Final
Feasibility Study

Former Alderwood Laundry and Dry Cleaners
3815 - 196th Street SW
Lynnwood, Washington
VCP NW3066

for
Lynnwood Public Facilities District

November 10, 2021

GeoEngineers
Earth Science + Technology

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File No. 17787-001-15

November 10, 2021

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ACRONYMS AND ABBREVIATIONS

ALDC	Alderwood Laundry and Dry Cleaners
ARARs	applicable or relevant and appropriate requirements
AS	air sparging
bcy	in-place cubic yards
BETX	benzene, ethylbenzene, toluene and total xylenes
bgs	below ground surface
CAO	cleanup action objective
CID	Contained-in Determination
City	City of Lynnwood
COC	contaminants of concern
CSM	Conceptual Site Model
DCA	Disproportionate Cost Analysis
DCE	dichloroethylene
Ecology	Washington State Department of Ecology
EPA	United States Environmental Protection Agency
FS	Feasibility Study
ft/ft	feet per foot
GAC	granulated activated carbon
HVOC	halogenated volatile organic compound
$\mu g/m^3$	micrograms per cubic meter
MTCA	Model Toxics Control Act
MW	monitoring well
NAVD	North American Vertical Datum
O&M	operation and maintenance
PCE	tetrachloroethylene
PCULs	Preliminary cleanup levels
PFD	Public Facilities District
RCW	Revised Code of Washington
RI	Remedial Investigation
ROW	Right-of-Way
SEPA	State Environmental Policy Act
SVE	soil vapor extraction
TCE	trichloroethylene
TCH	Thermal Conduction Heating
TEE	Terrestrial Ecological Evaluation

VC	vinyl chloride
VCP	Voluntary Cleanup Program
VI	vapor intrusion
WAC	Washington Administrative Code
WES	Washington Energy Services

1.0 INTRODUCTION

This report presents the Feasibility Study (FS) completed for the former Alderwood Laundry and Dry Cleaners Site (Site) located at 3815 - 196th Street SW in Lynnwood, Washington (Figure 1). The Lynnwood Public Facilities District (PFD) is conducting an independent cleanup of the Site in accordance with the requirements of the Model Toxics Control Act (MTCA). The Site is enrolled in the Washington State Department of Ecology's (Ecology) Voluntary Cleanup Program (VCP No. NW3066). The Site is identified in Ecology databases as Facility Site ID Number 17078 and Cleanup Site ID Number 12845.

This FS was completed to develop and evaluate cleanup action alternatives for addressing contamination identified at the Site and to select a preferred cleanup action alternative. The FS utilizes information presented in the Remedial Investigation (RI) Report (GeoEngineers 2018) and subsequent RI Addenda (GeoEngineers 2019 and GeoEngineers 2021a), which sufficiently characterize the Site for purposes of completing the FS and selecting a preferred cleanup action. The RI documents provide information regarding historical operations and land use, environmental and ecological conditions, pilot study investigations, nature and extent of contamination and conceptual site model (CSM) to develop and evaluate cleanup action alternatives. This FS was completed in accordance with the requirements of the MTCA Cleanup Regulation, Chapter 173-340 of the Washington Administrative Code (WAC) and Ecology's guidance and checklist for preparing an FS (Ecology 2016a).

1.1. Site Location and Description

The Site is defined as the locations of soil, soil vapor, and groundwater contamination resulting from historical releases of dry cleaner-related chlorinated solvents associated with the Former Alderwood Laundry and Dry Cleaners (ALDC). Based on the results of the RI, soil, soil vapor and groundwater beneath the former ALDC is contaminated primarily with tetrachloroethylene (PCE), and to a lesser extent with breakdown products of PCE, including trichloroethylene (TCE) and cis- and trans-1,2-dichloroethylene (DCE).

The Site is currently contained within Snohomish County Tax Parcels 372600400602, 372600401603 and 372600401604 owned by the Lynnwood PFD (herein referred to as the "PFD Property") and extends into the eastern portion of the west-adjacent Washington Energy Services (WES) Property located at 3909 196th Street SW (Snohomish County Tax Parcel 372600401701). Tax parcels containing the Site are shown relative to the former ALDC and surrounding features on Figure 2. PFD Property tax parcels comprise a total area of approximately 13 acres while the west-adjacent WES Property tax parcel comprises approximately 2.5 acres. The PFD Property is currently developed with the Lynnwood Convention Center and with other structures used by restaurants, retail spaces and offices. Significant portions of the PFD Property are developed with surface parking and there are several areas of landscaping. An approximately 100-foot-long by 60-foot-wide by 26-foot-deep underground stormwater infiltration facility is present beneath the parking area located west of the Convention Center building (Figure 2). The west-adjacent WES Property is developed with a commercial office and warehouse building used by WES for heating/cooling/ plumbing products sale and services.

The PFD Property is situated in the southwest quarter of Section 15, Township 27, and Range 4. The PFD Property is platted within the Alderwood Manor block in Snohomish County, Washington. Addresses of current businesses located on the PFD Property include 3711, 3715, 3717, 3805, 3815 and 3819 - 196th

Street SW, Lynnwood, Washington. The PFD's mailing address is 3711 - 196th Street SW in Lynnwood, Washington. The geographic coordinates of the PFD Property are N 47° 49' 18.77" and W122° 17' 06.09".

1.2. Historical Operations and Land Use

Historically, the PFD Property was first developed with residences in the late 1940s. In the early 1960s, the residences were removed, and three commercial-use buildings were constructed: the large existing office/retail space building in the western margin of the PFD Property, and multi-tenant retail strip mall buildings in the southwest and southeast portions of the PFD Property. By the mid-1970s, two additional retail/commercial buildings were developed in the northern and eastern portions of the PFD Property. A gasoline service station (Chevron, now removed and MTCA cleanup completed) operated in west portion of the PFD Property beginning in approximately the late-1960s. A second gasoline service station (ARCO, now removed and MTCA cleanup in process) and later an automobile muffler repair shop (now removed), operated in the southeast portion of the PFD Property between the mid-1960s and mid-2000s. These automotive facilities were removed, and the Lynnwood Convention Center constructed in 2004. Based on environmental data for the Chevron, ARCO and the ALDC Sites, that contaminant plumes associated with historical releases from each discrete source area are not co-mingled.

Between 1963 and 1982 a laundry and dry cleaner operated in the southernmost tenant space of the strip mall in the southwest portion of the PFD Property. The dry cleaner business used various names including "Alderwood Highland Center Laundry" and "Alderwood Laundry and Dry Cleaners." The initial lease signed in 1963 indicated the use of the facility as an "automatic laundry and dry-cleaning establishment." Architectural drawings from the 1960s strip mall development show the locations of coin-operated washing machines, associated floor drains and a boiler room (Figure 3). Available records do not indicate the locations of facility drainpipes or floor drains other than the trench drain situated under the machine bank footprint. Furthermore, there is no historical evidence that an underground heating oil tank was used for the boiler.

The 1963 lease agreement also indicated the cleaner space was 2,100 square feet, which is consistent with the size of the dry cleaner tenant space according to the 1960s-era architectural drawings. Although, it is unclear if the coin-operated machines were used for dry-cleaning or if the dry-cleaning equipment was separate from the coin-operated machines. According to a United States Department of Commerce report in 1986, nearly 20 percent of dry cleaning in the United States utilized coin-operated machines[1]. Most of the major manufacturers started selling coin-operated dry-cleaning machines around the early 1960s. If the dry-cleaning machine used at the ALDC was in a different location than the coin-operated machines, it would likely have been located in the southwest corner of the space where the boiler room is shown.

Currently, the Bamboo Tree restaurant occupies the southern tenant space of the strip mall building, corresponding approximately to the footprint of the former ALDC. Other current strip mall tenants in spaces situated north of the restaurant are Carniceria Grocery, Tropical Tan Salon and an administrative office. The building that was situated immediately south of the strip mall building that had been occupied by the Alderwood Veterinary Clinic was demolished in 2018. Fill material was placed within the footprint of the

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[1] A Chronology of Historical Developments in Dry Cleaning, State Coalition for Remediation of Dry Cleaners, November 2007.

former building to match surrounding grades and the area is now paved for use as surface parking. None of the current property structures have fully enclosed below-grade basements.

1.3. Future Land Use

According to the City of Lynnwood's (City) zoning map, the PFD Property and adjacent properties are zoned as City Center Core. This zoning corresponds to mixed use, business and residential. The PFD is evaluating future redevelopment options for the PFD Property, including where the dry cleaner-related contamination is located. The PFD plans to demolish the strip mall building within approximately the next 2 years. The long-term redevelopment plans for the PFD Property have not yet been established but could include construction of new hospitality-related structures and/or mixed use commercial/residential structures. Currently, there are no redevelopment plans for the WES Property and it is anticipated that this property will continue to be used for heating/cooling/plumbing products sale and services.

1.4. Site Characterization

Multiple environmental studies have been completed at the Site since 2001 to evaluate Site conditions and characterize the nature and extent of contamination resulting from historical releases from the former ADLC. The nature and extent of PCE and TCE contamination in soil and groundwater based on the RI activities completed at the Site through April 2021 are shown in plan view on Figures 4 and 5 and generalized geologic cross-sections on Figures 6 through 9. A pilot scale study to evaluate in-situ treatment using enhanced bioremediation and biochemical reduction technologies is currently underway as of the publishing of this FS in accordance with Ecology-approved Pilot Study Work Plan (GeoEngineers 2021b). The results of this pilot study will be presented as a supplemental document for use during planning and design to support implementation of the preferred cleanup action (see Section 4.3).

Site conditions based on the RI activities performed to date are summarized in the following sections (Sections 1.4.1 through 1.4.4).

1.4.1. Surface Conditions

Ground surface elevations at the Site and surrounding area range between approximately 430 and 450 feet (North American Vertical Datum [NAVD] 88; Figure 2). Ground surface elevations are highest (Elevation 450 feet) at the northwest corner of the WES Property and gradually slope downward to the south and southeast toward 196th Street SW. The southeast portion of the PFD Property is at approximately Elevation 430 feet. Between the WES and PFD Properties, there is an approximate 8-foot grade change with the WES Property being higher than the PFD Property. A vegetated slope separates the PFD Property boundary and west-adjacent WES Property. The vegetated slope ranges from approximately 10 to 20 feet wide along the property boundary with the widest section located west of the former dry cleaner space. A timber wall and a rockery wall support slope stability in the northwest and southwest portions of the PFD Property.

1.4.2. Soil Conditions

1.4.2.1. Soil Stratigraphy

RI activities completed between 2013 and 2021 identified a shallow fill layer extending from the ground surface to a depth ranging between approximately 3 and 6 feet below ground surface (bgs) overlying native glacial till deposits. The fill layer generally consists of silty sand with occasional gravel. The underlying glacial till deposits consists of medium dense silty sand with varying gravel content and occasional cobbles, becoming very dense with depth. The upper portion of the glacial till is weathered and may represent reworked native soil/fill. Weathered glacial till is generally encountered within the upper 8 to 15 feet and decreases in thickness from northwest to southeast. The glacial till extends to the base of the completed explorations to approximate depths of 40 to 58 feet bgs. Sand-rich beds or zones within the glacial till were encountered at approximate depths of 35 to 40 feet, which correspond to observed groundwater at the Site (further discussed in Section 1.4.3). As part of a recent (April 2021) field investigation, a significant silt/confining layer was encountered at approximately 58 feet bgs at location MW-3-Deep (Figure 4).

1.4.2.2. Soil Chemical Analytical Results

Soil samples collected as part of the RI were submitted for chemical analysis to evaluate the nature and extent of contamination at the Site. PCE and related contaminants were detected in soil samples obtained in the vicinity of the former dry cleaner at concentrations greater than MTCA cleanup levels at depth ranging from approximately 2 to 45 feet bgs.

The nature and extent of soil contamination based on the results of the RI are shown on Figures 4 and 6 through 9.

1.4.3. Groundwater Conditions

1.4.3.1. Local Hydrogeology

Two water-bearing zones were identified at the Site. The water-bearing zones include:

- A shallow water-bearing zone perched within the weathered glacial till layer located between approximately 8 and 21 feet bgs; and
- A deeper water-bearing zone contained in the identified sand-rich beds of the glacial till layer located between approximately 35 to 58 feet bgs.

The perched zone appears to be discontinuous in nature. The deeper water-bearing zone is relatively flat, with groundwater elevations ranging between 398.61 and 402.26 feet. The deeper water-bearing zone is located above a confining silt rich layer that has been identified at one deep boring (MW-3-Deep) and is suspected to be continuous across the Site. The groundwater flow direction was generally to the west/ southwest, with a horizontal hydraulic gradient of 0.0005 feet per foot (ft/ft) based on data at MW-1 and MW-10. The corresponding estimated average linear groundwater velocity calculated based on the available data and soil type range between approximately 0.0026 and 0.0029 feet per day (approximately 0.95 to 1.08 feet/year).

1.4.3.2. Groundwater Chemical Analytical Results

Groundwater samples collected as part of the RI identified concentrations of PCE and related contaminants exceeding MTCA cleanup levels beneath the former dry cleaner. PCE contaminated groundwater extends to the north and south and to the west beneath the eastern portion of the WES Property. The results of the groundwater monitoring data coupled with the presence of dense glacial till soil, a relatively flat groundwater gradient and number of years since the dry cleaner last operated (more than 30 years ago), suggest that contaminants in groundwater have likely reached equilibrium conditions.

As described in Section 1.4.2.1, a significant silt/confining layer was encountered at MW-3-Deep at approximately 58 feet bgs (Figure 4) during the recent (April 2021) field investigation; the silt/confining layer represents a vertical contamination bounding layer. A review of the regional geology suggests that this bounding layer is wide-spread throughout the area. In addition, discrete-depth groundwater samples collected as part of the April 2021 field investigation provide additional evidence that that vertical extent of groundwater contamination is limited. At MW-3-Deep, PCE was detected at a concentration greater than the MTCA Method A cleanup level in discrete grab groundwater samples collected at 40 and 50 feet bgs. At 60 feet bgs, PCE was detected at a concentration less than the MTCA Method A cleanup level.

The extent of groundwater contamination based on the RI is shown on Figures 5 through 9.

1.4.4. Vapor Intrusion Evaluation

1.4.4.1. PFD Property

Sub-slab soil gas sampling was conducted in April 2021 at the PFD Property strip mall building to further evaluate the potential for vapor intrusion (VI). As part of this investigation, seven sub-slab soil vapor samples, SV-1 through SV-7, were obtained beneath the strip mall concrete slab-on-grade. The approximate soil vapor sample locations are shown on Figure 10. Results of the sub-slab sampling indicated concentrations of PCE in soil vapor samples SV-2, SV-3, SV-4 and SV-7 at concentrations exceeding the sub-slab soil vapor screening levels for commercial (1,700 micrograms per cubic meter [$\mu g/m^3$]) and residential (320 $\mu g/m^3$) uses. The detected concentration of TCE in one sample, SV-2, also exceeded the sub-slab soil vapor screening levels for commercial (110 $\mu g/m^3$) and residential (11 $\mu g/m^3$). Other PCE breakdown products were not detected in the April 2021 sub-slab soil vapor samples collected. In general, the detected PCE/TCE concentrations in sub-slab soil vapor were the highest in the vicinity of the former dry cleaner and adjacent tenant space along the western portion of the strip mall.

In 2013, indoor air was sampled within the PFD Property strip mall building. In accordance with Ecology's Draft Guidance for Evaluating Soil Vapor in Washington State (Ecology 2009), sample locations were selected to represent both indoor air in the potential "worse case" locations corresponding to the PCE/TCE-impacted areas and the former dry cleaner tenant space, as well as "background/control" sample locations. Indoor air samples were collected to represent periods of minimal disturbance (i.e., the spaces were not occupied, doors and windows closed, and all ventilation systems were not operating). Results of the sampling event indicated that concentrations of PCE and breakdown products were less than the indoor air cleanup levels[2] with the exception of vinyl chloride (VC) within the Carniceria Grocery (Figure 10), which was only slightly above the indoor air cleanup level. It is important to note that VC has not been detected in soil, soil gas or groundwater at the Site, and therefore, is not likely attributed to historical dry cleaner releases.

Based on the results of the sub-slab soil vapor sampling exceeding the PCE screening levels for commercial uses and the length of time (8 years) that has passed since indoor air samples were previously obtained in the PFD Property strip mall building, indoor air sampling to evaluate current conditions is anticipated to occur in the near future.

The extent of soil gas concentrations based on the RI is shown on Figure 10.

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[2] At the time of the 2013 study, indoor/outdoor air sample results were compared to Cleanup Level and Risk Calculation (CLARC) Guidance – Online Database Method B Air Cleanup Levels – September 2012. Subsequent review of the indoor/outdoor air results relative to the current CLARC database dated February 2021 confirm that detected concentrations are less than the current MTCA Method B cleanup levels.

1.4.4.2. WES Property

In September 2016, GeoEngineers conducted a VI evaluation for the WES building located on the west-adjacent property in accordance with Ecology's 2016 Draft Vapor Intrusion Guidance (Ecology 2016b) based on the April 2016 groundwater monitoring result at MW-7 (Figure 5). At this location, PCE was detected in groundwater at a concentration of 270 µg/L which exceeded the MTCA screening level for the protection of indoor air (23 µg/L). Based on this screening level exceedance, GeoEngineers obtained a soil gas sample at SG-1 (Figure 10) at a depth of approximately 5 feet bgs. SG-1 was positioned near the location of MW-7 to further evaluate VI potential. PCE in the soil gas sample at SG-1 was detected at a concentration of 14,800 µg/m^3 which exceeded the MTCA sub-slab soil gas screening level of 320 µg/m^3. TCE in the soil gas sample at SG-1 was detected at a concentration of 1.07 µg/m^3 which was less than MTCA sub-slab soil gas screening level of 12 µg/m^3 (current screening level is 11 µg/m^3). Other breakdown products including cis- and trans-DCE, VC, and chloroform were not detected.

GeoEngineers further evaluated VI potential by using an analytical model to predict indoor air concentrations for the WES building base on the soil vapor sample result. Indoor air concentrations predicted by the model were determined to be 19 µg/m^3 for PCE. This concentration was then compared to the acceptable indoor air exposure threshold for a commercial worker. The acceptable commercial worker indoor air PCE concentration threshold has been calculated to be 51 µg/m^3 assuming an adult worker present in the WES building for 10 hours per day, 250 days a year for 20 years. Based on a comparison of the predicted indoor air concentration to the acceptable commercial worker threshold, the detected PCE concentration at SG-1 did not pose an unacceptable risk for VI into the WES building.

Subsequent sub-slab soil gas sampling beneath the WES building in March 2019 and February 2020 identified concentrations of PCE greater than the MTCA sub-slab soil gas screening level at multiple locations within the footprint of the building (Figure 10). Concentrations of TCE were below the MTCA sub-slab soil gas screening level at each of the locations sampled. In conjunction with the sub-slab soil gas sampling, indoor and outdoor air samples were also collected to evaluate risk for VI into the WES building. The results of the indoor/outdoor air sampling confirmed the results of the initial modeling used to evaluate commercial worker protection. At each of the sampling locations, concentrations of PCE and TCE were less than both the MTCA screening levels for protection of commercial workers and the MTCA cleanup levels for indoor air, except for location IA-1 positioned in the southern portion of the WES building. At location IA-1, detected concentrations of PCE and TCE exceeded the indoor air cleanup levels. However, the detected concentrations at this location were less than the screening levels for protection of commercial workers (i.e., the current land use). Additionally, concentrations of PCE and TCE in sub-slab soil gas samples (SSV-1 and SSV-2) nearest to the IA-1 sample location either were not detected or were less than Ecology's sub-slab screening levels for both commercial worker and residential use scenarios.

2.0 BASIS FOR CLEANUP ACTION

2.1. Cleanup Action Objectives

The cleanup action objectives (CAOs) are to eliminate, reduce, or otherwise control to the extent feasible and practicable, unacceptable risks to human health and the environment posed by Site-related hazardous substances in media of concern in accordance with the MTCA Cleanup Regulation (WAC 173-340) and other applicable regulatory requirements. Specifically, the CAOs for the cleanup action are to mitigate risks associated with the following potential exposure routes and receptors:

- Contact (dermal, incidental ingestion or inhalation) with contaminated soil by construction workers during future Site redevelopment or renovation.
- Leaching of contaminants contained within the soil column to groundwater.
- Contact (dermal or incidental ingestion) with contaminated groundwater by commercial workers, visitors and/or future residents.
- Contaminant migration of soil vapor via vapor intrusion into indoor air and inhalation by commercial workers, visitors and/or future occupants.

CAOs form the basis for evaluating and selecting remedial technologies and cleanup actions that will be successful. CAOs consist of location-, chemical- and medium-specific goals for protecting human health and the environment. CAOs are dependent on the chemicals and pathways that represent a risk to people and natural resources associated with a site. Development of CAOs involves: (1) identification of applicable or relevant and appropriate requirements (ARARs) that set the framework and requirements for the development of cleanup standards and implementation of a cleanup action; (2) development of cleanup standards and points of compliance at which an acceptable risk level can be attained; and (3) identification of the locations and media requiring cleanup based on selected cleanup standards.

2.2. Potentially Applicable or Relevant and Appropriate Requirements

Under WAC 173-340-710, MTCA requires that cleanup actions comply with all legally applicable local, state and federal laws, and requirements that are legally applicable and determined by Ecology to be relevant and appropriate requirements for the cleanup site. Legally "applicable" requirements under MTCA are those cleanup standards, standards of control, and other human health and environmental protection requirements, criteria, or limitations adopted under state or federal law that specifically address a hazardous substance, cleanup action, location, or other circumstances at a site (WAC 173-340-200). "Relevant and appropriate" requirements are cleanup standards, standards of control, and other human health and environmental requirements, criteria, or limitations established under state or federal law that, while not legally applicable to the hazardous substance, cleanup action, location, or other circumstance at a site, address problems or situations sufficiently similar to those encountered at the site that their use is well suited to the particular site (WAC 173-340-200).

Cleanup actions to address Site contaminants will be performed pursuant to MTCA (Revised Code of Washington [RCW] 70A.305) and its implementing Cleanup Regulation (WAC 173-340) as an independent action under the VCP. Other local, state, and/or federal laws and regulations that are currently known to be applicable to the cleanup action are the following:

- MTCA and its implementing Cleanup Regulation (RCW 70A.305; Chapter 173-340 WAC)
- Minimum standards for well construction and decommissioning (RCW 18.104; Chapter 173-160 WAC)
- State Environmental Policy Act (SEPA) (RCW 43.21C, Chapters 197-11 and 173-802 WAC)
- Water Pollution Control Act (RCW 90.48)
- National Pollution Discharge Elimination System Program (Chapter 173-220 WAC)
- Solid and Hazardous Waste Management Act (RCW 70A.300)
- Dangerous Waste Regulations (173-303 WAC)

- Washington Clean Air Act (RCW 70A.15)
- Ambient Air Quality Standards (Chapter 173-746 WAC)
- General Regulations for Air Pollution Sources (WAC 173-400)
- Regulation I, Articles 5 and 6 of the Puget Sound Clean Air Agency
- Washington Industrial Safety and Health Act (RCW 49.17)
- Federal Occupational Safety and Health Act (29 Code of Federal Regulations 1910, 1926)
- National Historic Preservation Act (16 USC 470 et seq. Section 106)
- Lynnwood Public Works Permits (wastewater, utilities, Right-of-Way, industrial waste discharge) and other City requirements as appropriate.

ARARs and their descriptions/applicability are presented in Table 1. Necessary permits will be obtained prior to implementing the cleanup action.

2.3. Cleanup Standards

Cleanup standards consist of: (1) cleanup levels that are protective of human health and the environment; (2) the point of compliance at which the cleanup levels must be met; and (3) additional regulatory requirements, specified in applicable state and federal laws, that apply to a cleanup action because of the type of action and/or the location of the Site. Preliminary cleanup levels (PCULs) and points of compliance developed for media of concern as part of the RI are expected to be adopted as final cleanup levels by Ecology for the Site and serve as the basis for developing CAOs, evaluating remedial alternatives and selecting the preferred remedial alternative.

2.3.1. Proposed Soil Cleanup Levels

PCULs for soil were developed based on zoning (i.e., City Center Core/commercial and retail), current and anticipated future land use. The soil PCUL for PCE and breakdown products are MTCA Method A for Unrestricted Land Use. Where there is no Method A cleanup level for a particular compound, the PCUL is the MTCA Method B formula value (Eq. 747-1) for the protection of groundwater is selected as the PCUL. Soil PCULs were selected based on the following transport and exposure pathways:

- **Site workers, visitors and/or future occupants in contact with soil** – The majority of the Site is covered by pavement or buildings except for a few localized areas of landscaping, which has at least 3 or more inches of topsoil or vegetative cover at the surface. The opportunity for direct contact exposures to soil under current/future conditions is limited to construction or utility workers involved in underground utility work at the Site. Although the opportunity for direct exposure to individuals other than Site workers is limited, the soil PCULs are based on unrestricted land use to be protective of visitors and/or future occupants that may come in contact with the soil under future Site uses.
- **Soil to groundwater transport pathway** – PCE and breakdown products likely leached from soil through the vadose zone into groundwater. Dissolved-phase PCE was identified in discontinuous zones of perched groundwater at approximate depths of 8 to 21 feet bgs and in deeper groundwater at approximate depths of 27 to 51.5 feet bgs. The soil PCULs are based on the protection of groundwater (as drinking water) for leaching of PCE and breakdown products through the vadose zone.

WAC 173-340-7940 requires a Terrestrial Ecological Evaluation (TEE) to be completed at sites where there has been a release of hazardous substances to soil. The TEE is intended to assess potential ecological risks (i.e., plants and animals that could be affected by contamination). A TEE was performed as part of the RI and it was determined that the Site is excluded from the MTCA TEE requirement because "there is less than 1.5 acres of contiguous, undeveloped land on the Site or within 500 feet of any area of the Site (WAC 173-340-7491[1][c][i])." Therefore, contamination at the Site does not pose a risk to terrestrial ecological receptors due to the extensive commercial development and surface pavement present in the surrounding area.

2.3.2. Proposed Groundwater Cleanup Levels

PCULs for groundwater were developed based on zoning (i.e., City Center Core/commercial and retail), current and anticipated future land use. The groundwater PCUL for PCE and breakdown products is the MTCA Method A groundwater cleanup level. Where there is no Method A cleanup level for a particular compound, the PCUL is the MTCA Method B Standard Formula value (Eq. 720-1 and 720-2) for drinking water (lowest of carcinogen or non-carcinogen, as appropriate). Groundwater PCULs were selected based on the following transport and exposure pathways:

- **Site workers in contact with groundwater** – Groundwater at the Site is currently not used as a source of drinking water. Therefore, the opportunity for direct contact exposures to groundwater under current conditions is limited to construction or utility workers involved in underground utility work at the Site. Construction workers could be exposed to groundwater during future Site redevelopment.
- **Groundwater as drinking water** – Although groundwater is not a current source of drinking water, it cannot be ruled out as a potential future source. Therefore, the groundwater PCULs are based on protection of groundwater beneficial uses.

2.3.3. Proposed Indoor Air Cleanup Levels

PCULs for indoor air were developed based on zoning (i.e., City Center Core/commercial and retail), current and anticipated future land use and per Ecology's December 31, 2019, Opinion Letter (Ecology 2019). The PCULs for PCE and breakdown products are based on the MTCA Method B indoor air cleanup levels for unrestricted land use, although indoor air screening levels based on a commercial worker scenario are also considered based on current land use. The indoor air PCULs were selected based on the following transport and exposure pathways:

- **Soil vapor intrusion and indoor air inhalation by commercial workers, visitors and/or future occupants** – Soil vapor (i.e., the air in the pore space between soil grains in the unsaturated zone) can be affected by volatilization of PCE and other breakdown products from soil or groundwater. The risk of exposure from soil vapor is by intrusion/seepage from the source area into the indoor air and subsequent inhalation by commercial workers, visitors and/or future occupants.

