

FEASIBILITY STUDY ADDENDUM  
West of 4th - Site Unit 1  
Prepared for: West of 4th Group

Project No. 050067 • April 2023 PUBLIC REVIEW DRAFT



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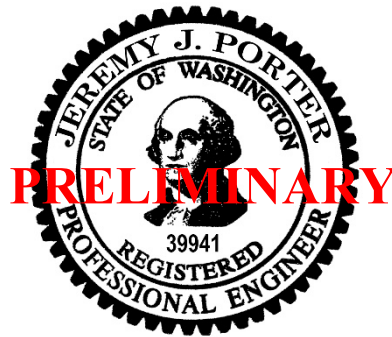
# FEASIBILITY STUDY ADDENDUM

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## Acronyms

AO	Agreed Order
ABP	Art Brass Plating
ARAR	applicable or relevant and appropriate requirement
Aspect	Aspect Consulting, LLC
AS	air sparging
BE	Burlington Environmental
BDC	Blaser Die Casting
bgs	below ground surface
CI	Capital Industries
cis-DCE	cis-1,2-dichloroethene
COC	constituent of concern
CUL	Cleanup level
CVOC	chlorinated volatile organic compounds
DCA	disproportionate cost analysis
DCE	dichloroethene
EAnB	Enhanced Anaerobic Bioremediation
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FS	Feasibility Study
ISCO	<i>In-Situ</i> Chemical Oxidation
ISCR	<i>In-Situ</i> Chemical Reduction
M	million
mg/kg	milligrams/kilograms
mg/L	milligrams per liter
µg/L	micrograms per liter
MNA	Monitored Natural Attenuation
MTCA	Model Toxics Control Act
NPV	Net Present Value

O&M	operation and maintenance
PCE	tetrachloroethene
PCUL	preliminary cleanup level
PGG	Pacific Groundwater Group
PLP	potentially liable person
PRB	permeable reactive barrier
RAO	Remedial Action Objective
RI	Remedial Investigation
ROW	right-of-way
SCM	Site Conceptual Model
SU1	Site Unit 1
SU2	Site Unit 2
SVE	soil vapor extraction
TCE	trichloroethene
TOC	total organic carbon
UIC	underground injection control
VC	vinyl chloride
VI	vapor intrusion
VIAMM	vapor intrusion assessment monitoring and mitigation
VOC	volatile organic compound
W4	West of 4th
WAC	Washington Administrative Code
Waterway	Lower Duwamish Waterway
ZVI	zero-valent iron

## Executive Summary

This West of 4th (W4) Group Site Unit 1 Feasibility Study (FS) Addendum report (SU1 FS Addendum) has been prepared on behalf of potentially liable persons (PLPs) [Art Brass Plating (ABP), Blaser Die Casting (BDC), Capital Industries (CI), and Burlington Environmental, LLC (BE)] identified by the Washington State Department of Ecology (Ecology) in Agreed Order (AO) No. DE10402 for the W4 Site. The W4 Site is located in the Georgetown neighborhood of Seattle, between 4th Avenue South and the Lower Duwamish Waterway (Waterway). For the purposes of the FS, the Site has been divided into two site units, Site Unit 1 (SU1; ABP and BE) and Site Unit 2 (SU2; BDC, CI, and BE), as described in the AO and shown on Figure 1-1.

The W4 SU1 and SU2 FS reports (Aspect, 2016 and PGG, 2016, respectively) were approved by Ecology in a letter dated October 25, 2016 (Ecology, 2016). Based on subsequent discussions with Ecology, additional actions were selected to be implemented, including two pilot studies in SU1 to further evaluate certain remedial technologies that were identified in the FS, and then a re-evaluation of potential remedies in two focused FS Addenda – one for SU1 and one for SU2. This work was described in AO Amendment No. 1 dated November 20, 2017 (AO Amendment). This SU1 FS Addendum develops and evaluates a focused set of remedial alternatives to address contaminated media at SU1 in accordance with Washington Administration Code (WAC) 173-340-350(8) and the AO Amendment, to enable Ecology to select a cleanup action.

This Executive Summary provides an overview of the SU1 FS Addendum.

## Background

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SU1 constituents of concern (COCs) include the chlorinated volatile organic compound (CVOC) trichloroethene (TCE) and associated degradation products (primarily vinyl chloride [VC]), and metals used in electroplating (primarily nickel). The ABP Facility at 5516 3rd Avenue South is a source of COCs in SU1; other sources include groundwater containing TCE and VC that has migrated into SU1 from upgradient of the ABP Facility.

Groundwater is relatively shallow, with a depth to water between 4 and 10 feet. A plume of TCE-contaminated groundwater extends from the ABP Facility southwest to the Waterway. The plume migrates laterally and downward until approximately 1st Avenue South, at which point advective flow transitions upward and the plume becomes shallower as it approaches the Waterway.

Interim remedial actions in SU1 that have been implemented include the following:

- Source control through operation of a soil vapor extraction (SVE) and air sparging (AS) system to remove chlorinated COCs from soil and groundwater at and around the ABP Facility.



- Implementation of a vapor intrusion assessment, monitoring and mitigation plan (VIAMMP) for permanent structures within the footprint of contaminated shallow soil and groundwater.

Remedial actions upgradient of SU1 include source control measures at the BE facility.

## Basis for Remedial Action

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Preliminary cleanup levels (PCULs) for COCs are based on potential exposure pathways. PCULs and potential exposure pathways are summarized in Section 3 of this SU1 FS Addendum. Potentially affected media include soil, groundwater, surface water, and air. Potential receptors include aquatic organisms in the Waterway and humans (including workers, residents, recreational beach users, and fishers/shellfish harvesters), via direct contact with soil or groundwater, inhalation of dust or air, or ingestion of contaminated aquatic organisms.

Three generalized areas within SU1 where PCULs are exceeded have been defined for consideration of remedial actions. These areas and their drivers for cleanup are as follows:

- **The ABP Source Area** (Source Area) includes the ABP Facility and its immediate vicinity where soil and groundwater are impacted by chlorinated COCs (primarily TCE) and plating metals (primarily nickel). Groundwater in the area of plating metals impacts also has low pH.
- **Downgradient TCE Plume** includes groundwater downgradient of the Source Area where chlorinated COCs including TCE exceed PCULs.
- **Vinyl Chloride Plumes Outside SU1 Source Area and Downgradient TCE Plume.**

It is assumed, for the purposes of this SU1 FS Addendum, that PCULs identified herein will become CULs after Ecology's approval of the draft Cleanup Action Plan (dCAP). Remedial Action Objectives (RAOs) are generally stated as follows:

- Achieve CULs at the standard point of compliance for soil, groundwater, air, and surface water, if practicable within a reasonable time frame.
- Use engineered and institutional controls to protect potential receptors from contaminants exceeding CULs for potentially complete exposure pathways.

Specific RAOs for each medium and exposure pathway were described in the SU1 FS.

Remediation levels (RELs) for CVOCs in groundwater were developed in the SU1 FS to help determine when and where active treatment may be appropriate. RELs are defined in Ecology's Model Toxics Control Act (MTCA) as a concentration (or other method of identification) of a hazardous substance in soil, water, air, or sediment above which a particular cleanup action component will be required as part of a cleanup action at a site (WAC 173-340-355). RELs do not replace CULs, which define the concentration of hazardous substances above which a contaminated medium must be remediated in some manner.

RELs for groundwater near the Waterway, including in porewater (Porewater RELs), were further refined in this SU1 FS Addendum based on the results of groundwater and porewater monitoring conducted in 2020 and the results of the pilot studies (see Section 2).

## Remedial Alternative Descriptions

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The SU1 FS evaluated nine alternatives that provided a broad range of treatment and containment options. In accordance with the AO Amendment, this SU1 FS Addendum evaluates two alternatives, which are modifications of alternatives evaluated in the FS, as follows:

The alternatives evaluated in this SU1 FS Addendum, and their primary treatment components, are as follows:

- **Alternative 2A<sup>1</sup>:**
  - **Source Area:** pH neutralization
  - **Downgradient TCE Plume:** *In-Situ* Chemical Reduction (ISCR)/ Enhanced Anaerobic Bioremediation (EAnB) in South Fidalgo Street
  - **Contingency Actions:** ISCR in the Source Area to further reduce TCE concentrations, and ISCR/EAnB near the shoreline to address VC in porewater
- **Alternative 2B<sup>2</sup>:**
  - **Source Area:** pH neutralization
  - **Downgradient TCE Plume:** ISCR/EAnB in South Fidalgo Street and ISCR/EAnB along the Waterway shoreline

Both alternatives also incorporate engineered and institutional controls and monitored natural attenuation (MNA) in conjunction with active treatment, to ensure protectiveness during the restoration period and ultimately achieve cleanup levels across the Site.

## Remedial Alternative Evaluation

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The two remedial alternatives were evaluated in accordance with MTCA requirements (WAC 173-340-360). Both alternatives meet MTCA threshold requirements, including protection of human health and the environment; complying with cleanup standards; complying with applicable state and federal laws; and providing for compliance monitoring.

MTCA requires that the selected cleanup action use permanent solutions to the maximum extent practicable. A disproportionate cost analysis (DCA) was conducted to determine

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<sup>1</sup> Alternative 2A is an updated version of Alternative 2 of the FS.

<sup>2</sup> Alternative 2B is what Ecology had identified as its preferred alternative in its FS comment letter, with modifications as described above. It has been named '2B' for the purposes of this SU1 FS Addendum because it is most like Alternative 2A.

which alternatives meet this requirement. The DCA quantifies the environmental benefit of each remedial alternative, and then compares alternative benefits versus costs. Environmental benefit was quantified by first rating the alternatives with respect to six criteria: (1) protectiveness; (2) permanence; (3) long-term effectiveness; (4) management of short-term risks; (5) technical and administrative implementability; and (6) consideration of public concerns. Rating values were assigned on a scale of 1 to 10, where 1 indicates the criterion is satisfied to a very low degree, and 10 indicates the criterion is satisfied to a very high degree. Primary differentiating factors among the alternatives are as follows:

- **Protectiveness.** Both alternatives are protective. Alternative 2B is rated slightly higher than Alternative 2A because it potentially achieves RELs in porewater faster<sup>3</sup>.
- **Management of short-term risks.** Alternative 2B is rated slightly lower than Alternative 2A because Alternative 2B has the potential for generating secondary water quality impacts closer to the Waterway.
- **Implementability.** Alternative 2B is rated slightly lower than Alternative 2A because it requires access and active treatment on private property.
- **Consideration of Public Concerns.** Alternative 2B is rated slightly higher than Alternative 2A because of the potential for achieving RELs in porewater faster.
- **Cost.** The total cost (combined capital and O&M costs) of Alternative 2B was higher (\$4.7 million [M]) than Alternative 2A (\$4.0 M).

