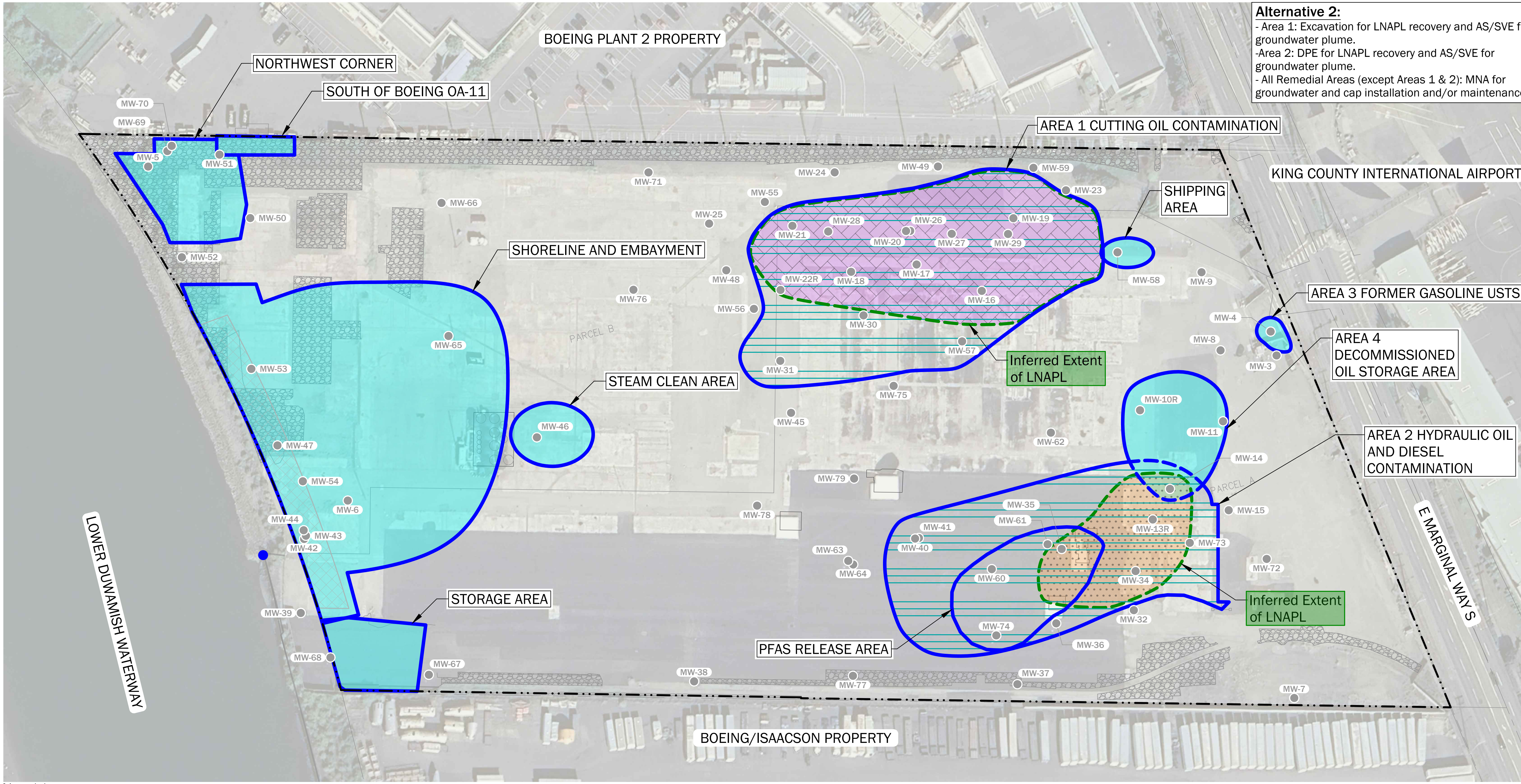

Note(s):

1. PFAS = per-and-polyfluoroalkyl substances; LNAPL = light non-aqueous phase liquid; UST = underground storage tank
2. Excavation in Alternative 2 includes overburden
3. Cap installation and maintenance will be property-wide.

Source(s):

- Basemap from Shannon & Wilson Remedial Investigation Report, dated September 13, 2024
- Aerial from Microsoft Bing Images

Coordinate System: WA State Plane, North Zone, NAD83, US Foot

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Legend

- Parcel Boundary
- Property Fence
- Outfall Location
- Monitoring Well Location
- Approximate Property Boundary
- Estimated Extent of LNAPL in Soil and Groundwater
- Remedial Areas
- Estimated Extent of Remedial Area
- Capping and Monitored Natural Attenuation (MNA)
- Unpaved Surface
- Bulkhead Area
- Dual Phase Extraction (DPE)
- Excavation
- Air Sparging/Soil Vapor Extraction (AS/SVE)

N

0 120

Feet

Alternative 2

Jorgensen Forge Corporation Property
Tukwila, Washington

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Figure 6-1

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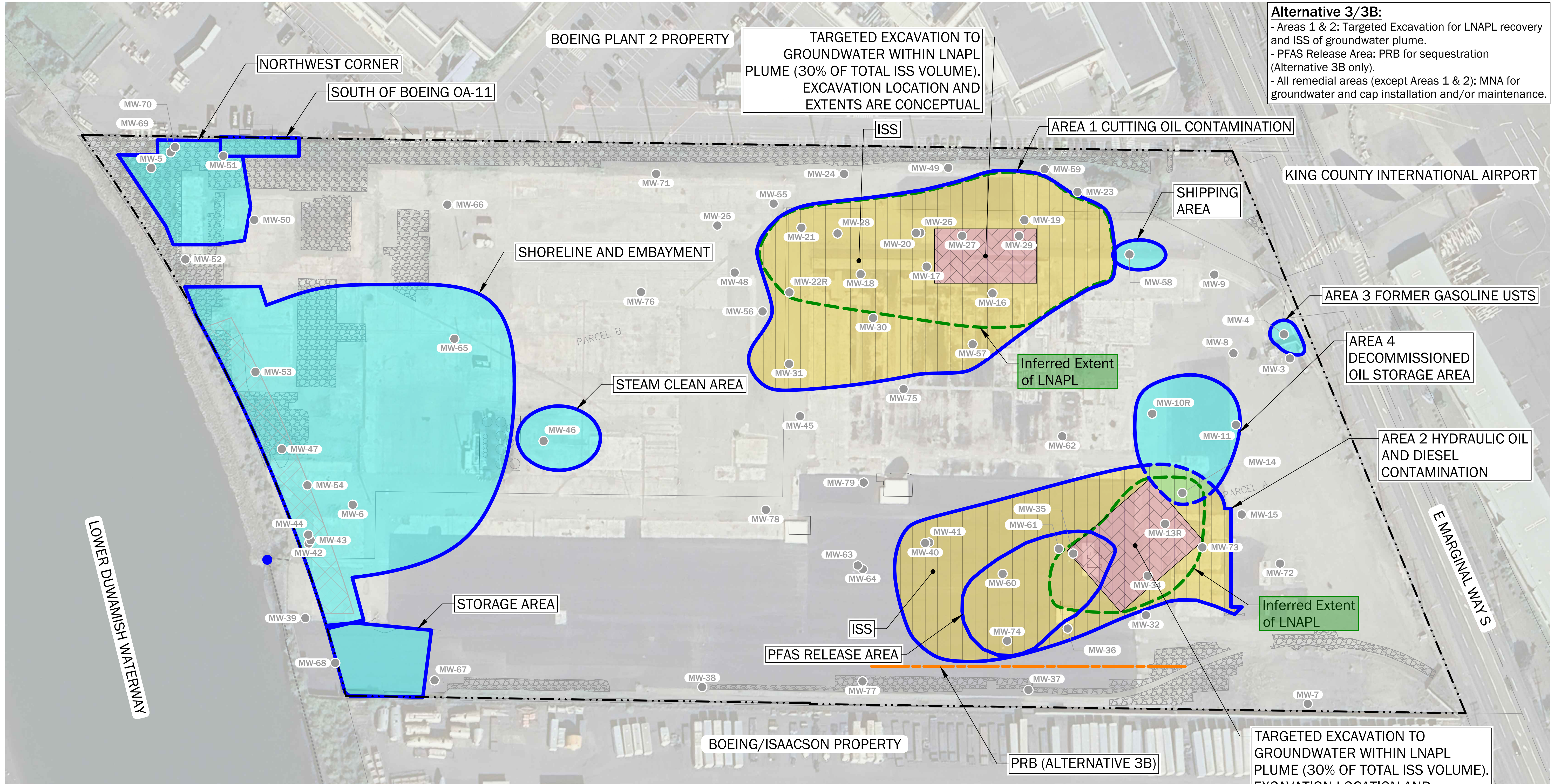

Note(s):

1. PFAS = per-and-polyfluoroalkyl substances; LNAPL = light non-aqueous phase liquid; MNA = monitored natural attenuation; UST = underground storage tank
2. Excavation in Alternative 3/3B includes overburden. Overburden was accounted for in Alternative cost estimates (Appendix A).