2.3.4. Points of Compliance

Points of compliance are the points on the Site where soil, soil gas and groundwater cleanup levels shall be attained.

2.3.4.1. Soil

The point of compliance for direct contact with soil is from the ground surface to 15 feet bgs (per WAC 173-340-740[6]). However, because contaminated groundwater is present at the Site, the point of compliance for soil is throughout the Site.

2.3.4.2. Groundwater

The standard point of compliance for groundwater is throughout the Site.

2.3.4.3. Soil Vapor

The point of compliance for soil vapor is ambient air throughout the Site.

2.4. Contaminants of Concern

Contaminants of concern (COCs) include potentially hazardous or toxic compounds, which have a history of use at the Site, or which were detected in environmental media during environmental investigations. Potential COCs that were evaluated during the RI included benzene, ethylbenzene, toluene and total xylenes (BETX), petroleum hydrocarbons (gasoline-, diesel- and lube oil-range hydrocarbons) and chlorinated solvents (HVOCs). Based on the RI findings, petroleum hydrocarbons and BETX were not detected, and are therefore not considered COCs for the Site. PCE was the most frequently detected HVOC followed by TCE, cis-DCE and trans-DCE. Although VC does not appear to be associated with the ALDC Site, VC was retained as a Site COC because it is a breakdown product of PCE.

2.5. Areas and Media Requiring Cleanup Action Alternative Evaluation

The areas and media requiring remedial alternative evaluation were identified based on locations and concentrations of the PCE and breakdown products exceeding PCULs. The media requiring cleanup action alternative evaluation include soil, soil gas and groundwater.

3.0 CLEANUP ACTION ALTERNATIVE DEVELOPMENT

3.1. Identification and Screening of Remedial Technologies

Potentially applicable remedial technologies for Site COCs in media of concern were screened and evaluated for developing cleanup action alternatives in accordance with MTCA requirements (WAC 173-340-350). Sources of information used to develop the list of remedial technologies include United States Environmental Protection Agency (EPA) publications and databases, vendor information, and professional experience gained at similar sites.

Under MTCA, remedial alternatives are developed from remedial technologies that are screened and identified as capable of meeting cleanup requirements to achieve the CAOs. Initial screening of remedial technologies allows development of a range of tools that can be used individually or in combination to address contamination at the Site. The screening process determines the most appropriate technologies and process options for addressing COCs in soil, soil gas and groundwater based on their expected implementability, reliability and relative cost as follows:

- **Implementability** – This evaluation encompasses both technical and administrative feasibility of implementing a technology. Aspects of implementability include the ability to obtain permits, the availability of treatment methods, physical conditions of the site, and availability of required equipment and skilled workers.

- **Effectiveness** – This evaluation focuses on: (1) the potential effectiveness of a technology in handling the estimated areas or volumes of media and meeting CAOs; (2) the potential impacts to human health and the environment during the construction and implementation phase; and (3) how proven and reliable a technology is with respect to the contaminants and conditions at the site.
- **Cost** – This evaluation takes into consideration relative capital, and operation and maintenance (O&M) cost rather than detailed estimates. During the screening process, the relative capital and O&M cost between alternatives (based on engineering judgement) is evaluated as to whether costs are high, low, or moderate relative to the other technologies. Since remedial alternatives and associated quantities are not defined during technology screening stage, relative cost is presented qualitatively as a range rather than quantitatively.

Remedial technologies to address COCs in media of concern are discussed in the following sections. In general, remedial technologies that had limited implementability, low effectiveness, and/or high relative cost were screened out and the most appropriate technologies were retained for use in the development of remedial alternatives. Technologies retained through the screening process were selected as is or combined into remedial alternatives, as appropriate, for a detailed alternative evaluation. Under MTCA, criteria used to evaluate cleanup alternatives developed to address Site contaminants include threshold requirements that a cleanup action shall: (1) protect human health and the environment; (2) comply with cleanup standards; (3) comply with applicable state and federal laws; and (4) provide for compliance monitoring. In addition, other MTCA requirements considered when selecting from cleanup action alternatives that fulfill the threshold requirements include the use permanent solutions to the maximum extent practicable, providing for a reasonable restoration time frame, and consideration of public concerns. A detailed description of the MTCA evaluation criteria is presented in Section 4.1.

3.1.1. Remedial Technologies for Soil

Descriptions and screening of applicable remedial technologies for soil are presented in Table 2. The following are the remedial technologies for soil which were retained for development of remedial alternatives:

- **Source area removal including excavation and offsite disposal to a permitted landfill** – Source removal through excavation and off-site disposal is applicable to portions of the Site that are readily accessible. PCE and/or breakdown products at concentrations exceeding the PCULs are present in soil extending vertically from the ground surface to depths of at least 45 feet bgs. Without extensive shoring systems to access soil contamination at depth, the vertical extent of source removal is limited and would therefore target the upper 6 feet in portions of the Site within the source area to: (1) immediately addresses the potential for direct human exposure; (2) allow for worker protection during future redevelopment of the PFD Property; and (3) reduce the potential for contaminant migration to groundwater through leaching. The PFD plans to demolish the strip mall building within approximately the next 2 years which would allow access to the contaminated soil beneath the former ALDC tenant space (source area).
- **In-situ treatment including enhanced anaerobic bioremediation, soil vapor extraction (SVE) and thermal conduction heating** – In-situ treatment technologies are applicable to portions of the Site that are readily accessible, including beneath the PFD strip mall building where the ALDC was formerly located (following planned demolition of the strip mall) and surrounding area. The presence of the WES building practically limits the lateral extent of in-situ treatment for addressing Site contamination.

Remediation of contamination adjacent to/beneath the WES building would therefore rely on natural processes and/or implementation of groundwater treatment technologies as described below in Section 3.1.2.

- **Containment and capping including low permeability caps comprised of asphalt or concrete pavement, buildings with concrete slab on grade and permeable soil cover within landscape areas** – Containment technologies are applicable to prevent direct exposure to site workers, visitors and/or future occupants as well as limit stormwater infiltration that may cause leaching and the downward migration of contaminants to groundwater.
- **Institutional controls including environmental covenants and land use restrictions** – Institutional controls are applicable in combination with other technologies to ensure the long-term effectiveness of the cleanup action. Institutional controls would only apply to portions of the Site where residual contamination remains in place at concentrations exceeding the PCULs. Institutional controls would be established to protect site workers, visitors and/or future occupants by providing notice of site conditions and provide requirements to prevent exposure to contaminants during any future soil disturbance in portions of the PFD and/or WES Properties where residual contamination remains in place.

3.1.2. Remedial Technologies for Groundwater

Descriptions and screening of applicable remedial technologies for groundwater are presented in Table 3. Several remedial technologies for addressing groundwater contamination beneath the WES building were evaluated and determined to not be feasible due to the presence of this structure. It was determined that the cost and impracticability of removing the WES building to gain access to this contamination results in only retaining remediation methods for residual contamination beneath the WES building that incorporate in-situ treatment technologies at the building perimeter to enhance natural attenuation processes beneath the WES building (Alternatives 2, 3 and 4, see Sections 3.2.2, 3.2.3 and 3.2.4) or natural attenuation processes alone (Alternative 1 only, see Section 3.2.1). Based on the results of screening, the following are the remedial technologies for groundwater that are retained for development of remedial alternatives:

- **In-situ treatment including chemical reduction, enhanced anaerobic bioremediation and air sparging (AS) coupled with SVE** –In-situ treatment technologies are applicable to portions of the Site that are readily accessible, including beneath the strip mall where the ALDC was formerly located (following planned demolition of the strip mall) and surrounding area. As noted above, the presence of the WES building practically limits the lateral extent of in-situ treatment for addressing Site contamination. Remediation of contamination adjacent to/beneath the WES building would therefore rely on natural processes that would be enhanced through the reduction in contaminant mass by source removal on PFD Property and/or in-situ treatment.
- **Monitoring to assess attenuation of contaminants in groundwater via natural processes** – Monitored natural attenuation is applicable for portions of the Site in which residual contamination remains in place at concentrations exceeding the PCULs following active cleanup. Monitored natural attenuation would be utilized to evaluate plume stability and overall mass reduction over time.
- **Institutional controls including environmental covenants and groundwater use restrictions** – Institutional controls are applicable in combination with other technologies to ensure the long-term effectiveness of the cleanup action. Institutional controls would only apply to groundwater at the Site where residual contamination remains in place at concentrations exceeding the PCULs. Institutional

controls would be established to protect site workers, visitors and/or future occupants by providing notice of site conditions and limit the use of groundwater as drinking water in portions of the PFD and/or WES Properties where residual contamination remains in place.

3.1.3. Remedial Technologies for Soil Vapor

Descriptions and screening of applicable remedial technologies for soil gas are presented in Table 3. Based on the results of screening, the following are the remedial technologies for soil gas that are retained for development of remedial alternatives[3]:

- **In-situ treatment using SVE** – SVE treatment technologies are applicable to portions of the Site that are readily accessible, including beneath the strip mall where the ALDC was formerly located (following planned demolition of the strip mall) and surrounding area. As previously noted, the presence of the WES building practically limits the extent of SVE treatment for addressing soil vapor. Results of indoor air sampling completed for the WES building (Section 1.4.4) confirm that concentrations of PCE and breakdown products are below screening levels for commercial workers (current land use).
- **Monitoring to assess sub-slab soil gas concentrations and indoor/outdoor air quality** – Compliance monitoring is applicable for portions of the Site in which there is a potential for vapor intrusion into enclosed structures and subsequent inhalation by commercial workers, visitors and/or future occupants.
- **Institutional controls including environmental covenants and land use restrictions** – Institutional controls are applicable in combination with other technologies to ensure the long-term effectiveness of the cleanup action. Institutional controls would only apply to portions of the Site where residual contamination remains in place at concentrations and under site conditions which potentially allow intrusion into enclosed structures at concentrations exceeding the indoor air PCULs. Institutional controls would be established to protect site workers, visitors and/or future occupants by providing notice of site conditions and prevent ground disturbance activities that could result in the creation of vapor migration pathways into the enclosed structures (i.e., penetration of building foundations).

3.2. Description of Cleanup Action Alternatives

Cleanup action alternatives were developed by combining technologies and process options retained through the remedial technology screening evaluation (Tables 2 through 4) to address COCs in media of concern to meet the CAOs. Cleanup action alternatives developed for the Site are summarized in Table 5 and described in the following sections. Four alternatives were developed which represent a reasonable number and range of potentially applicable cleanup actions to provide a further basis for comparative evaluation. The cleanup action alternatives developed for the Site are based on a conceptual-level design for implementation of individual technologies described above. The design parameters used to develop the alternatives are based on engineering judgment and the current knowledge of Site conditions. The final design for the preferred cleanup action alternative will incorporate any subsequent characterization and analysis of Site media as well as specific plans for redevelopment of the Site in order to better define and

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[3] Remedial technologies retained for soil and groundwater (Sections 3.1.1 and 3.1.2) will also reduce contaminant levels in soil vapor and indoor air.

describe the cleanup action and associated costs. The comparative analysis for the cleanup action alternatives summarized below is presented in Section 4.2.

3.2.1. Alternative 1 – Shallow Source Area Removal and Capping with Institutional Controls and Monitored Natural Attenuation

Cleanup Action Alternative 1 relies on the removal of source area material followed by site restoration in conjunction with containment (i.e., protective caps) and institutional controls to prevent direct contact and the migration of remaining contaminants contained in the subsurface. Soil removal would address the source area on the PFD Property which will be readily accessible following strip mall demolition and allow for worker protection during future redevelopment of the PFD Property. Remediation of residual contamination remaining in place beneath portions of the PFD and WES Properties following source removal relies on natural attenuation processes. Following soil removal, placement of protective caps and implementation of institutional controls and long-term groundwater monitoring would be performed to verify plume stability and overall contaminant mass reduction over time. In addition, long-term vapor monitoring would be performed to evaluate the potential exposure to commercial workers, visitors and/or future occupants from residual contamination remaining in place. Implementation of this alternative would occur following demolition of the existing strip mall building to facilitate access to contaminated soil beneath the footprint of the former ALDC tenant space. The specific actions to be performed at the Site as part of Cleanup Action Alternative 1 are summarized below.

Active Cleanup:

- Develop and implement an Engineering Design Report (EDR) describing the plans and procedures that will be used for cleanup of the Site. The EDR would establish performance criteria for use during construction (i.e., soil removal) and during long-term groundwater/vapor monitoring to evaluate compliance with the cleanup standards. The EDR would also include a Compliance Monitoring Plan (CMP) to describe the procedures for performance/confirmation sample collection, sample frequency, data review, quality control and reporting for evaluating and documenting soil conditions during construction and post-construction groundwater and vapor conditions.
- Decommission monitoring wells MW-2, MW-3, MW-3D, MW-15 and pilot study injection well RW-1 located within the footprint of the remedial excavation by a Washington State licensed driller.
- Removal followed by off-site disposal of an estimated 1,400 in-place cubic yards (bcy) of soil to a permitted landfill from the source area (former ALDC). This alternative consists of excavating soil on the PFD Property within the source area in the upper 6 feet bgs corresponding to depths where contaminants could otherwise be encountered during future PFD Property redevelopment. The approximate soil removal area is shown on Figure 11. Excavated soil would be disposed under a "Contained-In" Determination (CID) at a permitted off-site disposal facility. Remedial excavations will be backfilled with clean fill and overburden material generated during construction that is determined to be both structurally and chemically suitable for reuse and/or imported structural fill. Verification soil samples would be collected to document soil conditions at the final limit of excavation.
- Place new asphalt pavement within the footprint of the soil removal area and maintain the existing asphalt/concrete pavement and permeable soil cover within the landscape areas in other portions of the Site to prevent stormwater infiltration and contaminant leaching/migration through the soil column as well as to provide a physical barrier to prevent direct contact to remaining Site contaminants.

- Install replacement monitoring wells (e.g., MW-2A and MW-3A) by a licensed driller following site restoration.
- Complete post-construction groundwater monitoring utilizing the existing network of monitoring wells (MW-1, MW-4 through MW-17) and replacement monitoring wells (MW-2A and MW-3A) following soil removal activities and restoration. It is assumed that groundwater monitoring would be competed on a quarterly basis for up to 1 year to evaluate and document groundwater conditions following construction excavation and restoration to establish baseline conditions for long-term monitoring (described below).
- Implement a deed restriction (environmental covenant) compliant with the Uniform Environmental Covenants Act and with Ecology's model environmental covenant to address residual contamination that remains on both the PFD and WES Properties. The environmental covenant would be applicable only to those areas in which residual contamination exceeds the cleanup standards (Section 2.3) and would be established to: (1) protect site workers, visitors and/or future occupants by providing notice of site conditions; (2) require that future ground disturbance activities at the PFD and WES Properties prevent exposure to soil with residual contamination at concentrations greater than the PCULs; (3) prevent activities that would create preferential soil vapor migration pathways into enclosed structures; and (4) restrict the use of groundwater. Long-term monitoring and maintenance (described below) would then be used to verify the overall effectiveness of the cleanup action.

Long-Term Monitoring and Maintenance:

- Develop and implement an Engineering and Institutional Controls Monitoring Plan to: (1) identify the engineering and institutional controls that are being utilized at the Site; (2) provide guidelines for the monitoring and maintenance of the Site controls to ensure protection of human health and the environment; and (3) provide guidelines on the proper handling and disposal of soil and groundwater encountered during future Site maintenance and/or development activities.
- Complete long-term groundwater monitoring utilizing the existing network of monitoring wells (MW-1, MW-4 through MW-17) and replacement monitoring wells (MW-2A and MW-3A) following implementation of the environmental covenants for the WES and PFD Properties to verify plume stability and natural attenuation performance. Performance criteria based on groundwater screening levels for the protection of vapor intrusion for commercial/unrestricted land use, established by the EDR as appropriate, will be used to evaluate long-term compliance with the cleanup standards. For the purpose of this FS, it is assumed that groundwater monitoring would be competed once per Ecology Five Year Periodic Review period for an additional 50 years targeting the dry season months[4]. This duration is based on a trend analysis of the groundwater data at MW-3 located within the source area. After this time period, Ecology would be consulted to determine additional groundwater monitoring requirements (if any) for the Site.

Complete indoor/outdoor air and/or sub-slab soil vapor monitoring to evaluate the potential for vapor intrusion. Performance criteria based on indoor/outdoor and/or sub-slab soil vapor cleanup/screening

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[4]Groundwater monitoring data collected as part of the RI show that the highest concentration of Site COCs are observed during the summer dry season months. Long-term monitoring would target the dry season months to represent a worst case scenario in evaluating long-term plume stability and natural attenuation performance.

levels for commercial/unrestricted land use, established by the EDR as appropriate, will be used to evaluate compliance with the cleanup standards. For the purpose of this FS, it is assumed that indoor air and/or soil vapor monitoring would be performed once per Ecology Five Year Periodic Review period for 50 years (consistent with long-term groundwater monitoring activities). After this time period, Ecology would be consulted to determine additional indoor/outdoor air and/or sub-slab soil vapor monitoring requirements (if any) for the Site. The estimated cost of Cleanup Action Alternative 1 is $2,280,000 (Table A-1, Appendix A). The cost estimate is in 2021 dollars, includes contingencies, and represents an order-of-magnitude cost estimate with a range of -30 percent to +50 percent based on EPA guidance (EPA 2000). Representative Site features such as pavement and representative monitoring wells that would be utilized to evaluate long-term groundwater conditions are shown on Figure 11.

3.2.2. Alternative 2 – Shallow Source Area Removal and Capping with In-Situ Enhanced Bioremediation, Biochemical Reduction and Institutional Controls

Cleanup Action Alternative 2 relies on the removal of shallow source area material followed by site restoration in conjunction with in-situ treatment utilizing enhanced bioremediation and biochemical reduction technologies, containment (i.e., protective caps) and institutional controls to prevent direct contact and the migration of remaining contaminants contained in the subsurface. In-situ treatment would focus on accessible portions of the Site with the highest observed contaminant concentrations (i.e., PFD Property and area east of the WES building). Remediation of residual groundwater contamination beneath the WES building relies on both the transport of biological and chemical reagents in groundwater downgradient from the injection area, and on natural attenuation processes. Performance monitoring would be completed during in-situ treatment to evaluate enhanced bioremediation performance and overall contaminant mass reduction within the treatment area. Long-term groundwater monitoring would then be performed to verify plume stability and contaminant mass reduction over time in portions of the Site with residual contamination. In addition, long-term vapor monitoring would be performed to evaluate potential exposure to commercial workers, visitors and/or future occupants from residual contamination remaining in place. Implementation of this alternative would occur following demolition of the existing strip mall building to facilitate access to contaminated soil beneath the footprint of the former ALDC tenant space. The specific actions to be performed at the Site as part of Cleanup Action Alternative 2 are summarized below.

Active Cleanup:

- Develop and implement an EDR describing the plans and procedures that will be used for cleanup of the Site. The EDR would establish performance criteria for use during construction (i.e., soil removal), in-situ treatment and during long-term groundwater/vapor monitoring to evaluate compliance with the cleanup standards. The EDR would also include a CMP to describe the procedures for performance/ confirmation sample collection, sample frequency, data review, quality control and reporting for evaluating and documenting soil conditions during construction, groundwater conditions during in-situ treatment and post-construction groundwater and vapor conditions. Decommission monitoring wells MW-2, MW-3, MW-3D, MW-15 and pilot study injection well RW-1 located within the footprint of the remedial excavation by a Washington State licensed driller.
- Removal followed by offsite disposal of an estimated 1,400 bcy of soil to a permitted landfill from the source area (former ALDC). This alternative consists of excavating soil on the PFD Property within the source area in the upper 6 feet bgs corresponding to depths where contaminants could otherwise be

encountered during future PFD Property redevelopment. The approximate soil removal area is shown on Figure 12. Excavated soil would be disposed under a CID at a permitted off-site disposal facility. Remedial excavations will be backfilled with clean fill and overburden material generated during construction that is determined to be both structurally and chemically suitable for reuse and/or imported structural fill. Verification soil samples would be collected to document soil conditions at the final limit of excavation.

- Place new asphalt pavement within the footprint of the soil removal area and maintain the existing asphalt/concrete pavement and permeable soil cover within the landscape areas in other portions of the Site to prevent stormwater infiltration and contaminant leaching/migration through the soil column as well as to provide a physical barrier to prevent direct contact to remaining Site contaminants.
- Install replacement wells (MW-2A and MW-3A) by a licensed driller following site restoration.
- Injection of reagents into the subsurface (i.e., nutrients, oxygen, or other amendments) to enhance bioremediation of chlorinated contaminants through metabolic reactions in conjunction with iron-based reagents to promote in situ biochemical reduction (ISCR) of PCE and its breakdown products. Injection point would target the area with the highest soil and groundwater contamination. Injection intervals would target both the shallow perched water-bearing zone (approximately 8 to 12 feet bgs) and the deeper water-bearing zone (approximately 35 to 58 feet bgs). It is anticipated that the zone of treatment influence would likely extend downgradient beneath the WES building through the dispersion and advection of reagents added to groundwater in the easternmost portion of the WES Property. Incorporate findings from the pilot study to evaluate overall design parameters and radius of influence for injection wells[5]. For FS level cost estimating purposes, up to 38 injection points utilizing standard drilling methods (i.e., hollow-stem auger, sonic or similar) and aboveground pumps to deliver the reagents into the subsurface with a focus on the saturated soils are anticipated to treat PCE contamination and breakdown products. For FS level planning purposes, it is assumed that in-situ enhanced bioremediation and biochemical reduction treatment will achieve compliance with the groundwater cleanup levels within the treatment area footprint (Figure 12) in approximately 5 to 7 years following injection based on a review of site specific conditions and case studies for similar sites, discussions with vendors and data evaluation, case studies for similar sites, discussions with vendors and professional judgment.
- Complete performance/compliance monitoring to evaluate groundwater conditions and contaminant concentrations within the treatment area utilizing a network of monitoring wells following soil removal activities, restoration and injection of reagents. It is assumed that performance/compliance monitoring would be initially competed on a quarterly basis for up to 1 year following initial reagent injection. Performance/compliance monitoring would then be completed on a semi-annual basis targeting the wet season and dry season months to verify plume stability and document contaminant mass reduction over time resulting from in-situ treatment (anticipated to be approximately 5 to 7 years). Note that additional rounds of reagent injection may be completed based on the performance monitoring results.
- Implement a deed restriction (environmental covenant) compliant with the Uniform Environmental Covenants Act and with Ecology's model environmental covenant to address residual contamination

[5] A pilot study to evaluate in-situ treatment utilizing enhanced bioremediation and biochemical reduction as a cleanup action alternative is currently being performed in accordance with an Ecology-approved Pilot Study Work Plan (GeoEngineers, 2021b and 2021c).

that remains on the PFD and/or WES Properties. Similar to Alternative 1, environmental covenants would be established for the PFD and/or WES Properties for only those areas in which residual contamination remains in-place at concentrations exceeding the cleanup standards (Section 2.3) and would be established to: (1) protect site workers, visitors and/or future occupants by providing notice of site conditions; (2) require that future ground disturbance activities prevent exposure to soil with residual contamination at concentrations greater than the PCULs; (3) prevent activities that would create preferential soil vapor migration pathways into enclosed structures; and (4) restrict the use of groundwater. Long-term monitoring and maintenance (described below) would then be used to verify the overall effectiveness of the cleanup action.

Long-Term Monitoring and Maintenance:

- Develop and implement an Engineering and Institutional Controls Monitoring Plan to: (1) identify the engineering and institutional controls that are being utilized at the Site; (2) provide guidelines for the monitoring and maintenance of the Site controls to ensure protection of human health and the environment; and (3) provide guidelines on the proper handling and disposal of soil and groundwater encountered during future Site maintenance and/or development activities.
- Complete long-term groundwater monitoring utilizing the existing network of monitoring wells (MW-1, MW-4 through MW-17) and replacement monitoring wells (MW-2A and MW-3A) following implementation of the environmental covenants for the WES and/or PFD Properties to verify plume stability and natural attenuation performance of the remaining residual groundwater contamination. Performance criteria based on groundwater screening levels for the protection of vapor intrusion for commercial/unrestricted land use, established by the EDR as appropriate, will be used to evaluate long-term compliance with the cleanup standards. For the purpose of this FS, it is assumed that groundwater monitoring would be competed once per Ecology Five Year Periodic Review period for an additional 15 years (based on the overall reduction of groundwater contamination [i.e., approximately 50 percent]) targeting the dry season months. After this time period, Ecology would be consulted to determine additional groundwater monitoring requirements (if any) for the Site.
- Complete indoor/outdoor air and/or sub-slab soil vapor monitoring to evaluate the potential for vapor intrusion. Performance criteria based on indoor/outdoor and/or sub-slab soil vapor cleanup/screening levels for commercial/unrestricted land use, established by the EDR as appropriate, will be used to evaluate compliance with the cleanup standards. For the purpose of this FS, it is assumed that indoor air and/or soil vapor monitoring would be performed once per Ecology Five Year Periodic Review period for 15 years (consistent with long-term groundwater monitoring activities). After this time period, Ecology would be consulted to determine additional indoor air/sub-slab soil vapor monitoring requirements (if any) for the Site.

The estimated cost of Cleanup Action Alternative 2 is $2,550,000 (Table A-2, Appendix A). The cost estimate is in 2021 dollars, include contingencies, and represent order-of-magnitude with a range of -30 percent to +50 percent based on EPA guidance (EPA 2000). Representative Site features such as pavement and representative monitoring wells that would be utilized to evaluate long-term groundwater conditions are shown on Figure 12.

3.2.3. Alternative 3 – Shallow Source Area Removal and Capping with In-Situ Air Sparging/Soil Vapor Extraction and Institutional Controls

Cleanup Action Alternative 3 relies on the removal of shallow source area material followed by site restoration in conjunction with AS and SVE, containment (i.e., protective caps) and institutional controls to prevent direct contact and the migration of remaining contaminants contained in the subsurface. In-situ treatment would focus on accessible portions of the Site with the highest observed contaminant concentrations (i.e., PFD Property and area east of the WES building). Remediation of residual groundwater contamination beneath the WES building relies on both the AS/SVE treatment within the zone of influence and on natural attenuation processes. Performance monitoring would be completed during is-situ treatment to evaluate AS/SVE system performance and overall contaminant mass reduction within the treatment area. Long-term groundwater monitoring would then be performed to verify plume stability and contaminant mass reduction over time in portions of the Site containing residual contamination. In addition, long-term vapor monitoring would be performed to evaluate potential exposure to commercial workers, visitors and/or future occupants from residual contamination remaining in place. Implementation of this alternative would occur following demolition of the existing strip mall building to facilitate access to contaminated soil beneath the footprint of the former ALDC tenant space. The specific actions to be performed at the Site as part of Cleanup Action Alternative 3 are summarized below.