Alternatives were ranked based on a weighted, quantitative scoring system consistent with the FS and used at other Ecology sites. The MTCA benefits ranking was obtained for each alternative by multiplying the rating values assigned for the six evaluation criteria by their corresponding weighting factors and summing the weighted values. The benefit rankings were 5.9 for Alternative 2A and 6.1 for Alternative 2B.

The benefit/cost ratio, which is a relative measure of cost-effectiveness, is obtained by dividing each alternative's benefits ranking by its estimated cost. Alternative 2A has the higher benefit/cost ratio, at 1.5 versus 1.3, and was deemed to satisfy the MTCA requirement for an alternative to be permanent to the maximum extent practicable.

Both alternatives provide for a reasonable restoration time frame. The estimated times to achieve particular cleanup objectives range as follows:

- The time to achieve VI-based CULs is estimated at 25 years for Alternatives 2A and 2B.
- The time to achieve surface water-based CULs discharging to the Waterway is estimated at 35 years for Alternative 2B and 50 years for Alternative 2A.

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<sup>3</sup> The ability of EAnB/ISCR treatment to be as effective at the shoreline as it was shown to be in Fidalgo Street is uncertain because of different hydraulic (i.e., tidal fluctuation) and biogeochemical conditions.

- The time to achieve Porewater RELs discharging to the Waterway is estimated at 5 years for Alternative 2B and 13 years for Alternative 2A.
- The time to achieve surface water-based CULs everywhere is estimated to be close to 280 years.

EPA is overseeing the design of the cleanup plan for the Lower Duwamish Waterway Superfund Site (LDW Site). The LDW Site cleanup is being conducted sequentially, moving from upstream to downstream in three separate sections (“upper reach”, “middle reach”, and “lower reach”). Pre-design work is underway for the southernmost 2 miles (the upper reach) of the waterway, and cleanup expected to begin in 2025. Separate pre-design work is also underway for the approximately 1.5 mile middle reach.

SU1 groundwater discharges to the lower reach, for which there currently is no schedule for design or cleanup. Based on the expected time for design and cleanup and the upper and middle reaches, cleanup of the lower reach is expected to be conducted at least 10 years in the future.

Cleanup activities vary by location and include capping, dredging, enhanced natural recovery, and monitored natural recovery. In the area of SU1 groundwater discharge, a combination of capping and monitored natural recovery is planned. Ecology is conducting a source control sufficiency analysis along the LDW to determine whether upland contamination is a risk for re-contaminating sediments after implementation of the remedy. Because SU1 COCs in groundwater near the Waterway are not LDW Site COCs, the SU1 groundwater plume does not represent a concern for this analysis. Dredging would not be an effective remedy for a VC plume discharging to the LDW; therefore, disturbance of the future sediment cap is not a concern.

According to the LDW Site Record of Decision (ROD), shellfish concentrations are expected to reach target goals within 17 years of beginning construction (EPA, 2014). Therefore, Porewater RELs (i.e., concentrations protective of human health via shellfish consumption) should be achieved by 2042 (i.e., within 20 years) to be consistent with the expectations for the LDW Site cleanup. As noted above, both Alternative 2A and 2B exceed this goal, with a maximum estimated time to achieve Porewater RELs of 13 years. Monitoring will be conducted to confirm this estimate, and contingency actions can be implemented if needed.

## Conclusions and Recommendations

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The SU1 FS considered nine remedial alternatives that provide a range of treatment options for metals and CVOC contamination. This SU1 FS Addendum identified two remedial alternatives that were modified from the original nine based on Ecology comments and the results of interim pilot studies and monitoring. Both alternatives meet MTCA Threshold Requirements, including protection of human health and the environment. To date, interim actions and the CVOC Pilot Study have substantially reduced CVOC concentrations in the Source Area and in the Downgradient TCE Plume.

Alternative 2A is the preferred cleanup action for SU1 based on the analysis and considerations presented in this SU1 FS Addendum. There are no unacceptable risks to

## ASPECT CONSULTING

human health or the environment under current conditions, and this alternative will achieve levels protective of human health and the environment under future exposure conditions within the time frame of the ongoing LDW Site cleanup. Alternative 2A has the highest benefit-to-cost ratio, satisfies the MTCA requirement to be permanent to the maximum extent practicable, and will achieve the applicable cleanup levels at the designated points of compliance within a reasonable restoration time frame. This alternative is protective of human health and the environment and is significantly less expensive—\$4.0 M—than Alternative 2B (\$4.7 M).

Under implementation of Alternative 2A, groundwater and porewater monitoring would be conducted to determine if the remedy is performing as expected, verify that receptors are protected, and confirm that groundwater restoration will occur within a reasonable time frame.

*This Executive Summary should be used in the context of the full report.*

# 1 Introduction

The West of 4<sup>th</sup> Group Site Unit 1 Feasibility Study Addendum report has been prepared on behalf of potentially liable persons (PLPs) [Art Brass Plating (ABP), Blaser Die Casting (BDC), Capital Industries (CI), and Burlington Environmental, LLC (BE)] identified by the Washington State Department of Ecology (Ecology) in Agreed Order (AO) No. DE10402 for the West of 4th (W4) Site (the Site). The AO requires the four PLPs (the W4 Group) to complete a Feasibility Study (FS) and prepare a Draft Cleanup Action Plan (dCAP) for the W4 Site. The environmental consultants addressing technical aspects of the FS and dCAP on behalf of the W4 Group are: Aspect Consulting (Aspect) for ABP; Farallon Consulting (Farallon) for CI; Pacific Groundwater Group (PGG) for BDC; and Pacific Crest Environmental (Pacific Crest) for BE.

The W4 SU1 and SU2 FS reports (Aspect, 2016 and PGG, 2016, respectively) were approved by Ecology in a letter dated October 25, 2016 (Ecology, 2016). Based on subsequent discussions with Ecology, additional actions were selected to be implemented, including two pilot studies in SU1 to further evaluate certain remedial technologies that were identified in the FS, and then a re-evaluation of potential remedies in two focused FS Addenda – one for SU1 and one for SU2. This work was described in AO Amendment No. 1 dated November 20, 2017 (AO Amendment).

The Site is located in the Georgetown neighborhood of Seattle. The Site extends from 4th Avenue South to the Lower Duwamish Waterway (the Waterway), a distance of about 2,200 feet, and is generally flat with a gradual slope to the west. The Site includes a mixture of commercial, industrial, and residential land uses. For the purposes of the FS, the W4 Site has been divided into two site units, Site Unit 1 (SU1; ABP and BE) and Site Unit 2 (SU2; BDC, CI and BE), as described in the AO. Figure 1-1 shows the locations of the four PLPs and the SU1 and SU2 boundaries. This SU1 FS Addendum is specific to the SU1 portion of the Site.

## 1.1 Purpose

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This SU1 FS Addendum, in accordance with AO Amendment No. 1 dated November 20, 2017 (AO Amendment), has been prepared to refine the evaluation of remedial alternatives that was conducted in the *Final Feasibility Study, W4 Group – Site Unit 1* (SU1 FS: Aspect 2016). This refinement has been completed to address Ecology comments on the SU1 FS and within the context of data collected in SU1 since 2016, including pilot studies, groundwater and porewater monitoring, and the collection of water level data to evaluate groundwater flow variability. This SU1 FS Addendum is intended to be an extension and part of the SU1 FS rather than a replacement.

The W4 FS reports for SU1 and SU2 developed and evaluated remedial alternatives to address contaminated media in accordance with Washington Administrative Code (WAC) 173-340-350(8) and enable Ecology to select a cleanup action (SU1 FS, Aspect 2016; SU2 FS, PGG, 2016). The W4 FS reports integrated and built upon information developed in previous technical memoranda. Information that has already been presented

in the W4 FS reports and memoranda are not repeated in this document unless additional information allows refinement relevant to evaluation of remedial alternatives. The following documents are available for reference on the W4 website (<http://clients.aspectconsulting.com/W4/>):

- *Revised Preliminary Site Cleanup Standards* (Farallon, 2014)
- *Site Conceptual Model Technical Memorandum (Revised)* (Aspect, 2014)
- *Revised Fate and Transport Modeling Plan* (PGG, 2015a)
- *Revised Technology Screening FS Technical Memorandum* (PGG, 2015b)
- *Draft Fate and Transport Summary Memorandum for SU1* (Aspect, 2015a)
- *Draft Remedial Alternatives Technical Memorandum for Site Unit 1* (Aspect, 2015b)
- *Feasibility Study, W4 Group – Site Unit 1* (Aspect, 2016)

## 1.2 Report Organization

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This report is organized as follows:

- Section 1 describes the purpose of the SU1 FS Addendum and the organization of this report.
- Section 2 summarizes activities completed since submittal of the W4 FS Reports in 2018.
- Section 3 provides a summary of the Site Conceptual Model (SCM), including a discussion of preliminary cleanup levels (PCULs) and any updates to the SCM since the W4 FS Reports.
- Section 4 identifies the Basis for Remedial Action, including ARARs, Cleanup Standards, Remedial Action Objectives (RAOs).
- Section 5 describes updated remedial alternatives for SU1.
- Section 6 evaluates and compares the alternatives being considered for remediation of SU1, and discusses potential uncertainties associated with remedy evaluation and selection.
- Section 7 identifies a preferred alternative.
- Section 8 proposes an implementation schedule for the cleanup action plan.
- Section 9 provides references used in the preparation of this report.

The text is followed by tables and figures that support the text and illustrate conditions at the Site and conceptual layouts for the alternatives.

Appendices to this report provide supporting information referenced within the text. These appendices include a summary of data collected during post-FS investigations and pilot study results.

## 2 Overview of Activities Completed Since 2016

This section provides an overview of data collection and pilot studies completed since the 2016 W4 FS reports submittal as well as on-going SU1 interim actions.

### 2.1 2020 Porewater Monitoring

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As outlined in the *2020 Groundwater Sampling and Lower Duwamish Waterway Sediment Porewater Sampling Work Plan* (Aspect, 2020), the objectives of the porewater sampling were to determine current porewater concentrations of chlorinated volatile organic compounds (CVOCs) within the SU1 plume discharge area of the Waterway and measure concentrations of geochemical parameters to provide additional lines of evidence for biodegradation. Data are also being used in development of remediation levels (RELs; refer to Section 4.5). Porewater monitoring data are presented in Section 3.3.

### 2.2 Ongoing Groundwater Monitoring

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Semi-annual groundwater monitoring has continued since submittal of the *Site Conceptual Model Technical Memorandum* (SCM Memo; Aspect, 2014). Groundwater monitoring data are reported in quarterly progress reports. A summary of current groundwater monitoring data is provided in Section 3.3. A monitoring well location figure is provided for reference (Figure 2-1)

### 2.3 Groundwater Flow Direction Study

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Starting in 2018, the W4 PLPs conducted a 13-month water level study in the area of 1st Avenue South and East Marginal Way South. Continuous water levels were collected from 32 select wells to enable a detailed assessment of groundwater flow paths in the area, as discussed in the *Groundwater Elevation Data Collection Work Plan* (Aspect, 2017). Results were submitted to Ecology in the *Groundwater Elevation Data Collection Study Technical Memorandum* (Groundwater Flow Memorandum; Pacific Crest Environmental, 2020).