Source(s):

- Basemap from Shannon & Wilson Remedial Investigation Report, dated September 13, 2024
- Aerial from Microsoft Bing Images

Coordinate System: WA State Plane, North Zone, NAD83, US Foot

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Legend

- Parcel Boundary
- Property Fence
- Permeable Reactive Barrier (PRB)
- Outfall Location
- Monitoring Well Location
- Approximate Property Boundary
- Estimated Extent of LNAPL in Soil and Groundwater
- Remedial Areas
- Estimated Extent of Remedial Area
- Cap Installation and/or Maintenance
- Unpaved Surface
- Bulkhead Area
- In-Situ Solidification/Stabilization (ISS)
- Excavation

N

0 120

Feet

Alternative 3/3B

Jorgensen Forge Corporation Property
Tukwila, Washington

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Figure 6-2

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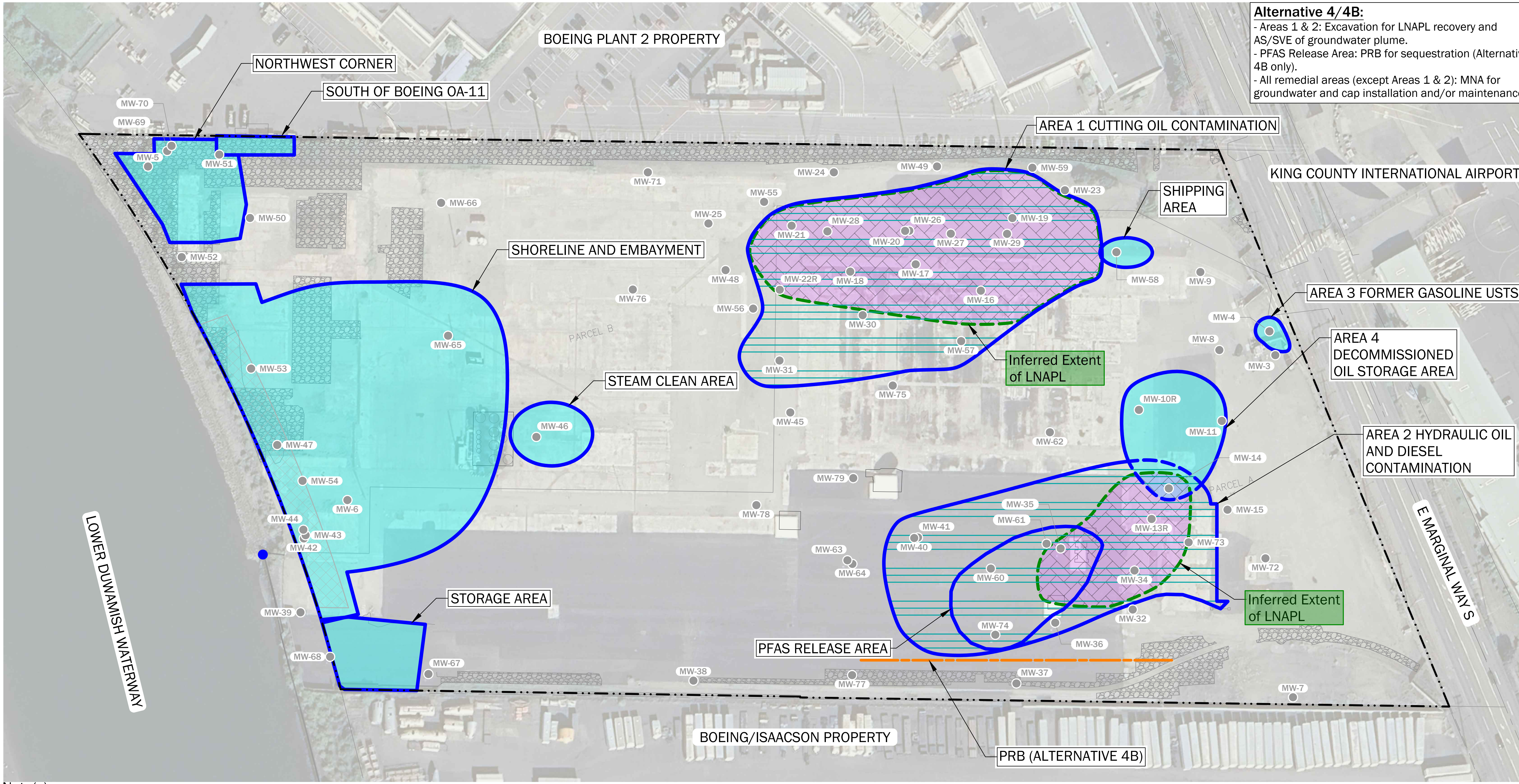

Note(s):

1. PFAS = per-and-polyfluoroalkyl substances; LNAPL = light non-aqueous phase liquid; MNA = monitored natural attenuation; UST = underground storage tank
2. Excavation in Alternative 4/4B includes overburden. Overburden was accounted for in Alternative cost estimates (Appendix A).

Source(s):

- Basemap from Shannon & Wilson Remedial Investigation Report, dated September 13, 2024
- Aerial from Microsoft Bing Images

Coordinate System: WA State Plane, North Zone, NAD83, US Foot

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Legend

- Parcel Boundary
- Property Fence
- Permeable Reactive Barrier (PRB)
- Outfall Location
- Monitoring Well Location
- Approximate Property Boundary
- Estimated Extent of LNAPL in Soil and Groundwater
- Remedial Areas
- Estimated Extent of Remedial Area
- Cap Installation and/or Maintenance
- Unpaved Surface
- Bulkhead Area
- Air Sparging/Soil Vapor Extraction (AS/SVE)
- Excavation

N

0 120

Feet

Alternative 4/4B

Jorgensen Forge Corporation Property
Tukwila, Washington

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Figure 6-3

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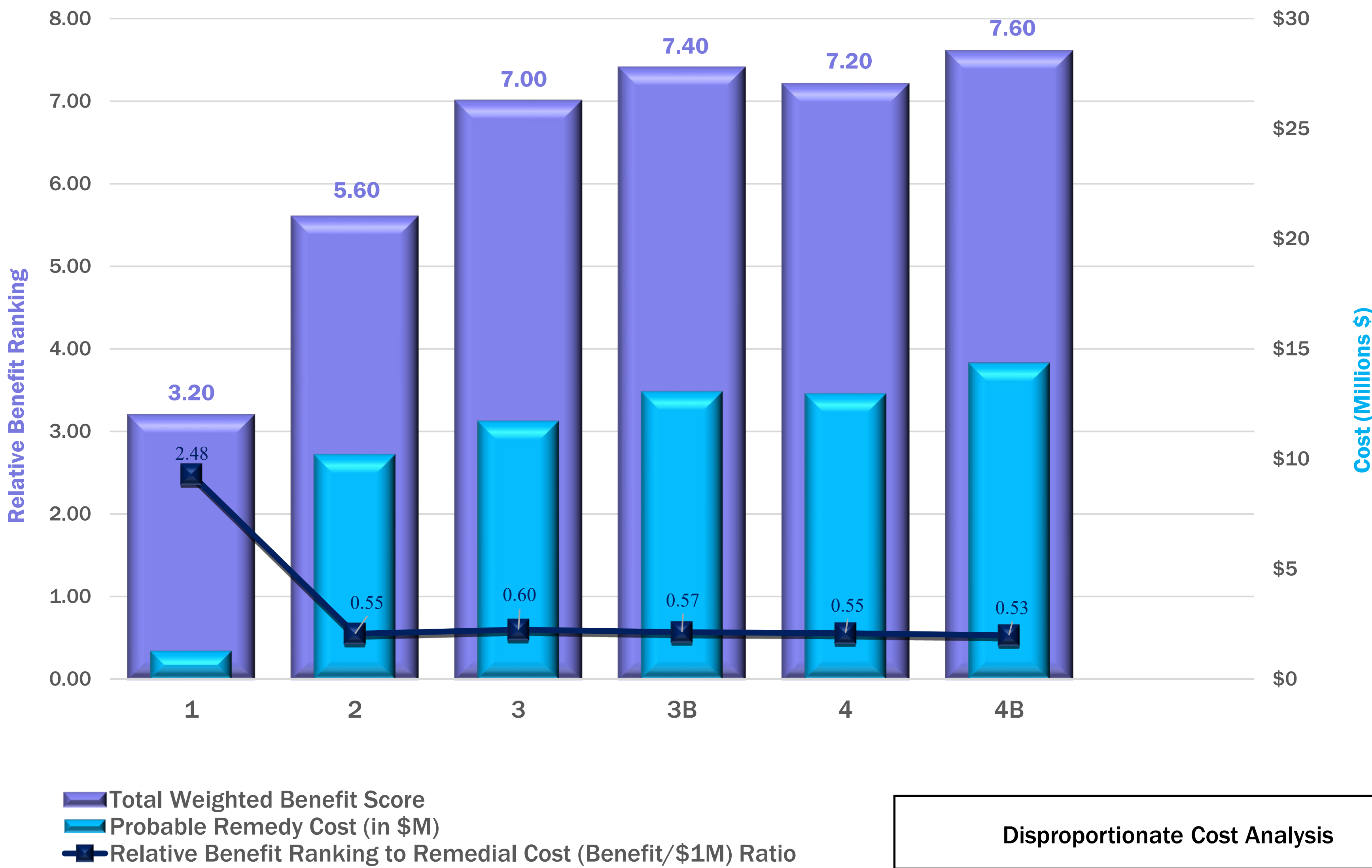

Disproportionate Cost Analysis

Jorgensen Forge Corporation Property
Tukwila, Washington

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Figure 9-1

Appendices

Appendix A
Cleanup Action Alternatives Cost Estimates

Table A-1

Alternative 1: MNA (All Remedial Areas)