Active Cleanup:

- Develop and implement an EDR describing the plans and procedures that will be used for cleanup of the Site. The EDR will establish performance criteria for use during construction (i.e., soil removal), in-situ treatment and during long-term groundwater/vapor monitoring to evaluate compliance with the cleanup standards. The EDR will also include a CMP, which will describe the procedures for performance/confirmation sample collection, sample frequency, data review, quality control and reporting for evaluating and documenting soil conditions during construction, groundwater conditions during in-situ treatment and post-construction groundwater and vapor conditions.
- Decommission monitoring wells MW-2, MW-3, MW-3D, MW-15 and pilot study injection well RW-1 located within the footprint of the remedial excavation by a Washington State licensed driller.
- Removal followed by offsite disposal of an estimated 1,400 bcy of soil to a permitted landfill from the source area (former ALDC). This alternative consists of excavating soil on the PFD Property within the source area in the upper 6 feet bgs corresponding to depths where contaminants could otherwise be encountered during future PFD Property redevelopment. The approximate soil removal area is shown on Figure 13. Excavated soil would be disposed under a CID at a permitted off-site disposal facility. Remedial excavations will be backfilled with clean fill and overburden material generated during construction that is determined to be both structurally and chemically suitable for reuse and/or imported structural fill. Verification soil samples would be collected to document soil conditions at the final limit of excavation.
- Place new asphalt pavement within the footprint of the soil removal area and maintain the existing asphalt/concrete pavement and permeable soil cover within the landscape areas in other portions of the Site to prevent stormwater infiltration and contaminant leaching/migration through the soil column as well as to provide a physical barrier to prevent direct contact to remaining Site contaminants.
- Install replacement wells (MW-2A and MW-3A) by a licensed driller following site restoration.

- Installation and startup of a AS/SVE treatment system that would target the area with the highest soil and groundwater contamination. In addition, a treatment compound would be installed to house the system controls, blowers and granulated activated carbon (GAC) vessels that would be used to capture contaminants in the soil vapor prior to discharge to the atmosphere. The zone of treatment influence would extend across to the easternmost margin of the WES Property. Prior to full-scale application, a pilot scale study would be performed to evaluate overall design parameters and radius of influence for AS wells. For FS level cost estimating purposes, up to 11 AS and 8 SVE wells are anticipated to treat PCE contamination and its breakdown products. This assumption is based on design parameters for an adjacent cleanup project (former Atlantic Richfield Company [ARCO 862] site [VCP No. NW2452, Cleanup Site ID No. 11235]) utilizing this remedial technology. For FS level planning purposes, it is assumed that in-situ AS/SVE treatment will achieve compliance with the groundwater cleanup levels within the treatment area (Figure 13) in approximately 5 to 7 years following system startup based on a review of site specific conditions, data evaluation, case studies for similar sites, discussions with vendors and professional judgment.
- Complete annual AS/SVE treatment system operation and maintenance on an as needed basis to ensure performance of system components and compliance with permitted atmospheric vapor discharges.
- Complete performance/compliance monitoring to evaluate groundwater conditions and contaminant concentrations within the treatment area utilizing a network of monitoring wells following soil removal activities, restoration and AS/SVE treatment system installation and startup. It is assumed that performance/compliance monitoring would be initially competed on a quarterly basis for up to one year AS/SVE system installation and startup. Performance/compliance monitoring would then be completed on a semi-annual basis targeting the wet season and dry season months to verify plume stability and document contaminant mass reduction over time resulting from in-situ treatment (anticipated to be approximately 5 to 7 years).
- Decommission the components of the in-situ AS/SVE treatment system including AS wells, SVE wells and treatment system compound and its associated components upon confirmation that the CAOs have been met.
- Implement a deed restriction (environmental covenant) compliant with the Uniform Environmental Covenants Act and with Ecology's model environmental covenant to address residual contamination that remains on the PFD and WES Properties. Similar to the previous alternatives, environmental covenants would be established for the PFD and/or WES Properties for only those areas in which residual contamination remains in- place at concentrations exceeding the cleanup standards (Section 2.3) and would be established to: (1) protect site workers, visitors and/or future occupants by providing notice of site conditions; (2) require that future ground disturbance activities prevent exposure to soil with residual contamination at concentrations greater than the PCULs; (3) prevent activities that would create preferential soil vapor migration pathways into enclosed structures; and (4) restrict the use of groundwater. Long-term monitoring and maintenance (described below) would then be used to verify the overall effectiveness of the cleanup action.

Long-Term Monitoring:

- Develop and implement an Engineering and Institutional Controls Monitoring Plan to: (1) identify the engineering and institutional controls that are being utilized at the Site; (2) provide guidelines for the monitoring and maintenance of the Site controls to ensure protection of human health and the environment; and (3) provide guidelines on the proper handling and disposal of soil and groundwater encountered during future Site maintenance and/or development activities.

- Complete long-term groundwater monitoring utilizing the existing network of monitoring wells (MW-1, MW-4 through MW-17) and replacement monitoring wells (MW-2A and MW-3A) following implementation of the environmental covenants for the WES and/or PFD Properties to verify plume stability and natural attenuation performance of the remaining residual groundwater contamination. Performance criteria based on groundwater screening levels for the protection of vapor intrusion for commercial/unrestricted land use, established by the EDR as appropriate, will be used to evaluate long-term compliance with the cleanup standards. For the purpose of this FS, it is assumed that groundwater monitoring would be competed once per Ecology Five Year Periodic Review period for an additional 15 years (based on the overall reduction of groundwater contamination [i.e., approximately 50 percent]) targeting the dry season months. After this time period, Ecology would be consulted to determine additional groundwater monitoring requirements (if any) for the Site.
- Complete indoor/outdoor air and/or sub-slab soil vapor monitoring to evaluate the potential for vapor intrusion. Performance criteria based on indoor/outdoor and/or sub-slab soil vapor cleanup/screening levels for commercial/unrestricted land use, established by the EDR as appropriate, will be used to evaluate compliance with the cleanup standards. For the purpose of this FS, it is assumed that indoor air and/or soil vapor monitoring would be performed once per Ecology Five Year Periodic Review period for 15 years (consistent with long-term groundwater monitoring activities). After this time period, Ecology would be consulted to determine additional indoor air/sub-slab soil vapor monitoring requirements (if any) for the Site.

The estimated cost of Cleanup Action Alternative 3 is $2,880,000 (Table A-3, Appendix A). The cost estimate is in 2021 dollars, include contingencies, and represent order-of-magnitude with a range of -30 percent to +50 percent based on EPA guidance (EPA 2000). Representative Site features such as pavement and representative monitoring wells that would be utilized to evaluate long-term groundwater conditions are shown on Figure 13.

3.2.4. Alternative 4 –In-Situ Thermal Conduction Heating with Soil Vapor Extraction, Capping, Monitored Natural Attenuation and Institutional Controls

Cleanup Action Alternative 4 relies on the Thermal Conduction Heating (TCH) and SVE and institutional controls to prevent direct contact and the migration of remaining contaminants contained in the subsurface. In-situ treatment would focus on accessible portions of the Site with the highest observed contaminant concentrations (i.e., PFD Property and area east of the WES building). Remediation of residual groundwater contamination beneath the WES building relies on both thermal treatment within the zone of influence and on natural attenuation processes. Performance monitoring would be completed during is-situ treatment to evaluate THC/SVE system performance and overall contaminant mass reduction within the treatment area. Long-term groundwater monitoring would then be performed to verify plume stability and contaminant mass reduction over time in portions of the Site containing residual contamination. In addition, long-term vapor monitoring would be performed to evaluate potential exposure to commercial workers, visitors and/or future occupants from residual contamination remaining in place. Implementation of this alternative would occur following demolition of the existing strip mall building to facilitate access to contaminated soil beneath the footprint of the former ALDC tenant space. The specific actions to be performed at the Site as part of Cleanup Action Alternative 4 are summarized below.

Active Cleanup:

- Develop and implement an EDR describing the plans and procedures that will be used for cleanup of the Site. The EDR will establish performance criteria for use during construction (i.e., soil removal), in-situ treatment and during long-term groundwater/vapor monitoring to evaluate compliance with the cleanup standards. The EDR will also include a CMP which will describe the procedures for performance/confirmation sample collection, sample frequency, data review, quality control and reporting for evaluating and documenting soil conditions during construction, groundwater conditions during in-situ treatment and post-construction groundwater and vapor conditions.
- Decommission monitoring wells MW-1, MW-2, MW-3, MW-3D, MW-15 and pilot study injection well RW-1 located within the footprint of the TCH treatment area by a Washington State licensed driller.
- Installation and startup of a TCH treatment system that would target the area with the highest soil and groundwater contamination. It is anticipated that the thermal treatment wells would be spaced at approximately 15 feet on center with heating elements placed in each well to transfer heat through the subsurface via conduction. A concrete thermal blanket would then be placed across the treatment surface area to limit heat loss near the ground surface. In addition to the installation of the thermal treatment wells, a network of SVE recovery wells would be installed throughout the treatment area to extract soil vapor and steam generated during the in-situ thermal treatment. A treatment compound would be installed to house the controls for the heating elements, blowers and GAC vessels to recover contaminants in the soil vapor before being discharged to the atmosphere. Prior to full-scale application, a pilot scale study would be performed to evaluate overall design parameters and radius of influence for TCH/SVE/Thermal monitoring wells. For FS level cost estimating purposes, up to 68 TCH wells, 19 SVE wells and 5 temperature monitoring wells are anticipated to treat PCE contamination and its breakdown products. For FS level planning purposes, it is anticipated that in-situ TCH treatment will achieve the soil cleanup objectives within approximately 1 to 2 years of operation based on a review of site specific conditions and data evaluation, case studies for similar sites, discussions with vendors and professional judgment.
- Install up to three monitoring well by a licensed driller within the treatment area to evaluate in-situ treatment performance.
- Complete performance/compliance monitoring utilizing a network of monitoring wells during in-situ thermal treatment to evaluate groundwater conditions and contaminant concentrations within the treatment area. It is assumed that groundwater monitoring would be competed on a quarterly basis for up to 2 years following system startup to verify plume stability and document contaminant mass reduction over time resulting from in-situ treatment.
- Decommission the components of the in-situ TCH treatment system including TCH wells, SVE wells, temperature monitoring wells, and treatment system compound and its associated components upon confirmation that the CAOs have been met.
- Place new asphalt pavement within the footprint of the thermal treatment area and maintain the existing asphalt/concrete pavement and permeable soil cover within the landscape areas in other portions of the Site to prevent stormwater infiltration and contaminant leaching/migration through the soil column as well as to provide a physical barrier to prevent direct contact to remaining Site contaminants.

- Implement a deed restriction (environmental covenant) compliant with the Uniform Environmental Covenants Act and with Ecology's model environmental covenant to address residual contamination anticipated to remain on the PFD and/or WES Properties. Similar to the previous alternatives, environmental covenants would be established for the PFD and/or WES Properties for only those areas in which residual contamination remains in place at concentrations exceeding the cleanup standards (Section 2.3) and would be established to: (1) protect site workers, visitors and/or future occupants by providing notice of site conditions; (2) require that future ground disturbance activities prevent exposure to soil with residual contamination at concentrations greater than the PCULs; (3) prevent activities that would create preferential soil vapor migration pathways into enclosed structures; and (4) restrict the use of groundwater. Long-term monitoring and maintenance (described below) would then be used to verify the overall effectiveness of the cleanup action.

Long-Term Monitoring and Maintenance:

- Develop and implement an Engineering and Institutional Controls Monitoring Plan to: (1) identify the engineering and institutional controls that are being utilized at the Site; (2) provide guidelines for the monitoring and maintenance of the Site controls to ensure protection of human health and the environment; and (3) provide guidelines on the proper handling and disposal of soil and groundwater encountered during future Site maintenance and/or development activities.
- Complete long-term groundwater monitoring utilizing the existing network of monitoring wells (MW-4 through MW-14, MW-16 and MW-17) and new monitoring wells following implementation of the environmental covenants for the WES and/or PFD Properties to verify plume stability and natural attenuation performance of the remaining residual groundwater contamination. Performance criteria based on groundwater screening levels for the protection of vapor intrusion for commercial/ unrestricted land use, established by the EDR as appropriate, will be used to evaluate long-term compliance with the cleanup standards. For the purpose of this FS, it is assumed that groundwater monitoring would be competed once per Ecology Five Year Periodic Review period for an additional 15 years (based on the overall reduction of groundwater contamination [i.e., approximately 50 percent]) targeting the dry season months. After this time period, Ecology would be consulted to determine additional groundwater monitoring requirements (if any) for the Site.
- Complete indoor/outdoor air and/or sub-slab soil vapor monitoring to evaluate the potential for vapor intrusion. Performance criteria based on indoor/outdoor and/or sub-slab soil vapor cleanup/screening levels for commercial/unrestricted land use, established by the EDR as appropriate, will be used to evaluate compliance with the cleanup standards. For the purpose of this FS, it is assumed that indoor air and/or soil vapor monitoring would be performed once per Ecology Five Year Periodic Review period for 15 years (consistent with long-term groundwater monitoring activities). After this time period, Ecology would be consulted to determine additional indoor air/sub-slab soil vapor monitoring requirements (if any) for the Site.

The estimated cost of Cleanup Action Alternative 4 is $4,400,000 (Table A-4, Appendix A). The cost estimate is in 2021 dollars, include contingencies, and represent order-of-magnitude with a range of -30 percent to +50 percent based on EPA guidance (EPA 2000). Representative Site features such as pavement and representative monitoring wells that would be utilized to evaluate long-term groundwater conditions are shown on Figure 14.

4.0 EVALUATION OF CLEANUP ALTERNATIVES

Evaluation criteria and a comparative analysis of the cleanup action alternatives developed for the Site are summarized in the following sections. Each alternative is evaluated with respect to the MTCA evaluation criteria and are compared to each other relative to their expected performance under each criterion. The components of the cleanup action alternatives are described above in Section 3.2 and are summarized in Table 5. A detailed evaluation of the alternatives relative to the MTCA evaluation criteria is presented in Table 6, and the results of the evaluation are summarized in Table 7. Concept design level cleanup action cost estimates for each alternative are presented in Appendix A.

4.1. Cleanup Alternative Evaluation Criteria

Threshold requirements for cleanup actions under MTCA and the additional criteria used to evaluate the cleanup action alternatives are described in the following sections.

4.1.1. Threshold Requirements

Cleanup actions performed under MTCA must comply with basic threshold requirements. Cleanup action alternatives that do not comply with the threshold requirements are not considered suitable cleanup actions under MTCA. As provided in WAC 173-340-360(2)(a), the four threshold requirements for remedial actions are that they must:

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

The following sections further describe the threshold requirements.

4.1.1.1. Protection of Human Health and the Environment

The results of cleanup actions performed under MTCA must ensure that both human health and the environment are protected.

4.1.1.2. Compliance with Cleanup Standards

Compliance with cleanup standards requires, in part, that cleanup levels are met at the applicable points of compliance. If a cleanup action does not comply with cleanup standards, the cleanup action is an interim action, not a cleanup action. Where a cleanup action involves containment of hazardous substance concentrations exceeding cleanup levels at the point of compliance, the cleanup action may be determined to comply with cleanup standards, provided the requirements specified in WAC 173-340-740(6)(f) are met.

4.1.1.3. Compliance with Applicable State and Federal Laws

Cleanup actions conducted under MTCA must comply with applicable state and federal laws. The term “applicable state and federal laws” includes legally applicable requirements and those requirements that Ecology determines to be relevant and appropriate as described in WAC 173-340-710.

4.1.1.4. Provision for Compliance Monitoring

The cleanup action must allow for compliance monitoring in accordance with WAC 173-340-410. Compliance monitoring consists of protection monitoring, performance monitoring and confirmational monitoring. Protection monitoring is conducted to confirm that human health and the environment are adequately protected during construction, and the operation and maintenance period of a cleanup action. Performance monitoring is conducted to confirm that the cleanup action has attained cleanup standards, remediation levels and/or other performance standards, as appropriate. Confirmational monitoring is conducted to confirm the long-term effectiveness of the cleanup action.

4.1.2. Other MTCA Requirements

Under MTCA, when selecting from the alternatives that meet the minimum requirements, the alternatives shall be further evaluated against the following additional criteria:

- Use permanent solutions to the maximum extent practicable [WAC 173-340-360(2)(b)(i)]. MTCA requires that when selecting from cleanup action alternatives that fulfill the threshold requirements, the selected action shall use permanent solutions to the maximum extent practicable [WAC 173-340-360(2)(b)(i)]. MTCA specifies that the permanence of these qualifying alternatives shall be evaluated by balancing the costs and benefits of each of the alternatives using a "disproportionate cost analysis" in accordance with WAC 173-340-360(3)(e). The criteria for conducting this analysis are described in Section 4.1.3 below.
- Provide a reasonable restoration time frame [WAC 173-340-360(2)(b)(ii)]. In accordance with WAC 173-340-360(2)(b)(ii), MTCA places a preference on those cleanup action alternatives that, while equivalent in other respects, can be implemented in a shorter period of time. MTCA includes a summary of factors to be considered in evaluating whether a remedial action provides for a reasonable restoration time frame [WAC 173-340-360(4)(b)].
- Consideration of Public Concerns [WAC 173-340-360(2)(b)(iii)]. In accordance with WAC 173-340-360(2)(b)(iii), MTCA specifies that the evaluation and selection of a cleanup action for a site needs to consider anticipated and/or actual concerns expressed by the public.

4.1.3. MTCA Disproportionate Cost Analysis

The MTCA Disproportionate Cost Analysis (DCA) is used to further evaluate which of the alternatives that meet the threshold requirements are permanent to the maximum extent practicable. This analysis involves comparing the costs and benefits of alternatives and selecting the alternative whose incremental costs are not disproportionate to the incremental benefits. The evaluation criteria for the DCA are specified in WAC 173-340-360(2) and (3), and include protectiveness, permanence, cost, long-term effectiveness, management of short-term risks, implementability and consideration of public concerns.

As outlined in WAC 173-340-360(3)(e), MTCA provides a methodology that uses the criteria listed below to determine whether the costs associated with each cleanup alternative are disproportionate relative to the incremental benefit of the alternative above the next lowest-cost alternative. The comparison of benefits relative to costs may be quantitative but will often be qualitative. Costs are disproportionate to benefits if the incremental costs of the more permanent alternative exceed the incremental degree of benefits achieved by the other lower-cost alternative [WAC 173-340-360(e)(i)]. Where two or more alternatives are equal in benefits, the less costly alternative is retained as the preferred alternative [WAC 173-340-360(e)(ii)(c)].

MTCA criteria used in the DCA are described in the following sections.

4.1.3.1. Protectiveness

The overall protectiveness of a cleanup action alternative is evaluated based on several factors. First, the extent to which human health and the environment are protected and the degree to which overall risk at a Site is reduced are considered. Both on-site and off-site reduction in risk resulting from implementing the alternative are considered.

4.1.3.2. Permanence

MTCA specifies that when selecting a cleanup action alternative, preference shall be given to actions that are "permanent solutions to the maximum extent practicable." Evaluation criteria include the degree to which the alternative permanently reduces the toxicity, mobility or mass of hazardous substances, including the effectiveness of the alternative in destroying the hazardous substances, the reduction or elimination of hazardous substance releases and sources of releases, the degree of irreversibility of waste treatment processes, and the characteristics and quantity of treatment residuals generated.

4.1.3.3. Cost

The analysis of cleanup action alternative costs under MTCA includes the costs associated with implementing an alternative, including design, construction, long-term monitoring and institutional controls. Costs are intended to be comparable among different alternatives to assist in the overall analysis of relative costs and benefits of the alternatives. The costs to implement an alternative include the costs of design, engineering and construction, long-term costs and agency oversight costs. Long-term costs include operation and maintenance costs, monitoring costs, equipment replacement costs and the cost of maintaining institutional controls. Unit costs used to develop overall remediation costs for this FS were derived using a combination of cost estimates solicited from applicable vendors and contractors; review of actual costs incurred during similar, applicable projects; and professional judgment.

4.1.3.4. Long-Term Effectiveness

Long-term effectiveness is a parameter that expresses the degree of certainty that the alternative will be successful in maintaining compliance with cleanup standards over the long-term performance of the cleanup action. The MTCA regulations contain a specific preference ranking for different types of technologies that is to be considered as part of the comparative analysis. The ranking places the highest preference on technologies such as reuse/recycling, treatment, immobilization/solidification, and disposal in an engineered, lined, and monitored facility. Lower preference rankings are applied for technologies such as on-site isolation/containment with attendant engineered controls, and institutional controls and monitoring.

4.1.3.5. Management of Short-term Risks

Evaluation of this criterion considers the relative magnitude and complexity of actions required to maintain protection of human health and the environment during implementation of the cleanup action. Cleanup actions carry short-term risks, such as potential mobilization of contaminants during construction, or safety risks typical of large construction projects. Some short-term risks can be managed through the use of Best Management Practices during project design and construction, while other risks are inherent to project alternatives and can offset the long-term benefits of an alternative.

4.1.3.6. Implementability

Implementability is an overall metric expressing the relative difficulty and uncertainty of implementing the cleanup action. Evaluation of implementability includes consideration of technical factors such as the availability of mature technologies and experienced contractors to accomplish the cleanup work. It also includes administrative factors associated with permitting and completing the cleanup.

4.1.3.7. Consideration of Public Concerns

The public involvement process under MTCA is used to identify potential public concerns regarding remedial action alternatives. The extent to which an alternative addresses those concerns is considered as part of the evaluation process. This includes concerns raised by individuals, community groups, local governments, tribes, federal and state agencies, and other organizations that may have an interest in or knowledge of the Site. In particular, the public concerns for this Site would generally be associated with environmental concerns and performance of the cleanup action, which are addressed under other criteria such as protectiveness and permanence.

4.2. Evaluation and Comparison of Cleanup Action Alternatives

Cleanup action alternatives developed for the Site were evaluated with respect to the MTCA threshold and other relevant requirements described above, then were compared to each other relative to the expected performance under each criterion. The following sections provide an evaluation and comparative analysis of the cleanup action alternatives developed to address Site contamination.

4.2.1. Threshold Requirements

Cleanup action alternatives developed for the Site incorporate varying combinations of source removal, in-situ treatment, and/or capping and containment, in combination with institutional controls to meet the minimum threshold requirements of protecting human health and the environment, complying with cleanup standards, and complying with applicable state and federal laws within a reasonable time frame. Remediation technologies are intended to be protective of the ecological receptors, prevent direct contact and prevent the migration of contaminants beyond the current Site extent. Performance and/or compliance monitoring would be completed for each cleanup action alternative to confirm compliance with the cleanup standards. To ensure the effectiveness and compliance with cleanup standards over time, Alternatives 1 through 4, which leave residual contamination in place, also have provisions for long-term monitoring and maintenance of engineering controls that isolate and contain Site contaminants, and groundwater monitoring to evaluate plume stability, mass reduction over time and ultimately confirm compliance with the cleanup standards.

Alternatives 1 achieves the lowest level of protectiveness due to the limited amount of contaminant mass reduction and its reliance on natural processes to degrade residual contamination remaining in place in conjunction with engineering and institutional controls to prevent the use of groundwater as drinking water and direct contact. Alternatives 2 and 3 achieve a moderate level of protectiveness because in addition to the removal of soil within the upper 6 feet where contaminants could otherwise be encountered during future redevelopment and institutional and engineering controls similar to Alternative 1, Alternatives 2 and 3 include in-situ treatment technologies to further reduce residual contaminant mass. Alternative 4 results in the highest degree of protectiveness due to the overall level of mass reduction within the contaminant source area within a relatively short time frame.

4.2.2. Other MTCA Requirements

4.2.2.1. Permanent to the Maximum Extent Practicable

Similar to threshold criteria, Alternative 1 achieves the lowest level of permanence due to the limited degree of overall mass reduction and reliance on natural processes to attenuate residual contamination remaining in place. Alternatives 2 and 3 achieve a higher degree of permanence over Alternative 1 through the use of in-situ treatment technologies that are expected to result in additional contaminant mass reduction and result in a shorter time frame to meet the overall CAOs. Alternative 4 is expected to achieve the highest degree of contaminant mass reduction and is therefore more permanent than Alternatives 1, 2 and 3.

4.2.2.2. Reasonable Restoration Time Frame

Each of the cleanup action alternatives evaluated are expected to achieve the CAOs within a reasonable restoration time frame utilizing a combination of source removal, in-situ treatment and implementation of institutional controls. In accordance with WAC 173-340-360(4)(f), active remedial measures to the extent practicable are being employed under each remedial alternative to reduce contaminant mass within the source area and prevent exposure to residual contamination remaining in place. However, longer restoration time frames are expected where residual contamination remains in place in inaccessible portions of the Site (i.e., residual contamination beneath the WES Building and at depth within the soil column).

Restoration time frames for active cleanup under each alternative as described in this section were developed based on more than 10 years of site-specific Site RI data pertaining to soil conditions, groundwater contaminant trends and plume stability; remedial technology case studies for similar sites; discussions with vendors regarding this Site and similar sites; and professional judgment. Performance criteria to be established during development of the EDR will be used to evaluate compliance with the CAOs.

- Under Alternative 1, the restoration time frame for active cleanup is assumed to be on the order of 1 to 2 years to complete design, permitting, contracting and construction to address shallow source area material within the upper soil horizon that could otherwise be encountered during future redevelopment, install new containment barriers, and implement institutional controls to prevent human exposure to residual contamination remaining in place within portions of the PFD and WES Properties following active cleanup.
- Under Alternative 2, the restoration time frame for active cleanup is assumed to be on the order of 5 to 7 years to complete design, permitting, contracting and construction to address shallow source area material within the upper soil horizon that could otherwise be encountered during future redevelopment, install new containment barriers, treat groundwater within the area of the highest observed concentrations through the injection of enhanced bioremediation and biochemical reduction solutes, and implement institutional controls to prevent human exposure to residual contamination remaining in place within portions of the PFD and/or WES Properties following active cleanup.
- Under Alternative 3, the restoration time frame for active cleanup is assumed to be on the order of 5 to 7 years to complete design, permitting, contracting and construction to address shallow source area material within the upper soil horizon that could otherwise be encountered during future redevelopment, install new containment barriers, treat soil and groundwater within the area of the highest observed concentrations through AS/SVE, and implement institutional controls to prevent human exposure to residual contamination remaining in place within portions of the PFD and/or WES Properties following active cleanup.
- Under Alternative 4, the restoration time frame for active cleanup is assumed to be on the order of 2 to 3 years to complete design, permitting, contracting and construction to address shallow source area material within the upper soil horizon that could otherwise be encountered during future redevelopment, install new containment barriers, treat soil and groundwater within the area of the

highest observed concentrations through thermal conduction, and implement institutional controls to prevent human exposure to residual contamination remaining in place within portions of the PFD and/or WES Properties following active cleanup.

Subsequent to the completion of the active remedies, long-term monitoring and cap maintenance as described in Section 3.2 would be performed under each cleanup action alternative to ensure that the function of the containment barriers remains effective to prevent human health direct contact with residual contamination remaining in place and to limit stormwater infiltration to prevent the downward migration of residual contamination to groundwater. In addition, long-term groundwater and vapor monitoring under each alternative would be performed to ensure a stable groundwater plume, evaluate overall mass reduction and attenuation performance of residual contamination in groundwater over time, and ensure that vapor intrusion is not occurring at levels of regulatory concern (commercial and/or unrestricted) based on land use.