As detailed in the results memo, data confirmed groundwater flow at the Site is to the west and southwest. Water level study results illustrate that, despite the fluctuations in groundwater elevations induced by Waterway tides and seasonal variations, flow paths in the study area are relatively stable over extended periods of time. The flow stability improves confidence in the long-term protectiveness of monitored natural attenuation (MNA) as a component of the selected remedial alternative. The relative stability of the groundwater flow direction also has implications for the location and design of treatment elements that are based on intercepting contaminants in groundwater in both site units. The design of cut-off walls in a stable environment can be targeted to a specific area with a higher degree of confidence rather than cut-off walls in a more variable groundwater flow environment previously assumed.

Factors influencing groundwater flow direction include:



- **Tidal fluctuation in the Waterway.** Tidal influence decreases with distance from the Waterway<sup>4</sup>. Low tide in the Waterway is correlated with a more westerly groundwater flow direction and high groundwater gradient value. High tides are correlated with more southerly groundwater flow directions and lower groundwater gradient value. These opposing tidal extreme conditions occur daily for a few hours at a time, and their net effect is implicitly accounted for in the analysis of groundwater flow directions provided in the Groundwater Flow Memorandum.
- **Construction dewatering associated with construction of the Georgetown Wet Weather Treatment Station (WWTS).** Construction dewatering began August 7, 2018 in an area south of SU2 at the corner of 4th Avenue South and South Michigan Street. Calculations of groundwater gradient and flow direction were completed for two data sets representing conditions before and after initiation of WWTS pumping. The influence on groundwater flow decreases further away from the WWTS. In general, the WWTS construction dewatering resulted in a southerly shift in gradient weighted flow directions; for example, in well sets with flows to the west-southwest prior to pumping shift to the southwest. Influences on groundwater flow from the WWTS pumping do not represent long-term average groundwater flow directions.

## 2.4 Summary of SU1 Pilot Studies

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In accordance with the AO Amendment, two pilot studies were conducted to evaluate the potential effectiveness and determine conceptual design basis for SU1 FS alternatives. One pilot study (CVOC Pilot Study) evaluated *in situ* treatment of CVOCs (primarily trichloroethene [TCE], cis-1,2-dichloroethene [cis-DCE], and vinyl chloride [VC]) in groundwater in the South Fidalgo Street (Fidalgo Street) area near the Waterway. The other pilot study (Metals Immobilization Pilot Study) evaluated *in situ* treatment methods for immobilizing elevated metals (primarily nickel) in groundwater at the ABP Facility through pH adjustment. Details and results of the pilot studies are provided in the *CVOC Pilot Study Completion Report* and the *Metals Immobilization Pilot Study Completion Report* in Appendices A and B, respectively. A summary of pilot study activities and conclusions is described below.

### 2.4.1 CVOC Pilot Study

The CVOC Pilot Study included injection of 9,051 gallons of a combined ELS-microemulsion and EHC-Liquid powder solution to stimulate both *in-situ* chemical reduction (ISCR) and enhanced anaerobic bioremediation (EAnB) of CVOCs. Injections were completed using direct-push technology along a transect in Fidalgo Street orthogonal to groundwater flow. Injections were completed in October 2018.

Performance monitoring of groundwater and soil gas has been conducted regularly in and downgradient of the treatment area since 2018, with the most recent monitoring event conducted in September 2021. Performance monitoring data have indicated effective and

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<sup>4</sup> The 2018 groundwater elevation study did not extend to the Waterway. Tidal influences on water levels diminish to 0.5 feet or less approximately 800 feet east/northeast (upgradient) of the Waterway. Tidal studies are detailed in RI reports from ABP (Aspect, 2012) and CI (Farallon, 2012).

sustained treatment, with greater than 90 percent reduction in total CVOCs as of the last monitoring event. Treatment appears to be a combination of biotic and abiotic mechanisms. Secondary effects from the treatment were limited and manageable. Refer to Appendix A for additional details.

### **2.4.2 Metals Immobilization Pilot Study**

The Metals Immobilization Pilot Study included bench testing of potential amendments, initial field injection of a sodium bicarbonate reagent, and follow-up injection of an adapted reagent that combined sodium bicarbonate and sodium hydroxide. The initial field injection consisted of injecting 9,940 gallons of 1.0 Molar sodium bicarbonate solution into two injection wells located adjacent to the ABP Facility. This injection was performed in September 2018 and groundwater was monitored for 6 months following the injection. The results of this injection showed modest treatment of metals, but effectiveness was limited by density-driven flow of the reagent below the targeted treatment zone.

To mitigate the density effects, a follow-up injection of a lower-density solution (20,300 gallons of 0.1 Molar sodium bicarbonate and 0.1 Molar sodium hydroxide) was performed in August 2019 and monitored for 6 months following injection. The results of the second injection showed greater than 90 percent reduction in nickel concentrations that were sustained for at least six months, indicating that the modified reagent solution was effective at immobilizing metals. Refer to Appendix B for additional details.

## **2.5 SU1 Interim Actions**

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Chlorinated solvents in SU1 groundwater in the Water Table Interval<sup>5</sup> exceed screening levels for the vapor intrusion (VI) pathway. Because of the concern for this pathway, two interim actions were implemented prior to the completion of the ABP RI Report: (1) a VI mitigation program; and (2) source control interim action. These actions are described below.

### **2.5.1 Vapor Intrusion Mitigation Program**

The VI mitigation program is outlined in the joint W4 deliverable, *Revised Vapor Intrusion Assessment, Monitoring, and Mitigation Plan* (VIAMM Plan; Farallon, 2015). The VIAMM Plan provides an overview of the tiered process used to assess potential VI issues and the VI mitigation process. The VIAMM Plan included a tabulated listing of the buildings where Tier 1 through Tier 5 VI Assessment and Mitigation measures will be continued as interim action work through completion of the Cleanup Action Plan.

Currently, vapor mitigation remains active at the ABP Facility and two properties west of ABP (218 and 220 South Findlay Street). Groundwater monitoring data are reviewed consistent with the tiered decision process to confirm that vapor mitigation is being implemented where appropriate.

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<sup>5</sup> The Water Table Interval includes monitoring wells screened above 20 feet bgs. Hydrogeologic units are discussed further in Section 3.2.

### ***2.5.2 ABP Source Control Interim Action***

In September 2008, ABP installed an air sparging/soil vapor extraction (AS/SVE) system to remove CVOCs from soil and groundwater at and around the ABP Facility. The system includes 28 AS wells, 13 SVE wells, and 10 trenches. Extracted vapors are treated with granular activated carbon.

The objectives of the AS/SVE system were as follows:

- Prevent vapor intrusion at the ABP Facility and the adjacent 220 Findlay office building.
- Reduce soil and groundwater concentrations of TCE, cis-DCE, and VC to levels that significantly reduce the restoration time frame and are protective of the indoor air pathway.

The SVE system has operated continuously (except for periodic shutdowns for monitoring and maintenance) since startup in 2008. In late 2011, the AS portion of the system was shut down to conduct a rebound analysis. Between October 2012 and October 2015, the AS operated on an approximate six-month on-off pulsing schedule, and in October 2015, the AS system was shut down indefinitely to conduct an extended rebound analysis. The system has removed approximately 87 pounds of TCE from the subsurface. During AS operation, groundwater concentrations of TCE declined 92 to 99.8 percent at wells in and around the treatment area.

After AS shutdown, TCE concentrations rebounded in several source area wells, most notably at MW-1 and MW-3 where overall reductions in 2020<sup>6</sup> compared to baseline data in 2008 were 83 percent and 69 percent, respectively. Concentrations at these wells show seasonal variability but overall appear to be relatively stable since 2017. A full description of system monitoring, and an analysis of system performance was provided in the ABP RI Report (Aspect, 2012). Recent SVE monitoring data is provided in the 2020 Q1 quarterly progress report (Aspect, 2020).

The interim action has reduced CVOC concentrations downgradient of the ABP Facility. Trend plots of total CVOC concentrations at monitoring wells along the TCE plume centerline are shown on Figure 2-2. In 2020, Ecology agreed the existing SVE system could be transitioned to vapor mitigation. In 2022, vapor mitigation equipment was installed in accordance with the Ecology-approved mitigation plan (Aspect, 2022).

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<sup>6</sup> Percent reduction based on the average concentration in March and September 2020.

## 3 Site Conceptual Model

### 3.1 Background

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The hydrogeologic units encountered in borings completed at the Site include Younger Alluvium and Older Alluvium. The upper portion of the Younger Alluvium has been modified and is referred to as the Fill Unit. The lithologic units correspond to the hydrogeologic units encountered at the Site. Figures illustrate data in three separate panels using the W4 standardized nomenclature for groundwater monitoring and sampling intervals which are:

- **Water Table Interval.** This interval includes monitoring wells screened above 20 feet below ground surface (bgs) and reconnaissance groundwater samples collected above 20 feet bgs.
- **Shallow Interval.** This interval includes monitoring wells screened below 20 feet and above 40 feet bgs, and reconnaissance groundwater samples collected between 21 feet and 40 feet bgs.
- **Intermediate Interval.** This interval includes monitoring wells and reconnaissance groundwater samples screened below 40 feet bgs.

### 3.2 Preliminary Cleanup Levels and Constituents of Concern

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The W4 joint deliverable, *Revised Preliminary Site Cleanup Standards* outlined the preliminary cleanup standards for the Site (Farallon, 2014). Since 2014, surface water criteria for protection of human health have been updated (EPA, 2022). Groundwater and air criteria for the protection of indoor air have been updated as well in accordance with Washington State's Draft Guidance for Evaluation Soil Vapor Intrusion in Washington State (Ecology, 2018) and Ecology's Cleanup Level and Risk Calculation (CLARC) database. Updated preliminary cleanup levels (PCULs) are presented in Table 3-1, where applicable. Appendix C includes summary tables of prospective cleanup levels considered during the selection process.

SU1 COCs can be categorized as follows (Farallon, 2014):

#### CVOCs

- Tetrachloroethene (PCE)<sup>7</sup>
- TCE
- cis-DCE
- trans-1,2-Dichloroethene (trans-DCE)
- 1,1-Dichloroethene (1,1-DCE)
- VC

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<sup>7</sup> PCE is not a degradation product of TCE, and ABP did not use PCE in its manufacturing processes. Localized detections of PCE in groundwater suggest the potential for a source other than ABP.