Jorgensen Forge Corporation Property

Tukwila, Washington

Item No.	Item Description	Unit	Estimated Quantity[1]	Unit Cost[2] (2025 $)	Estimated Cost	Cost Basis
Indirect Capital Construction Costs						
1	Work Plan	LS	1	$50,000	$50,000	Assumes lump sum costs to prepare work planning documents.
2	Project Management	% of O&M	6%	--	$12,600	Project management includes meetings, planning, coordination, cost and performance reporting. Indirect percentages based on EPA 2000 guidance (EPA 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. OSWER 9355.0-75) and professional judgment.
3	Restrictive Covenant	LS	1	$20,000	$20,000	Costs include coordination with Ecology, property owners, etc. Costs based on professional judgment.
				Indirect Capital Costs Sub-Total	**$82,600**	
Annual Operation and Maintenance Costs (50 years)						
4	Ecology Oversight	% of O&M Yearly	1%	--	$700	Professional judgment.
5	Groundwater Monitoring and Reporting - MNA only	LS/EVENT	1	$50,000	$50,000	Assume annual monitoring of 25 wells for 5 years, followed by every 5 years for 45 years. Based on prior project experience.
6	Monitoring Well and Cap Maintenance	LS/YR	1	$10,000	$10,000	Assumed maintenance and repair cost of site monitoring wells and paved areas. Based on prior project experience.
7	Institutional Controls	LS/YR	1	$10,000	$10,000	Assume annual costs for 50 years for maintaining institutional controls. Based on prior project experience.
				Present Value Operation and Maintenance Costs over estimated duration of 50 years	**$1,082,333**	Present value calculated using equal series present value formula assuming discount rate of 2.3%. Based on "Real 30-year discount rate" published in November 2024 Office of Management and Budget Circular No. A-94.
				Total Estimated Costs for Alternative 1 (without Contingency)	**$1,164,933**	
				Low Range of Estimated Costs for Alternative 1 (-30%) Without Contingency	**$815,453**	Accuracy of the total remedial alternative cost is considered -30 to +50 %, a range based on EPA Guidance (EPA 2000).
				High Range of Estimated Costs for Alternative 1 (+50%) Without Contingency	**$1,747,400**	
				Contingency (Not included in Costs)	**10%**	Contingency includes (1) scope contingency, which refers to unknowns, unforeseen circumstances, or unanticipated conditions that cannot be quantified based on available data at the time the estimate is prepared, and (2) bid contingency, which refers to differences between costs identified at the time the estimate is prepared and actual costs at the time the work is performed. EPA identifies the typical range for scope contingency as 10 to 25 percent, and the typical range for bid contingency as 10 to 20 percent (EPA 2000).

Notes:

[1] Quantity is an estimate at the level of "concept design."

2 Unit costs based on review of: construction cost estimates solicited from applicable vendors and contractors; actual costs incurred during similar, applicable projects; RS Means Construction Cost Data, and professional judgment. Unit costs are presented in 2025 dollars.

MNA = Monitored Natural Attenuation; LS = lump sum; EPA = Environmental Protection Agency; O&M = operation and maintenance

TESC = Temporary erosion and sediment control; OSWER = Office of Solid Waste and Emergency Response

Table A-2

Alternative 2: Excavation for LNAPL Recovery & AS/SVE (Area 1); DPE for LNAPL Recovery & AS/SVE (Area 2)

Jorgensen Forge Corporation Property

Tukwila, Washington

Item No.	Item Description	Unit	Estimated Quantity[1]	Unit Cost[2] (2025 $)	Estimated Cost	Cost Basis
Direct Capital Construction Costs						
GENERAL REQUIREMENTS						
1	Mobilization	% of TDC	3%	--	$166,036	3 percent of total direct capital costs. Professional judgment.
2	Temporary Site Controls	LS	1	$25,000	$25,000	Includes cost for temporary facilities (office trailer, portable toilet), necessary utilities, establish and maintain TESC and traffic controls. Cost includes removal of these controls and facilities prior to demobilization. Based on vendor quote (ICS dated April 2025).
3	Surveying	LS	1	$15,000	$15,000	Based on vendor quote (ICS dated April 2025), to complete pre-construction and post-construction survey.
4	Decommission Monitoring Wells	LS	1	$10,000	$10,000	Assume two days of work by licensed driller for decommissioning including travel. Includes coordination and follow-up documentation to Ecology. Based on bid pricing for previous projects.
5	Installation of Monitoring Wells	EA	5	$10,000	$50,000	Assume new wells to be installed as needed post-construction. Based on previous project experience.
EXCAVATION						
6	Excavation Surface Demolition and Disposal	TON	1,045	$46	$48,091	Removal and disposal of impervious surfaces within the excavation footprint. Based on previous project experience.
7	Overburden Excavation	BCY	10,723	$8	$85,781	Includes cost for excavation, stockpiling and handling of overburden material (top 5 feet). Based on vendor quote (ICS dated April 2025).
8	Excavation	BCY	15,100	$16	$241,600	Includes cost for excavation, stockpiling and handling of material. Based on vendor quote (ICS dated April 2025).
9	Setup, Operation, Maintenance and Removal of LNAPL recovery system	LS	1	$50,000	$50,000	Includes cost for installation, operation and maintenance and removal of LNAPL recovery system required to collect free-phase LNAPL from open excavation. Based on vendor quote (ICS dated April 2025).
10	Recovered Product Disposal	LS	1	$30,000	$30,000	Includes cost for cost for handling, loading, transport and off-site disposal of recovered LNPL (assume 10,000 gallons) at a recyling facility. Based on vendor quote (ICS dated April 2025).
11	Transport and Dispose Contaminated Material at Subtitle D Landfill	TON	29,920	$100	$2,992,000	Includes cost for handling, loading, transport and off-site disposal of non-dangerous contaminated material at an approved Subtitle D disposal facility. Assume all excavated material from Area 1 and 90% of excavated material from Area 2 will be disposed at Subtitle D landfill. Based on bid pricing for previous projects.
12	Import and Place Geotextile as Visual Marker	SY	6,434	$6	$38,601	Cost includes placement of geotextile as a visual marker at the limits (base and sidewalls) of remedial excavation during backfilling. Based on vendor quote (ICS dated April 2025).
13	Import, Place and Compact Backfill	TON	7,720	$40	$308,811	Cost includes import, placement and compaction of gravel borrow during backfilling. Based on vendor quote (ICS dated April 2025).
14	Place and Compact Backfill (Overburden)	CY	10,723	$8	$85,781	Cost includes placement and compaction of stockpiled overburden. Based on vendor quote (ICS dated April 2025)
DUAL PHASE EXTRACTION						
15	Pilot Study	LS	1	$20,000	$20,000	Pilot study and data collection to determine system requirements. Cost based on previous project experience.
16	Extraction Well Installation	EA	5	$10,000	$50,000	Assume new extraction wells to be installed for the DPE system. Assume 5 extraction wells (2-in dia) to a depth of 25 feet per remediation area. Based on previous project experience.
17	Remediation Equipment (DPE)	LS	1	$175,000	$175,000	Assume new turn-key skid-mounted DPE system with a 500 scfm blower, extraction pumps, tanks, separators, air strippers, thermal oxidizer and other miscellaneous equipment. Based on vendor quote (ICS dated April 2025).
18	Remediation System Installation and Startup	LS	1	$80,000	$80,000	Cost includes labor, equipment and materials for trenching, conveyance piping, system manifold, electrical connections, fencing and system startup. Based on vendor quote (ICS dated April 2025).
AIR SPARGING/SOIL VAPOR EXTRACTION						
19	Pilot Study	LS	1	$20,000	$20,000	Pilot study and data collection to determine system requirements. Cost based on previous project experience.
20	Remediation Well Installation	EA	30	$10,000	$300,000	Assume new 2-in dia wells to be installed for AS/SVE treatment to a depth of 25 feet. Based on previous project experience.
21	Remediation Equipment (AS/SVE)	LS	1	$150,000	$150,000	New turn-key skid-mounted SVE system with a 500 scfm blower and thermal oxidizer for vapor treatment. Turn-key skid-mounted air sparge system with specifications to handle the assumed air sparge wells based on pilot test results. Based on vendor quote (ICS dated April 2025).
22	Remediation System Installation and Startup	LS	1	$80,000	$80,000	Cost includes labor, equipment and materials for trenching, conveyance piping, system manifold, electrical connections, fencing and system startup. Based on vendor quote (ICS dated April 2025).