4.2.2.3. Considerations of Public Concerns

Each of the alternatives proposed to address Site contaminants are generally expected to be acceptable to the public. Alternative 4 achieves the greatest level of protection and certainty as a result of the greatest level of contaminant treatment/removal; however, this alternative is the most intrusive and would require a high level of planning and design to install the system components, as compared to Alternatives 2 and 3. In addition, Alternative 4 would require significant planning, coordination and mitigation due to the installation of a significant number of well points, expected power consumption and level of effort required to operate and maintain this system. Additionally, there may be a concern for damage to existing utility infrastructure resulting from temperatures required to treat COCs under this alternative and may require relocation. Alternatives 2 and 3 would also result in a high level of protection and certainty through source removal/in-situ treatment and containment technologies; however, the degree of planning and potential impacts to local businesses and utility infrastructure is considered less than under Alternative 4 and therefore fewer public concerns are associated with Alternatives 2 and 3. The public may be concerned about the level of residual contamination that would be left in place under Alternative 1 as compared to the other alternatives; however, containment technologies combined with institutional controls will protect human health and the environment and prevent contaminant exposure and thus offset the potential for significant public concern.

4.2.3. MTCA Disproportionate Cost Analysis

The MTCA DCA is used to make a relative comparison of the costs to the benefits of the remedial alternatives under consideration (i.e., protectiveness, permanence, long-term effectiveness, management of short-term risks, implementability and public concern) for the Site. The comparison of benefits relative to costs is a semi-quantitative comparison. Several semi-quantitative factors are used (e.g., relative mass of contaminant treated/removed, relative percentage of area of impacts remaining following implementation of the cleanup alternative and cost estimate). The relative benefit score is qualitative and therefore the benefits to cost comparison is a qualitative assessment. The remedial alternative with the highest ratio of benefit to cost is identified as the preferred alternative.

The benefits evaluation for each MTCA criterion applied a numeric score using a scale of 1 (lowest) to 10 (highest) and the methodology described above in Section 4.1.3. Table 5 presents an evaluation of the relative benefits ranking and numeric score for the individual criterion. Table 6 summarizes the results of the DCA and ranks each of the cleanup action alternatives based on the ratio of relative benefit to cost.

Preliminary planning level construction cost estimates for each cleanup action alternative incorporated into the DCA are presented in Appendix A and are estimates within -30 to +50 percent based on EPA's Guide to Developing and Documenting Cost Estimates During the Feasibility Study (EPA 2000). The conclusions of this evaluation are shown on Figure 15.

4.3. Preferred Cleanup Action Alternative and Basis for Selection

Under MTCA, "costs are disproportionate to benefits if the incremental costs of the alternative over that of a lower cost alternative exceed the incremental degree of benefits achieved by the alternative over that of lower cost alternative" (WAC 173-340-360[3][e][i]). From the resulting benefit/cost ratio (Figure 11), the overall cost for Alternatives 3 and 4 are disproportionate to the environmental benefit that they provide relative to Alternatives 1 and 2. Furthermore, the environmental benefit for 2 is greater than for Alternative 1. As a result, Alternative 2 emerges as the preferred alternative for the Site. This alternative may be refined during the design development, planning and permitting process.

Alternative 2 addresses Site contamination through soil removal and in-situ treatment combined with containment technologies (i.e., capping) and institutional controls to address Site contaminants. This alternative is permanent to the maximum extent practicable and reduces immediate risk to potential human and ecological receptors through active cleanup and long-term monitoring.

Active cleanup actions under Alternative 2 to meet the CAOs include:

- Removal of contaminated soil within the source area in the upper 6 feet where contaminants could otherwise be encountered during future redevelopment.
- Installation of new asphalt pavement within the footprint of the soil removal area to prevent stormwater infiltration and contaminant leaching/migration through the soil column. This physical barrier will also prevent direct contact with Site contaminants contained in the subsurface.
- Injection of reagents into the subsurface to enhance bioremediation of chlorinated contaminants through metabolic reactions in conjunction with iron-based reagents to promote in situ biochemical reduction of PCE and its breakdown products. Injection points would target the area with the highest soil and groundwater contamination. Dispersion and advection processes are expected to extend the downgradient zone of influence of these reagents to reach groundwater beneath the WES building.
- Implement deed restrictions (environmental covenants) compliant with the Uniform Environmental Covenants Act and with Ecology's model environmental covenant for the WES and/or PFD Properties. The environmental covenant would apply to only those portions of the PFD and/or WES Properties where residual contamination remains in place at concentrations greater than the PCULs and would provide requirements such that any future ground disturbance activities prevent exposure to soil with residual contamination, activities that would create preferential pathways for vapor migration into enclosed structures and restrict the use of groundwater to protect site workers, visitors and/or future occupants, as appropriate.

The restoration time frame to complete the active cleanup is assumed to be on the order of 5 to 7 years. During development of the engineering design, the results from the pilot study will be utilized to refine the restoration time frame estimate as well as performance parameters for in-situ treatment. Following source removal, in-situ treatment, and implementation of the environmental covenant, long-term monitoring and maintenance activities would then be performed to ensure that the CAOs continue to be met. Long-term monitoring and maintenance activities under Alternative 2 include:

- Monitoring and maintenance of the new/existing concrete and asphalt paved surfaces to prevent stormwater infiltration and contaminant leaching/migration through the soil column as well as to provide a physical barrier to prevent direct contact to residual Site contaminants.
- Groundwater monitoring utilizing a network of wells to evaluate groundwater conditions and contaminant concentrations over time. The target end point for groundwater monitoring will be based on protection of vapor intrusion into indoor air and potential exposure to commercial workers, visitors and/or future occupants from residual contamination remaining in place.
- Indoor/outdoor and/or sub-slab vapor monitoring to evaluate the potential for vapor intrusion. The target endpoint for vapor monitoring will be based on protection of commercial workers, visitors and/or future occupants from residual contamination remaining in place.

Implementation of Alternative 2 will result in the containment and prevention of direct human contact with COCs, prevention of stormwater infiltration, leaching of residual COCs contained within the soil column, and migration of COCs to groundwater and the removal of contaminated soil within the source area in the upper 6 feet where contaminants could otherwise be encountered during future redevelopment.

5.0 LIMITATIONS

We have prepared this report for use by the Lynnwood Public Facilities District for the Former Alderwood Laundry and Dry Cleaner Site located at 3815 196th Street SW in Lynnwood, Washington. Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted environmental science practices in this area at the time this document was prepared. No warranty or other conditions, express or implied, should be understood. This document (email, text, table, and/or figure) and any attachments are only a copy of a master document. The master hard copy is stored by GeoEngineers, Inc. and will serve as the official document of record.

6.0 REFERENCES

GeoEngineers, Inc. 2018. “Remedial Investigation Report, Alderwood Laundry and Dry Cleaner, Ecology Facility Site ID 17078, Ecology Cleanup Site ID 12845, 3815 196th Street SW, Lynnwood, Washington,” prepared for Lynnwood Public Facilities District, March 7, 2018.

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TABLES

Table 1

Applicable or Relevant and Appropriate Requirements

Former Alderwood Laundry and Dry Cleaners

Lynwood, Washington

Subject Regulated	State/Local Statutes and Implementing Regulations	Federal Statutes and Implementing Regulations	Description and Applicability
Hazardous Waste Cleanup	Model Toxics Control Act (MTCA) Cleanup Regulation (RCW 70A.305; Chapter 173-340 WAC)	Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 USC Chapter 103; 40 CFR Chapter I, Subchapter J)	State law has precedence; primary regulations governing upland cleanup actions at the Site. Most state and local permits are waived because the work is being conducted under an Agreed Order, but MTCA requires that permit substantive requirements must be met. All federal permits governing the remedial action are still required.
Environmental Impact Review	State Environmental Policy Act (SEPA) (RCW 43.21C, Chapters 197-11 and 173-802 WAC)	National Environmental Policy Act (NEPA) (42 USC Chapter 55 § 4321 et seq.; 40 CFR Chapter V, Parts 1500-1508)	The City of Lynnwood or Ecology would be the lead agency and make the determination of compliance with SEPA.
Water Quality	Water Pollution Control Act (RCW 90.48)	Federal Water Pollution Control Act (aka Clean Water Act (CWA) (33 USC Chapter 26 §1251 et seq.; 40 CFR Chapter 1, Subchapter D)	State implements most components of the CWA. Water quality is considered in the development of cleanup objectives, short-term performance during construction, and long-term performance of the remedy.
Discharge of Construction Stormwater	Water Pollution Control Act (RCW 90.48); National Pollution Discharge Elimination System Program (Chapter 173-220 WAC)	CWA Section 402	If dewatering is required in connection with implementation of the cleanup remedy, an NPDES permit administered by the State will be required. Local NPDES requirements for stormwater may also apply.
Management, Transport and Disposal of Hazardous Wastes	Solid and Hazardous Waste Management Act (RCW 70A.300); Dangerous Waste Regulations (Chapter 173-303 WAC)	Resource Conservation and Recovery Act (RCRA) (40 CFR 260 and 261); 49 USC Chapter 51 Transportation of Hazardous Material; 40 CFR 171-180	Federal regulations are implemented by the State. Pertains to soil and water, and debris waste handling and landfill disposal. Management and disposal process are administered by the State and all substantive requirements must be met. Transportation is regulated by the US Department of Transportation.
Management, Transport and Disposal of Solid Wastes	Solid and Hazardous Waste Management Act (RCW 70A.300; Chapters 173-305, 173-350 WAC and others)	Resource Conservation and Recovery Act (40 CFR 257 Subpart A)	Affects land disposal and transportation of excavated material and debris from the Site; process is administered by the State and all substantive requirements must be met.
Air Quality	Clean Air Act (RCW 70A.15); Ambient Air Quality Standards (Chapter 173-746 WAC) ; General Regulations for Air Pollution Sources (WAC 173-400); Regulation I, Articles 5 and 6 of the Puget Sound Clean Air Agency	Clean Air Act (42 USC, Chapter 85 Air Pollution, Prevention and Control)	Administered by the State and local authorities; substantive requirements apply to construction activities during implementation of the remedy.
Health and Safety	Washington Industrial Safety and Health Act (WISHA) (RCW 49.17; Chapters 296-62, 296-843 WAC and others)	Occupational Safety and Health Act (OSHA) (29 USC Chapter 15; 29 CFR 1910, 1926)	Applicable to investigation and construction phases of a cleanup.
Objects, Landscapes or Structures of Historical or Archaeological significance	Regulations regarding these resources are part of SEPA, the Governor's Executive Order 05-05, and SMA (i.e., no one single regulation or authority), RCW 27.53; WAC 365-196-450 and others also apply	National Historic Preservation Act (16 USC 470 et seq. Section 106)	State laws govern local projects; federal law governs those requiring federal permits or funds. Protection of significant historic, archaeological and traditional cultural sites from damage or loss during development is coordinated by the State's Department of Archaeological and Historic Preservation (State Historic Preservation Office) and includes evaluating compliance with Section 106 of the federal law.
City of Lynnwood Regulations, Codes and Standards	State level regulations	SEPA exemption levels locally raised for environmental review (Section 201 of 2ESSSB 6406 and WAC 197-11-800(1)(c))	Applicable to excavation and construction phases of a cleanup.

Notes:

ARAR = Applicable or Relevant and Appropriate Requirement; CFR = Code of Federal Regulations; RCW = Revised Code of Washington; WAC = Washington Administrative Code; USC = United States Code; SEPA = State Environmental Policy Act

WISHA = Washington Industrial Safety and Health Act; MTCA = Model Toxics Control Act; CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act; NEPA = National Environmental Policy Act; CWA = Clean Water Act

RCRA = Resource Conservation and Recovery Act; OSHA = Occupational Safety and Health Act

Table 2

Soil Remedial Technologies Screening

Former Alderwood Laundry and Dry Cleaners

Lynnwood, Washington

Remedial Technology Identification			Description of Remedial Technology	Implementability of Remedial Technology	Effectiveness of Remedial Technology	Relative Cost of Remedial Technology		Summary of Screening	Technology Retained (Yes/No)
General Response Action	Type of Remedial Technology	Process Option				Capital	O&M		
No Action	No Action	None	No institutional controls or treatment.	Not effective for protecting human health and environment.	Implementable but not acceptable to the general public or government agencies.	None	None	Used as a baseline for comparison.	No
Institutional Controls (ICs)	Governmental/ Property Controls	Environmental Covenant	Legal restrictions associated with future land use and activities (e.g., development, construction, etc.); may also be used to specify long-term maintenance requirements of remediation systems.	Technically implementable. Specific legal requirements and authority would need to be met.	Not effective for remediating contaminants. Can be effective at reducing risks and maintaining integrity of a remedy.	Low	Low	Applicable and/or required in combination with other technologies.	Yes
		Land Use Restrictions, Material Management Plans/ Requirements	Restrictions on activities such as excavation to prevent physical damage to components of the cleanup alternative (e.g., caps) and/or exposure to hazardous substances that remain in-place. Implement soil management plans/requirements so that contaminated soils are managed properly in an event that it is necessary to disturb/excavate (e.g., utility work, etc.).	Technically implementable but administratively more difficult. Requires an implementing agency.	Not effective for remediating contaminants. Enforcement would be required for restrictions to be effective.	Low	Low	Applicable and/or required in combination with other technologies.	Yes
	Informational Devices	State registries of contaminated sites, Public notices, Deed notices, Fact sheets and/or Advisories	Informational tools provide information or notification with regard to a remedy or residual contamination at a site. The informational devices provide a means to inform property owners and tenants regarding Site issues and/or planned activities.	Placing information concerning the Site through recorded notices, Site Registries, or other notification methods is relatively easy to implement.	While informational tool provide relatively high visibility to attempt to control Site activities, limited enforcement capability exists within these controls to ensure that requested actions are taking place.	Low	Low	Applicable in combination with other technologies.	Yes
	Assess Restrictions	Warning Signs and Fencing	Placement of fencing and warning signs to prevent access and inform the public regarding health risks.	Technically implementable but fencing is not likely to be consistent with current/future land use.	Not effective for remediating contaminants. Effective in minimizing human exposure to contaminated media by preventing access.	Low	Low	May not be effective due to current/future site use.	No
Containment/ Capping	Low-Permeability Cap with Drainage Controls	Asphalt and/or Concrete Cap	Surface capping includes engineered low-permeability caps which are designed to prevent infiltration, gas migration, and direct contact; and soil, pavement or building caps which prevent direct contact and also provide drainage controls to prevent infiltration.	Technically implementable. A majority of the Site is currently paved and stormwater collection systems are in place to manage stormwater.	Effective for preventing exposure to hazardous substances that remain in-place, erosion of source material, and reducing stormwater infiltration and contaminant migration.	Low to Moderate	Low	Applicable and/or required in combination with other technologies.	Yes
	Low-Permeability Cap with Drainage Controls	A minimum of 1-Foot of Soil Cover with Underlying Low-Permeability Barrier	Install soil cover (a minimum of 1-foot thick) with underlying barrier (plastic or similar) over contaminated soil in unpaved areas. Surface/storm water collection and discharge would be designed to reduce infiltration of stormwater at the site. Primary function of the cover is to prevent/minimize contaminant migration and exposure to hazardous substances that remain in-place.	Technically implementable but not consistent with current/future land use.	Effective for preventing exposure to hazardous substances that remain in-place, and reducing stormwater infiltration and contaminant migration.	Low to Moderate	Low	May not be effective due to current/future site use.	No
	Permeable Cap	Permeable Soil Cover	Install and/or maintain existing 6-feet thick (conditional point of compliance) soil cover over contaminated soil. Can be vegetated at the surface based on current/future site use. Primary function of the cover is to prevent/minimize exposure to hazardous substances that remain in-place. Not effective at reducing stormwater infiltration.	Technically implementable. Implementability and applicability depends on current and future site uses. Requires disposal of material removed to facilitate placement of cover.	Effective for preventing exposure to hazardous substances that remain in-place and erosion of source material. Not effective at reducing stormwater infiltration and contaminant migration.	Low	Low	Applicable and/or required in combination with other technologies.	Yes

Remedial Technology Identification			Description of Remedial Technology	Implementability of Remedial Technology	Effectiveness of Remedial Technology	Relative Cost of Remedial Technology		Summary of Screening	Technology Retained (Yes/No)
General Response Action	Type of Remedial Technology	Process Option				Capital	O&M		
In-Situ Treatment	Biological Treatment	Enhanced Bioremediation	The activity of naturally occurring microbes is stimulated by circulating water-based solutions through contaminated soil to enhance degradation of organic contaminants. Nutrients, oxygen, or other amendments may be used to enhance bioremediation and contaminant desorption from subsurface materials.	Technically implementable. Requires network of injection wells to deliver water-bass solutions through the contaminated soil. May require multiple rounds of injection to achieve desired outcome.	Effective for treating chlorinated organics compounds. Effectiveness may be limited by presence of fine-grained soils and may result in the vertical migration of contaminants through the soil column.	Moderate	Moderate	Applicable and/or required in combination with other technologies. Existing structures (i.e., WES building) would limit application of this technology.	Yes
		Bioventing	Oxygen is delivered to contaminated unsaturated soil by forced air movement (either extraction or injection of air) to increase oxygen concentrations and stimulate biodegradation.	Technically implementable. Requires network of injection wells to deliver oxygen through the contaminated soil. May require permanent support compound to house blowers and piping to connect to bioventing wells.	Effective for treating volatile organic compounds. Injection of oxygen may cause build up of contaminants in soil vapor which may potentially migrate into indoor air.	Low to Moderate	Moderate	Potential for soil vapor migration to indoor areas based on current/future land use assumptions would limit effectiveness of implementation.	No
	Physical Treatment	Soil Vapor Extraction (SVE)	Vacuum is applied through extraction pipes screened within unsaturated zone soil to create a pressure/concentration gradient, which induces gas-phase volatile organics to diffuse through soil to extraction wells.	Technically implementable. Requires network of piping to SVE wells and treatment compound containing blowers and vapor collection/treatment systems. Requires treatment of collected vapors before permitted discharge to atmosphere.	Effective for treating chlorinated organic compounds. Effectiveness may be limited by presence of fine-grained soils.	Moderate	Moderate	Applicable and/or required in combination with other technologies needed to treat saturated soil. Existing structures (i.e., WES Building) would limit application of this technology.	Yes
	Physical Treatment	Soil Flushing	The extraction of contaminants from soil with aqueous solution accomplished by passing fluid through in-place soils using an injection or infiltration process. Extraction fluids must be recovered from underlying groundwater.	Technically implementable, but would require significant safety components to prevent exacerbating groundwater contamination. Regulatory concerns over potential to wash contaminants beyond fluid capture zones and introduction of surfactants in to the subsurface would make permitting difficult.	Effective for more soluble chemicals. Presence of fine-grained soils and debris limits effectiveness.	High	Moderate	High cost and uncertainty relative to other remedial technologies.	No
In-Situ Treatment	Chemical Treatment	In-Situ Stabilization (ISS)	ISS is accomplished by injecting solutions of chemical reagents with contaminated media to physically bond or enclose the contaminant mass (solidification), or to induce chemical reactions between the stabilizing agent and contaminants to reduce their mobility (stabilization).	Technically implementable. However, not effective at treating volatile organics. Solidification and stabilization processes can result in an increase in volume. Treatability testing is required.	Effective for reducing mobility of metals; however, technology is less effective at treating volatile organics.	Moderate	Low	Not applicable to contaminants on site.	No
	Thermal Treatment	Vitrification	Electrodes for applying head are used to melt contaminated soil and sludges producing glass and crystalline structures with very low leaching characteristics.	Technically implementable but limited to contaminated media less than 30 feet below ground surface. Organic and inorganic off-gassing mush be controlled.	Effective for treating non-volatile inorganic contaminants within vadose soil.	High	Moderate	High cost and uncertainty relative to other remedial technologies.	No
		Thermal Conduction Heating (TCH)	Electrically-powered heaters are installed to heat contaminated soil to target treatment temperatures. The increased temperature volatilizes VOCs, allowing removal by vapor extraction methods from vapor extraction points (SVE wells).	Technically implementable. Requires network of piping to SVE wells and treatment compound containing vapor collection/treatment systems. Also requires network of heating elements wired to a power source. Existing utility infrastructure and buildings would need to be considered in placement of TCH system.	Effective for treating volatile organic compounds. Common in-situ source control technology for saturated and unsaturated soil.	High	Low	Applicable and/or required in combination with other technologies. Existing structures (i.e., WES building) would limit application of this technology.	Yes
		Electrical Resistive Heating (ERH)	Electrical current is generated between electrodes installed in subsurface, which gradually raises the ground temperature. The increased temperature volatilizes lighter hydrocarbons, allowing removal by vapor extraction methods.	Technically implementable. Requires network of piping to SVE wells and treatment compound containing vapor collection/treatment systems. Also requires network of electrodes wired to a power source. Existing utility infrastructure and buildings would need to be considered in placement of ERH system.	Resistance heating tends to target saturated zones and can incidentally treat select soil types in a mixture of lithologies. Therefore, ERH has a lower relative certainty of effectiveness given the thickness of the unsaturated zone of contaminated soil at the Site.	High	Low	High cost and uncertainty relative to other remedial technologies.	No
		Steam Enhanced Extraction (SEE)	Installation of a series of steam injection wells in the contaminated soil areas. Steam is generated in an on-site boiler and injected through the wells, which raises the temperature of the soil. Similar to the application of ERH, contaminants are extracted by vapor extraction methods.	Technically implementable. Requires network of piping of steam injections points and compound to house the boiler. Existing utility infrastructure and buildings would need to be considered in placement of SEE system.	Site lithology would limit the distribution of steam in the subsurface and effectiveness. Condensation of injected steam results in additional water that must be extracted and treated.	High	Low	High cost and uncertainty relative to other remedial technologies.	No

Remedial Technology Identification			Description of Remedial Technology	Implementability of Remedial Technology	Effectiveness of Remedial Technology	Relative Cost of Remedial Technology		Summary of Screening	Technology Retained (Yes/No)
General Response Action	Type of Remedial Technology	Process Option				Capital	O&M		
Removal	Soil Excavation and Off-Site Disposal	Excavation and Landfill	Removal of contaminated soil using common excavation techniques. Disposal of contaminated soil at an off-site, permitted landfill. May require treatment of contaminated soil at landfill facility prior to disposal.	Technically implementable where accessibility allows for excavation.	Effective for all site contaminants and commonly used remedy. Less effective for contamination extending to depths greater than 20 feet without extensive shoring systems.	High	Low	Applicable. Without shoring, the vertical extent is limited by practicability to a maximum of 20 feet bgs. The existing WES Building limits the lateral extent of removal on WES Property, making it impracticable to perform soil removal beneath the WES building.	Yes
	Soil Excavation, Ex-Situ Treatment and Off-Site Disposal/On Site Reuse	Solidification/ Stabilization (S/S)	Removal of impacted soil using common excavation techniques. Contaminants are physically bound or enclosed within a stabilized mass using cementitious reagents (cement, lime, etc.) or surface adsorption/chemical reagents.	Requires sufficient space on site to set up temporary treatment plant and treat/process excavated material prior to disposal. S/S processes may result in an increase in the overall volume of material for off-site disposal/on-site reuse. Additionally S/S processes increases density which increases disposal costs.	Stabilization is a common and effective technology for reducing the leachability of metals in soil. Not effective technology for volatile organics.	High	Low	High cost and uncertainty relative to other remedial technologies. Not applicable to contaminants on site.	No
		Soil Washing	Removal of impacted soil using common excavation techniques. Wash soil with water-based surfactants, detergents, acids, etc., to remove chemicals from soil particles. Treat or dispose of high chemical concentration residuals fluids.	Technically implementable. Require sufficient space on site to set up temporary treatment plant and treat/process excavated material prior to disposal/reuse. Require treatment of residual fluids.	Effective for more soluble chemicals. Presence of fine-grained soils and debris limits effectiveness.	High	Moderate	High cost and uncertainty relative to other remedial technologies. High degree of difficulty to implement given site current and future use.	No
	Soil Excavation, Ex-Situ Treatment and Off-Site Disposal/On Site Reuse	Incineration	Removed soil is heated above approximately 1,600 degrees Fahrenheit to volatilize and combust organic contaminants. Incinerator off-gas is treated in an air pollution control system.	Potentially difficult to implement. Limited space for on-site treatment system and staging. Specific feed size and material handling requirements may impact implement ability. Suitable off-site facility not currently identified.	Proven effective treatment for organics.	High	High	High cost and difficult to implement relative to other remedial technologies.	No
		Bioremediation	Biodegradation of contaminants in removed soil is enhanced through modification of the material for microbial growth. Treatment is conducted in landfarm arrangement, aboveground reactor, or in treatment cells (biopiles).	Difficult to implement. Landfarming option may require use of a large amount of space, depending on quantity of excavated material. Slurry and biopile treatment require reactor or treatment cell construction. Leachate and off-gas require collection and treatment. Addition of additives may increase total bulk volume of treated material.	Proven effective treatment for organics.	Moderate to High	Moderate to High	High cost and difficult to implement relative to other remedial technologies.	No

Notes:

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

ERH = Electrical Resistive Heating; SEE = Steam Enhanced Extraction; S/S = Solidification/Stabilization

Shading indicates remedial technology retained for cleanup action evaluation.