**Plating Metals**

- Cadmium
- Copper
- Nickel
- Zinc

**Non-plating Metals<sup>8</sup> (aka Redox-Sensitive Metals)**

- Arsenic
- Manganese

Ecology identified 1,4-dioxane<sup>9</sup> as a groundwater COC for the W4 Site in the AO and iron as a groundwater COC during the RI process; based on updates to the PCULs, they are not carried forward as site COCs. The concentrations of 1,4-dioxane in groundwater samples collected in the W4 Site are well below the PCUL for 1,4-dioxane (20,000 micrograms per liter [ $\mu\text{g/L}$ ]). The maximum concentration of 1,4-dioxane in the W4 Site as reported in the SCM Memo was 150  $\mu\text{g/L}$ . Previously freshwater criteria were listed for iron; however, the Waterway is a tidally influenced marine environment and freshwater criteria are not applicable. Iron does not have criteria for marine waters.

### **3.3 Nature and Extent of Contamination**

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The nature and extent of contamination within SU1 has been discussed in detail in the RI reports prepared for ABP (Aspect, 2012) and BE (PSC, 2003) and the SCM Memo (Aspect, 2014). This section provides a summary of current conditions.

#### ***3.3.1 Soil***

The nature and extent of soil contamination is assumed to have not significantly changed since the preparation of the SCM Memo (Aspect, 2014), which identified concentrations of CVOCs and plating metals (primarily TCE and nickel) above preliminary cleanup levels in soil at and immediately adjacent to the ABP Facility. Soil sampling for metals was conducted at the ABP Facility as part of the Metals Immobilization Pilot Study in 2018 (Aspect, 2018). That soil sampling event identified elevated metals concentrations in soil within the area of the pilot study, consistent with the SCM previously documented in the ABP RI (Aspect, 2012), SCM Memo (Aspect, 2014), and SU1 FS (Aspect, 2016).

#### ***3.3.2 Groundwater***

Groundwater nature and extent figures for TCE, cis-DCE, VC, and total chlorinated ethenes are provided in Figures 3-1 through 3-4. Porewater data for these same parameters are provided in Figures 3-5 through 3-8. Figures have also been updated for select metals: dissolved copper, dissolved nickel, dissolved zinc, and total arsenic (Figures 3-9 through 3-12, respectively). Data are presented relative to PCULs listed in Table 3-1, when available.

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<sup>8</sup> Elevated concentrations of the non-plating metals in groundwater are due to microbial degradation of organic materials in the aquifer matrix that has resulted in generally anaerobic conditions. Anaerobic conditions favor the dissolution of the non-plating metal COCs from the native aquifer materials.

<sup>9</sup> The presence of 1,4-dioxane at concentrations below the CUL in SU1 groundwater appears to be due to migration of groundwater originating from areas east of 4th Avenue South (East of 4th Area) and is being addressed by Burlington Environmental under AO DE 7347.

## 3.4 Potential Receptors and Exposure Pathways

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The following provides a summary of the potential receptors and exposure pathways, detailed in the SCM Memo (Aspect, 2014).

### 3.4.1 Potential Receptors

The Site includes upland and aquatic areas. Potential receptors in the upland areas include:

- Aboveground workers (e.g., employees at commercial facilities)
- Belowground workers (e.g., construction workers conducting digging or trenching operations)
- Residents

Potential receptors in aquatic areas include:

- Recreational beach users
- Recreational fisher/shellfish harvesters
- Subsistence fisher/shellfish harvesters
- Aquatic organisms

As described in the SU1 FS with Ecology concurrence (Aspect, 2016), the Site qualifies for a terrestrial ecological exclusion.

### 3.4.2 Potential Exposure Pathways

Potentially impacted media at the Site include soil, groundwater, air, and surface water. Potential exposure pathways for each medium are identified below. Site use includes a mixture of industrial, commercial, and residential.

#### Soil

Potential direct exposure pathways for soil contamination include:

- Direct contact
- Dust inhalation

Although existing surface materials (asphalt and concrete) prevent contaminated soils from being inhaled or contacted, this is a potential future exposure pathway in the event that coverings are removed or below-ground work is conducted.

Soil contamination may also contribute to contamination in other media through intermedia transport, as follows:

- Air contamination, via the soil-to-air migration pathway (i.e., volatilization)
- Groundwater contamination, via the soil-to-groundwater migration pathway (i.e., leaching)

Potential groundwater and air exposure pathways are discussed below.

### **Groundwater**

Potential direct exposure pathways for groundwater contamination include:

- Incidental direct contact

This pathway is considered a potential current and/or future exposure pathway only for below-ground workers. Above-ground residents and workers are not expected to contact groundwater, which is located 4 to 10 feet bgs.

As described in the SU1 FS with Ecology concurrence, Site groundwater will not be a source of drinking water in the foreseeable future.

Groundwater contamination may also contribute to contamination in other media, as follows:

- Air contamination, via the groundwater-to-air migration pathway (i.e., volatilization)
- Surface water contamination, via the groundwater-to-surface water migration pathway (i.e., discharge to surface water)

### **Air**

VOCs in contaminated soil and groundwater may volatilize into soil gas, which in turn may migrate into indoor or outdoor air (i.e., vapor intrusion). Potential exposure pathways for VOCs in air include:

- Inhalation of outdoor air
- Inhalation of indoor air

### **Surface Water/Sediments**

The nearest surface water/sediment receptor, the Waterway, is a brackish water body that is not a potential drinking water source. Potential exposure pathways for contaminated surface water and sediment include:

- Incidental direct contact to humans
- Direct contact by aquatic organisms
- Aquatic or terrestrial organism ingestion of contaminated aquatic organisms
- Human ingestion of contaminated aquatic organisms

## 4 Basis for SU1 Remedial Action

This section identifies the ARARs, RAOs, and PCULs used as the basis for developing and evaluating remedial alternatives, as follows:

- Section 4.1 identifies the SU1 ARARs that are most likely to have a significant influence on the identification and assembly of remedial alternatives to be evaluated in this SU1 FS Addendum.
- Section 4.2 discusses the cleanup standards.
- Section 4.3 discusses the remediation levels.
- Section 4.4 identifies three areas of SU1 with distinct characteristics that are targeted for remedial action.
- Section 4.5 identifies the RAOs that describe what the proposed remedy is expected to accomplish.

### 4.1 Applicable or Relevant and Appropriate Requirements (ARARs)

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ARARs are discussed in the SU1 FS and no updates are necessary to those listed therein (Aspect, 2016).

### 4.2 Cleanup Standards

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A cleanup standard includes both a cleanup level (CUL; chemical- and media-specific concentration of a contaminant that is protective of human health and the environment via all exposure pathways) and a point of compliance (the location where the CUL must be attained to achieve protectiveness). For the purposes of the FS, the PCULs are the presumptive CULs, but the Ecology-issued Cleanup Action Plan will define final CULs and points of compliance.

Updates to PCULs were presented in Section 3 and Table 3-1 reflects changes to these criteria since completion of the SU1 FS.

As discussed in the SU1 FS with Ecology concurrence, the following points of compliance are used to evaluate remedial alternatives (Aspect, 2016):

- **Soil**
  - Protection of Groundwater Quality: throughout SU1
  - Protection of Air: from ground surface to the uppermost water table
  - Protection of Direct Contact: throughout SU1 to a depth of 15 feet bgs
- **Groundwater:** Standard point of compliance defined as “...*throughout the site from the uppermost level of the saturated zone extending vertically to the lowest*”



*most depth which could potentially be affected by the site.*” WAC 173-340-720(8)(b).

- Protection of Surface Water and Direct Contact throughout SU1
- Protection of Indoor Air: at Water Table Interval throughout SU1
- **Air**
  - Ambient air (indoor and outdoor air): throughout the site (WAC 173-340-750)

### 4.3 Remediation Levels

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MTCA recognizes that a cleanup action may involve a combination of cleanup action components and provides that RELs may be used to identify concentrations (or other methods of identification) of hazardous substances at which different cleanup action components will be used (WAC 173-340-355). RELs are concentration thresholds above which particular cleanup action components may be applied and are usually specific to a particular remediation technology.

CULs must be established for every site, whereas RELs may not be necessary, and do not replace CULs. CULs define the concentration of hazardous substances above which a contaminated medium (e.g., groundwater) must be remediated in some manner (e.g., treatment, containment, institutional controls). RELs may be applied when a combination of cleanup action components are used to achieve cleanup standards, to define where and when each component is applied.

Potential RELs for TCE and VC in different areas of the Site were identified in Section 7.2.4.1 of the SU1 FS (Aspect, 2016) based on concentrations that were predicted using fate-and-transport modeling. These RELs were predicted to not result in concentrations exceeding the surface water CUL at the mudline in the Waterway. The groundwater RELs for TCE and VC define concentrations at which it may be appropriate to transition from active treatment to MNA at locations downgradient from the source.

For this SU1 FS Addendum, empirical data from the 2020 porewater monitoring data and the results of the CVOC Pilot Study were used to develop RELs for Waterway porewater (Porewater RELs). These RELs are used in alternative development in Section 5 as a basis for the extent and duration of active treatment near the Waterway in the Fidalgo Street area. The Porewater RELs will provide treatment goals that would protect exposure pathways until CULs can be achieved throughout the Site. Porewater REL development is described in Appendix D. The Porewater RELs for the Site are as follows:

- 3.2 µg/L TCE
- 0.82 µg/L VC

As described in Appendix D, achievement of Porewater RELs is evaluated on a surface area-weighted average concentration (SWAC) basis because the risk driver for this analysis is human consumption of shellfish exposed to contaminated porewater. Because porewater sampling is a complex undertaking and frequent porewater studies are

impracticable, groundwater monitoring upgradient of the Waterway will be used for remedial design and as a preliminary indication of remediation performance, with follow-up porewater monitoring to verify protectiveness. RELs along a treatment transect will be determined by calculating CVOC concentrations in groundwater along treatment transects or in porewater on a SWAC basis, as described in Appendix D, and applying the estimated reduction needed to achieve Porewater RELs.

The approach is to assess groundwater at the shoreline and estimate a reduction needed in groundwater to achieve Porewater RELs. Based on the 2020 porewater data, Site porewater exceeds Porewater RELs by a factor of approximately six; therefore, the goal of treatment upgradient of the porewater study area is to reduce the average concentration of CVOCs by at least 83 percent. Based on the CVOC Pilot Study results (summarized in Section 2.4.1 and provided in Appendix A), this is an achievable goal within a restoration time frame using the preferred Alternative 2A described in detail below.

## 4.4 Remedial Action Objectives

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RAOs are specific goals to be achieved by remedial alternatives that meet cleanup standards and provide adequate protection of human health and the environment under a specified land use. Site-wide and SU1-specific RAOs for the W4 area are identified in the SU1 FS with Ecology concurrence. Specific RAOs for each medium and exposure pathway are provided in Section 5.4 of the SU1 FS. In summary, RAOs are:

- Achieve CULs at the standard point of compliance for soil, groundwater, air, and surface water, if practicable;
- Protect potential exposure pathways using engineered and institutional controls for contaminants exceeding CULs. A comprehensive list of exposure pathways by media and receptor is provided in the SCM Memo (Aspect, 2014) and summarized above in Section 3.3. The key exposure pathways at the Site affecting development and evaluation of remedial alternatives include:
  - Direct contact with (ingestion of) contaminated soil;
  - Inhalation of contaminated vapors; and
  - Ingestion of contaminated shellfish.