Item No.	Item Description	Unit	Estimated Quantity[1]	Unit Cost[2] (2025 $)	Estimated Cost	Cost Basis
CAPPING						
23	Pavement Installation	SF	106,152	$5	$530,760	Cost includes labor, equipment and materials to install base course (5 in), top course (2 in) and HMA (3 in) to restore the surface over active remediation areas and other capping areas. Based on vendor quote (ICS dated April 2025).
24	Pavement Repair	SF	148,104	$1	$148,104	Cost includes labor, equipment and materials for repairs to damaged portions of exisiting paved surfaces at the site. Assume 15% to 20% of existing paved surface requires repairs. Based on vendor quote (ICS dated April 2025).
				Direct Capital Costs Sub-Total	**$5,700,564**	
Indirect Capital Construction Costs						
25	Pre-Remedial Design Investigation	LS	1	$100,000	$100,000	Based on previous project experience.
26	Remedial Design	% of TDC	3%	--	$171,017	Includes pre-remedial design investigations, remedial design sampling plans, design support studies, engineering survey, plans and specifications, engineers estimate, bid documents and contracting support. Indirect percentages based on EPA 2000 guidance (EPA 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. OSWER 9355.0-75) and professional judgment.
27	Permitting	% of TDC	1%	--	$57,006	Indirect percentages based on EPA 2000 guidance (EPA, 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. OSWER 9355.0-75) and professional judgment.
28	Construction Management/Oversight	% of TDC	6%	--	$342,034	Construction management includes field oversight, contractor submittal review, design modifications, construction schedule tracking and completion report. Indirect percentages based on EPA 2000 guidance (EPA 2000) and professional judgment.
29	Project Management	% of TDC	6%	--	$342,034	Project management includes meetings, planning, coordination, cost and performance reporting. Indirect percentages based on EPA 2000 guidance (EPA 2000) and professional judgment.
30	Ecology Oversight	% of TDC	1%	--	$57,006	Professional judgment.
31	Restrictive Covenant	LS	1	$20,000	$20,000	Costs include coordination with Ecology, property owners, etc. Costs based on professional judgment.
				Indirect Capital Costs Sub-Total	**$1,089,096**	
Annual Operation and Maintenance Costs (30 years)						
32	Groundwater Monitoring and Reporting - MNA following Treatment	LS/EVENT	1	$50,000	$50,000	Assume annual monitoring of 25 wells for 5 years post-construction, followed by every 5 years for 25 years. Based on prior project experience.
33	Monitoring Well and Cap Maintenance	LS/YR	1	$10,000	$10,000	Assumed maintenance and repair cost of site monitoring wells and paved areas. Based on prior project experience.
34	DPE System O&M	LS/EVENT	1	$5,000	$5,000	Assume monthly site visits for year 1, followed by quarterly site visits until year 10. Includes cost for labor, materials, equipment, analytical costs, and utilities. Based on prior project experience.
35	Institutional Controls	LS/YR	1	$10,000	$10,000	Assume annual costs for 30 years for maintaining institutional controls. Based on prior project experience.
				Present Value Operation and Maintenance Costs over estimated duration of 30 years	**$1,061,193**	Present value calculated using equal series present value formula assuming discount rate of 2.3%. Based on "Real 30-year discount rate" published in November 2024 Office of Management and Budget Circular No. A-94.
				Total Estimated Costs for Alternative 2 (without Contingency)	**$7,850,853**	
				Low Range of Estimated Costs for Alternative 2 (-30%) Without Contingency	**$5,495,597**	Accuracy of the total remedial alternative cost is considered -30 to +50 %, a range based on EPA Guidance (EPA 2000).
				High Range of Estimated Costs for Alternative 2 (+50%) Without Contingency	**$11,776,279**	
				Contingency (Not included in Costs)	**30%**	Contingency includes (1) scope contingency, which refers to unknowns, unforeseen circumstances, or unanticipated conditions that cannot be quantified based on available data at the time the estimate is prepared, and (2) bid contingency, which refers to differences between costs identified at the time the estimate is prepared and actual costs at the time the work is performed. EPA identifies the typical range for scope contingency as 10 to 25 percent, and the typical range for bid contingency as 10 to 20 percent (EPA 2000).

Notes:

[1] Quantity is an estimate at the level of "concept design."

2 Unit costs based on review of: construction cost estimates solicited from applicable vendors and contractors; actual costs incurred during similar, applicable projects; RS Means Construction Cost Data, and professional judgment. Unit costs are presented in 2024 dollars.

MNA = Monitored Natural Attenuation; LS = lump sum; TDC = total direct capital costs; EPA = Environmental Protection Agency; SF = square feet; SY = square yards; BCY = bank cubic yards; LF = linear feet; EA = each; HMA = hot mix asphalt

LNAPL = light non aqueous phase liquid; AS = air sparging; DPE = dual phase extraction; TESC = Temporary erosion and sediment control; OSWER = Office of Solid Waste and Emergency Response

Table A-3

Alternative 3: Targeted Excavation for LNAPL Recovery & ISS (Areas 1 & 2)

Jorgensen Forge Corporation Property

Tukwila, Washington

Item No.	Item Description	Unit	Estimated Quantity[1]	Unit Cost[2] (2025 $)	Estimated Cost	Cost Basis
Direct Capital Construction Costs						
GENERAL REQUIREMENTS						
1	Mobilization	% of TDC	3%	--	$197,283	3 percent of total direct capital costs. Professional judgment.
2	Temporary Site Controls	LS	1	$25,000	$25,000	Includes cost for temporary facilities (office trailer, portable toilet), necessary utilities, establish and maintain TESC and traffic controls. Cost includes removal of these controls and facilities prior to demobilization. Based on vendor quote (ICS dated April 2025).
3	Surveying	LS	1	$15,000	$15,000	Based on vendor quote (ICS dated April 2025), to complete pre-construction and post-construction survey.
4	Decommission Monitoring Wells	LS	1	$10,000	$10,000	Assume two days of work by licensed driller for decommissioning including travel. Includes coordination and follow-up documentation to Ecology. Based on bid pricing for previous projects.
5	Installation of Monitoring Wells	EA	5	$10,000	$50,000	Assume new wells to be installed as needed post-construction. Based on previous project experience.
EXCAVATION						
6	Excavation Surface Demolition and Disposal	TON	2,684	$46	$123,479	Removal and disposal of impervious surfaces within the excavation footprint. Based on previous project experience.
7	Excavation	BCY	11,600	$16	$185,600	Includes cost for excavation, stockpiling and handling of material. Assume 30% of ISS volume will be excavated to account for ISS fluff. Based on bid pricing for previous projects.
8	Setup, Operation, Maintenance and Removal of LNAPL recovery system	LS	1	$50,000	$50,000	Includes cost for installation, operation and maintenance and removal of LNAPL recovery system required to collect free-phase LNAPL from open excavation. Based on vendor quote (ICS dated April 2025).
9	Recovered Product Disposal	LS	1	$30,000	$30,000	Includes cost for cost for handling, loading, transport and off-site disposal of recovered LNPL (assume 10,000 gallons) at a recyling facility. Based on vendor quote (ICS dated April 2025).
10	Transport and Dispose Contaminated Material at Subtitle D Landfill	TON	21,865	$100	$2,186,454	Includes cost for handling, loading, transport and off-site disposal of non-dangerous contaminated material at an approved Subtitle D disposal facility. Assume all excavated material from Area 1 and 90% of excavated material from Area 2 will be disposed at Subtitle D landfill. Based on bid pricing for previous projects.
11	Transport and Dispose Contaminated Material at Subtitle C Landfill	TON	1,031	$400	$412,258	Includes cost for handling, loading, transport and off-site disposal of dangerous waste at an approved Subtitle C disposal facility. Assume 10% of excavated material from Area 2 will be disposed at Subtitle C lanfill due to overlap with PFAS area. Based on bid pricing for previous projects.
ISS						
12	ISS Treatability Testing	LS	1	$30,000	$30,000	Treatability testing to determine ISS mix design. Cost based on previous project experience.
13	ISS Treatment	CY	38,544	$60	$2,312,644	Cost includes labor, equipment and materials for ISS using an excavator. Assume top 5 ft of overburden within the ISS footprint is excavated and stockpiled and solidification of soil from 5 ft to 12 ft with average solidication thickness of 7 ft across the ISS footprint. Includes costs for procuring treatment amendments. Assume Type 1 Portland cement (10% by weight) for ISS in Areas 1 and 2 and granular activated carbon (4% by weight) for ISS in PFAS portion of Area 2. Based on vendor quote (Entact dated April 2025).
14	ISS Performance Monitoring	LS	1	$50,000	$50,000	Labor and analytical costs to evaluate ISS performance criteria. Based on previous project experience.
CAPPING						
19	Pavement Installation	SF	196,920	$5	$984,600	Cost includes labor, equipment and materials to install base course (5 in), top course (2 in) and HMA (3 in) to restore the surface over active remediation areas and other capping areas. Based on vendor quote (ICS dated April 2025).
20	Pavement Repair	SF	111,078	$1	$111,078	Cost includes labor, equipment and materials for repairs to damaged portions of exisiting paved surfaces at the site. Assume 15% to 20% of existing paved surface requires repairs. Based on vendor quote (ICS dated April 2025).
				Direct Capital Costs Sub-Total	$6,773,396	

Item No.	Item Description	Unit	Estimated Quantity[1]	Unit Cost[2] (2025 $)	Estimated Cost	Cost Basis
Indirect Capital Construction Costs						
21	Pre-Remedial Design Investigation	LS	1	$100,000	$100,000	Based on previous project experience.
22	Remedial Design	% of TDC	3%	--	$203,202	Includes pre-remedial design investigations, remedial design sampling plans, design support studies, engineering survey, plans and specifications, engineers estimate, bid documents and contracting support. Indirect percentages based on EPA 2000 guidance (EPA 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. OSWER 9355.0-75) and professional judgment.
23	Permitting	% of TDC	1%	--	$67,734	Indirect percentages based on EPA 2000 guidance (EPA 2000) and professional judgment.
24	Construction Management/Oversight	% of TDC	6%	--	$406,404	Construction management includes field oversight, contractor submittal review, design modifications, construction schedule tracking and completion report. Indirect percentages based on EPA 2000 guidance (EPA 2000) and professional judgment.
25	Project Management	% of TDC	6%	--	$406,404	Project management includes meetings, planning, coordination, cost and performance reporting. Indirect percentages based on EPA 2000 guidance (EPA 2000) and professional judgment.
26	Ecology Oversight	% of TDC	1%	--	$67,734	Professional judgment.
27	Restrictive Covenant	LS	1	$20,000	$20,000	Costs include coordination with Ecology, property owners, etc. Costs based on professional judgment.
				Indirect Capital Costs Sub-Total	**$1,271,477**	
Annual Operation and Maintenance Costs (30 years)						
28	Groundwater Monitoring and Reporting - MNA following Treatment	LS/EVENT	1	$50,000	$50,000	Assume annual monitoring of 25 wells for 5 years post-construction, followed by every 5 years for 25 years. Based on prior project experience.
29	Monitoring Well and Cap Maintenance	LS/YR	1	$10,000	$10,000	Assumed maintenance and repair cost of site monitoring wells and paved areas. Based on prior project experience.
30	AS/SVE System O&M	LS/EVENT	1	$5,000	$5,000	Assume monthly site visits for year 1, followed by quarterly site visits until year 5. Includes cost for labor, materials, equipment, analytical costs, and utilities. Based on prior project experience.
31	Institutional Controls	LS/YR	1	$10,000	$10,000	Assume annual costs for 30 years for maintaining institutional controls. Based on prior project experience.
				Present Value Operation and Maintenance Costs over estimated duration of 30 years	**$977,783**	Present value calculated using equal series present value formula assuming discount rate of 2.3%. Based on "Real 30-year discount rate" published in November 2024 Office of Management and Budget Circular No. A-94.
				Total Estimated Costs for Alternative 3 (without Contingency)	**$9,022,656**	
				Low Range of Estimated Costs for Alternative 3 (-30%) Without Contingency	**$6,315,859**	Accuracy of the total remedial alternative cost is considered -30 to +50 %, a range based on EPA Guidance (EPA 2000).
				High Range of Estimated Costs for Alternative 3 (+50%) Without Contingency	**$13,533,984**	
				Contingency (Not included in Costs)	**30%**	Contingency includes (1) scope contingency, which refers to unknowns, unforeseen circumstances, or unanticipated conditions that cannot be quantified based on available data at the time the estimate is prepared, and (2) bid contingency, which refers to differences between costs identified at the time the estimate is prepared and actual costs at the time the work is performed. EPA identifies the typical range for scope contingency as 10 to 25 percent, and the typical range for bid contingency as 10 to 20 percent (EPA 2000).