Table 3
Groundwater Remedial Technologies Screening
Former Alderwood Laundry and Dry Cleaners
Lynnwood, Washington

Remedial Technology Identification			Description of Remedial Technology	Implementability of Remedial Technology	Effectiveness of Remedial Technology	Relative Cost of Remedial Technology		Summary of Screening	Technology Retained (Yes/No)
General Response Action	Type of Remedial Technology	Process Option				Capital	O&M		
No Action	No Action	None	No institutional controls or treatment.	Not effective for protecting human health and environment.	Implementable but not acceptable to the general public or government agencies.	None	None	Used as a baseline for comparison.	No
Institutional Controls (ICs)	Governmental/ Property Controls	Environmental Covenant	Legal restrictions associated with future land use and activities (e.g., development, construction, etc.); may also be used to specify long-term maintenance requirements of remediation systems.	Technically implementable. Specific legal requirements and authority would need to be met.	Not effective for remediating contaminants. Can be effective at reducing risks and maintaining integrity of a remedy.	Low	Low	Applicable and/or required in combination with other technologies.	Yes
		Groundwater Use Restrictions, Material Management Plans/ Requirements	Restrictions on groundwater extraction and use and/or exposure of humans and environment to hazardous substances present in groundwater. Implement groundwater management plans/requirements so that contaminated groundwater is managed properly in an event that it is necessary to remove groundwater (e.g., utility work, etc.).	Technically implementable but administratively more difficult. Requires an implementing agency.	Not effective for remediating contaminants. Enforcement would be required for restrictions to be effective.	Low	Low	Applicable and/or required in combination with other technologies.	Yes
	Informational Devices	State registries of contaminated sites, Public notices, Deed notices, Fact sheets and/or Advisories	Informational tools provide information or notification with regard to a remedy or residual contamination at a site. The informational devices provide a means to inform property owners and tenants regarding Site issues and/or planned activities.	Placing information concerning the Site through recorded notices, Site Registries, or other notification methods is relatively easy to implement.	While Informational ICs provide relatively high visibility to attempt to control Site activities, limited enforcement capability exists within these controls to ensure that requested actions are taking place.	Low	Low	Applicable in combination with other technologies.	Yes
Monitoring	Monitored Natural Attenuation (MNA)	Natural Attenuation	Monitoring of naturally occurring physical, chemical and biological processes that reduce the mass, toxicity, mobility, volume, or concentration of contaminants in groundwater. Involves monitoring over time to confirm that natural processes are occurring to reduce risk associated with contaminant concentrations. A contingency plan is needed if the expected processes do not occur.	Technically implementable but requires long-term monitoring. Cleanup time frame may be longer than other remedial technologies. Source to groundwater generally requires treatment such as removal, containment or stabilization.	Effectiveness is dependent on site conditions and time frame for implementation. Not effective in preventing contaminant migration and/or exposure.	Low	Low	Applicable in combination with other technologies. The most applicable technology for portions of the Site beneath the WES building, which makes it impractical to perform direct treatment technologies.	Yes
Containment	Physical Groundwater Barrier	Low-Permeability Vertical Barrier	Construction of a low-permeability vertical barrier such as driven steel sheet piles, soil-bentonite or cement-bentonite wall to restrict groundwater flow and contaminant migration in the downgradient direction. Barrier can be installed down to the nearest aquitard to provide full containment, or installed at a partial depth to direct groundwater deeper. Groundwater extraction may be required to achieve containment under some scenarios. Long-term monitoring of containment structure required.	Technically implementable but requires long-term monitoring. Cleanup time frame longer than other remedial technologies but shorter compared to MNA. Source to groundwater generally requires treatment such as removal, containment or stabilization.	Established technology effective for reducing mobility of contaminants. Effective for containing impacted groundwater or directing groundwater away from a source. However, does not provide treatment of contaminants. Effectiveness likely to increase if implemented to encapsulate the entire source area such that upgradient groundwater flows around the source area thereby minimizing contaminant mobility.	Moderate	Moderate	Not a permanent solution and would rely on other technologies to treat groundwater. Not applicable to portions of the groundwater plume located beneath the WES Property.	No
	Hydraulic Groundwater Barrier	Groundwater Pumping	Groundwater pumping to establish a hydraulic capture zone and restrict groundwater flow and contaminant migration in the downgradient direction. May be used in conjunction with a physical barrier to achieve full containment.	Technically implementable using standard groundwater extraction methods. The need to treat extracted groundwater to acceptable levels to allow discharge will reduce the implementability.	Potentially effective for hydraulic control of impacted groundwater. May be implemented to increase effectiveness of physical barrier technologies. Requires continuous long-term operation to achieve effective containment and maintenance of treatment components to prevent discharge of contaminated groundwater.	Moderate	High	Potentially applicable in combination with other technologies, but at high cost. Not expected to be cost effective if applied as sole containment method.	No

Remedial Technology Identification			Description of Remedial Technology	Implementability of Remedial Technology	Effectiveness of Remedial Technology	Relative Cost of Remedial Technology		Summary of Screening	Technology Retained (Yes/No)
General Response Action	Type of Remedial Technology	Process Option				Capital	O&M		
In-Situ Treatment	Biological Treatment	Enhanced Anaerobic Bioremediation	Injection of a hydrogen-releasing material and microbes into the contaminated zone to enhance degradation of chlorinated contaminants in groundwater through metabolic reactions.	Technically implementable. This method relies on advection and dispersion to distribute reagents in groundwater to effectively address contamination. Treatability testing is required.	Effective for treating volatile organic compounds. Common in-situ source control technology for groundwater.	Moderate	Low	Applicable and/or required in combination with other technologies. Existing structures (i.e., WES building) would limit application of this technology.	Yes
	Physical Treatment	Air Sparging (AS)/ Soil Vapor Extraction (SVE)	Sparging injects air into saturated zone body to volatilize contaminants which are then removed by Soil Vapor Extraction (SVE). Requires treatment of collected vapors before discharge to atmosphere.	Technically implementable. Requires network of piping to AS/SVE wells and treatment compound containing blowers and vapor collection/treatment systems. Existing utility infrastructure and buildings would limit placement of AS/SVE system.	Effective for treating volatile organic compounds. Common in-situ source control technology for saturated and unsaturated soil. Current/future land use considerations may reduce long term effectiveness and may require modifications to the system during redevelopment.	Moderate	Moderate	Applicable and/or required in combination with other technologies. Existing structures (i.e., WES building) would limit application of this technology.	Yes
	Chemical Treatment	In-Situ Chemical Oxidation (ISCO)	ISCO is accomplished by injecting solutions of chemical oxidation reagents with contaminated media. The reagents chemically oxidizes and destroys contaminants.	Technically implementable. This method relies on advection and dispersion to distribute reagents in groundwater to effectively address contamination. Treatability testing is required.	Effective for treating volatile organic compounds. Use of strong chemicals may pose health and safety concerns.	Moderate	Low	Less effective in treating contaminants as compared ISCR under current site conditions.	No
		In-Situ Chemical Reduction (ISCR)	ISCR is accomplished by injecting solutions of chemical reagents (i.e., soluble iron, carbon, potassium permanganate, sodium persulfate, etc.) into the contaminated zone to convert hazardous compounds to nonhazardous or less toxic compounds that are more stable, less mobile, or inert.	Technically implementable. This method relies on advection and dispersion to distribute reagents in groundwater to effectively address contamination. Treatability testing is required.	Effective for treating volatile organic compounds. Common in-situ source control technology for groundwater.	Moderate	Low	Applicable and/or required in combination with other technologies. Existing structures (i.e., WES building) would limit application of this technology.	Yes
		Permeable Reactive Barrier (PRB)	PRBs are walls containing reactive media that are installed across the path of contaminated groundwater flow to intercept and treat contaminated groundwater. The barrier allows water to pass through while the media remove the contaminants by precipitation, degradation, adsorption, or ion exchange. PRB wall can be installed by excavating a trench (continuous or funnel/gate) or by injection method.	Technically implementable where accessibility allows for placement of reactive barrier.	Effective treatment configuration under proper hydrogeologic conditions that direct Site groundwater through PRB. Effectiveness relies on selecting an effective reactive treatment component.	Moderate	Moderate	High cost and difficult to implement relative to other remedial technologies.	No
Ex-Situ Treatment	Pump and Treat	Adsorption	Extracted groundwater is treated by passing extracted groundwater through a fixed bed of adsorption media (e.g. activated alumina, activated carbon). As contaminated water is passed through the adsorption media, contaminants are adsorbed. When adsorption sites become filled, the column must be regenerated or disposed of and replaced with new media.	Technically implementable. Long treatment time frame. Permitting may be required for discharge of treated water. May need to be combined with pre- and post-treatment steps. Treatment byproducts (e.g., spent carbon) require management. Systems using this technology generally require skilled operators.	Effectiveness of adsorption treatment process is sensitive to a variety of untreated water contaminants and characteristics. Competition for adsorption sites could reduce the effectiveness of adsorption because other constituents may be preferentially adsorbed, resulting in a need for more frequent bed regeneration or replacement. Current/future land use considerations may reduce long term effectiveness and may require modifications to the system during future property redevelopment.	High	High	High cost and difficult to implement relative to other remedial technologies.	No
		Air Sparging	Similar to in-situ treatment, air is passed through the water column to enhance volatization of organic contaminants. Vapor is captured by collection systems.	Technically implementable. Long treatment timeframe. Permitting may be required for discharge of treated water.	Effective for treating volatile organic compounds. Current/future land use considerations may reduce long term effectiveness and may require modifications to the system during future property redevelopment.	High	High	High cost and difficult to implement relative to other remedial technologies.	No

Notes:

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

Shading indicates remedial technology retained for cleanup action evaluation.

Table 4

Soil Gas Remedial Technologies Screening

Former Alderwood Laundry and Dry Cleaners

Lynnwood, Washington

Remedial Technology Identification			Description of Remedial Technology	Implementability of Remedial Technology	Effectiveness of Remedial Technology	Relative Cost of Remedial Technology		Summary of Screening	Technology Retained (Yes/No)
General Response Action	Type of Remedial Technology	Process Option				Capital	O&M		
No Action	No Action	None	No institutional controls or treatment.	Not effective for protecting human health and environment.	Implementable but not acceptable to the general public or government agencies.	None	None	Used as a baseline for comparison.	No
Institutional Controls (ICs)	Governmental/ Property Controls	Environmental Covenant	Legal restrictions associated with future land use and activities (e.g., development, construction, etc.); may also be used to specify long-term maintenance requirements of remediation systems.	Technically implementable. Specific legal requirements and authority would need to be met.	Not effective for remediating contaminants. Can be effective at reducing risks and maintaining integrity of a remedy.	Low	Low	Applicable and/or required in combination with other technologies.	Yes
		Land Use Restrictions, Material Management Plans/Requirements	Restrictions on activities to prevent physical damage to components of the cleanup alternative (e.g., caps) and/or exposure to hazardous substances that remain in-place. Implement material management plans/requirements so that contaminated media are managed properly in an event that it is necessary to disturb/excavate (e.g., utility work, etc.).	Technically implementable but administratively more difficult. Requires an implementing agency.	Difficult to implement and administer as compared to other ICs.	Low	Low	Applicable and/or required in combination with other technologies.	Yes
	Informational Devices	State registries of contaminated sites, Public notices, Deed notices, Fact sheets and/or Advisories	Informational tools provide information or notification with regard to a remedy or residual contamination at a site. The informational devices provide a means to inform property owners and tenants regarding Site issues and/or planned activities.	Placing information concerning the Site through recorded notices, Site Registries, or other notification methods is relatively easy to implement.	While Informational ICs provide relatively high visibility to attempt to control Site activities, limited enforcement capability exists within these controls to ensure that requested actions are taking place.	Low	Low	Applicable in combination with other technologies.	Yes
Monitoring	Monitoring (Sampling and Analysis)	Indoor Air and/or Soil Gas Sampling and Analysis	Indoor air monitoring provides information on the concentration of contaminants and provides an ability to directly evaluate whether vapor intrusion is occurring at the Site. Soil gas and groundwater monitoring can provide data to identify if contaminants are present that could be transported into a building via the vapor intrusion pathway. However, monitoring of soil gas and groundwater after completion of the remedial action will not provide data to evaluate whether vapor intrusion is occurring.	Monitoring can be readily implemented prior to construction, and following construction. Established practices and procedures exist for monitoring indoor air, soil gas and groundwater. Access issues may result in monitoring not always occurring at the preferred location.	Monitoring by itself is not effective for vapor intrusion control; however, can be used to evaluate changes in the potential for vapor intrusion. Indoor air monitoring provides information for assessing if COCs concentrations are below long-term exposure goals and that vapor intrusion control measures are effective. Soil gas and groundwater monitoring allows an evaluation of whether COCs concentrations in the subsurface could migrate into buildings.	Low	Low	Applicable in combination with other technologies.	Yes
Physical Barriers or Containment	Vapor Barrier	Synthetic Liners and/or Seamless, Spray-Applied Membranes	Synthetic liners are typically constructed of high-density polyethylene (HDPE), linear low-density polyethylene (LLDPE), or polyvinyl chloride (PVC). HDPE geomembrane liners have three layers of material. The material is stiff, strong, and resistant to tears and punctures. LLDPE liners are more flexible than HDPE liners and can be elongated in one or more directions to accommodate uneven or unsettled ground. PVC liners are thinner and more flexible than LLDPE liners and are very easy to patch or seam together. A common spray-applied vapor barrier is Liquid Boot®, which is spray applied as a cold, water based, seamless monolithic, membrane.	Vapor barriers are easy to install for future building construction because designs and installation materials and practices are established. Care needs to be taken to prevent compromising the vapor barrier after installation of building modifications or new utilities. Implementation of repairs or other vapor barrier modifications may be difficult post-construction of a new building. Installation on existing structures is very difficult to implement	Vapor barriers are typically applied in conjunction with passive venting as a low cost additional safeguard against vapor intrusion. Together these two technologies have a proven record of preventing the migration of contaminants into buildings, though this effectiveness depends upon the design, installation quality, and long-term maintenance of the barrier.	Moderate	Low	Applicable for new or future buildings. Future site assumptions for PFD Property make application of this technology uncertain. Not applicable for existing structures.	No

Remedial Technology Identification			Description of Remedial Technology	Implementability of Remedial Technology	Effectiveness of Remedial Technology	Relative Cost of Remedial Technology		Summary of Screening	Technology Retained (Yes/No)
General Response Action	Type of Remedial Technology	Process Option				Capital	O&M		
Physical Barriers or Containment	Modified Soil Barriers	Barrier Constructed of Bentonite-Soil Mixture	This technology consists of applying a bentonite-soil mixture under a building to create a barrier with minimal air pores. These relatively impermeable soils reduce the upward migration of contaminants.	Modified soil barriers are easy to install for future buildings as designs and installation materials and practices are established. Qualified contractors are available. Implementation of repairs or other vapor barrier modifications may be difficult post-construction of a new building. Installation on existing structures is very difficult to implement.	Modified soil barriers limit the migration of contaminants into buildings by establishing a low-permeability barrier under the building. This effectiveness depends upon the design, installation quality, and long-term maintenance of the barrier. Drying may limit the effectiveness of the barrier.	Low to Moderate	Low	Applicable for new or future buildings. Future site assumptions for PFD Property make application of this technology uncertain. Not applicable for existing structures.	No
Physical Barriers or Containment	Modified On-Grade Foundations	Monolithic Concrete Pours	This technology includes monolithic concrete pours that limit cold joints and may include low air-entrainment, post-tension reinforcement, and thickened-mat slabs.	Modified on-grade foundations can be implemented in new buildings as designs and installation materials and practices are established. Qualified contractors are available. Implementation of repairs or other vapor barrier modifications may be difficult postconstruction of a new building.	This technology may reduce indoor air concentrations, but the technology does not eliminate pathways through the building slab. Long-term integrity of the monolithic concrete slab is hard to achieve for buildings with a larger footprint.	High	Low	Applicable for new or future buildings. Future site assumptions for PFD Property make application of this technology uncertain.	No
Physical Barriers or Containment	Conduit Sealing	Expanding foam, Pourable Polyurethane and/or Plugs	Conduit sealing is used for dry conduits that serve as a direct pathway for vapors from the sub-slab into the building.	This technology can be readily implemented in new construction, on existing and future residential and commercial buildings. Proven materials and installation practices exist for conduit sealing.	This technology is only effective at minimizing the vapor intrusion pathway associated with dry conduits. This technology needs to be combined with other technologies to achieve vapor intrusion control.	Low	Low	As conduits, holes, or other penetrations in the building foundation that enable vapor intrusion may not be accessible, the effectiveness of this technology will vary and may not be implementable.	No
Physical Barriers or Containment	Surface Coatings	Expandable Sealants	Cracks or holes in floors can be sealed using expandable sealants to block a vapor intrusion migration pathway. These sealants can also be applied in the annulus around a conduit penetration of the floor.	This technology can be implemented in new buildings. In new construction, proven materials and installation practices exist for surface coatings. Implementation of long-term maintenance of surface coatings is limited for those areas where carpeting or tile has been installed. Installation on existing structures is very difficult to implement	While having been used for vapor intrusion mitigation, the effectiveness depends on the design and installation quality, as well as long-term maintenance. Re-application of the coating may be required for long-term maintenance. As all cracks, holes, or other penetrations in the building foundation that enables vapor intrusion may not be accessible, the effectiveness of this technology will vary and may not be protective.	Low	Low to Moderate	As cracks or holes in the building foundation that enable vapor intrusion may not be accessible, the effectiveness of this technology will vary and may not be implementable.	No
Sub-Slab Pressure Control	Sub-Slab Passive Ventilation	Sub-Slab Passive Ventilation	A sub-slab passive ventilation system consists of perforated pipes within an aggregate or sand layer, manifolded to a vertical riser that conveys the vapors to a vent above the building roof. The roof vent riser typically terminates with a wind-driven turbine that would create a slight negative pressure in the subsurface, thus inducing vapor flow from the subsurface to the outside air via the vent. Being a passive system, no mechanical equipment is included with the ventilation.	This technology can be readily integrated into the construction of new residential or commercial buildings. Standard construction procedures and practices would be involved. Installation commonly includes provisions to modify, if needed, to an active mechanical depressurization system, especially for larger commercial buildings.	This technology is effective to the extent that the induced negative pressure and capture of vapors covers the extent of the building slab. As a pressure differential typically exists between the sub-slab and the building, a vapor barrier is commonly needed for this passive ventilation system to achieve the desired effectiveness for vapor intrusion control.	Low to Moderate	Low	Applicable for new or future buildings. Future site assumptions for PFD Property makes application of this technology uncertain. Not applicable for existing structures.	No
Sub-Slab Pressure Control	Sub-Slab Pressurization	Sub-Slab Pressurization	Outside air is actively introduced below the building slab using a blower. The small, positive pressure created just below the building slab forces outside air into the pore spaces. This pressure layer eliminates the convective flow of vapors from the underlying soil. A system of exhaust vents is included to control the distribution of the sub-slab pressurization.	This technology can be implemented in new buildings, whether residential or commercial. Installation and operation of this system would rely on standard construction practices and readily available materials. This technology cannot be implemented for buildings with a basement below the water table.	Contaminant concentrations in ambient air would have to be sufficiently low as not to be of concern for vapor intrusion risk to human health. A layer of aggregate or sand placed below the slab enhances the effectiveness of this technology by creating a suitable pathway for uniform distribution of the air and associated sub-slab pressurization. If direct conduits or other seams are present allowing an undesired ventilation pathway, the pressure distribution may not be uniform under the building slab. Construction needs to be carefully performed to ensure that slab penetrations do not allow short-circuiting of the air.	High	High	For new or future buildings, more cost-effective vapor intrusion control technologies are available. Not applicable for existing structures.	No

Remedial Technology Identification			Description of Remedial Technology	Implementability of Remedial Technology	Effectiveness of Remedial Technology	Relative Cost of Remedial Technology		Summary of Screening	Technology Retained (Yes/No)
General Response Action	Type of Remedial Technology	Process Option				Capital	O&M		
Sub-Slab Pressure Control	Sub-Slab Depressurization	Sub-Slab Depressurization	This technology is similar to sub-slab pressurization with regard to sub-slab construction in that a blower is connected to the system; however, in this case, the blower creates a slight negative sub-slab pressure by removing air beneath the foundation. This induces soil gas flow into sub-slab piping with discharge from the blower to a vent on the roof. The exhaust of the system may require treatment depending upon contaminant concentrations.	As with sub-slab pressurization, this technology can be implemented in new residential or commercial buildings using standard construction practices and readily available materials. This technology may be subject to vapor treatment requirements and cannot be implemented for buildings with a basement below the water table.	This technology has been shown to be effective in controlling vapor intrusion. Besides removing contaminants from under the building slab, the negative pressure contributes to a net air movement from the building to the sub-slab if air flow pathways exist in the building slab.	Moderate to High	High	Applicable for new or future buildings. More cost-effective vapor intrusion control technologies are available. Not applicable for existing structures.	No
Point of Exposure Control	Exhaust of Indoor Space	Exhaust of Indoor Space	Fans remove air from the building interior and facilitate inflow/circulation of ambient air into the building through doors, windows, or other openings. Similar to bulk air exhaust associated with bathrooms and kitchens, and large open buildings such as warehouses.	This technology could be implemented in new residential or commercial buildings. Implementation involves standard construction materials and procedures.	While effective in removing air from a room, applying this technology to a whole building could result in negative pressure zones in the building. Such negative pressure zones could enhance vapor intrusion.	Low	Moderate to High	Costs are dependent on energy consumption, so cost-effectiveness can be low compared to other vapor intrusion control technologies.	No
	Mechanical HVAC Adjustments	Mechanical HVAC Adjustments	Mechanical heating, ventilation, and air conditioning (HVAC) systems provide ventilation for buildings by conveying outdoor air into building enclosures. The air exchange rate associated with HVAC systems is the rate at which the indoor air is exchanged with outdoor air. An HVAC system can also induce a positive pressure in a building if operated at a sufficient level, thus reducing the migration of contaminants into buildings. The operation of HVAC system can also dilute contaminant concentrations in indoor air, the extent dependent upon contaminant concentrations in the ambient air.	An effective HVAC system for vapor intrusion prevention can be readily designed and installed in new residential or commercial buildings. Long-term implementation requires that the HVAC system operate as intended if vapor intrusion control is to be sustained.	Exchanging indoor air with outdoor air, contaminants can be removed to the extent of the dilution potential of the ambient air. HVAC systems are especially applicable to commercial buildings which rely on the HVAC system for normal air exchange associated with ventilation and heating. Effectiveness is less for residential buildings as the HVAC system is not consistently used for ventilation control.	Moderate to High	High	Operating cost are high relative to other vapor intrusion remedies. Effectiveness is less for residential buildings as the HVAC system is not consistently used for ventilation control.	No
In-Situ Treatment	Soil Vapor Extraction (SVE)	Soil Vapor Extraction (SVE)	Vacuum is applied through extraction pipes screened within unsaturated zone soil to create a pressure/concentration gradient, which induces gas-phase volatile organics to diffuse through soil to extraction wells.	Technically implementable. Requires network of piping to SVE wells and treatment compound containing blowers and vapor collection/treatment systems. Requires treatment of collected vapors before permitted discharge to atmosphere.	Effective for treating chlorinated organic compounds. Effectiveness may be limited by presence of fine-grained soils.	Moderate	Moderate	Applicable and/or required in combination with other technologies. Existing structures (i.e., WES building) would limit application of this technology.	Yes

Notes:

O&M = Operations and Maintenance; SVE= Soil Vapor Extraction; HDPE = High-Density Polyethylene; LLDPE = Linear Low-Density Polyethylene; PVC = Polyvinyl Chloride; HVAC = Heating, Ventilation, and Air Conditioning

Shading indicates remedial technology retained for cleanup action evaluation.

Table 5

Cleanup Action Alternative Descriptions

Former Alderwood Laundry and Dry Cleaners
Lynnwood, Washington

Matrix	Contaminants of Concern (COCs)	Cleanup Action Objectives (CAOs)	Cleanup Action Alternative Components			
			Alternative 1 - Source Area Removal With Capping and Institutional Controls	Alternative 2 - Source Area Removal, In-Situ Bioremediation and Biochemical Reduction, Capping and Institutional Controls	Alternative 3 - Source Area Removal with AS/SVE, Capping and Institutional Controls	Alternative 4 - Thermal Conduction Heating with SVE, Capping and Institutional Controls
Soil, Soil Gas and Groundwater	■ PCE and its Breakdown Products.	■ Prevent contact (dermal or incidental ingestion) by Site workers, visitors and/or future occupants with hazardous substances in soil and groundwater. ■ Prevent leaching of hazardous substances through the soil colum to groundwater. ■ Prevent inhalation of contaminated soil vapors within indoor spaces occupied by Site workers, visitors and/or future occupants	■ Asphalt demolition, soil removal and offsite disposal of source area material to a permitted landfill. Removal would target soil exceeding the PCUL at the PFD Property within the source area in the upper 6 feet where contaminants could otherwise be encountered during future redevelopment. ■ Verification Soil Sampling. ■ Installation of new physical containment barrier (i.e., asphalt/concrete pavement) within the soil removal area following construction to prevent direct exposure, stormwater infiltration and COC migration. ■ Maintenance of existing physical containment barriers outside of the soil removal area including surface pavement and 6-foot permeable soil cover that prevents direct exposure, stormwater infiltration and leaching of contaminants in soil to groundwater. ■ Performance groundwater monitoring following soil removal. ■ Implementation of Institutional Controls. ■ Long-term groundwater monitoring and indoor/sub-slab soil gas monitoring to verify compliance with the CAOs.	■ Asphalt demolition, soil removal and offsite disposal of source area material to a permitted landfill. Removal would target soil exceeding the PCUL at the PFD Property within the source area in the upper 6 feet where contaminants could otherwise be encountered during future redevelopment. ■ Verification Soil Sampling. ■ Installation of new physical containment barrier (i.e., asphalt/concrete pavement) within the soil removal area following construction to prevent direct exposure, stormwater infiltration and COC migration. ■ Maintenance of existing physical containment barriers outside of the soil removal area including surface pavement and 6-foot permeable soil cover that prevents direct exposure, stormwater infiltration and leaching of contaminants in soil to groundwater. ■ In-situ treatment through injection of chemical reagents for enhanced bioremediation and biochemical reduction of PCE contamination breakdown products from saturated soil and groundwater within the area of highest observed contamination. ■ Performance groundwater monitoring following soil removal and during in-situ treatment. ■ Implementation of Institutional Controls. ■ Long-term groundwater monitoring and indoor/sub-slab soil gas monitoring to verify compliance with the CAOs.	■ Asphalt demolition, soil removal and offsite disposal of source area material to a permitted landfill. Removal would target soil exceeding the PCUL at the PFD Property within the source area in the upper 6 feet where contaminants could otherwise be encountered during future redevelopment. ■ Verification Soil Sampling. ■ Installation of new physical containment barrier (i.e., asphalt/concrete pavement) within the soil removal area following construction to prevent direct exposure, stormwater infiltration and COC migration. ■ Maintenance of existing physical containment barriers outside of the soil removal area including surface pavement and 6-foot permeable soil cover that prevents direct exposure, stormwater infiltration and leaching of contaminants in soil to groundwater. ■ Installation of Air Sparging (AS) and Soil Vapor Excavation (SVE) wells connected to a centrally located treatment compound to remove PCE contamination and breakdown products from soil and groundwater within the area of highest observed contamination. ■ Performance groundwater monitoring following soil removal and during in-situ treatment. ■ Implementation of Institutional Controls. ■ Long-term groundwater monitoring and indoor/sub-slab soil gas monitoring to verify compliance with the CAOs.	■ Asphalt demolition, soil removal and offside disposal of contaminated soil to a permitted landfill to facilitate installation of an in-situ Thermal Conductive Heat (TCH) treatment system. ■ Installation of TCH, Soil Vapor Excavation (SVE) and temperature monitoring wells connected to a centrally located treatment compound to remove PCE contamination and breakdown products from soil and groundwater within the area of highest observed contamination. ■ Installation of a concrete thermal blanket within the footprint of the TCH treatment area. ■ Maintenance of existing physical containment barriers outside of the TCH treatment footprint including surface pavement and 6-foot permeable soil cover that prevents direct exposure, stormwater infiltration and leaching of contaminants in soil to groundwater. ■ Performance groundwater monitoring during in-situ treatment. ■ Implementation of Institutional Controls. ■ Long-term groundwater monitoring and indoor/sub-slab soil gas monitoring to verify compliance with the CAOs.
Estimated Alternative Cost (+50%/-30%)[1]			$2,180,000	$2,550,000	$2,880,000	$4,400,000
Estimated Volume of Contaminated Soil Removed/Treated			2,500 bcy	16,500 bcy	20,000 bcy	35,000 bcy
Estimated Restoration Time Frame for Active Cleanup[2]			1-2 Years	5-7 Years	5-7 Years	2-3 Years

Notes:

[1] Alternative cost estimates are presented in Appendix A.

[2] Long-term monitoring to document residual contaminant mass reduction over time through natural processes and/or enhance by in-situ treatment is anticipated to be on the order of 15 to 50 years.