Exceedances of direct contact-based cleanup levels are very limited<sup>10</sup> beneath the ABP Facility and are or will be effectively addressed through institutional controls. The primary risk drivers for remediation at the Site are vapor inhalation and shellfish consumption.

## 4.5 Areas Targeted for Remedial Action in SU1

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The nature and extent of contamination for the Site was provided in the SCM Memo (Aspect, 2014; Ecology approval December 19, 2014); current conditions based on

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<sup>10</sup> It is unclear whether direct-contact exceedances still exist, as areas where such exceedances were identified have undergone subsequent treatment but are inaccessible for confirmation sampling under current Site conditions.

subsequent groundwater and porewater monitoring is described above in Section 3.3. For the purposes of the SU1 FS, three generalized areas within SU1 were defined for consideration of remedial actions. These areas have not been updated since the SU1 FS but are summarized here for reference. The areas targeted for remedial action, and their drivers for cleanup, are as follows:

- **Source Area:** The Source Area includes the ABP Facility and its immediate vicinity. Soil and Water Table Interval groundwater in the Source Area are impacted by CVOCs<sup>11</sup> and plating metals. The estimated areal extent of TCE and nickel PCUL exceedances are depicted on the Figures 3-1 and 3-10, respectively. TCE is the dominant CVOC COC and nickel is the dominant plating metal COC.
- **Downgradient TCE Plume:** The areal extent of TCE PCUL exceedances in groundwater downgradient of the Source Area is shown on Figure 3-1. The TCE plume occurs in the Shallow and Intermediate Intervals. TCE is the dominant CVOC over much of this area, but through a combination of natural attenuation and treatment during the CVOC Pilot Study, degradation products cis-DCE and VC become more dominant west of 2nd Avenue South to the Waterway.
- **Disperse VC Plume(s):** As depicted on Figure 3-3, VC PCUL exceedances in groundwater also occur outside the two areas described above.

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<sup>11</sup> CVOC concentrations in the Source Area have been reduced by the ongoing AS/SVE interim action.

## 5 Description of SU1 Alternatives

This section describes the remedial alternatives evaluated in this SU1 FS Addendum. The SU1 FS identified and evaluated nine remedial alternatives (Alternatives 1 through 9) that incorporated varying degrees of aggressiveness in their conceptual designs to achieve Site RAOs for COCs. AO Amendment No. 1 expected that, at a minimum, this SU1 FS Addendum would evaluate the preferred alternative identified in the SU1 FS (FS Alternative 1)<sup>12</sup> and the preferred alternative identified by Ecology in their comment letter<sup>13</sup>. Those alternatives have been modified, based on the results of the pilot studies and monitoring conducted during the FS, as follows:

- The preferred alternative identified in the SU1 FS has been modified to include treatment in Fidalgo Street, based on the efficacy of the CVOC Pilot Study and recent groundwater and porewater monitoring.
- The preferred alternative identified in Ecology’s comment letter has been modified, as discussed with Ecology in FS Addendum coordination calls, to replace the air sparge curtain along the Waterway with treatment using ISCR and EAnB, based on the efficacy of the CVOC Pilot Study.
- Both alternatives have been modified to include combined ISCR/EAnB, rather than one or the other of these technologies. The technology selected for the pilot study, which resulted in effective CVOC treatment, combined ISCR and EAnB.

The alternatives evaluated in this SU1 FS Addendum are as follows:

- **Alternative 2A<sup>14</sup>:**
  - **Source Area:** pH neutralization
  - **Downgradient TCE Plume:** ISCR/EAnB in Fidalgo Street
  - **Contingency Actions:** ISCR in the Source Area to further reduce TCE concentrations, and ISCR/EAnB near the shoreline to address VC in porewater.
- **Alternative 2B<sup>15</sup>:**
  - **Source Area:** pH neutralization

<sup>12</sup> Based on Ecology comments on the SU1 FS, a modified version of FS Alternative 2 (Alternative 2A) was selected instead of FS Alternative 1.

<sup>13</sup> Ecology had identified their preferred alternative as FS Alternative 5, but without additional source area treatment of CVOCs.

<sup>14</sup> Alternative 2A is an updated version of Alternative 2 of the SU1 FS.

<sup>15</sup> Alternative 2B is what Ecology had identified as its preferred alternative in its FS comment letter, with modifications as described above. It has been named ‘2B’ for the purposes of this SU1 FS Addendum because it is most like Alternative 2A.

- **Downgradient TCE Plume:** ISCR/EAnB in Fidalgo Street and ISCR/EAnB along the Waterway shoreline
- **Contingency Actions:** ISCR in the Source Area to further reduce TCE concentrations

Both alternatives also incorporate engineered and institutional controls and MNA in conjunction with active treatment to ensure protectiveness during the restoration period, and ultimately achieve cleanup levels across the Site.

Each alternative is described below, including conceptual design and implementation strategies and an estimated cost of implementation. Cost estimates have been updated based on the results of the pilot studies and conceptual design criteria. Restoration time frame estimates have not been updated from the SU1 FS, because incorporation of recently collected data is not expected to significantly change those estimates.

## 5.1 Alternative 2A

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Alternative 2A uses pH neutralization to immobilize dissolved metals in groundwater and relies on MNA to address the residual CVOC impacts in the Source Area following the interim AS/SVE removal action. MNA is also used to address CVOC impacts in the Downgradient TCE Plume and VC in areas outside the Downgradient TCE Plume. This alternative includes the following elements:

- Applying a pH neutralization solution in areas of depressed groundwater pH (in the Source Area) through injection points to raise the pH and immobilize/precipitate plating metals dissolved in groundwater.
- MNA of CVOCs and plating metals in soil and groundwater in and downgradient of the Source Area following pH neutralization.
- Applying an EAnB/ISCR amendment as a permeable reactive barrier (PRB) along Fidalgo Street in the Downgradient TCE Plume Area to treat CVOCs dissolved in groundwater.
- Implementing engineered and institutional controls and monitoring until RAOs are achieved, including:
  - Converting the SVE system to a VI mitigation system for the ABP Facility until CVOC concentrations in soil and groundwater are protective of air.
  - Maintaining existing vapor mitigation systems at 218 and 220 South Findlay Street until CVOC concentrations in soil and groundwater are protective of air.
  - Maintaining the ABP Facility as an effective cap until concentrations of TCE in soil are demonstrated to be protective of direct contact with soil.
  - Placing an environmental covenant on the ABP property.
  - Providing notifications to area underground utility providers until CVOC CULs in water table groundwater are achieved.

- Periodic compliance monitoring (protection, performance, and confirmation monitoring) of the remedial action.

Application of these components is described below.

### **5.1.1 AS/SVE System**

The existing AS/SVE system has been in operation since 2008 and is at a point of diminishing returns. Pulsed operation of the AS system was conducted from 2012 and 2015. Some rebound in groundwater concentrations was observed after AS shutdown from 2015 to 2017, but concentrations of CVOCs in groundwater remain below Source Area RELs. Mass removal of CVOCs by the SVE system is minimal.

Elevated concentrations of CVOCs are present in the vadose zone and are expected to remain after shutdown of the AS/SVE system. These concentrations are expected to slowly dissipate through natural attenuation processes such as volatilization, leaching, and degradation. The majority of CVOC exceedances in the vadose zone are in the seasonally saturated zone where natural attenuation processes are expected to flush out and degrade contamination over time.

The SVE system will be transitioned to provide vapor mitigation for the ABP Facility. A mitigation performance assessment and evaluation of soil vapor conditions to aid this transition is underway. Optimization of the mitigation system will be performed to determine which remaining wells and trenches should be maintained, and whether the blower should be resized or replaced to reduce power consumption. Treatment of vapor mitigation system discharge is not anticipated based on current mass removal rates.

### **5.1.2 pH Neutralization**

Figure 5-1 shows the estimated extent of groundwater with pH less than 6 at the Water Table Interval beneath and immediately downgradient of the ABP Facility. As discussed in the Revised Technology Screening Memo (PGG, 2015b), raising the groundwater pH to more-neutral conditions (i.e., around pH 7) can induce precipitation of metals from groundwater and sorption to soil. The effectiveness of pH adjustment for immobilizing plating metals at the ABP Facility was demonstrated through pilot testing (see Appendix B).

Based on the results of the pilot study, for the purposes of this SU1 FS Addendum, the following application is assumed<sup>16</sup>:

- Injection wells will be used to introduce an aqueous pH neutralization solution consisting of 0.1M sodium bicarbonate and 0.05M sodium hydroxide.
- Injection will be conducted at 6 existing SVE or monitoring wells within the footprint of the ABP Facility, the 2 existing injection wells installed for the *Metals Immobilization Pilot Study* (see Appendix B), and up to 60 additional temporary direct-push injection points to be installed in the area shown on Figure 5-1 for application of the buffer solution. Up to 140,000 gallons of reagent will be

<sup>16</sup> The final design for full-scale application will evaluate and consider local pH conditions and will focus reagent application on areas and depth intervals of lowest pH.

injected over 10 days, and the total number of injection points will be determined in remedial design. The injection points are assumed to be installed approximately 20 feet deep and reagent injected into the 10- to 20-foot depth (Water Table Interval).

- For temporary injection point application, the reagent solution would be pumped from the tank into a piping manifold connected to injection points. Instrumentation would be provided for monitoring and controlling solution flow rates to different segments of the injection-well system.
- Existing monitoring wells would be used to track system performance and adjust injection parameters to achieve near-neutral groundwater pH and reduced concentrations of dissolved metals.

More than one injection may be needed to achieve sufficient distribution and the desired pH shift. For the purposes of the FS, we have assumed an initial injection of 135,000 gallons throughout the depressed pH area, monitoring for one year to evaluate rebound, and a contingency for a follow-up injection of 25,000 gallons at existing wells in the area of lowest pH in the event that the minimum target pH is not sustained after the first injection.

### ***5.1.3 Fidalgo Street ISCR/EAnB Application and Assumptions***

The purpose of treatment of the Downgradient TCE Plume along Fidalgo Street is to reduce groundwater concentrations of CVOCs approaching the Waterway and achieve Porewater RELs. The CVOC Pilot Study demonstrated that ISCR/EAnB substantially reduces CVOC concentrations in and downgradient of the treatment area (see Appendix A).