Notes:

[1] Quantity is an estimate at the level of "concept design."

2 Unit costs based on review of: construction cost estimates solicited from applicable vendors and contractors; actual costs incurred during similar, applicable projects; RS Means Construction Cost Data, and professional judgment. Unit costs are presented in 2024 dollars.

MNA = Monitored Natural Attenuation; LS = lump sum; TDC = total direct capital costs; EPA = Environmental Protection Agency; SF = square feet; SY = square yards; BCY = bank cubic yards; LF = linear feet; EA = each; HMA = hot mix asphalt

ISS = In Situ Solidification; LNAPL = light non aqueous phase liquid; AS = air sparging; DPE = dual phase extraction; TESC = Temporary erosion and sediment control; OSWER = Office of Solid Waste and Emergency Response

Table A-4

Alternative 3B: Targeted Excavation for LNAPL Recovery & ISS (Areas 1 and 2); PRB (PFAS Release Area)

Jorgensen Forge Corporation Property

Tukwila, Washington

Item No.	Item Description	Unit	Estimated Quantity[1]	Unit Cost[2] (2025 $)	Estimated Cost	Cost Basis
Direct Capital Construction Costs						
GENERAL REQUIREMENTS						
1	Mobilization	% of TDC	3%	--	$197,283	3 percent of total direct capital costs. Professional judgment.
2	Temporary Site Controls	LS	1	$25,000	$25,000	Includes cost for temporary facilities (office trailer, portable toilet), necessary utilities, establish and maintain TESC and traffic controls. Cost includes removal of these controls and facilities prior to demobilization. Based on vendor quote (ICS dated April 2025).
3	Surveying	LS	1	$15,000	$15,000	Based on vendor quote (ICS dated April 2025), to complete pre-construction and post-construction survey.
4	Decommission Monitoring Wells	LS	1	$10,000	$10,000	Assume two days of work by licensed driller for decommissioning including travel. Includes coordination and follow-up documentation to Ecology. Based on bid pricing for previous projects.
5	Installation of Monitoring Wells	EA	5	$10,000	$50,000	Assume new wells to be installed as needed post-construction. Based on previous project experience.
EXCAVATION						
6	Excavation Surface Demolition and Disposal	TON	2,684	$46	$123,479	Removal and disposal of impervious surfaces within the excavation footprint. Based on previous project experience.
7	Excavation	BCY	11,600	$16	$185,600	Includes cost for excavation, stockpiling and handling of material. Assume 30% of ISS volume will be excavated to account for ISS fluff. Based on bid pricing for previous projects.
8	Setup, Operation, Maintenance and Removal of LNAPL recovery system	LS	1	$50,000	$50,000	Includes cost for installation, operation and maintenance and removal of LNAPL recovery system required to collect free-phase LNAPL from open excavation. Based on vendor quote (ICS dated April 2025).
9	Recovered Product Disposal	LS	1	$30,000	$30,000	Includes cost for cost for handling, loading, transport and off-site disposal of recovered LNPL (assume 10,000 gallons) at a recyling facility. Based on vendor quote (ICS dated April 2025).
10	Transport and Dispose Contaminated Material at Subtitle D Landfill	TON	21,865	$100	$2,186,454	Includes cost for handling, loading, transport and off-site disposal of non-dangerous contaminated material at an approved Subtitle D disposal facility. Assume all excavated material from Area 1 and 90% of excavated material from Area 2 will be disposed at Subtitle D landfill. Based on bid pricing for previous projects.
11	Transport and Dispose Contaminated Material at Subtitle C Landfill	TON	1,031	$400	$412,258	Includes cost for handling, loading, transport and off-site disposal of dangerous waste at an approved Subtitle C disposal facility. Assume 10% of excavated material from Area 2 will be disposed at Subtitle C lanfill due to overlap with PFAS area. Based on bid pricing for previous projects.
ISS						
12	ISS Treatability Testing	LS	1	$30,000	$30,000	Treatability testing to determine ISS mix design. Cost based on previous project experience.
13	ISS Treatment	CY	38,544	$60	$2,312,644	Cost includes labor, equipment and materials for ISS using an excavator. Assume top 5 ft of overburden within the ISS footprint is excavated and stockpiled and solidification of soil from 5 ft to 12 ft with average solidication thickness of 7 ft across the ISS footprint. Includes costs for procuring treatment amendments. Assume Type 1 Portland cement (10% by weight) for ISS in Areas 1 and 2 and granular activated carbon (4% by weight) for ISS in PFAS portion of Area 2. Based on vendor quote (Entact dated April 2025).
14	ISS Performance Monitoring	LS	1	$50,000	$50,000	Labor and analytical costs to evaluate ISS performance criteria. Based on previous project experience.
CAPPING						
15	Pavement Installation	SF	196,920	$5	$984,600	Cost includes labor, equipment and materials to install base course (5 in), top course (2 in) and HMA (3 in) to restore the surface over active remediation areas and other capping areas. Based on vendor quote (ICS dated April 2025).
16	Pavement Repair	SF	111,078	$1	$111,078	Cost includes labor, equipment and materials for repairs to damaged portions of exisiting paved surfaces at the site. Assume 15% to 20% of existing paved surface requires repairs. Based on vendor quote (ICS dated April 2025).

Item No.	Item Description	Unit	Estimated Quantity[1]	Unit Cost[2] (2025 $)	Estimated Cost	Cost Basis
IN-SITU CHEMICAL WITH SORPTIVE TECHNOLOGIES						
17	In-Situ Chemical - Pilot Study	LS	1	$20,000	$20,000	Pilot study and data collection to determine reagent estimates. Cost based on previous project experience.
18	SE Property Boundary Sorption Barrier - Products, Construction and Operation	LS	1	$836,000	$836,000	Treatment with PlumeStop® Colloidal Activated Carbon™ in the SE property boundary of the site to address the PFAS area. Assume 365 ft long barrier wall between MW-74 and SE property boundary to prevent offsite migration of PFAS . Based on vendor conceptual cost estimate - Regenesis, dated April 2025. Includes shipping costs to the Site. Includes labor, equipment, materials and freight for drilling, mixing and injection. Total 150 injection points using direct push methods, with a total 25 days of injection.
19	Performance Monitoring	EVENT	2	$15,000	$30,000	Labor and analytical costs to evaluate effectiveness of treatment. Assume 2 rounds of monitoring at 5 MWs. Based on previous project experience.
				Direct Capital Costs Sub-Total	**$7,659,396**	
Indirect Capital Construction Costs						
20	Pre-Remedial Design Investigation	LS	1	$100,000	$100,000	Based on previous project experience.
21	Remedial Design	% of TDC	3%	--	$229,782	Includes pre-remedial design investigations, remedial design sampling plans, design support studies, engineering survey, plans and specifications, engineers estimate, bid documents and contracting support. Indirect percentages based on EPA 2000 guidance (EPA, 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. OSWER 9355.0-75) and professional judgment.
22	Permitting	% of TDC	1%	--	$76,594	Indirect percentages based on EPA 2000 guidance (EPA 2000) and professional judgment.
23	Construction Management/Oversight	% of TDC	6%	--	$459,564	Construction management includes field oversight, contractor submittal review, design modifications, construction schedule tracking and completion report. Indirect percentages based on EPA 2000 guidance (EPA 2000) and professional judgment.
24	Project Management	% of TDC	6%	--	$459,564	Project management includes meetings, planning, coordination, cost and performance reporting. Indirect percentages based on EPA 2000 guidance (EPA 2000) and professional judgment.
25	Ecology Oversight	% of TDC	1%	--	$76,594	Professional judgment.
26	Restrictive Covenant	LS	1	$20,000	$20,000	Costs include coordination with Ecology, property owners, etc. Costs based on professional judgment.
				Indirect Capital Costs Sub-Total	**$1,422,097**	
Annual Operation and Maintenance Costs (30 years)						
27	Groundwater Monitoring and Reporting - MNA following Treatment	LS/EVENT	1	$50,000	$50,000	Assume annual monitoring of 25 wells for 5 years post-construction, followed by every 5 years for 25 years. Based on prior project experience.
28	Monitoring Well and Cap Maintenance	LS/YR	1	$10,000	$10,000	Assumed maintenance and repair cost of site monitoring wells and paved areas. Based on prior project experience.
29	AS/SVE System O&M	LS/EVENT	1	$5,000	$5,000	Assume monthly site visits for year 1, followed by quarterly site visits until year 5. Includes cost for labor, materials, equipment, analytical costs, and utilities. Based on prior project experience.