PCUL = proposed cleanup level; AS = Air Sparging; SVE = Soil Vapor Extraction; TCH = Thermal Conduction Heating; COC = Contaminant of Concern; bcy = bank (in-place) cubic yards; N/A = Not Applicable

Table 6

Evaluation of Cleanup Action Alternatives

Former Alderwood Laundry and Dry Cleaners
Lynwood, Washington

Evaluation Criteria	Alternative 1 - Source Area Removal With Capping and Institutional Controls	Alternative 2 - Source Area Removal, In-Situ Bioremediation and Biochemical Reduction, Capping and Institutional Controls	Alternative 3 - Source Area Removal with AS/SVE, Capping and Institutional Controls	Alternative 4 - Thermal Conduction Heating with SVE, Capping and Institutional Controls
Compliance with MTCA Threshold Criteria				
Protection of Human Health and the Environment	**Yes** - Alternative would protect human health and the environment through a combination of existing containment technologies and institutional controls. Shallow soil within the source area would be removed in the upper 6 feet where contaminants could otherwise be encountered during future redevelopment.	**Yes** - Alternative would protect human health and the environment through a combination of existing containment technologies and institutional controls. Shallow soil within the source area would be removed in the upper 6 feet where contaminants could otherwise be encountered during future redevelopment. Contamination is further address through in-situ enhanced bioremediation and biochemical reduction.	**Yes** - Alternative would protect human health and the environment through a combination of existing containment technologies and institutional controls. Shallow soil within the source area would be removed in the upper 6 feet where contaminants could otherwise be encountered during future redevelopment. Contamination is further address through in-situ Air Sparging (AS) and Soil Vapor Extraction (SVE).	**Yes** - Alternative would protect human health and the environment through a combination of existing containment technologies and institutional controls. Contamination is further address through in-situ Thermal Conduction Heating (TCH) and Soil Vapor Extraction (SVE).
Compliance With Cleanup Standards	Yes - Alternative is expected to comply with cleanup standards. This alternative utilizes soil removal with containment technologies and institutional controls to prevent exposure to contaminants in the subsurface. Compliance would rely on long-term monitoring to evaluate natural attenuation performance, and maintenance of institutional controls. Future development of property could potentially require additional environmental cleanup or special provisions if soil disturbance occurs below 6 feet.	**Yes** - Alternative is expected to comply with cleanup standards. This alternative utilizes soil removal, in-situ treatment with containment technologies and institutional controls to prevent exposure to contaminants in the subsurface. Compliance would rely on long-term monitoring to evaluate attenuation performance, and maintenance of institutional controls. Future development of property could potentially require additional environmental cleanup or special provisions if soil disturbance occurs below 6 feet.	**Yes** - Alternative is expected to comply with cleanup standards. This alternative utilizes soil removal, in-situ treatment with containment technologies and institutional controls to prevent exposure to contaminants in the subsurface. Compliance would rely on long-term monitoring to evaluate attenuation performance, and maintenance of institutional controls. Future development of property could potentially require additional environmental cleanup or special provisions if soil disturbance occurs below 6 feet.	**Yes** - Alternative is expected to comply with cleanup standards. This alternative utilizes in-situ treatment, containment technologies, and institutional controls to prevent exposure to contaminants in the subsurface. Compliance would rely on long-term monitoring and maintenance of institutional controls.
Compliance With Applicable State and Federal Regulations	**Yes** - Alternative complies with applicable state and federal regulations.	**Yes** - Alternative complies with applicable state and federal regulations.	**Yes** - Alternative complies with applicable state and federal regulations.	**Yes** - Alternative complies with applicable state and federal regulations.
Provision for Compliance Monitoring	**Yes** - Alternative includes provisions for compliance monitoring.	**Yes** - Alternative includes provisions for compliance monitoring.	**Yes** - Alternative includes provisions for compliance monitoring.	**Yes** - Alternative includes provisions for compliance monitoring.
Restoration Time Frame				
Restoration Time Frame	Following demolition of the strip mall building, the duration for soil removal activities and site restoration is anticipated to be less than 3 months. Containment in the form of new asphalt pavement within the soil removal footprint and existing pavement and/or permeable soil cover would prevent direct exposure, stormwater infiltration and leaching of residual contaminants in soil to groundwater. Institutional controls would then be implemented limit the use of groundwater as drinking water, prevent ground disturbances and to maintain the soil caps to meet the CAOs. To verify that the CAOs are being met, long-term soil gas and groundwater monitoring would be performed to evaluate plume stability and natural attenuation performance, and ensure that building occupants are not being exposed to contaminant vapors. Long-term monitoring is assumed for 50 years. However, additional long-term monitoring may be required to verify compliance with the CAOs.	Following demolition of the strip mall building, the duration for soil removal activities and site restoration is anticipated to be less than 3 months. Subsequent in-situ treatment is expected to remediate groundwater within the PFD Property within a 5-7 year time frame. Containment in the form of new asphalt pavement within the soil removal footprint and existing pavement and/or permeable soil cover would prevent direct exposure, stormwater infiltration and leaching of residual contaminants in soil to groundwater. Institutional controls would then be implemented limit the use of groundwater as drinking water, prevent ground disturbances and to maintain the soil caps to meet the CAOs in areas with residual contamination. To verify that the CAOs are being met, long-term soil gas and groundwater monitoring would be performed to evaluate plume stability and natural attenuation performance, and ensure that building occupants are not being exposed to contaminant vapors. Due to the level of contaminate reduction, long-term monitoring is assumed for 15 years. However, additional long-term monitoring may be required to verify compliance with the CAOs.	Following demolition of the strip mall building, the duration for soil removal activities and site restoration is anticipated to be less than 3 months. Subsequent in-situ treatment is expected to achieve the cleanup action objectives for this component of the cleanup action within a 5-7 year time frame. Containment in the form of new asphalt pavement within the soil removal footprint and existing pavement and/or permeable soil cover would prevent direct exposure, stormwater infiltration and leaching of residual contaminants in soil to groundwater. Institutional controls would then be implemented limit the use of groundwater as drinking water, prevent ground disturbances and to maintain the soil caps to meet the CAOs in areas with residual contamination. To verify that the CAOs are being met, long-term soil gas and groundwater monitoring would be performed to evaluate plume stability and natural attenuation performance, and ensure that building occupants are not being exposed to contaminant vapors. Due to the level of contaminate reduction, long-term monitoring is assumed for 15 years. However, additional long-term monitoring may be required to verify compliance with the CAOs.	Following demolition of the strip mall building, in-situ treatment is expected to achieve the cleanup action objectives for this component of the cleanup action within a 1 to 2 year time frame. Containment in the form of new concrete pavement within the treatment footprint and existing pavement and/or permeable soil cover would prevent direct exposure, stormwater infiltration and leaching of residual contaminants in soil to groundwater. Institutional controls would then be implemented limit the use of groundwater as drinking water, prevent ground disturbances and to maintain the soil caps to meet the CAOs in areas with residual contamination. To verify that the CAOs are being met, long-term soil gas and groundwater monitoring would be performed to evaluate plume stability and natural attenuation performance, and ensure that building occupants are not being exposed to contaminant vapors. Due to the level of contaminant reduction, long-term monitoring is assumed for 10 years. However, additional long-term monitoring may be required to verify compliance with the CAOs.

Evaluation Criteria	Alternative 1 - Source Area Removal With Capping and Institutional Controls	Alternative 2 - Source Area Removal, In-Situ Bioremediation and Biochemical Reduction, Capping and Institutional Controls	Alternative 3 - Source Area Removal with AS/SVE, Capping and Institutional Controls	Alternative 4 - Thermal Conduction Heating with SVE, Capping and Institutional Controls
Relative Benefits Ranking (Scored from 1-lowest to 10-highest)				
Protectiveness	**Score = 2** Achieves a low level of protectiveness as residual contamination remains in place following soil removal without further treatment. Natural attenuation processes to reduce the toxicity, mobility and mass of COCs are expected to occur over a long time period. Short-term on-site and off-site risk of exposure are increased due to removal action and off-site disposal; however, these exposure risks are managed through waste handling and construction safety practices.	**Score = 5** Achieves a moderate level of protectiveness because although residual contamination remains in place following soil removal, in-situ treatment will reduce the toxicity, mobility and mass of residual COCs remaining in saturated soil and in groundwater within a reasonable time frame as compared to Alternative 1. Short-term on-site and off-site risk of exposure are increased due to removal action and off-site disposal; however, these exposure risks are managed through waste handling and construction safety practices.	**Score = 6** Achieves a moderate level of protectiveness because although residual contamination remains in place following soil removal, in-situ treatment will reduce the toxicity, mobility and mass of residual COCs remaining in unsaturated and saturated soil and groundwater within a reasonable time frame as compared to Alternative 1. Short-term on-site and off-site risk of exposure are increased due to removal action and off-site disposal and during operation of the AS/SVE treatment system; however, these exposure risks are managed through waste handling and construction safety practices.	**Score = 8** Achieves a moderate-high level of protectiveness as this alternative is expected to improve overall environmental quality by removing COCs throughout the soil column within the area of TCH influence within a relatively short time frame. During in-situ treatment, containment barriers will prevent direct exposure and limit soil to groundwater leaching. Similar to the other alternatives, compliance will be performed to evaluate contaminant attenuation performance in groundwater.
Permanence	**Score = 1** Achieves a low level of permanence since this alternative relies on shallow soil removal and use of containment barriers and natural attenuation processes to reduce the toxicity, mobility and/or mass of COCs.	**Score = 5** Achieves a higher level of permanence over Alternative 1 with the addition of in-situ treatment to reduce the toxicity, mobility and mass of residual COCs remaining in place. Similar to Alternative 1, containment barriers and compliance monitoring would be utilized to prevent direct exposure and evaluate attenuation performance of COCs over time.	**Score = 6** Achieves similar level of permanence as Alternative 2. Soil removal and in-situ treatment will reduce the toxicity, mobility and mass of residual COCs remaining in place. Similar to Alternative 1, containment barriers and compliance monitoring would be utilized to prevent direct exposure and evaluate attenuation performance of COCs over time.	**Score = 8** Achieves a higher level of permanence than Alternatives 1, 2 and 3 and receives a higher score due to more complete treatment of COCs throughout the soil column and because this in-situ treatment technology provides a higher level of reduction in the toxicity, mobility and mass of COCs compared to Alternatives 2 and 3.
Long-Term Effectiveness	**Score = 1** This alternative relies on natural attenuation processes occurring over a long time frame to address COCs that would remain in place following soil removal. Removal of the source area in the upper 6 feet where contaminants could otherwise be encountered during future redevelopment and utilization of containment barriers to prevent exposure and limit soil to groundwater leaching is expected to increase the overall long-term effectiveness of this alternative.	**Score = 5** Provides a moderate level of certainty with regard to long-term effectiveness. Slightly higher score is achieved due to the addition of in-situ treatment of COCs within the area of the highest observed contamination. However, it received a lower score than Alternatives 3 and 4 as enhanced bioremediation and biochemical reduction technologies rely on saturated soil for reagent distribution and microbial mobility in the subsurface.	**Score = 6** Provides a moderate level of certainty with regard to long-term effectiveness. Slightly higher score over Alternative 2 is achieved due to expected reduction of toxicity, mobility and mass of residual COCs treatment contained within the vadose within the area of the highest observed contamination.	**Score = 7** Provides a high level of certainty with regard to long-term effectiveness due to the permanent removal of COCs in the source area in addition to containment technologies implemented similar to Alternatives 1 through 3. However, Alternative 4 relies on natural attenuation of residual COCs remaining in place, reducing the score to some degree.
Management of Short-Term Risks	**Score = 8** Achieves a high level of confidence in managing short-term risk to human health and environment since this alternative involves soil removal utilizing standard earthwork equipment followed by site restoration. Exposure risk to Site COCs during construction can be managed through waste handling and construction safety practices.	**Score = 7** Achieves a high level of confidence in managing short-term risk to human health and environment since this alternative involves soil removal utilizing standard earthwork equipment followed by site restoration. Short-term risks are expected to be slightly higher over Alternative 1 due to the injection of reagents into the subsurface.	**Score = 7** Achieves a moderate-high level of confidence in managing short-term risk to human health and environment since this alternative involves soil removal utilizing standard earthwork equipment followed by site restoration. Short-term risks are expected to be slightly higher over Alternative 2 resulting from operation and maintenance of the AS/SVE treatment System.	**Score = 5** Achieves a moderate level of confidence in managing short-term risk to human health and environment. Installation, operation and maintenance of the TCH treatment system is expected to required significant technical support over Alternative 3 due to the complexity of this remedial technology.
Technical and Administrative Implementability	**Score = 8** Achieves a moderate-high level of implementability since this alternative involves soil removal utilizing standard earthwork equipment, construction of an asphalt cap and long-term compliance monitoring which are all proven remedial technologies.	**Score = 7** Achieves a moderate-high level of implementability since this alternative involves soil removal utilizing standard earthwork equipment, construction of an asphalt cap, installation of temporary reagent injection points followed by compliance monitoring which are all proven remedial technologies.	**Score = 7** Achieves a moderate-high level of implementability since this alternative involves soil removal utilizing standard earthwork equipment, construction of an asphalt cap, installation of temporary reagent injection points followed by compliance monitoring which are all proven remedial technologies. This alternative receives a slightly lower score than Alternative 2 due to the additional effort to maintain and operate the AS/SVE treatment system.	**Score = 5** Achieves a moderate level of implementability due to the level of planning and design to implement the TCH treatment technology. Implementation will be challenging since it will require the installation of a significant number of well points, expected power consumption and level of effort required to operate and maintain this system. Additionally, there may be a concern for damage to existing utility infrastructure resulting from temperatures required to treat COCs under this alternative and may require relocation.
Consideration of Public Concerns	**Score = 2** Residual contamination remaining in place below containment features could be a concern to the public and nearby property owners and would need to be managed if likely to be encountered based on future redevelopment of the Site.	**Score = 6** Residual contamination remaining in place below containment features could be a concern to the public and nearby property owners and would need to be managed if likely to be encountered based on future redevelopment of the Site. However, the further addition of in-situ treatment to reduce the toxicity, mobility and mass of COCs reduces public concerns to a degree.	**Score = 6** Residual contamination remaining in place below containment features could be a concern to the public and nearby property owners and would need to be managed if likely to be encountered based on future redevelopment of the Site. However, the further addition of in-situ treatment to reduce the toxicity, mobility and mass of COCs reduces public concerns to a degree.	**Score = 8** It is anticipated that there will be a low level of public concern under this alternative. Although there will be residual contamination remaining in place in areas not accessible to THC, in-situ treatment will significantly reduce the overall contaminant mass as compared to the other alternatives.

Notes:

COC = Contaminant of Concern; AS = Air Sparging; SVE = Soil Vapor Extraction; TCH = Thermal Conduction Heating

Table 7

Cleanup Action Alternative Evaluation Summary and Ranking

Former Alderwood Laundry and Dry Cleaners

Lynnwood, Washington

Remedial Alternative	Alternative 1 - Source Area Removal With Capping and Institutional Controls	Alternative 2 - Source Area Removal, In-Situ Bioremediation and Biochemical Reduction, Capping and Institutional Controls	Alternative 3 - Source Area Removal with AS/SVE, Capping and Institutional Controls	Alternative 4 - Thermal Conduction Heating with SVE, Capping and Institutional Controls
Evaluation				
Compliance with MTCA Threshold Criteria	Yes	Yes	Yes	Yes
Restoration Time Frame for Active Cleanup[1]	1-2 Years	5-7 Years	5-7 Years	2-3 Years
Relative Benefits Ranking[2]				
Protectiveness (weighted as 30%)	0.6	1.5	1.8	2.4
Permanence (weighted as 20%)	0.2	1	1.2	1.6
Long-Term Effectiveness (weighted as 20%)	0.2	1	1.2	1.4
Management of Short-Term Risks (weighted as 10%)	0.8	0.7	0.7	0.5
Technical and Administrative Implementability (weighted as 10%)	0.8	0.7	0.7	0.5
Consideration of Public Concerns (weighted as 10%)	0.2	0.6	0.6	0.8
Overall Weighted Benefit Score	**2.80**	**5.50**	**6.20**	**7.20**
Disproportionate Cost Analysis				
Practicability of Remedy	Practicable	Practicable	Practicable	Practicable
Remedy Permanent to Maximum Extent Practicable	Yes	Yes	Yes	Yes
Probable Remedy Cost (+50%/-30%, rounded)	$2,180,000	$2,550,000	$2,880,000	$4,400,000
Relative Benefit Ranking to Remedial Cost (Benefit/$1M)	1.28	2.16	2.15	1.64
Costs Disproportionate to Incremental Benefits	No	No	Yes	Yes
Overall Alternative Ranking	**2nd**	**1st**	**3rd**	**4th**

Notes:

[1] Long-term monitoring to document residual contaminant mass reduction over time through natural process and/or enhance by in-situ treatment is anticipated to be on the order of 15 to 50 years.

[2] Weightings were established by Ecology as referenced in their Opinion Letter dated December 28, 2009.

FIGURES

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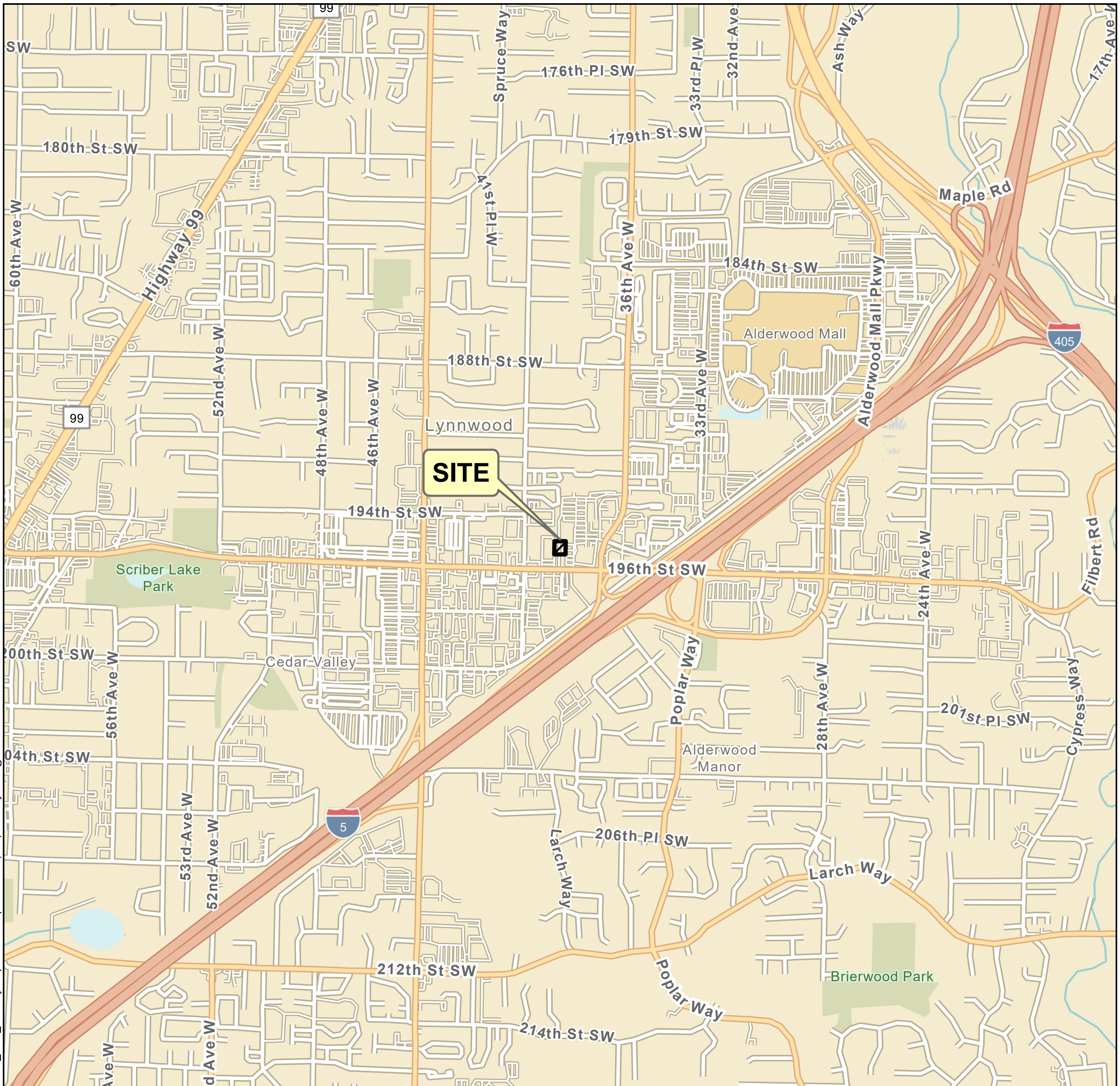

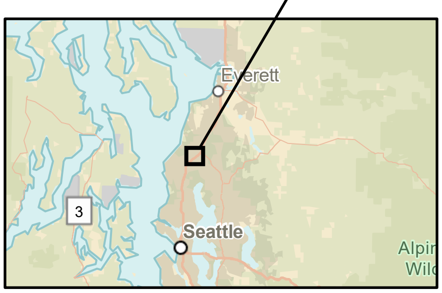

N
W E
S

2,000 0 2,000

Feet

Notes:

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Data Source: ESRI

Projection: NAD 1983 StatePlane Washington North FIPS 4601 Feet

Vicinity Map

Alderwood Laundry and Dry Cleaners
Lynnwood, Washington

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Figure 1

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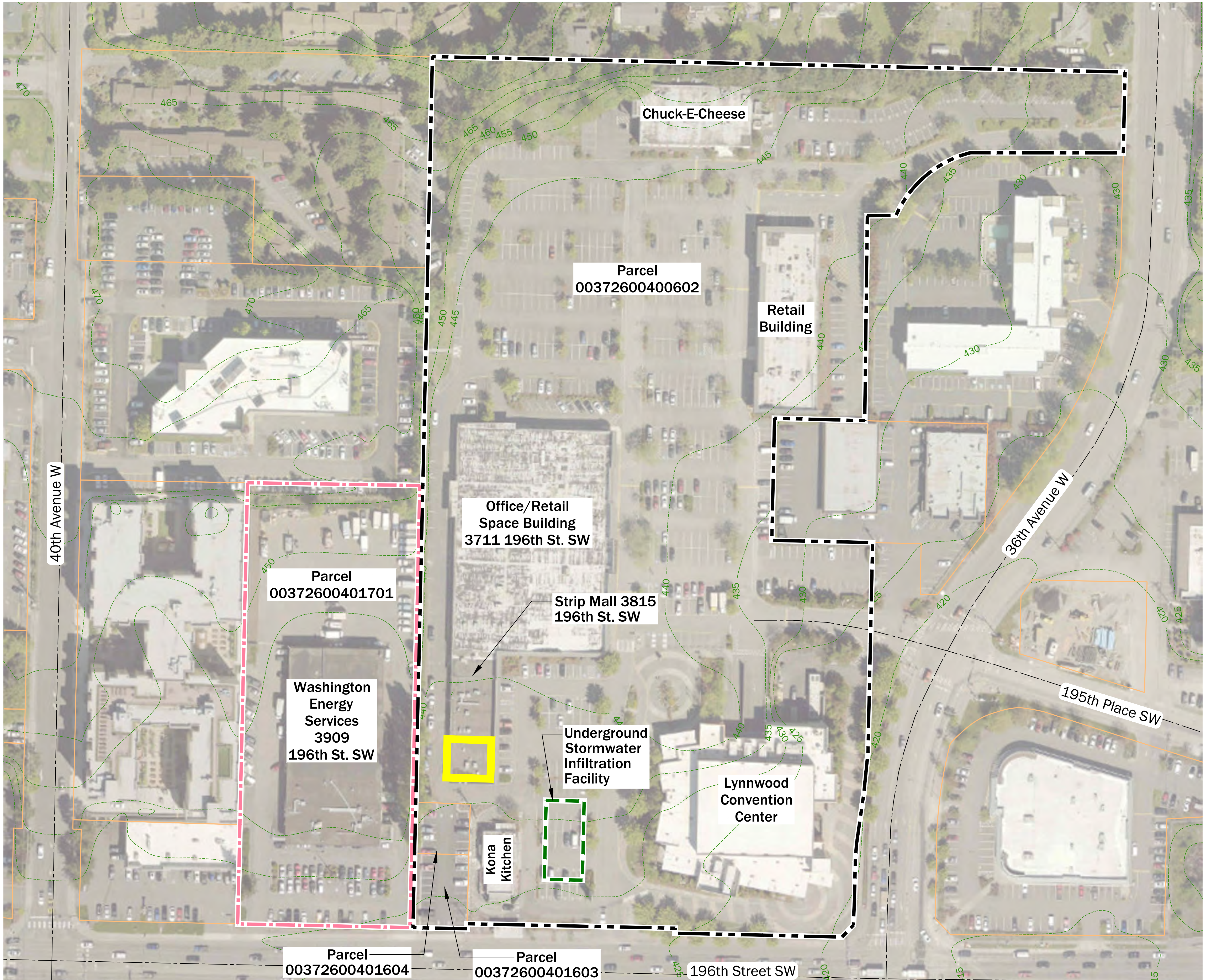

Legend

- Lynnwood Public Facilities District Property Boundary
- West Adjoining Property Boundary
- Parcel Boundary
- Topographic Contour (5-Ft. Interval)
- Approximate Footprint of Former Alderwood Laundry & Dry Cleaners

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Data Source: Aerial from King County dated 2019 and street centerlines. Topographic contours from Snohomish County GIS Data 2020.

Vertical Datum: NAVD 88.

Projection: NAD83 Washington State Planes, North Zone, US Foot.