Based on the results of the pilot study, for the purposes of this SU1 FS Addendum, the following application is assumed:

- The lateral and vertical extent of treatment will target the area of the plume requiring treatment to achieve Porewater RELs. The lateral extent based on historical groundwater and porewater data is shown on Figure 5-2, and the vertical extent of treatment is assumed to be from 20 to 30 feet bgs based on pilot study recommendations (see Appendix A). As part of design, a baseline investigation would be conducted along potential treatment transects as follows:
  - CVOC concentrations along each transect would be evaluated through a combination of monitoring wells, to be used as future performance monitoring points, and direct-push sampling to refine the lateral and vertical extent of CVOCs.
  - The area targeted for treatment would be determined by the area required to reduce the average concentration in groundwater upgradient of the porewater study area by at least 75 percent (see Section 4.5).
- The ISCR/EAnB reagent used in the pilot study (ELS-emulsion and EHC-Liquid power) would be applied using the same pressurized delivery (approximately 15 to 44 pounds per square inch [psi]) via direct-push injections as were employed

for the pilot study. Transects would consist of two offset rows of injection points spaced approximately 6 feet on-center.

- A reagent mixture containing approximately 13,000 mg/L total organic carbon (TOC) would be injected.
- Methane in soil gas would be monitored during the treatment period, and accumulation of methane beneath nearby structures would be mitigated using passive venting wells.

As explained in more detail in the CVOC Pilot Study Completion Report (Appendix A), more than one injection will likely be needed to maintain treatment during the time period until upgradient groundwater has sufficiently attenuated such that additional active treatment is no longer needed to meet Porewater RELs<sup>17</sup>. Subsequent injections would be located along the same transects and likely require less reagent to achieve objectives. The frequency of injections to maintain treatment is expected to decrease with time. For the purposes of the FS, we have assumed that four subsequent injection events would be performed using approximately two-thirds of the initial reagent quantity.

#### ***5.1.4 Monitoring, Engineered Control, and Institutional Control Assumptions***

Engineered and institutional controls would be maintained until compliance monitoring indicates they are no longer necessary. For the purposes of preparing FS cost estimates, the following assumptions were made:

- Vapor mitigation systems at the ABP Facility and 218 and 220 South Findlay Street properties would be operated until groundwater in the Water Table Interval achieves CULs protective of VI (approximately 15 years for ABP Facility and 25 years for 218 and 220 South Findlay Street properties based on modeling [Aspect, 2016]). A VI assessment, monitoring, and mitigation program will continue to be a part of this engineered control while soil and groundwater concentrations exceed levels protective of indoor air quality.
- An environmental covenant would be placed on the ABP property.
- Groundwater monitoring in SU1 would be conducted until CULs are attained across SU1, which is approximately 55 years for CVOCs and 280 years for metals, based on modeling (Aspect, 2016). The monitoring program would be identified in the dCAP and subject to adjustments during periodic reviews. For the purposes of cost estimating for this SU1 FS Addendum, monitoring assumptions were, as follows:
  - Performance monitoring would be conducted at wells in the Source Area during pH adjustment to evaluate effectiveness and modify neutralization applications as appropriate.

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<sup>17</sup> The proposed location of an additional injection transect in Fidalgo Street (east of the pilot study area) is subject to access limitations, due to the 24/7 operation of the Westrock shipping department located here.



- Performance monitoring would be conducted at wells in the Downgradient TCE Plume Area during ISCR/EAB to evaluate effectiveness and determine if additional injections are appropriate. Once groundwater treatment objectives are met, porewater sampling would be conducted to confirm that Porewater RELs are met.
- Confirmation soil monitoring would be performed to evaluate achievement of CULs in the vadose zone. Achievement of soil cleanup levels protective of groundwater would be evaluated via groundwater monitoring for empirical demonstration.
- Confirmation monitoring would be conducted at a subset of existing wells to confirm the plume boundaries, including concentrations at the shoreline, are stable or shrinking.
- Confirmation monitoring after active treatment, through Year 55 would be conducted biannually with a subset of wells along the plume centerline and at the shoreline monitored annually. Potential monitoring costs after Year 55 were not included as these do not significantly affect costs in a Net Present Value (NPV) analysis.

### ***5.1.5 Cost and Restoration Time Frame***

Cost estimates were developed in accordance with EPA cost estimating guidance (EPA, 2000) and are FS-level (+50/-30 percent of actual costs). Total project costs were calculated using NPV analysis assuming a discount rate of 2 percent. Cost estimates include construction, operation and maintenance (O&M), and monitoring costs through the estimated restoration time frame for CVOCs (approximately 55 years). Monitoring requirements for residual metals contamination beyond this time frame are assumed to be limited, and the costs are expected to be insignificant under an NPV analysis.

Restoration time frame was estimated based on the time for all RAOs to be achieved, which is driven by the time to achieve surface water protection CULs in groundwater. Restoration time frames were estimated in the SU1 FS.

The estimated NPV cost for Alternative 2A is \$4.0 M. Details are provided in Table 5-1. The estimated time to achieve all SU1 RAOs, including surface water CULs in groundwater at the standard point of compliance is approximately 50 years for CVOCs and 280 years for metals.

### ***5.1.6 Potential Contingency Actions***

Contingency actions may be implemented if an alternative is insufficiently protective or RAOs for achieving CULs within a reasonable restoration time frame are not met. The potential pathways of greatest concern—and therefore the most likely to trigger contingency actions—are achieving VI-based CULs in shallow groundwater near the Source Area and achieving Porewater RELs in groundwater discharging to the Waterway. Therefore, this alternative includes potential contingency actions for addressing CVOCs in the Source Area and the Waterway.

Similar to SU1 FS Alternative 2, the contingency action identified for this alternative was ISCR in the Source Area to further address CVOCs if required to achieve vapor-

intrusion-based cleanup levels within a reasonable time frame (see Section 7.2.5 of the 2016 SU1 FS Report). The estimated NPV cost for Source Area treatment at year 5 is \$1.1 M. Details are provided in Table 5-3.

At the Waterway, performance monitoring data will be evaluated at the time of Ecology's 5-year review to determine whether contingency actions may be necessary. The data will be used to update the estimated time to achieve Porewater RELs and will be considered in context of the LDW Site cleanup time frame. This will provide sufficient time to implement a contingency action to accelerate treatment, if needed. For the purposes of this SU1 FS Addendum, the contingency action identified for this alternative to achieve Porewater RELs is implementation of ISCR or ISCR/EAnB near the shoreline, which is described as part of Alternative 2B below.

The evaluation and implementation of contingency actions will occur as follows:

- Review performance monitoring groundwater trends in shoreline wells
- Use the performance monitoring data to recalculate the time predicted to achieve Porewater RELs
- If the updated time frame to achieve Porewater RELs based on groundwater data is unacceptable (i.e., longer than the LDW Site cleanup time frame), then:
  - Porewater sampling may be conducted to evaluate whether Porewater RELs have been achieved; and/or
  - The contingency action for shoreline treatment will be implemented (ISCR or ISCR/EAnB), following the general approach for shoreline treatment described under Alternative 2B in Section 5.2.1.

The performance monitoring plan, including methods for estimating restoration time frame, would be included in the dCAP.

The estimated NPV cost for shoreline EAnB treatment at year 5 is \$0.77 M. Details are provided in Table 5-4.

## 5.2 Alternative 2B

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Alternative 2B includes the same components as Alternative 2A but adds ISCR/EAnB treatment of dissolved CVOC impacts along the Waterway shoreline as a remedy component instead of a contingency action. In summary, Alternative 2B includes the following:

- Application of a pH neutralization solution in areas of depressed groundwater pH (in the Source Area) through injection points and wells to raise the pH and immobilize/precipitate plating metals dissolved in groundwater.
- Application of an EAnB/ISCR amendment as a PRB along Fidalgo Street in the Downgradient TCE Plume Area to treat CVOCs dissolved in groundwater.
- Application of an EAnB/ISCR amendment as a PRB along the shoreline in the Downgradient TCE Plume Area to treat CVOCs dissolved in groundwater.

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- MNA of CVOCs and plating metals in soil and groundwater in and downgradient of the Source Area following pH neutralization.
- Implementing engineered and institutional controls and monitoring until RAOs are achieved.

Refer to Alternative 2A (Section 5.1) for the conceptual design for pH neutralization, ISCR/EAnB along Fidalgo Street, and monitoring, engineered controls, and institutional controls. Application of ISCR/EAnB along the Waterway shoreline is described below.

### ***5.2.1 Shoreline ISCR/EAnB Application and Assumptions***

The purpose of treatment of the Downgradient TCE Plume along the Waterway shoreline is to reduce groundwater concentrations of CVOCs discharging to the Waterway faster than can be achieved by treatment in Fidalgo Street alone.

The effectiveness and suitability of the ISCR/EAnB reagent used in the CVOC pilot study is more uncertain close to the shoreline for the following reasons:

- More tidal mixing
- Groundwater geochemistry influenced by saltwater
- Dominance of TCE degradation products
- Secondary effects to surface water

It is possible that an alternative reagent (e.g., one that is more focused on ISCR mechanisms than EAnB) would be better suited for the Waterway shoreline area. As a result, a phased approach may be appropriate with implementing on a limited field-scale, followed by modification of the approach, if warranted, based on performance monitoring data. For the purposes of this SU1 FS Addendum, the following assumptions were made:

- The injection transect would be located along the shoreline but as close to the existing building as practicable, to reduce potential secondary effects to water quality from impacting the Waterway.
- The lateral and vertical extent of treatment will target the area of the plume requiring treatment to achieve Porewater RELs. The lateral extent based on historical groundwater and porewater data is shown on Figure 5-3, and the vertical extent of treatment is assumed to be from 20 to 30 feet bgs based on pilot study recommendations (see Appendix A). As part of the design, a baseline investigation would be conducted along potential treatment transects as follows:
  - CVOC concentrations along each transect would be evaluated through a combination of monitoring wells, to be used as future performance monitoring points, and direct-push sampling to refine the lateral and vertical extent of CVOCs.
  - The area targeted for treatment would be determined by the area required to reduce the average concentration in groundwater upgradient of the porewater study area by at least 83 percent (see Section 4.5).

- An ISCR-only pilot study (described further below) would be conducted to determine the optimum reagent prior to full-scale implementation.
- Reagent would be applied using the same pressurized delivery (approximately 15 to 44 psi) via direct-push injections. The transect would consist of two offset rows of injection points spaced on approximately 6-foot centers. For cost estimating purposes, an ISCR/EAnB reagent and a contingency for inclusion of a zero-valent iron (ZVI)-based amendment have been included. The results of the ISCR-only pilot test will determine whether the ZVI contingency is needed.
- A reagent mixture containing ZVI would be injected.
- Two injections will be performed. It is anticipated that treatment in Fidalgo Street would reduce CVOC concentrations entering the Shoreline Treatment Area before additional injections would be needed.

As noted above, an ISCR pilot study would be conducted along the shoreline before implementing the full-scale shoreline treatment. The CVOC pilot study in South Fidalgo Street utilized an ISCR/EAnB reagent, but it may not be as effective or suitable along the shoreline. An ISCR reagent may be better suited for the Waterway shoreline area due to the increased tidal mixing, groundwater geochemistry, dominance of TCE degradation products, and secondary effects to surface water.