Item No.	Item Description	Unit	Estimated Quantity[1]	Unit Cost[2] (2025 $)	Estimated Cost	Cost Basis
30	Institutional Controls	LS/YR	1	$10,000	$10,000	Assume annual costs for 30 years for maintaining institutional controls. Based on prior project experience.
Present Value Operation and Maintenance Costs over estimated duration of 30 years					**$977,783**	Present value calculated using equal series present value formula assuming discount rate of 2.3%. Based on "Real 30-year discount rate" published in November 2024 Office of Management and Budget Circular No. A-94.
Total Estimated Costs for Alternative 3B (without Contingency)					**$10,059,276**	
Low Range of Estimated Costs for Alternative 3B (-30%) Without Contingency					**$7,041,493**	Accuracy of the total remedial alternative cost is considered -30 to +50 %, a range based on EPA Guidance (EPA 2000).
High Range of Estimated Costs for Alternative 3B (+50%) Without Contingency					**$15,088,914**	
Contingency (Not included in Costs)					**30%**	Contingency includes (1) scope contingency, which refers to unknowns, unforeseen circumstances, or unanticipated conditions that cannot be quantified based on available data at the time the estimate is prepared, and (2) bid contingency, which refers to differences between costs identified at the time the estimate is prepared and actual costs at the time the work is performed. EPA identifies the typical range for scope contingency as 10 to 25 percent, and the typical range for bid contingency as 10 to 20 percent (EPA 2000).

Notes:

[1] Quantity is an estimate at the level of "concept design."

2 Unit costs based on review of: construction cost estimates solicited from applicable vendors and contractors; actual costs incurred during similar, applicable projects; RS Means Construction Cost Data, and professional judgment. Unit costs are presented in 2024 dollars.

MNA = Monitored Natural Attenuation; LS = lump sum; TDC = total direct capital costs; EPA = Environmental Protection Agency; SF = square feet; SY = square yards; BCY = bank cubic yards; LF = linear feet; EA = each; HMA = hot mix asphalt

ISS = In Situ Solidification; LNAPL = light non aqueous phase liquid; AS = air sparging; DPE = dual phase extraction; TESC = Temporary erosion and sediment control; OSWER = Office of Solid Waste and Emergency Response

Table A-5

Alternative 4: Excavation for LNAPL Recovery & AS/SVE (Areas 1 and 2)

Jorgensen Forge Corporation Property

Tukwila, Washington

Item No.	Item Description	Unit	Estimated Quantity[1]	Unit Cost[2] (2025 $)	Estimated Cost	Cost Basis
Direct Capital Construction Costs						
GENERAL REQUIREMENTS						
1	Mobilization	% of TDC	3%	--	$211,843	3 percent of total direct capital costs. Professional judgment.
2	Temporary Site Controls	LS	1	$25,000	$25,000	Includes cost for temporary facilities (office trailer, portable toilet), necessary utilities, establish and maintain TESC and traffic controls. Cost includes removal of these controls and facilities prior to demobilization. Based on vendor quote (ICS dated April 2025).
3	Surveying	LS	1	$15,000	$15,000	Based on vendor quote (ICS dated April 2025), to complete pre-construction and post-construction survey.
4	Decommission Monitoring Wells	LS	1	$10,000	$10,000	Assume two days of work by licensed driller for decommissioning including travel. Includes coordination and follow-up documentation to Ecology. Based on bid pricing for previous projects.
5	Installation of Monitoring Wells	EA	5	$10,000	$50,000	Assume new wells to be installed as needed post-construction. Based on previous project experience.
EXCAVATION						
6	Excavation Surface Demolition and Disposal	TON	1,419	$46	$65,275	Removal and disposal of impervious surfaces within the excavation footprint. Based on previous project experience.
7	Overburden Excavation	BCY	14,554	$8	$116,433	Includes cost for excavation, stockpiling and handling of overburden material (top 5 feet). Based on vendor quote (ICS dated April 2025).
8	Excavation	BCY	20,400	$16	$326,400	Includes cost for excavation, stockpiling and handling of material. Based on vendor quote (ICS dated April 2025).
9	Setup, Operation, Maintenance and Removal of LNAPL recovery system	LS	1	$50,000	$50,000	Includes cost for installation, operation and maintenance and removal of LNAPL recovery system required to collect free-phase LNAPL from open excavation. Based on vendor quote (ICS dated April 2025).
10	Recovered Product Disposal	LS	1	$30,000	$30,000	Includes cost for cost for handling, loading, transport and off-site disposal of recovered LNPL (assume 10,000 gallons) at a recyling facility. Based on vendor quote (ICS dated April 2025).
11	Transport and Dispose Contaminated Material at Subtitle D Landfill	TON	39,282	$100	$3,928,181	Includes cost for handling, loading, transport and off-site disposal of non-dangerous contaminated material at an approved Subtitle D disposal facility. Assume all excavated material from Area 1 and 90% of excavated material from Area 2 will be disposed at Subtitle D landfill. Based on bid pricing for previous projects.
12	Transport and Dispose Contaminated Material at Subtitle C Landfill	TON	1,062	$400	$424,835	Includes cost for handling, loading, transport and off-site disposal of dangerous waste at an approved Subtitle C disposal facility. Assume 10% of excavated material from Area 2 will be disposed at Subtitle C lanfill due to overlap with PFAS area. Based on bid pricing for previous projects.
13	Import and Place Geotextile as Visual Marker	SY	8,732	$6	$52,395	Cost includes placement of geotextile as a visual marker at the limits (base and sidewalls) of remedial excavation during backfilling. Based on vendor quote (ICS dated April 2025).
14	Import, Place and Compact Backfill	TON	10,479	$40	$419,157	Cost includes import, placement and compaction of gravel borrow during backfilling. Based on vendor quote (ICS dated April 2025).
	Place and Compact Backfill (Overburden)	CY	14,554	$8	$116,433	Cost includes placement and compaction of stockpiled overburden. Based on vendor quote (ICS dated April 2025)

Item No.	Item Description	Unit	Estimated Quantity[1]	Unit Cost[2] (2025 $)	Estimated Cost	Cost Basis
AIR SPARGING/SOIL VAPOR EXTRACTION						
15	Pilot Study	LS	1	$20,000	$20,000	Pilot study and data collection to determine system requirements. Cost based on previous project experience.
16	Remediation Well Installation	EA	40	$10,000	$400,000	Assume new 2-in dia wells to be installed for AS/SVE treatment to a depth of 25 feet. Based on previous project experience.
17	Remediation Equipment (AS/SVE)	LS	1	$150,000	$150,000	New turn-key skid-mounted SVE system with a 500 scfm blower and thermal oxidizer for vapor treatment. Turn-key skid-mounted air sparge system with specifications to handle the assumed air sparge wells based on pilot test results. Based on vendor quote (ICS dated April 2025).
18	Remediation System Installation and Startup	LS	1	$80,000	$80,000	Cost includes labor, equipment and materials for trenching, conveyance piping, system manifold, electrical connections, fencing and system startup. Based on vendor quote (ICS dated April 2025).
CAPPING						
19	Pavement Installation	SF	126,842	$5	$634,210	Cost includes labor, equipment and materials to install base course (5 in), top course (2 in) and HMA (3 in) to restore the surface over active remediation areas and other capping areas. Based on vendor quote (ICS dated April 2025).
20	Pavement Repair	SF	148,104	$1	$148,104	Cost includes labor, equipment and materials for repairs to damaged portions of exisiting paved surfaces at the site. Assume 15% to 20% of existing paved surface requires repairs. Based on vendor quote (ICS dated April 2025).
				Direct Capital Costs Sub-Total	**$7,273,264**	
Indirect Capital Construction Costs						
21	Pre-Remedial Design Investigation	LS	1	$100,000	$100,000	Based on previous project experience.
22	Remedial Design	% of TDC	3%	--	$218,198	Includes pre-remedial design investigations, remedial design sampling plans, design support studies, engineering survey, plans and specifications, engineers estimate, bid documents and contracting support. Indirect percentages based on EPA 2000 guidance (EPA, 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. OSWER 9355.0-75) and professional judgment.
23	Permitting	% of TDC	1%	--	$72,733	Indirect percentages based on EPA 2000 guidance (EPA 2000) and professional judgment.
24	Construction Management/Oversight	% of TDC	6%	--	$436,396	Construction management includes field oversight, contractor submittal review, design modifications, construction schedule tracking and completion report. Indirect percentages based on EPA 2000 guidance (EPA 2000) and professional judgment.
25	Project Management	% of TDC	6%	--	$436,396	Project management includes meetings, planning, coordination, cost and performance reporting. Indirect percentages based on EPA 2000 guidance (EPA 2000) and professional judgment.
26	Ecology Oversight	% of TDC	1%	--	$72,733	Professional judgment.
27	Restrictive Covenant	LS	1	$20,000	$20,000	Costs include coordination with Ecology, property owners, etc. Costs based on professional judgment.
				Indirect Capital Costs Sub-Total	**$1,356,455**	