N S W E

120 0 120
Feet

Site Overview

Former Alderwood Laundry and Dry Cleaners
Lynnwood, Washington

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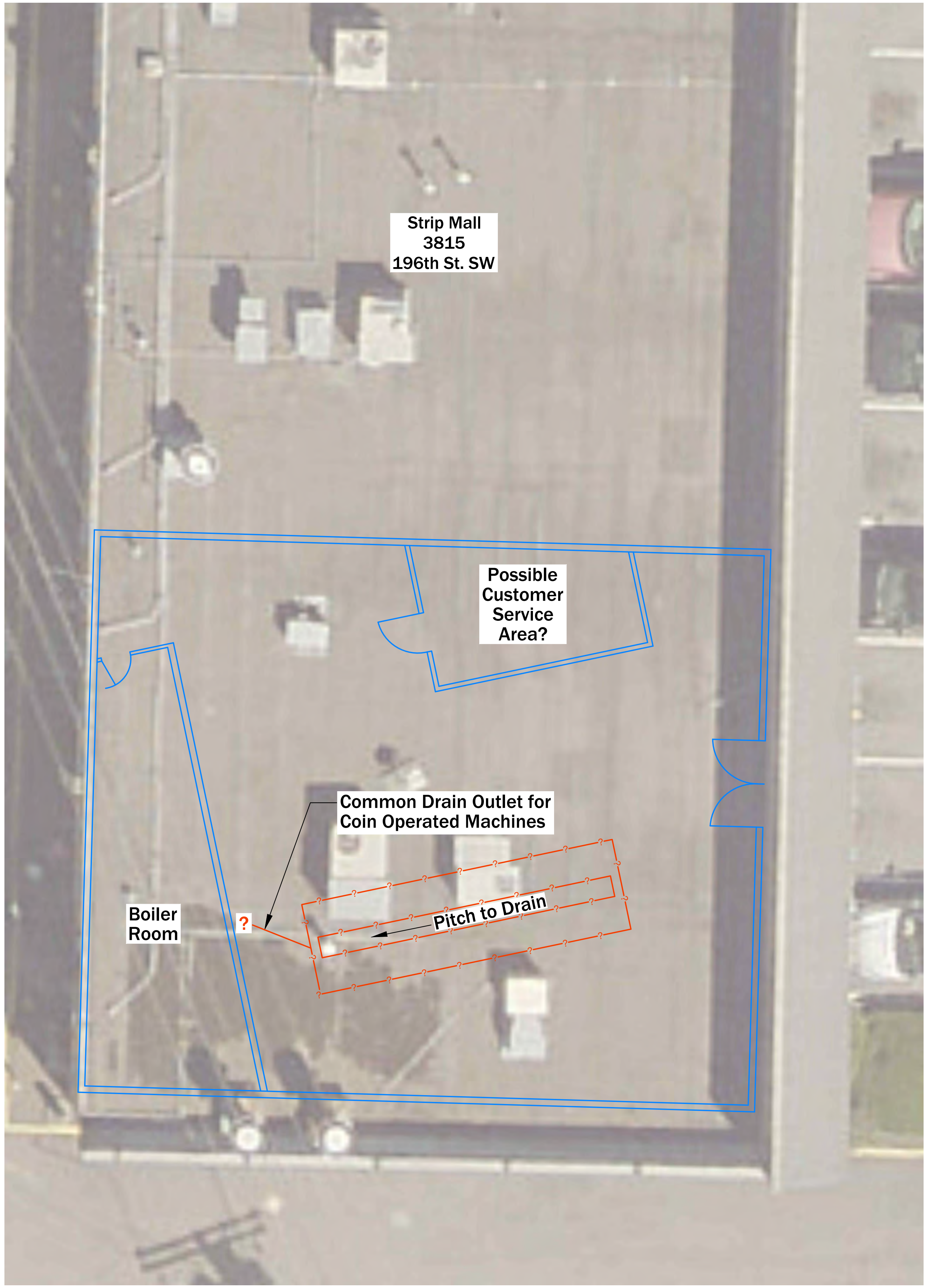
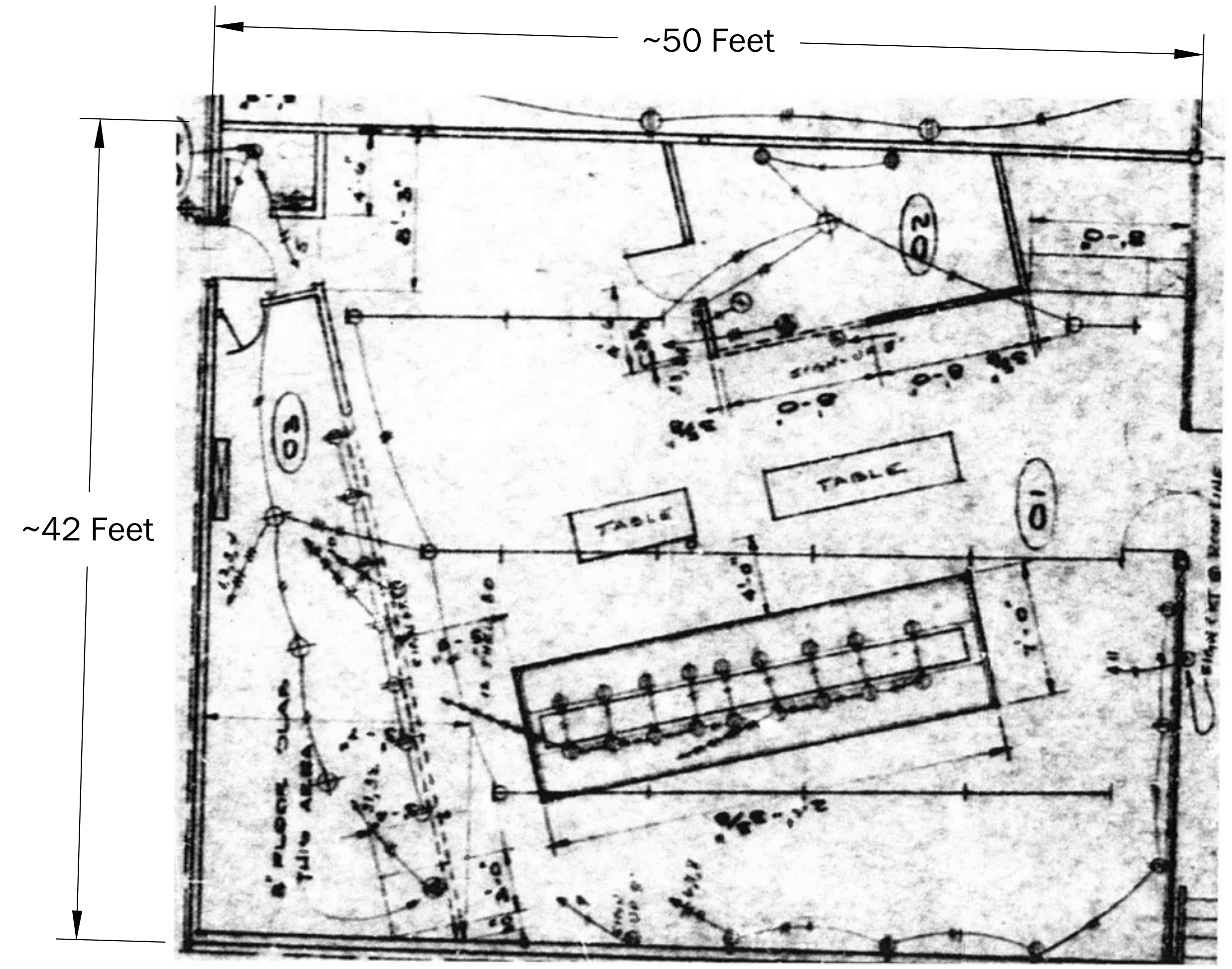
Figure 2

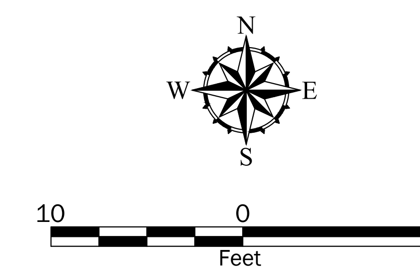
P:\17\17787001\CAD\15\Draft Feasibility Study\1778700115_FS_F02_Site Overview.dwg TAB:F02 Date Exported: 05/20/21 - 16:35 by syi





~2,100
Square
Feet

Historical Alderwood Laundry and Dry Cleaners (also known as Alterwood Highland Center Laundry) facility layout (circa 1963). Facility layout from architectural drawings of the initial strip mall development provided by the City of Lynnwood.



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Data Source: Aerial from King County dated 2019 and street centerlines..

Vertical Datum: NAVD 88.

Projection: NAD83 Washington State Planes, North Zone, US Foot.

Historic Drawing Overlay

Former Alderwood Laundry and Dry Cleaners
Lynnwood, Washington

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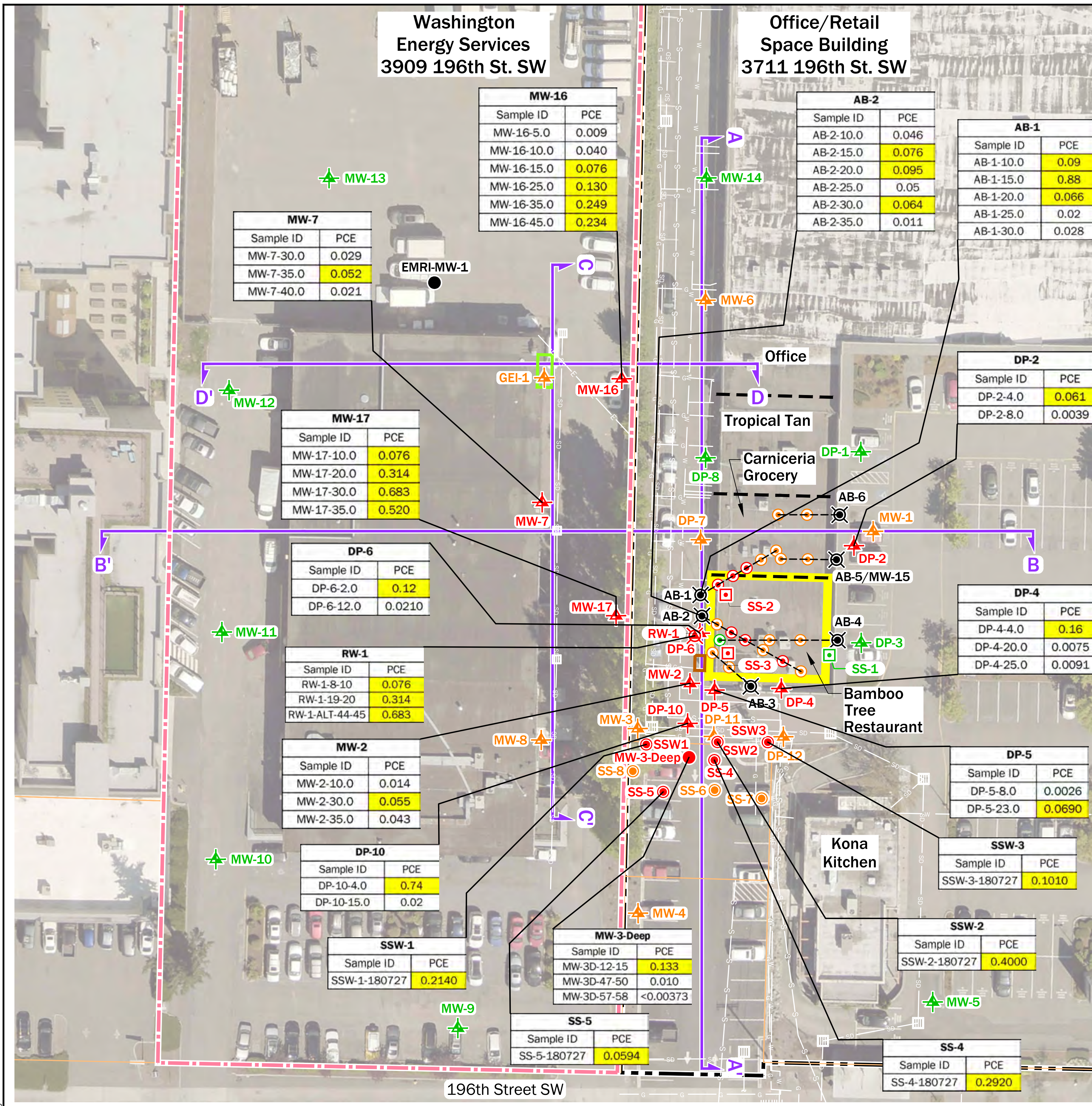
Figure 3



MW-16

Sample ID	PCE
MW-16-5.0	0.009
MW-16-10.0	0.040
MW-16-15.0	0.076
MW-16-25.0	0.130
MW-16-35.0	0.249
MW-16-45.0	0.234

AB-2

Sample ID	PCE
AB-2-10.0	0.046
AB-2-15.0	0.076
AB-2-20.0	0.095
AB-2-25.0	0.05
AB-2-30.0	0.064
AB-2-35.0	0.011

AB-1

Sample ID	PCE
AB-1-10.0	0.09
AB-1-15.0	0.88
AB-1-20.0	0.066
AB-1-25.0	0.02
AB-1-30.0	0.028

MW-7

Sample ID	PCE
MW-7-30.0	0.029
MW-7-35.0	0.052
MW-7-40.0	0.021

DP-2

Sample ID	PCE
DP-2-4.0	0.061
DP-2-8.0	0.0039

MW-17

Sample ID	PCE
MW-17-10.0	0.076
MW-17-20.0	0.314
MW-17-30.0	0.683
MW-17-35.0	0.520

DP-6

Sample ID	PCE
DP-6-2.0	0.12
DP-6-12.0	0.0210

DP-4

Sample ID	PCE
DP-4-4.0	0.16
DP-4-20.0	0.0075
DP-4-25.0	0.0091

RW-1

Sample ID	PCE
RW-1-8-10	0.076
RW-1-19-20	0.314
RW-1-ALT-44-45	0.683

MW-2

Sample ID	PCE
MW-2-10.0	0.014
MW-2-30.0	0.055
MW-2-35.0	0.043

DP-5

Sample ID	PCE
DP-5-8.0	0.0026
DP-5-23.0	0.0690

DP-10

Sample ID	PCE
DP-10-4.0	0.74
DP-10-15.0	0.02

SSW-3

Sample ID	PCE
SSW-3-180727	0.1010

SSW-2

Sample ID	PCE
SSW-2-180727	0.4000

SSW-1

Sample ID	PCE
SSW-1-180727	0.2140

MW-3-Deep

Sample ID	PCE
MW-3D-12-15	0.133
MW-3D-47-50	0.010
MW-3D-57-58	<0.00373

SS-5

Sample ID	PCE
SS-5-180727	0.0594

SS-4

Sample ID	PCE
SS-4-180727	0.2920

Legend

- DP-6/MW-2 — Exploration - MTCA Method A Cleanup Levels Exceedance for PCE/TCE in Soil
- DP-7/MW-4 — Exploration - HVOCs detected less than MTCA Method A Cleanup Levels in Soil
- DP-1/MW-9 — Exploration - HVOCs Not Detected
- AB-1 — Angled Boring by GeoEngineers, Inc.
- EMRI-MW-1 — Groundwater Monitoring Well by EMRI (1999)
- Soil Sample with PCE detection greater than MTCA Method A Cleanup Level
- Soil Sample with HVOC detections less than MTCA Method A or B Cleanup Levels
- Soil Sample with HVOCs Not Detected
- SSW1 — Confirmation Soil Sample
- MW-3-Deep — Deep Groundwater Assessment Boring with PCE/TCE detection greater than MTCA Method A Cleanup Level
- RW-1 — Pilot Study Injection Well with PCE/TCE detection greater than MTCA Method A Cleanup Level
- SS-2 — Sub Slab Soil Data April 2021 with PCE detection greater than MTCA Method A Cleanup Level
- SS-1 — Sub Slab Soil Data April 2021 with HVOCs Not Detected
- Lynnwood Public Facilities District Property Boundary
- West Adjoining Property Boundary
- Parcel Boundary
- Approximate Footprint of Former Alderwood Laundry & Dry Cleaners
- Backfilled Waste Oil UST Excavation
- Existing Concrete Grease Trap
- Existing Catch Basin
- Existing Storm Drain
- Existing Gas Line
- Existing Sewer Line
- Existing Water Line
- Electric Utility
- A – A' Cross Section Location

Data Box Explanation:

- PCE — Tetrachloroethylene
- TCE — Trichloroethylene
- ND — Not Detected
- MTCA — Model Toxics Control Act
- HVOC — Halogenated Volatile Organic Compounds
- mg/kg — milligrams per kilogram
- 0.16 — Shading indicates concentration greater than MTCA
- DP-4-4.0 — Sample Identification; Sample Depth in feet below ground surface

N S E W

50 0 50 Feet

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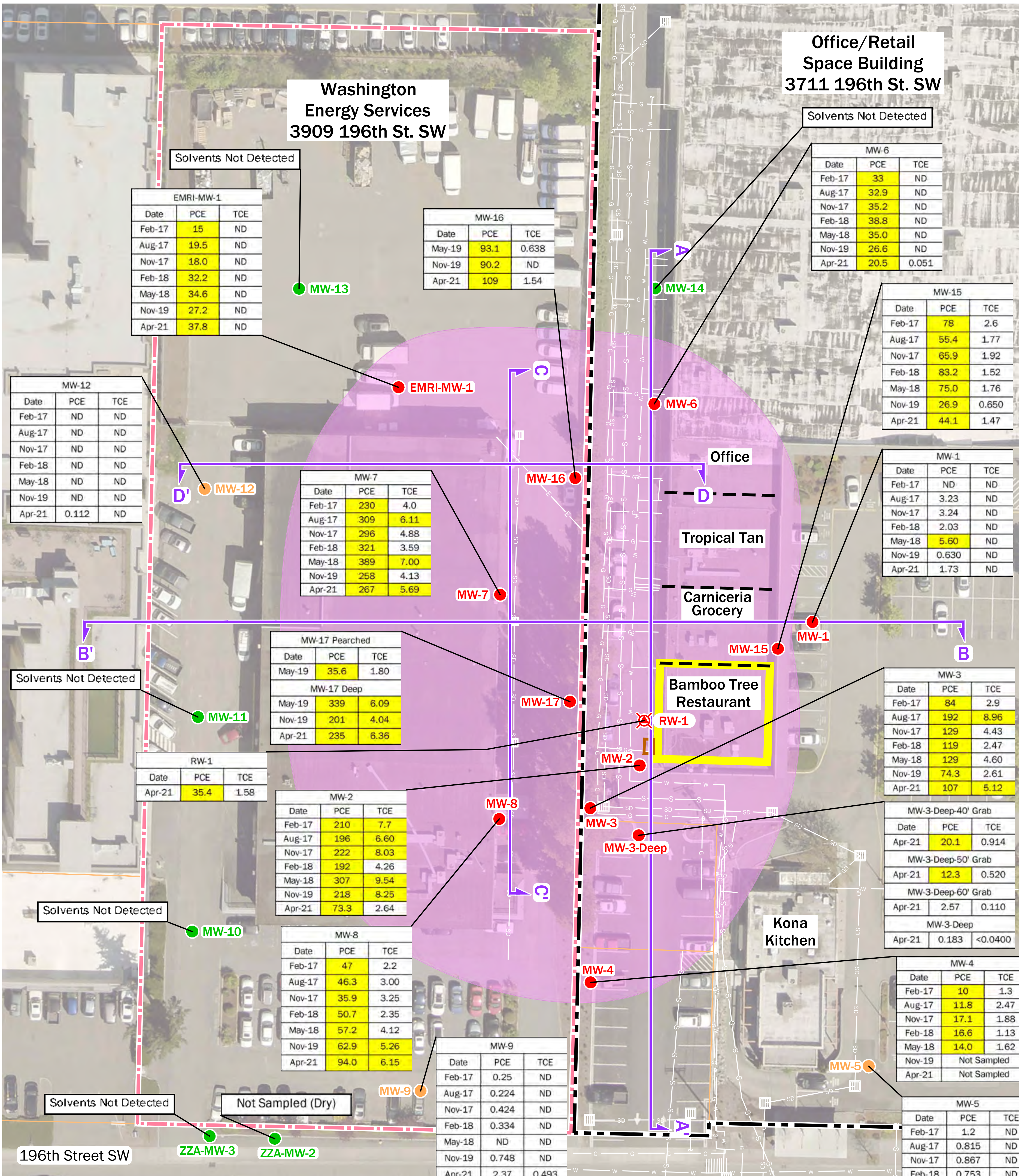
Soil Chemical Analytical Data

Former Alderwood Laundry and Dry Cleaners
Lynnwood, Washington

GeoEngineers

Figure 4



EMRI-MW-1		
Date	PCE	TCE
Feb-17	15	ND
Aug-17	19.5	ND
Nov-17	18.0	ND
Feb-18	32.2	ND
May-18	34.6	ND
Nov-19	27.2	ND
Apr-21	37.8	ND

MW-16		
Date	PCE	TCE
May-19	93.1	0.638
Nov-19	90.2	ND
Apr-21	109	1.54

MW-6		
Date	PCE	TCE
Feb-17	33	ND
Aug-17	32.9	ND
Nov-17	35.2	ND
Feb-18	38.8	ND
May-18	35.0	ND
Nov-19	26.6	ND
Apr-21	20.5	0.051

MW-15		
Date	PCE	TCE
Feb-17	78	2.6
Aug-17	55.4	1.77
Nov-17	65.9	1.92
Feb-18	83.2	1.52
May-18	75.0	1.76
Nov-19	26.9	0.650
Apr-21	44.1	1.47

MW-12		
Date	PCE	TCE
Feb-17	ND	ND
Aug-17	ND	ND
Nov-17	ND	ND
Feb-18	ND	ND
May-18	ND	ND
Nov-19	ND	ND
Apr-21	0.112	ND

MW-7		
Date	PCE	TCE
Feb-17	230	4.0
Aug-17	309	6.11
Nov-17	296	4.88
Feb-18	321	3.59
May-18	389	7.00
Nov-19	258	4.13
Apr-21	267	5.69

MW-1		
Date	PCE	TCE
Feb-17	ND	ND
Aug-17	3.23	ND
Nov-17	3.24	ND
Feb-18	2.03	ND
May-18	5.60	ND
Nov-19	0.630	ND
Apr-21	1.73	ND

MW-17 Pearched		
Date	PCE	TCE
May-19	35.6	1.80
MW-17 Deep		
May-19	339	6.09
Nov-19	201	4.04
Apr-21	235	6.36

MW-3		
Date	PCE	TCE
Feb-17	84	2.9
Aug-17	192	8.96
Nov-17	129	4.43
Feb-18	119	2.47
May-18	129	4.60
Nov-19	74.3	2.61
Apr-21	107	5.12

RW-1		
Date	PCE	TCE
Apr-21	35.4	1.58

MW-2		
Date	PCE	TCE
Feb-17	210	7.7
Aug-17	196	6.60
Nov-17	222	8.03
Feb-18	192	4.26
May-18	307	9.54
Nov-19	218	8.25
Apr-21	73.3	2.64

MW-3-Deep-40' Grab		
Date	PCE	TCE
Apr-21	20.1	0.914
MW-3-Deep-50' Grab		
Apr-21	12.3	0.520
MW-3-Deep-60' Grab		
Apr-21	2.57	0.110
MW-3-Deep		
Apr-21	0.183	<0.0400

MW-8		
Date	PCE	TCE
Feb-17	47	2.2
Aug-17	46.3	3.00
Nov-17	35.9	3.25
Feb-18	50.7	2.35
May-18	57.2	4.12
Nov-19	62.9	5.26
Apr-21	94.0	6.15

MW-4		
Date	PCE	TCE
Feb-17	10	1.3
Aug-17	11.8	2.47
Nov-17	17.1	1.88
Feb-18	16.6	1.13
May-18	14.0	1.62
Nov-19	Not Sampled	
Apr-21	Not Sampled	

MW-9		
Date	PCE	TCE
Feb-17	0.25	ND
Aug-17	0.224	ND
Nov-17	0.424	ND
Feb-18	0.334	ND
May-18	ND	ND
Nov-19	0.748	ND
Apr-21	2.37	0.493

MW-5		
Date	PCE	TCE
Feb-17	1.2	ND
Aug-17	0.815	ND
Nov-17	0.867	ND
Feb-18	0.753	ND
May-18	1.05	ND
Nov-19	0.722	ND
Apr-21	0.287	ND

Legend

MW-2 — Groundwater Sample with MTCA Method A Cleanup Level Exceedance for PCE/TCE

MW-1 — Groundwater Sample with PCE/TCE less than MTCA Method A Cleanup Levels

MW-9 — Groundwater Sample - Solvents Not Detected

MTCA — Model Toxics Control Act

HVOC — Halogenated Volatile Organic Compounds

Extent PCE > 5 ug/L in Groundwater

Lynnwood Public Facilities District Property Boundary

West Adjoining Property Boundary

Parcel Boundary

Approximate Footprint of Former Alderwood Laundry & Dry Cleaners

Existing Concrete Grease Trap

MW-3-Deep — Deep Groundwater Assessment Boring with PCE/TCE detection greater than MTCA Method A Cleanup Level

RW-1 — Pilot Study Injection Well with PCE/TCE detection greater than MTCA Method A Cleanup Level

A A' — Cross Section Location

Existing Catch Basin

Existing Storm Drain

Existing Gas Line

Existing Sewer Line

Existing Water Line

Electric Utility

Data Box Explanation:

PCE Tetrachloroethylene

TCE Trichloroethylene

ND Not Detected

ug/L micrograms per liter

Data boxes are provided for monitoring wells with detections of PCE/TCE.

Shading indicates concentration greater than MTCA.

All concentrations are in micrograms per liter.

N W E S

50 0 50

Feet

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Groundwater Chemical Analytical Data As of April 2021 (Last Sampled)

Former Alderwood Laundry and Dry Cleaners
Lynnwood, Washington

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Figure 5

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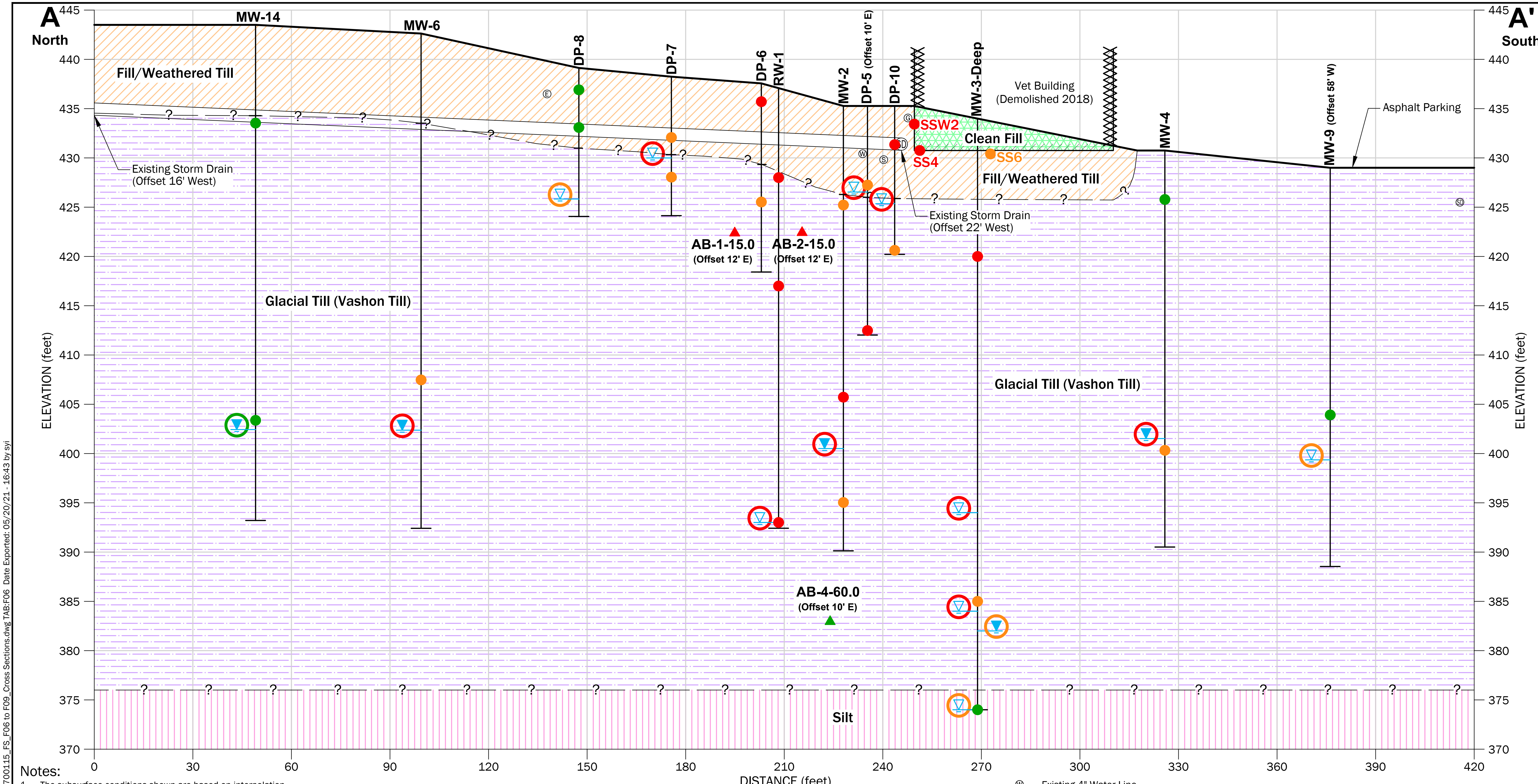

Notes:

1. The subsurface conditions shown are based on interpolation between widely spaced explorations and should be considered approximate; actual subsurface conditions may vary from those shown.
2. This figure is for informational purposes only. It is intended to assist in the identification of features discussed in a related document. Data were compiled from sources as listed in this figure. The data sources do not guarantee these data are accurate or complete. There may have been updates to the data since the publication of this figure. This figure is a copy of a master document. The hard copy is stored by GeoEngineers, Inc. and will serve as the official document of record.
3. Groundwater elevations and chemical data shown are from March 2013, February 2017, and/or April 2021, whichever reflects the most current data available.
4. For clarity of figure, 0 - 5 ' BGS utilities running parallel to the cross section are not shown.

Datum: NAVD 88, unless otherwise noted.