For the purposes of this SU1 FS Addendum, the pilot test would be implemented with the same assumptions noted above regarding injection transect location, vertical treatment depth, reagent, and delivery. Other assumptions include:

- The lateral and vertical extent of treatment for the pilot study will target the area of the plume with the highest VC concentrations, based on the results of the baseline investigation.
- One injection will be performed. Monitoring will be conducted to determine whether the reagent enhanced chemical reduction of VC. Results will be used to determine the following:
  - Whether ISCR alone or a combination of ISCR/EAnB reagent is likely more effective in the shoreline area;
  - Design parameters for a full-scale injection program;
  - Whether shoreline injections are likely to significantly reduce the time to achieve Porewater RELs. If effectiveness near the shoreline is limited due to tidal effects and geochemical conditions, or secondary water quality impacts from treatment are a concern, the implementation of shoreline treatment will be reconsidered in consultation with Ecology.

Treatment at the Waterway would be on private property, operated by CertainTeed Gypsum, and an access agreement would need to be negotiated. No public property is available for the pilot study between the Waterway and South Fidalgo Street.

### ***5.2.2 Cost and Restoration Time Frame***

The estimated cost for Alternative 2B is \$4.6 M. Details are provided in Table 5-2. The estimated time to achieve all SU1 RAOs, including surface water CULs at the standard point of compliance, is approximately 50 years for CVOCs and 280 years for metals.

### ***5.2.3 Potential Contingency Actions***

This remedial alternative relies on MNA to achieve RAOs for CVOCs in the Source Area. Similar to Alternative 2A, the contingency action identified for this alternative was ISCR in the Source Area to further address CVOCs if required to achieve vapor-intrusion-based cleanup levels within a reasonable time frame. The estimated NPV cost for Source Area treatment at year 5 is \$1.1 M. Details are provided in Table 5-3.

## 6 Evaluation of SU1 Remedial Alternatives

In this section, the two remedial alternatives described in Section 5 are evaluated with respect to MTCA criteria. MTCA criteria for evaluating remedial alternatives include<sup>18</sup>:

- Meeting MTCA threshold requirements
- Achieving cleanup within a reasonable restoration time frame
- Using permanent solutions to the maximum extent practicable as determined through a disproportionate cost analysis (DCA)

This evaluation is described below, and a summary of this evaluation is provided in Table 6-1.

### 6.1 MTCA Threshold Requirements

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Cleanup actions selected under MTCA must meet four “threshold” requirements identified in WAC 173-340-360(2)(a) to be accepted by Ecology. All cleanup actions must:

- Protect human health and the environment
- Comply with cleanup standards
- Comply with applicable state and federal laws
- Provide for compliance monitoring

All nine alternatives evaluated in the SU1 FS met these threshold requirements and Ecology concurred in its comment letter (Ecology 2016). Alternatives 2A and 2B are variations on FS Alternative 2 and also meet threshold requirements for the same reasons detailed in the SU1 FS.

### 6.2 Evaluation with Respect to Reasonable Restoration Time Frame

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MTCA places a preference on remedial alternatives that can achieve the required CULs at the points of compliance in a shorter period of time. Factors to be considered in evaluating whether an alternative provides for a reasonable restoration time frame are identified in WAC 173-340-360(4)(b).

A cleanup action is considered to have achieved restoration once cleanup standards have been met. As discussed in Section 8.2.2 of the SU1 FS (Aspect, 2016), all nine alternatives are expected to comply with cleanup standards. The restoration time frame for SU1 is driven by the time to meet groundwater CULs based on surface water

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<sup>18</sup> MTCA criteria also require consideration of public concerns. As described in the SU1 FS, consideration of public concerns is an inherent part of the Site cleanup process under MTCA. The draft FS and CAP will be issued for public review and comment, and Ecology determines whether changes to the reports are needed in response to public comments

protection at the standard point of compliance. The restoration time frames for surface water protection for CVOCs for the nine FS alternatives ranged from 30 years to 55 years<sup>19</sup>. Restoration time frames for surface water protection for plating metals for the nine FS alternatives ranged from 280 to more than 1,000 years. Based on the FS analysis, the estimated restoration time frames for Alternatives 2A and 2B are 50 years for CVOCs and 280 years for metals.

WAC 173-340-360(4)(b) provides a list of factors to be considered to determine whether a cleanup action provides for a reasonable restoration time frame, including:

- Potential risks posed by the site to human health and the environment
- Practicability of achieving shorter restoration time frame
- Current and potential future use of the site, surrounding areas, and associated resources that are, or may be, affected by releases from the site
- Availability of alternate water supplies
- Likely effectiveness and reliability of institutional controls
- Ability to control and monitor migration of hazardous substances from the site
- Toxicity of the hazardous substances at the site
- Natural processes, which reduce concentrations of hazardous substances and have been documented to occur at the site or under similar site conditions

A longer period of time may be used for the restoration time frame for a site to achieve cleanup levels at the point of compliance if the cleanup action selected has a greater degree of long-term effectiveness than on-site or off-site disposal, isolation, or containment options (WAC 173-340-360(4)(c)). Extending the restoration time frame cannot be used as a substitute for active remedial measures when such actions are practicable (WAC 173-340-360(4)(f)).

Contamination at SU1 represents a relatively low risk because there are no unacceptable exposures, and potential future exposures can be reliably treated or controlled under all nine remedial alternatives. In particular:

- Drinking water is not a current or potential future use of groundwater (Appendix F of SU1 FS)

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<sup>19</sup> As discussed in the SU1 FS, estimated restoration time frames are based on groundwater modeling that involves significant uncertainty. As a result, the estimated time frames are only very rough approximations, and should primarily be used to evaluate alternatives relative to one another. The modeled time frames are used in this SU1 FS Addendum as a measure of how alternatives would perform relative to each other, not as absolute estimates of when restoration will occur. Variation of many of these parameters are expected to result in similar adjustments among the range of alternatives, and the modeled restoration time frames are used as a relative indication of alternative effectiveness to inform the DCA.

- Engineered and institutional controls, including vapor intrusion monitoring and mitigation programs, have been effective at controlling exposures to date, and are expected to continue to do so as the plume attenuates<sup>20</sup>
- Contamination discharging at the Waterway does not represent an unacceptable risk to human or ecological receptors (Aspect, 2012)

There is some inherent uncertainty, particularly for alternatives with long estimated restoration time frames, in future conditions and associated future risks. Ecology has noted a preference for quickly achieving cleanup levels, particularly in groundwater approaching the Waterway. Whether a restoration time frame is reasonable is based partly on the ability to practicably achieve a significantly shorter time frame by more permanently addressing particular exposure pathways. For the alternatives evaluated, the estimated times to achieve particular cleanup objectives based on modeling described in the SU1 FS range as follows:

- The time to achieve VI-based CULs is estimated at 25 years for Alternatives 2A and 2B.
- The time to achieve surface water-based CULs discharging to the Waterway is estimated at 35 years for Alternative 2B and 50 years for Alternative 2A.
- The time to achieve surface water-based CULs everywhere is estimated to be close to 280 years.

Based on the CVOC Pilot Study results and analysis (see Appendix B), it is anticipated that Porewater RELs could be achieved within 13 years under Alternative 2A and within 5 years under Alternative 2B based on the estimated time for the clean water front migrating from the treatment area(s) to reach the Waterway (see Appendix E) and assuming a 2-year time frame for design and implementation. These time frames are significantly faster than the time predicted for the LDW Site cleanup to achieve its target levels (at least 20 years)<sup>21</sup>.

Both alternatives potentially provide for a reasonable restoration time frame. The practicability of achieving a shorter restoration time frame depends on the DCA described in Section 6.3.

## 6.3 Disproportionate Cost Analysis

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A DCA was performed to evaluate whether a cleanup action uses permanent solutions to the maximum extent practicable. The DCA quantifies the environmental benefits of each

<sup>20</sup> The effectiveness of engineered and institutional controls relies, in part, on owner willingness to allow the controls to be implemented and operated.

<sup>21</sup> According to the LDW ROD (EPA, 2014), protective levels are anticipated to be achieved within 17 years of beginning construction, assuming that construction will take 7 years. This time frame is consistent with Ecology guidance that sediment cleanups will generally achieve protective levels within 10 years of completing construction (Ecology, 2019). Construction of the LDW Site remedy for the upper reach is currently scheduled to begin in 2025. For the lower reach (the area where the groundwater plume discharges), this time frame will be significantly longer as design and construction is not currently scheduled.



remedial alternative, and then compares alternative benefits versus costs. Alternatives are ranked from most to least permanent, and the most permanent alternative is the ‘baseline’ alternative against which other alternatives are compared. Costs are disproportionate to benefits if the incremental cost of a more permanent alternative over that of a lower-cost alternative exceeds the incremental benefits achieved by the alternative over that of the lower-cost alternative. Alternatives that exhibit disproportionate costs are considered “impracticable” under MTCA.

Seven criteria are considered in the evaluation as specified in WAC 173-340-360(3)(f):

- **Protectiveness.** Overall protectiveness of human health and the environment, including the degree to which existing site risks are reduced, time required to reduce the risks and attain cleanup standards, on-site and off-site risks during implementation, and improvement in overall environmental quality.
- **Permanence.** Degree to which the alternative permanently reduces the toxicity, mobility, or volume of hazardous substances, including the adequacy of destroying hazardous substances, the reduction or elimination of hazardous substance releases and sources of releases, the degree of irreversibility of treatment, and the characteristics and quantity of the treatment residuals.
- **Cost.** Remedy design, construction, and long-term O&M costs to implement the alternative.
- **Long-term effectiveness.** Degree of certainty that the alternative will successfully and reliably address contamination that exceeds applicable CULs until CULs are attained, the magnitude of the residual risk with the alternative in place, and the effectiveness of controls to manage treatment residue and remaining wastes.
- **Short-term risk management.** The risks to human health and the environment during construction and implementation of the alternative, and the effectiveness of measures that will be taken to manage such risks.
- **Implementability.** Includes consideration of whether the alternative is technically possible; the availability of necessary off-site facilities, services, and materials; administrative and regulatory requirements; scheduling, size, and complexity of the alternative; monitoring requirements; access for construction, operations, and monitoring; and integration with existing facility operations and other current or potential remedial actions.
- **Consideration of public concerns.** Concerns from individuals, community groups, local governments, tribes, federal and state agencies, and other interested organizations are addressed by Ecology responding to public comments on the Draft FS report and the Draft Cleanup Action Plan.