Item No.	Item Description	Unit	Estimated Quantity[1]	Unit Cost[2] (2025 $)	Estimated Cost	Cost Basis
Annual Operation and Maintenance Costs (30 years)						
28	Groundwater Monitoring and Reporting - MNA following Treatment	LS/EVENT	1	$50,000	$50,000	Assume annual monitoring of 25 wells for 5 years post-construction, followed by every 5 years for 25 years. Based on prior project experience.
29	Monitoring Well and Cap Maintenance	LS/YR	1	$10,000	$10,000	Assumed maintenance and repair cost of site monitoring wells and paved areas. Based on prior project experience.
30	AS/SVE System O&M	LS/EVENT	1	$5,000	$5,000	Assume monthly site visits for year 1, followed by quarterly site visits until year 5. Includes cost for labor, materials, equipment, analytical costs, and utilities. Based on prior project experience.
31	Institutional Controls	LS/YR	1	$10,000	$10,000	Assume annual costs for 30 years for maintaining institutional controls. Based on prior project experience.
Present Value Operation and Maintenance Costs over estimated duration of 30 years					**$977,783**	Present value calculated using equal series present value formula assuming discount rate of 2.3%. Based on "Real 30-year discount rate" published in November 2024 Office of Management and Budget Circular No. A-94.
Total Estimated Costs for Alternative 4 (without Contingency)					**$9,607,502**	
Low Range of Estimated Costs for Alternative 4 (-30%) Without Contingency					**$6,725,251**	Accuracy of the total remedial alternative cost is considered -30 to +50 %, a range based on EPA Guidance (EPA 2000).
High Range of Estimated Costs for Alternative 4 (+50%) Without Contingency					**$14,411,252**	
Contingency (Not included in Costs)					**35%**	Contingency includes (1) scope contingency, which refers to unknowns, unforeseen circumstances, or unanticipated conditions that cannot be quantified based on available data at the time the estimate is prepared, and (2) bid contingency, which refers to differences between costs identified at the time the estimate is prepared and actual costs at the time the work is performed. EPA identifies the typical range for scope contingency as 10 to 25 percent, and the typical range for bid contingency as 10 to 20 percent (EPA 2000).

Notes:

[1] Quantity is an estimate at the level of "concept design."

2 Unit costs based on review of: construction cost estimates solicited from applicable vendors and contractors; actual costs incurred during similar, applicable projects; RS Means Construction Cost Data, and professional judgment. Unit costs are presented in 2024 dollars.

MNA = Monitored Natural Attenuation; LS = lump sum; TDC = total direct capital costs; EPA = Environmental Protection Agency; SF = square feet; SY = square yards; BCY = bank cubic yards; LF = linear feet; EA = each; HMA = hot mix asphalt

LNAPL = light non aqueous phase liquid; AS = air sparging; DPE = dual phase extraction; TESC = Temporary erosion and sediment control; OSWER = Office of Solid Waste and Emergency Response

Table A-6

Alternative 4B: Excavation for LNAPL Recovery & AS/SVE (Areas 1 and 2); PRB (PFAS Release Area)

Jorgensen Forge Corporation Property

Tukwila, Washington

Item No.	Item Description	Unit	Estimated Quantity[1]	Unit Cost[2] (2025 $)	Estimated Cost	Cost Basis
Direct Capital Construction Costs						
GENERAL REQUIREMENTS						
1	Mobilization	% of TDC	3%	--	$211,843	3 percent of total direct capital costs. Professional judgment.
2	Temporary Site Controls	LS	1	$25,000	$25,000	Includes cost for temporary facilities (office trailer, portable toilet), necessary utilities, establish and maintain TESC and traffic controls. Cost includes removal of these controls and facilities prior to demobilization. Based on vendor quote (ICS dated April 2025).
3	Surveying	LS	1	$15,000	$15,000	Based on vendor quote (ICS dated April 2025), to complete pre-construction and post-construction survey.
4	Decommission Monitoring Wells	LS	1	$10,000	$10,000	Assume two days of work by licensed driller for decommissioning including travel. Includes coordination and follow-up documentation to Ecology. Based on bid pricing for previous projects.
5	Installation of Monitoring Wells	EA	5	$10,000	$50,000	Assume new wells to be installed as needed post-construction. Based on previous project experience.
EXCAVATION						
6	Excavation Surface Demolition and Disposal	TON	1,419	$46	$65,275	Removal and disposal of impervious surfaces within the excavation footprint. Based on previous project experience.
7	Overburden Excavation	BCY	14,554	$8	$116,433	Includes cost for excavation, stockpiling and handling of overburden material (top 5 feet). Based on vendor quote (ICS dated April 2025).
8	Excavation	BCY	20,400	$16	$326,400	Includes cost for excavation, stockpiling and handling of material. Based on vendor quote (ICS dated April 2025).
9	Setup, Operation, Maintenance and Removal of LNAPL recovery system	LS	1	$50,000	$50,000	Includes cost for installation, operation and maintenance and removal of LNAPL recovery system required to collect free-phase LNAPL from open excavation. Based on vendor quote (ICS dated April 2025).
10	Recovered Product Disposal	LS	1	$30,000	$30,000	Includes cost for cost for handling, loading, transport and off-site disposal of recovered LNPL (assume 10,000 gallons) at a recyling facility. Based on vendor quote (ICS dated April 2025).
11	Transport and Dispose Contaminated Material at Subtitle D Landfill	TON	39,282	$100	$3,928,181	Includes cost for handling, loading, transport and off-site disposal of non-dangerous contaminated material at an approved Subtitle D disposal facility. Assume all excavated material from Area 1 and 90% of excavated material from Area 2 will be disposed at Subtitle D landfill. Based on bid pricing for previous projects.
12	Transport and Dispose Contaminated Material at Subtitle C Landfill	TON	1,062	$400	$424,835	Includes cost for handling, loading, transport and off-site disposal of dangerous waste at an approved Subtitle C disposal facility. Assume 10% of excavated material from Area 2 will be disposed at Subtitle C lanfill due to overlap with PFAS area. Based on bid pricing for previous projects.
13	Import and Place Geotextile as Visual Marker	SY	8,732	$6	$52,395	Cost includes placement of geotextile as a visual marker at the limits (base and sidewalls) of remedial excavation during backfilling. Based on vendor quote (ICS dated April 2025).
14	Import, Place and Compact Backfill	TON	10,479	$40	$419,157	Cost includes import, placement and compaction of gravel borrow during backfilling. Based on vendor quote (ICS dated April 2025).
15	Place and Compact Backfill (Overburden)	CY	14,554	$8	$116,433	Cost includes placement and compaction of stockpiled overburden. Based on vendor quote (ICS dated April 2025)

Item No.	Item Description	Unit	Estimated Quantity[1]	Unit Cost[2] (2025 $)	Estimated Cost	Cost Basis
AIR SPARGING/SOIL VAPOR EXTRACTION						
16	Pilot Study	LS	1	$20,000	$20,000	Pilot study and data collection to determine system requirements. Cost based on previous project experience.
17	Remediation Well Installation	EA	40	$10,000	$400,000	Assume new 2-in dia wells to be installed for AS/SVE treatment to a depth of 25 feet. Based on previous project experience.
18	Remediation Equipment (AS/SVE)	LS	1	$150,000	$150,000	New turn-key skid-mounted SVE system with a 500 scfm blower and thermal oxidizer for vapor treatment. Turn-key skid-mounted air sparge system with specifications to handle the assumed air sparge wells based on pilot test results. Based on vendor quote (ICS dated April 2025).
19	Remediation System Installation and Startup	LS	1	$80,000	$80,000	Cost includes labor, equipment and materials for trenching, conveyance piping, system manifold, electrical connections, fencing and system startup. Based on vendor quote (ICS dated April 2025).
CAPPING						
20	Pavement Installation	SF	126,842	$5	$634,210	Cost includes labor, equipment and materials to install base course (5 in), top course (2 in) and HMA (3 in) to restore the surface over active remediation areas and other capping areas. Based on vendor quote (ICS dated April 2025).
21	Pavement Repair	SF	148,104	$1	$148,104	Cost includes labor, equipment and materials for repairs to damaged portions of exisiting paved surfaces at the site. Assume 15% to 20% of existing paved surface requires repairs. Based on vendor quote (ICS dated April 2025).
IN-SITU CHEMICAL WITH SORPTIVE TECHNOLOGIES						
22	In-Situ Chemical - Pilot Study	LS	1	$20,000	$20,000	Pilot study and data collection to determine reagent estimates. Cost based on previous project experience.
23	SE Property Boundary Sorption Barrier - Products, Construction and Operation	LS	1	$836,000	$836,000	Treatment with PlumeStop® Colloidal Activated Carbon™ in the SE property boundary of the site to address the PFAS area. Assume 365 ft long barrier wall between MW-74 and SE property boundary to prevent offsite migration of PFAS . Based on vendor conceptual cost estimate - Regenesis, dated April 2025. Includes shipping costs to the Site. Includes labor, equipment, materials and freight for drilling, mixing and injection. Total 150 injection points using direct push methods, with a total 25 days of injection.
24	Performance Monitoring	EVENT	2	$15,000	$30,000	Labor and analytical costs to evaluate effectiveness of treatment. Assume 2 rounds of monitoring at 5 MWs. Based on previous project experience.
				Direct Capital Costs Sub-Total	**$8,159,264**	
Indirect Capital Construction Costs						
25	Pre-Remedial Design Investigation	LS	1	$100,000	$100,000	Based on previous project experience.
26	Remedial Design	% of TDC	3%	--	$244,778	Includes pre-remedial design investigations, remedial design sampling plans, design support studies, engineering survey, plans and specifications, engineers estimate, bid documents and contracting support. Indirect percentages based on EPA 2000 guidance (EPA, 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. OSWER 9355.0-75) and professional judgment.
27	Permitting	% of TDC	1%	--	$81,593	Indirect percentages based on EPA 2000 guidance (EPA 2000) and professional judgment.
28	Construction Management/Oversight	% of TDC	6%	--	$489,556	Construction management includes field oversight, contractor submittal review, design modifications, construction schedule tracking and completion report. Indirect percentages based on EPA 2000 guidance (EPA 2000) and professional judgment.

Item No.	Item Description	Unit	Estimated Quantity[1]	Unit Cost[2] (2025 $)	Estimated Cost	Cost Basis
29	Project Management	% of TDC	6%	--	$489,556	Project management includes meetings, planning, coordination, cost and performance reporting. Indirect percentages based on EPA 2000 guidance (EPA 2000) and professional judgment.
30	Ecology Oversight	% of TDC	1%	--	$81,593	Professional judgment.
31	Restrictive Covenant	LS	1	$20,000	$20,000	Costs include coordination with Ecology, property owners, etc. Costs based on professional judgment.
				Indirect Capital Costs Sub-Total	**$1,507,075**	
Annual Operation and Maintenance Costs (30 years)						
32	Groundwater Monitoring and Reporting - MNA following Treatment	LS/EVENT	1	$50,000	$50,000	Assume annual monitoring of 25 wells for 5 years post-construction, followed by every 5 years for 25 years. Based on prior project experience.
33	Monitoring Well and Cap Maintenance	LS/YR	1	$10,000	$10,000	Assumed maintenance and repair cost of site monitoring wells and paved areas. Based on prior project experience.
34	AS/SVE System O&M	LS/EVENT	1	$5,000	$5,000	Assume monthly site visits for year 1, followed by quarterly site visits until year 5. Includes cost for labor, materials, equipment, analytical costs, and utilities. Based on prior project experience.
35	Institutional Controls	YR	1	$10,000	$10,000	Assume annual costs for 30 years for maintaining institutional controls. Based on prior project experience.
				Present Value Operation and Maintenance Costs over estimated duration of 30 years	**$977,783**	Present value calculated using equal series present value formula assuming discount rate of 2.3%. Based on "Real 30-year discount rate" published in November 2024 Office of Management and Budget Circular No. A-94.
				Total Estimated Costs for Alternative 4B (without Contingency)	**$10,644,122**	
				Low Range of Estimated Costs for Alternative 4B (-30%) Without Contingency	**$7,450,885**	Accuracy of the total remedial alternative cost is considered -30 to +50 %, a range based on EPA Guidance (EPA 2000).
				High Range of Estimated Costs for Alternative 4B (+50%) Without Contingency	**$15,966,182**	
				Contingency (Not included in Costs)	**35%**	Contingency includes (1) scope contingency, which refers to unknowns, unforeseen circumstances, or unanticipated conditions that cannot be quantified based on available data at the time the estimate is prepared, and (2) bid contingency, which refers to differences between costs identified at the time the estimate is prepared and actual costs at the time the work is performed. EPA identifies the typical range for scope contingency as 10 to 25 percent, and the typical range for bid contingency as 10 to 20 percent (EPA 2000).

Notes:

[1] Quantity is an estimate at the level of "concept design."

2 Unit costs based on review of: construction cost estimates solicited from applicable vendors and contractors; actual costs incurred during similar, applicable projects; RS Means Construction Cost Data, and professional judgment. Unit costs are presented in 2024 dollars.

MNA = Monitored Natural Attenuation; LS = lump sum; TDC = total direct capital costs; EPA = Environmental Protection Agency; SF = square feet; SY = square yards; BCY = bank cubic yards; LF = linear feet; EA = each; HMA = hot mix asphalt

LNAPL = light non aqueous phase liquid; AS = air sparging; DPE = dual phase extraction; TESC = Temporary erosion and sediment control; OSWER = Office of Solid Waste and Emergency Response

Appendix B
Report Limitations and Guidelines For Use

Appendix B

REPORT LIMITATIONS AND GUIDELINES FOR USE[1]

This appendix provides information to help you manage your risks with respect to the use of this report. Please confer with GeoEngineers if you need to know more about how these "Report Limitations and Guidelines for Use" apply to your project or property.

Read These Provisions Closely

It is important to recognize that environmental engineering and geoscience practices (geotechnical engineering, geology and environmental science) are less exact than other engineering and natural science disciplines. GeoEngineers, Inc. (GeoEngineers) includes these explanatory "limitations" provisions in our reports to help reduce the risk of misunderstandings or unrealistic expectations that lead to disappointments, claims and disputes.

Environmental Services Are Performed for Specific Purposes, Persons and Projects

GeoEngineers has prepared this report for the Jorgensen Forge Corporation Property in general accordance with our professional services agreement with the Earle M. Jorgensen Company. This report has been prepared for the exclusive use of the Earle M. Jorgensen Company. This report may be made available to regulatory agencies for review. This report is not intended for use by others, and the information contained herein is not applicable to other properties.

GeoEngineers structures its services to meet the specific needs of its clients. Because each environmental study is unique, each environmental report is unique, prepared solely for the specific client and property. Use of this report is not recommended for any purpose or project other than as expressly stated in this report.

This Environmental Report is Based on a Unique Set of Project-Specific Factors

This report has been prepared for the Jorgensen Forge Corporation Property. GeoEngineers considered a number of unique, project-specific factors when establishing the scope of services for this Project. Unless GeoEngineers specifically indicates otherwise, it is important not to rely on this report if it was:

- Not prepared for you,
- Not prepared for your Project,
- Not prepared for the specific Site explored, or
- Completed before Project changes were made.

If changes to the Project or property occur after the date of this report, GeoEngineers cannot be responsible for any consequences of such changes in relation to this report unless we have been given the opportunity

[1] Developed based on material provided by GBA, GeoProfessional Business Association; www.geoprofessional.org.

to review our interpretations and recommendations in the context of such changes. Based on that review, we can provide written modifications or confirmation, as appropriate.

Reliance Conditions For Third Parties

This report was prepared for the exclusive use of the party(ies) to whom this report is addressed. No other party may rely on the product of our services unless we agree to such reliance in advance and in writing. Within the limitations of the agreed Project scope, schedule and budget, our services have been executed in accordance with our Agreement with the Client and generally accepted environmental practices in this area at the time this report was prepared.

Understand That Geotechnical Issues Have Not Been Addressed

Unless geotechnical engineering was specifically included in our scope of service, this report does not provide any geotechnical findings, conclusions, or recommendations, including but not limited to, the suitability of subsurface materials for construction purposes.

Do Not Separate Documentation From the Report

Environmental reports often include supplemental documentation, such as maps, figures and tables. Do not separate such documentation from the report. Further, do not, and do not permit any other party to redraw or modify any of the supplemental documentation for incorporation into other professionals' instruments of service.

Environmental Regulations Change and Evolve

Some substances may be present in the vicinity of the subject property in quantities or under conditions that may have led, or may lead, to contamination of the subject property, but are not included in current local, state or federal regulatory definitions of hazardous substances or do not otherwise present current potential liability. GeoEngineers cannot be responsible if the standards for appropriate inquiry, or regulatory definitions of hazardous substances, change or if more stringent environmental standards are developed in the future.

Subsurface Conditions Can Change

This environmental report is based on conditions that existed at the time the study was performed. The findings and conclusions of this report may be affected by the passage of time, by man-made events such as construction on or adjacent to the subject property, by new releases of hazardous substances, new information or technology that become available subsequent to the report date, or by natural events such as floods, earthquakes, slope instability or groundwater fluctuations. Please contact GeoEngineers before applying this report for its intended purpose so that GeoEngineers may evaluate whether changed conditions affect the continued applicability of the report.

Soil and Groundwater End Use

The cleanup levels referenced in this report are Site- and situation-specific. The cleanup levels may not be applicable for other properties or for other on-Site uses of the affected soil and/or groundwater. Note that hazardous substances may be present in some of the on-Site soil and/or groundwater at detectable concentrations that are less than the referenced cleanup levels. GeoEngineers should be contacted prior to the export of soil or groundwater from the subject property or reuse of the affected soil or groundwater on-Site to evaluate the potential for associated environmental liabilities. GeoEngineers will not assume responsibility for potential environmental liability arising out of the transfer of soil and/or groundwater from the subject property to another location, or the reuse of such soil and/or groundwater on-Site in any instances that we did not recommend, know of, or control.

Most Environmental Findings Are Professional Opinions

Our interpretations of subsurface conditions are based on field observations and chemical analytical data from widely spaced sampling locations at the subject property. Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. GeoEngineers reviewed field and laboratory data and then applied its professional judgment to render an informed opinion about subsurface conditions throughout the property. Actual subsurface conditions may differ significantly from those indicated in this report. Our report, conclusions and interpretations should not be construed as a warranty of the subsurface conditions.

Do Not Redraw The Exploration Logs

Environmental scientists prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in an environmental report should never be redrawn for inclusion in other design documents. Only photographic or electronic reproduction that preserves the entire original boring log is acceptable but separating logs from the report can create increase the risk of potential misinterpretation.

Biological Pollutants

GeoEngineers' Scope of Work specifically excludes the investigation, detection, prevention or assessment of the presence of Biological Pollutants. Accordingly, this report does not include any interpretations, recommendations, findings or conclusions regarding the detecting, assessing, preventing or abating of Biological Pollutants, and no conclusions or inferences should be drawn regarding Biological Pollutants as they may relate to this Project. The term "Biological Pollutants" includes, but is not limited to, molds, fungi, spores, bacteria and viruses, and/or any of their byproducts.

A Client that desires these specialized services is advised to obtain them from a consultant who offers services in this specialized field.