The DCA is provided in the following sections and summarized in Table 6-1. Environmental benefit is quantified by first rating the alternatives with respect to six of

the seven criteria<sup>22</sup>. Rating values are assigned on a scale of 1 to 10, where 1 indicates the criterion is satisfied to a very low degree, and 10 indicates the criterion is satisfied to a very high degree. Since Ecology does not consider the criteria to be of equal importance, each criterion is assigned a “weighting factor.” Consistent with feasibility studies and cleanup action plans conducted on other Ecology cleanup sites, weighting factors are assigned as follows:

- Overall protectiveness: 30 percent
- Permanence: 20 percent
- Long-term effectiveness: 20 percent
- Short-term effectiveness: 10 percent
- Implementability: 10 percent
- Consideration of public concerns: 10 percent

A MTCA benefits ranking is then obtained for each alternative by multiplying the six rating values by their corresponding weighting factors and summing the weighted values. The method used here is consistent with the DCA completed for the W4 SU1 and SU2 FS reports (Aspect, 2016 and PGG, 2016, respectively). Finally, the benefits ranking of each alternative is divided by the alternative’s estimated cost to obtain a benefit/cost ratio, which is a relative measure of the cost effectiveness of the alternative<sup>23</sup>.

Below, Alternatives 2A and 2B are compared for each criterion. This discussion is focused on the key differences between the two alternatives.

### **6.3.1 Overall Protectiveness**

Both remedial alternatives would be protective of human health and the environment and incorporate the same elements to address most exposure pathways. The differentiating factor between the two alternatives with respect to overall protectiveness is the time frame for achieving protective levels at the Waterway.

Groundwater concentrations exceed surface water CULs at the point of discharge to the Waterway and are predicted to exceed these levels for an extended period of time; however, a Site-specific assessment during the RI indicated that potential exposure scenarios do not provide an unacceptable level of risk currently or in the foreseeable future. The REL analysis (Appendix D) identified concentrations in porewater that would be protective of hypothetical long-term future use.

Both alternatives include treatment of groundwater prior to discharge to the Waterway along Fidalgo Street approximately 300 feet from the shoreline. Alternative 2B includes

<sup>22</sup> Cost is not considered in quantifying environmental benefit but is used to determine the cost-to-benefit ratio of each alternative (see Section 6.3.7).

<sup>23</sup> The described method is one of several possible ways to conduct the DCA. This method has been chosen to be consistent with the DCA of the SU1 and SU2 FS and is consistent with Ecology’s preference at other sites. Other DCA methods include quantitative analysis with different weighting systems or purely qualitative analyses.

treatment along the shoreline and is likely to achieve RELs faster than Alternative 2A. However, implementation of treatment along the shoreline will need to be carefully designed, tested, and potentially implemented in a phased approach to avoid secondary water quality impacts.

Porewater RELs are anticipated to be achieved faster than surface water CULs, based on the estimated time for the clean water front migrating from the treatment area(s) to reach the Waterway. Surface water CULs in groundwater at the shoreline are predicted to be achieved in approximately 50 years for Alternatives 2A and RELs within 13 years. For Alternative 2B, surface water CULs are predicted to be achieved in approximately 35 years at the shoreline and Porewater RELs may be achieved within 5 years.

Alternative 2A was given a rating of moderate (6). Alternative 2B would achieve RELs at the Waterway faster through shoreline treatment and was given a rating of high (7).

### **6.3.2 Permanence**

All alternatives are considered to have a relatively high permanence because, in general, the CVOCs are ultimately destroyed through a combination of active treatment and natural attenuation; and the plating metals (which cannot be ‘destroyed’) are immobilized to prevent migration to the Waterway, and do not present a health risk when immobilized in place because of their relatively low human toxicity. In the SU1 FS, alternatives were differentiated on this criterion primarily on the irreversibility of immobilization.

Alternatives 2A and 2B would have the same permanence as FS Alternative 2, and therefore were both given a rating of moderate (5).

### **6.3.3 Long-Term Effectiveness**

Both alternatives involve treatment technologies that, coupled with natural attenuation and engineered and institutional controls, are all considered highly likely to maintain protectiveness during the cleanup period and ultimately achieve cleanup standards within a reasonable restoration time frame. Capping and vapor mitigation are considered highly reliable as they would be accompanied by monitoring programs to confirm protectiveness. Institutional controls such as notifications to potentially affected utility companies during the period of restoration can also be effective, but depend on the utility company invoking procedures to address potential contamination and following best management practices (BMPs) when appropriate.

The CVOC and metals pilot studies demonstrated that the proposed technologies are effective at the Site. Therefore, the long-term effectiveness of both alternatives was rated higher than similar alternatives evaluated in the SU1 FS.

The effectiveness of each alternative at meeting RAOs were differentiated based on the time frame for restoration of groundwater discharging to the Waterway, the potential effectiveness of shoreline treatment, and the potential need for contingency actions. Alternative 2B includes treatment along the shoreline to reduce the time frame to achieve Porewater RELs, while Alternative 2A includes the same treatment as a contingency. The pilot study demonstrated successful treatment in Fidalgo Street, which is targeted by both alternatives. However, the efficacy demonstrated in the pilot study is not predictive of the effectiveness of ISCR/EAnB treatment along the shoreline because of the saline

intrusion, greater tidal fluctuations in groundwater elevations, and different biogeochemical groundwater conditions at the shoreline groundwater.

Based on these considerations, both alternatives were rated moderate (6) for this criterion.

#### **6.3.4 Short-Term Risk Management**

For both alternatives, the short-term risks to workers and the public can generally be managed using appropriate BMPs. Both alternatives involve handling of relatively low toxicity materials (pH neutralization solution and EAnB or ISCR amendments) and low-risk construction activities (well drilling, amendment injection).

Alternative 2A is rated high (8) for short-term risk management. Alternative 2B includes a slightly greater potential for secondary water quality effects due to treatment adjacent to the shoreline and is rated high but slightly lower (7) than Alternative 2A.

#### **6.3.5 Implementability**

Both alternatives target areas that are considered relatively accessible and would use readily available services/equipment and common implementation techniques. Injection programs in street ROWs will require a street-use permit and will be constrained by utilities. However, drilling during the RI was completed successfully in the general areas targeted for injection under these alternatives. Logistical challenges may include weekend or nighttime work during drilling on arterial streets or adjacent to sensitive businesses.

Alternative 2A was given a rating of high (7). Alternative 2B presents greater implementability challenges compared to Alternative 2A because of the need to conduct injections on private property (including associated access requirements and uncertainty in future accessibility to the shoreline area) and constraints to control potential secondary water quality impacts. This alternative was given a rating of moderate (6).

#### **6.3.6 Consideration of Public Concerns**

Ecology expects, based on its experience at other local sites, that the public will, in general:

- 1) Prefer alternatives that more quickly restore groundwater discharging to the Waterway
- 2) Generally support exposure controls (e.g., vapor mitigation, deed restrictions) when coupled with active remedial measures
- 3) Desire shrinkage of the extent of groundwater contamination
- 4) Be reluctant to allow free access to private property for implementation of remediation and monitoring.

Based on these expectations, the alternatives were rated as follows:

- Alternatives 2A was rated moderate (5).
- Alternative 2B was also rated moderate but slightly higher (6), due to its shorter time frame for achieving Porewater RELs.

This category will be reevaluated after the public comment period for the Draft Cleanup Action Plan.

### ***6.3.7 Benefits Rankings, Estimated Costs, and Benefit/Cost Ratios***

The MTCA benefits rankings, estimated costs, and benefit/cost ratios for the two remedial alternatives are presented at the bottom of Table 6-1. As previously noted, the MTCA benefits ranking is obtained for each alternative by multiplying the rating values assigned for the six evaluation criteria by their corresponding weighting factors and summing the weighted values. The benefit rankings were 6.0 for Alternative 2A and 6.2 for Alternative 2B.

The benefit/cost ratio, which is a relative measure of cost-effectiveness, is obtained by dividing each alternative's benefits ranking by its estimated cost. Alternative 2A has the higher benefit/cost ratio, at 1.5 versus 1.3 for Alternative 2B (Table 6-1).

### ***6.3.8 Disproportionate Cost Analysis Conclusion***

Based on the results of the DCA presented above, Alternative 2A has the highest benefit-to-cost ratio and is deemed to satisfy the MTCA requirement for an alternative to be permanent to the maximum extent practicable.

## **6.4 Uncertainty Analysis**

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This FS analysis involves uncertainty regarding a number of items, including:

- Accuracy of Site characterization
- Fate and transport of contaminants
- Future land and resource use
- Effectiveness and reliability of remedial technologies
- Effectiveness, cost, reliability, restoration time frame, and protectiveness of FS alternatives

Refer to the SU1 FS for discussion of these factors. As noted in the SU1 FS, the primary purpose of the FS is to identify likely viable remedial alternatives, comparatively evaluate them, and select a preferred cleanup action. Much of the uncertainty listed above is less critical when evaluating alternatives on a relative basis. Although specific metrics, such as cost, restoration time frame, and treatment effectiveness discussed in this SU1 FS Addendum may vary from the estimates provided in the FS, it is likely that the key conclusions reached in this report are still valid, since inaccuracies in assumptions often apply to a greater or lesser extent to all alternatives.

## 7 Conclusions and Recommendations

The SU1 FS considered nine remedial alternatives that provide a range of treatment options for metals and CVOC contamination. This SU1 FS Addendum identified two remedial alternatives that were modified from the original nine based on Ecology comments and the results of interim pilot studies and monitoring. All alternatives meet MTCA Threshold Requirements, including protection of human health and the environment. To date, interim actions and the CVOC Pilot Study have substantially reduced CVOC concentrations in the Source Area and in the Downgradient TCE Plume.

Alternative 2A is the recommended cleanup action for SU1 based on the analysis and considerations presented in this SU1 FS Addendum. Alternative 2A has the highest benefit-to-cost ratio and satisfies the MTCA requirement to be permanent to the maximum extent practicable and will achieve the applicable cleanup levels at the designated points of compliance within a reasonable restoration time frame. The cost for Alternative 2A is \$4.0 M compared to Alternative 2B at \$4.7 M. This alternative is protective of human health and the environment, and is significantly less expensive than Alternative 2B.

The primary benefit of Alternative 2B is that it is likely to achieve Porewater RELs faster; however, there are no unacceptable risks based on current conditions in the foreseeable future. Alternative 2B has additional uncertainty as to effectiveness and potential for secondary water quality impacts from treatment adjacent to the Waterway. Groundwater and porewater monitoring would be conducted to determine if the remedy is performing as expected, verify that receptors are protected, and confirm that groundwater restoration will occur within a reasonable time frame.

## 8 Schedule

Upon receipt of Ecology concurrence of the SU1 and SU2 FS Addenda, the FS and FS Addenda will undergo a period of public review and comment. If Ecology requires revisions to either or both of the FS Addenda based on public comments, the revised reports will be submitted to Ecology for approval. After Ecology approves the FS Addenda, a dCAP will be prepared that presents details regarding implementation of Alternative 2A, including a proposed schedule for key elements of the cleanup action and associated compliance monitoring. The dCAP will be submitted to Ecology within 120 days of Ecology concurrence.

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## 10 Limitations

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## **APPENDIX E**

### **Restoration Time Frame Calculations for Porewater**