Legend

- DP-7 — Exploration and Approximate Location
- ? — Interpreted Soil Unit Contact Line
- Soil Sample - PCE/TCE detection greater than MTCA Method A Cleanup Level
- Soil Sample - HVOCs detection less than MTCA Method A Cleanup Level
- Soil Sample - HVOCs Not Detected
- Angled Boring Soil Sample - PCE/TCE detection greater than MTCA Method A Cleanup Level
- Angled Boring Soil Sample - HVOCs Not Detected
- Grab Groundwater Sample
- Groundwater Sample from Monitoring Well
- MTCA — Model Toxics Control Act
- PCE/TCE detections greater than MTCA Method A Cleanup Level
- PCE/TCE detection less than MTCA Method A Cleanup Level
- HVOCs Not Detected
- PCE — Tetrachloroethylene
- TCE — Trichloroethylene
- HVOC — Halogenated Volatile Organic Compounds
- W — Existing 4" Water Line
- SD — Existing Storm Drain (Depth Approximated)
- S — Existing 8" Sanitary Sewer Line (Depth Approximated)
- G — Existing Gas Line
- E — Electric Utility

30 0 30
Horizontal Scale in Feet

10 0 10
Vertical Scale in Feet
Vertical Exaggeration: 3X

Cross Section A-A'

Former Alderwood Laundry and Dry Cleaners
Lynnwood, Washington

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Figure 6

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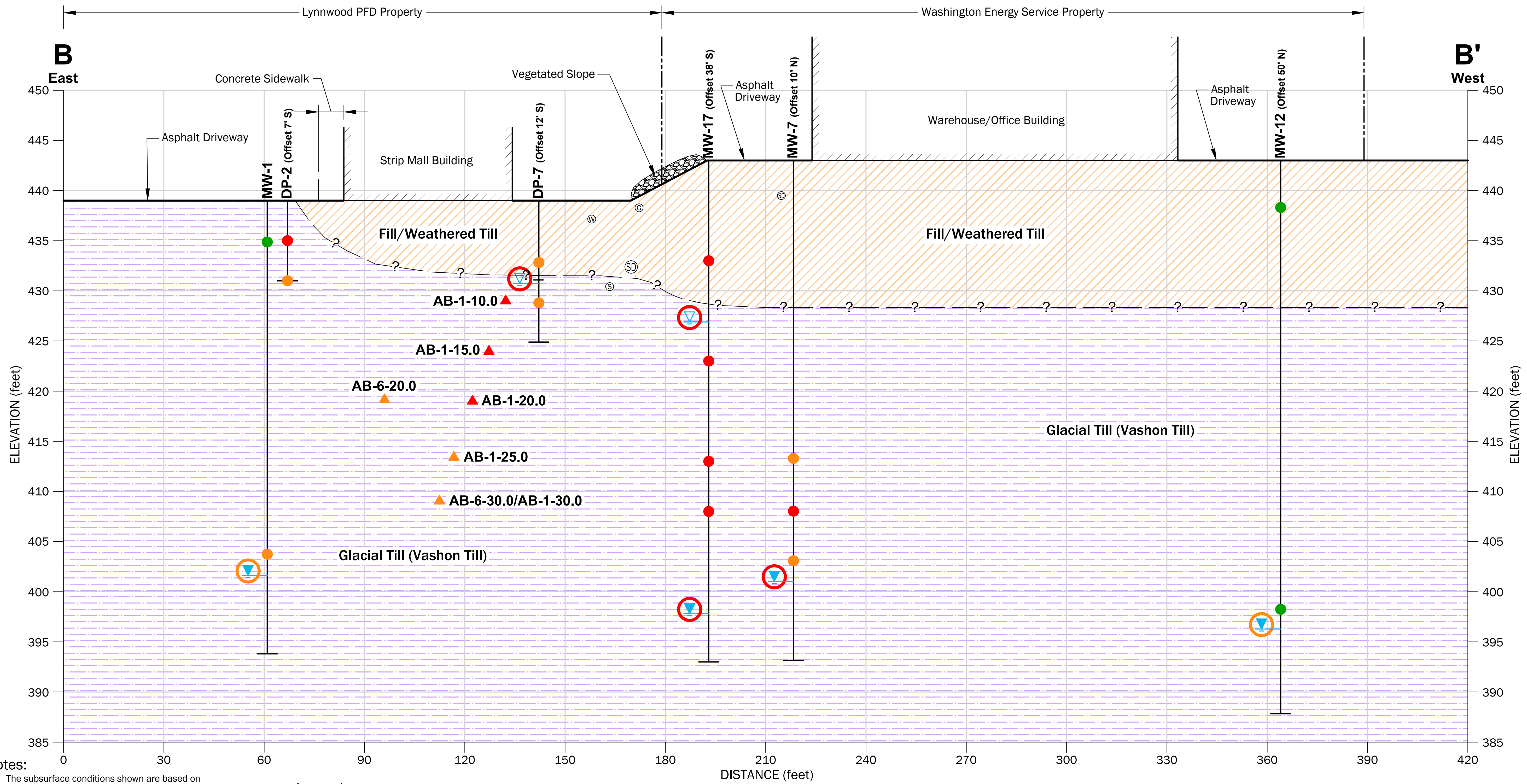

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Notes:

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3. Groundwater elevations and chemical data shown are from March 2013, February 2017, and/or April 2021, whichever reflects the most current data available.

Datum: NAVD 88, unless otherwise noted.

Legend

- DP-7 — Exploration and Approximate Location
- Interpreted Soil Unit Contact Line
- Soil Sample - PCE/TCE detection greater than MTCA Method A Cleanup Level
- Soil Sample - HVOCs detection less than MTCA Method A Cleanup Level
- Soil Sample - HVOCs Not Detected
- Angled Boring Soil Sample - PCE/TCE detection greater than MTCA Method A Cleanup Level
- Angled Boring Soil Sample - HVOCs detection less than MTCA Method A Cleanup Level
- Grab Groundwater Sample
- Groundwater Sample from Monitoring Well
- PCE/TCE detections greater than MTCA Method A Cleanup Level
- PCE/TCE detection less than MTCA Method A Cleanup Level
- PCE Tetrachloroethylene
- TCE Trichloroethylene
- MTCA Model Toxics Control Act
- HVOC Halogenated Volatile Organic Compounds
- Existing 4" Water Line
- Existing Storm Drain (Depth Approximated)
- Existing 8" Sanitary Sewer Line (Depth Approximated)
- Existing Gas Line
- Electric Utility

30 0 30
Horizontal Scale in Feet

10 0 10
Vertical Scale in Feet
Vertical Exaggeration: 3X

Cross Section B-B'

Former Alderwood Laundry and Dry Cleaners
Lynnwood, Washington

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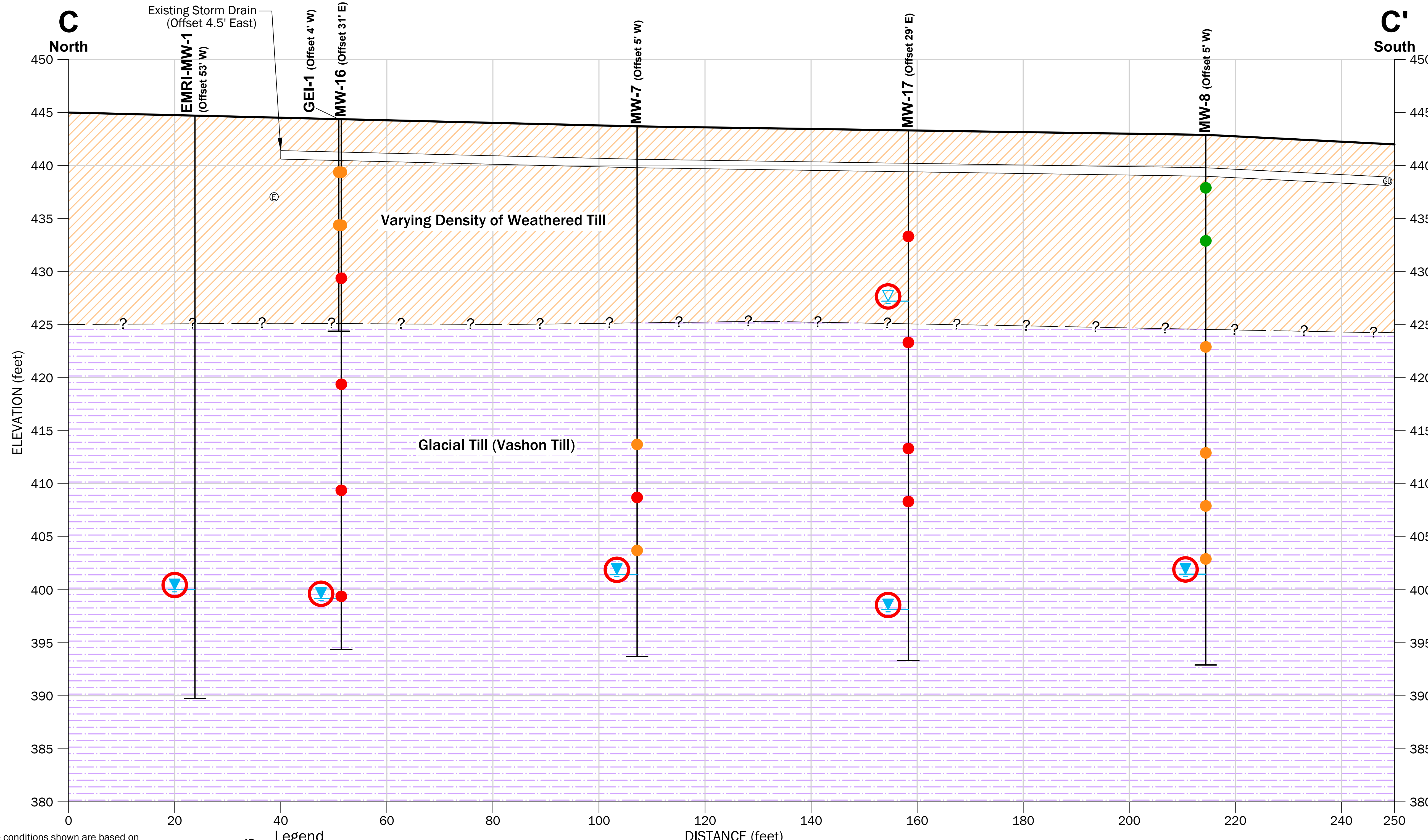
Figure 7



Notes:

1. The subsurface conditions shown are based on interpolation between widely spaced explorations and should be considered approximate; actual subsurface conditions may vary from those shown.
2. This figure is for informational purposes only. It is intended to assist in the identification of features discussed in a related document. Data were compiled from sources as listed in this figure. The data sources do not guarantee these data are accurate or complete. There may have been updates to the data since the publication of this figure. This figure is a copy of a master document. The hard copy is stored by GeoEngineers, Inc. and will serve as the official document of record.
3. Groundwater elevations and chemical data shown are from March 2013, February 2017, and/or April 2021, whichever reflects the most current data available.

Datum: NAVD 88, unless otherwise noted.

Legend

MW-16 — Exploration and Approximate Location

? — Interpreted Soil Unit Contact Line

Soil Sample - PCE/TCE detection greater than MTCA Method A Cleanup Level

Soil Sample - HVOCs detection less than MTCA Method A Cleanup Level

Soil Sample - HVOCs Not Detected

Grab Groundwater Sample

Groundwater Sample from Monitoring Well

PCE/TCE detections greater than MTCA Method A Cleanup Level

PCE Tetrachloroethylene

TCE Trichloroethylene

MTCA Model Toxics Control Act

HVOC Halogenated Volatile Organic Compounds

Existing Storm Drain (Depth Approximated)

Electric Utility

20 0 20
Horizontal Scale in Feet

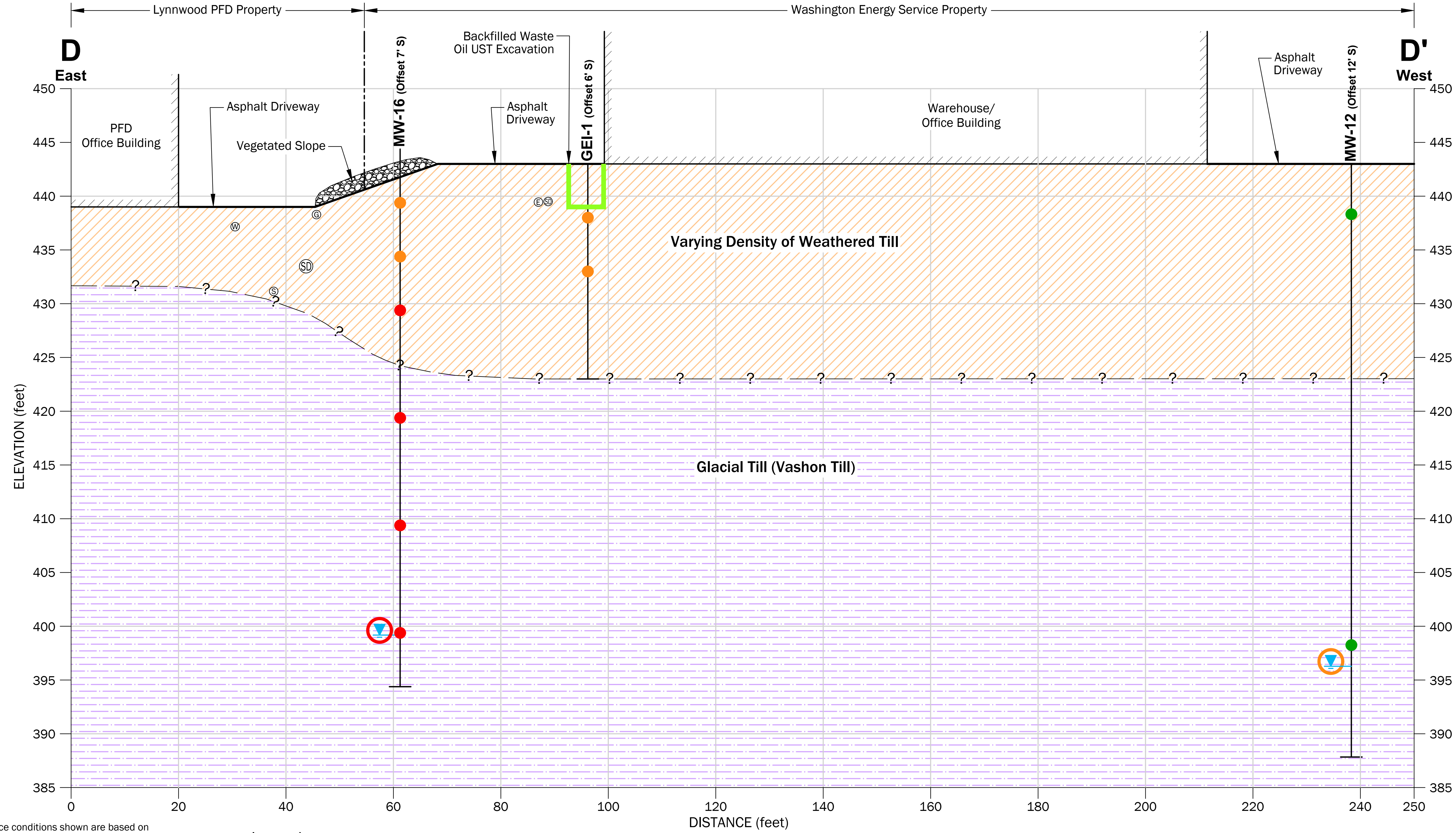
10 0 10
Vertical Scale in Feet
Vertical Exaggeration: 2X

Cross Section C-C'

Former Alderwood Laundry and Dry Cleaners
Lynnwood, Washington

GeoEngineers

Figure 8



Notes:

1. The subsurface conditions shown are based on interpolation between widely spaced explorations and should be considered approximate; actual subsurface conditions may vary from those shown.
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3. Groundwater elevations and chemical data shown are from March 2013, February 2017, and/or April 2021, whichever reflects the most current data available.

Datum: NAVD 88, unless otherwise noted.

Legend

- MW-16 — Exploration and Approximate Location
- ? — Interpreted Soil Unit Contact Line
- Soil Sample - PCE/TCE detection greater than MTCA Method A Cleanup Level
- Soil Sample - HVOCs detection less than MTCA Method A Cleanup Level
- Soil Sample - HVOCs Not Detected
- Subslab Soil Vapor Sample
- Grab Groundwater Sample
- Groundwater Sample from Monitoring Well
- PCE/TCE detections greater than MTCA Method A Cleanup Level
- PCE/TCE detection less than MTCA Method A Cleanup Level
- PCE — Tetrachloroethylene
- TCE — Trichloroethylene
- MTCA — Model Toxics Control Act
- HVOC — Halogenated Volatile Organic Compounds
- Ⓦ Existing 4" Water Line
- Ⓢⓓ Existing Storm Drain (Depth Approximated)
- Ⓢ Existing 8" Sanitary Sewer Line (Depth Approximated)
- Ⓖ Existing Gas Line
- Ⓔ Electric Utility

20 0 20
Horizontal Scale in Feet

10 0 10
Vertical Scale in Feet
Vertical Exaggeration: 2X

Cross Section D-D'

Former Alderwood Laundry and Dry Cleaners
Lynnwood, Washington

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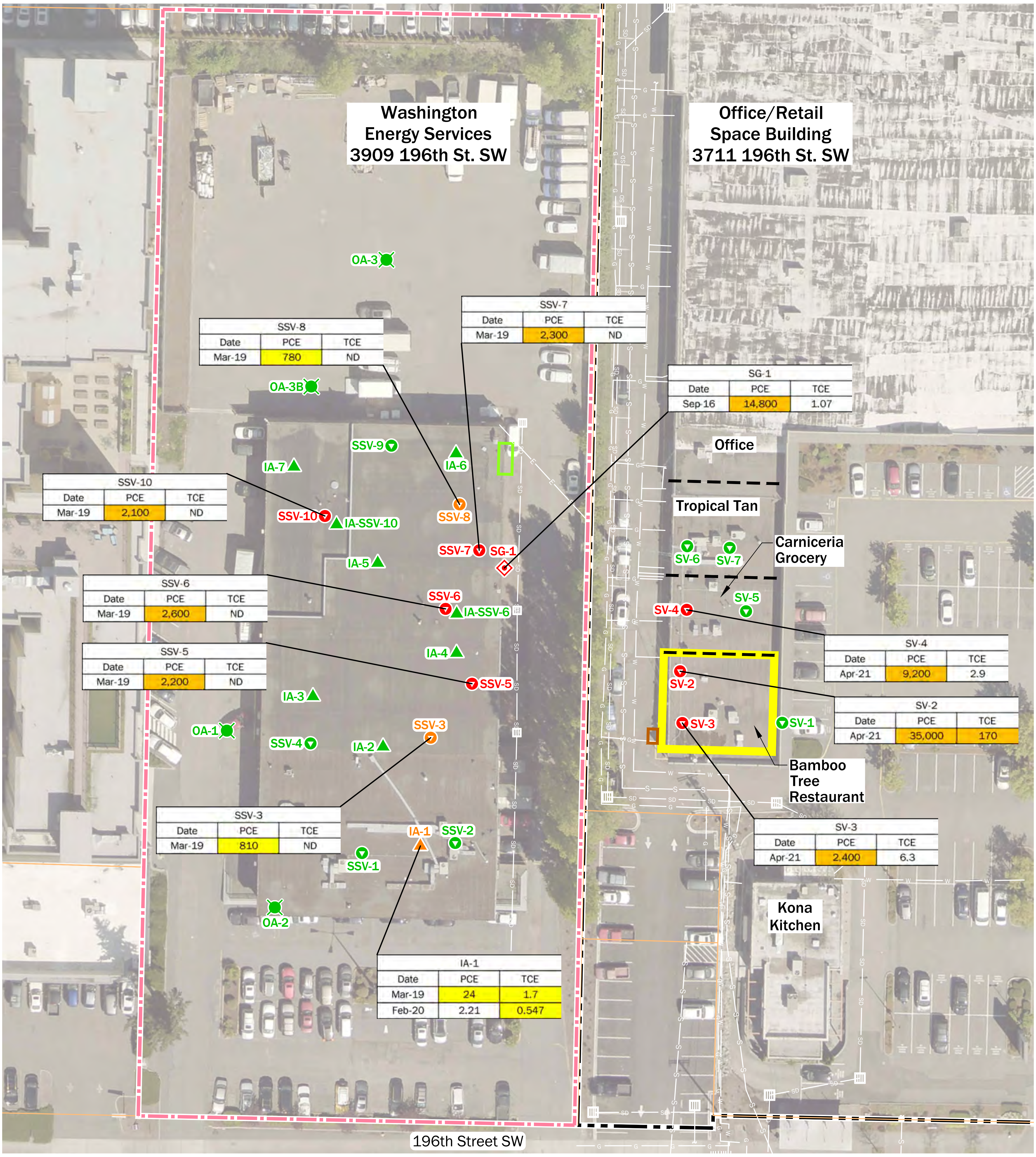
Figure 9



Legend

- SSV-5 Exceedance of the MTCA Soil Gas Screening Level or Indoor Air Cleanup Level for Commercial Workers
- SSV-8 Exceedance of the MTCA Soil Gas Screening Level or Indoor Air Cleanup Level
- SSV-1 No Exceedance of the MTCA Soil Gas Screening Level or Indoor Air Cleanup Level
- SG-1 Soil Vapor Sample Location
- SSV-8 Sub-Slab Soil Gas Sample Location
- IA-1 Indoor Air Vapor Sample Location
- OA-1 Outdoor Air Vapor Sample Location

- Lynnwood Public Facilities District Property Boundary
- West Adjoining Property Boundary
- Parcel Boundary
- Approximate Footprint of Former Alderwood Laundry & Dry Cleaners
- Backfilled Waste Oil UST Excavation
- Existing Concrete Grease Trap
- Existing Catch Basin
- Existing Storm Drain
- Existing Gas Line
- Existing Sewer Line
- Existing Water Line
- Electric Utility

Data Box Explanation:

PCE	Tetrachloroethylene
TCE	Trichloroethylene
ND	Not Detected
MTCA	Model Toxics Control Act
HVOC	Halogenated Volatile Organic Compounds
ug/m^3	microgram per cubic meter
810	Shading Indicates Concentration Greater Than MTCA Soil Gas Screening Level or Indoor Air Cleanup Level
35,000	Shading Indicates Concentration Greater Than MTCA Soil Gas Screening Level or Indoor Air Cleanup Level for Commercial Workers

N S E W

50 0 50
Feet

Soil Vapor Chemical Analytical Data

Former Alderwood Laundry and Dry Cleaners
Lynnwood, Washington

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Figure 10

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: Aerial from King County dated 2019 and street centerlines. Vertical Datum: NAVD 88. Projection: NAD83 Washington State Planes, North Zone, US Foot.

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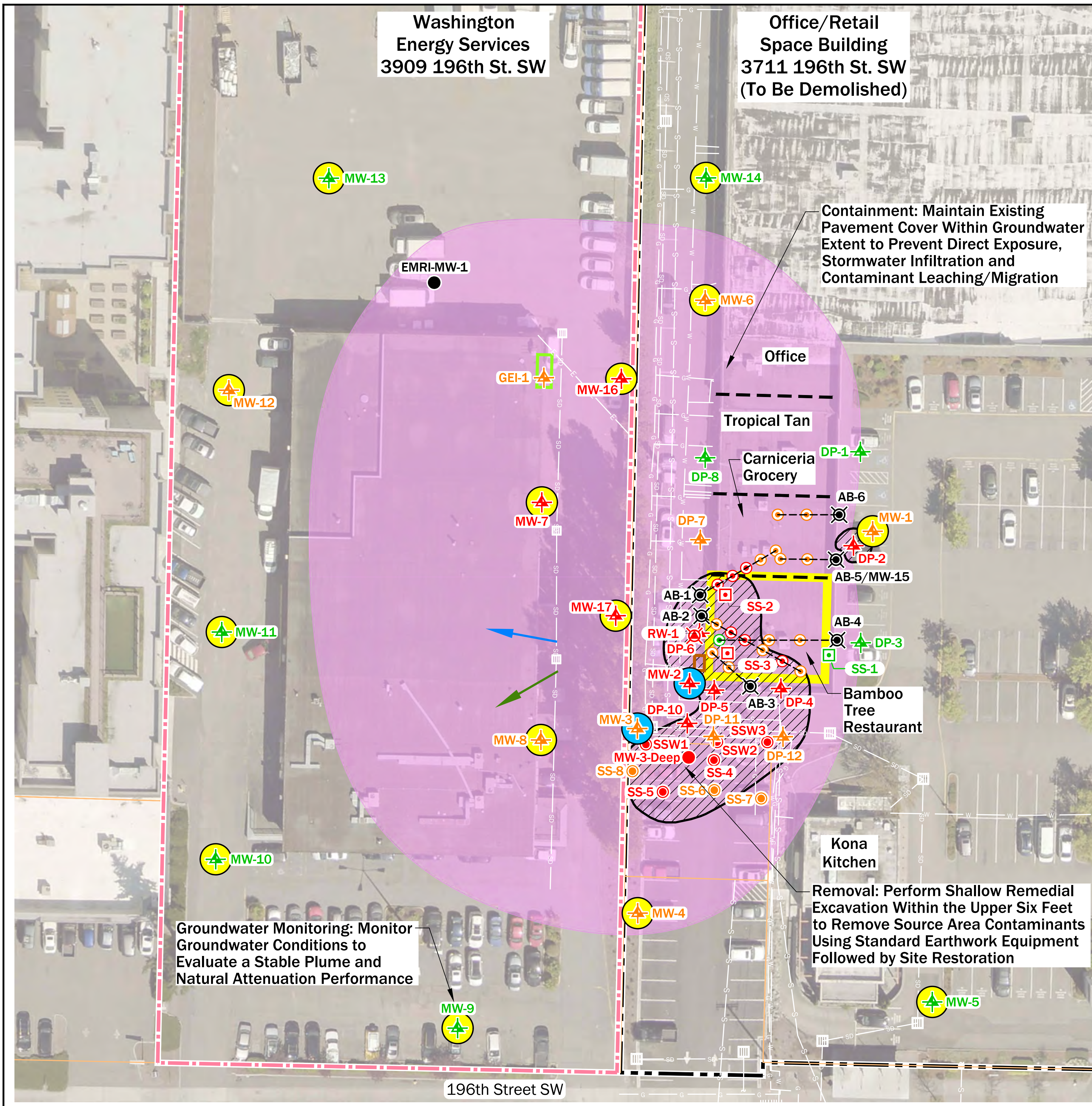

Legend

- DP-6/MW-2 — Exploration - MTCA Method A Cleanup Levels Exceedance for PCE/TCE in Soil
- DP-7/MW-4 — Exploration - HVOCs detected less than MTCA Method A Cleanup Levels in Soil
- DP-1/MW-9 — Exploration - HVOCs Not Detected
- AB-1 — Angled Boring by GeoEngineers, Inc.
- EMRI-MW-1 — Groundwater Monitoring Well by EMRI (1999)
- Soil Sample with PCE detection greater than MTCA Method A Cleanup Level
- Soil Sample with HVOC detections less than MTCA Method A or B Cleanup Levels
- Soil Sample with HVOCs Not Detected
- SSW1 — Confirmation Soil Sample
- MW-3-Deep — Deep Groundwater Assessment Boring with PCE/TCE detection greater than MTCA Method A Cleanup Level
- RW-1 — Pilot Study Injection Well with PCE/TCE detection greater than MTCA Method A Cleanup Level
- SS-2 — Sub Slab Soil Data April 2021 with PCE detection greater than MTCA Method A Cleanup Level
- SS-1 — Sub Slab Soil Data April 2021 with HVOCs Not Detected
- Lynnwood Public Facilities District Property Boundary
- West Adjoining Property Boundary
- Parcel Boundary
- Approximate Footprint of Former Alderwood Laundry & Dry Cleaners
- Backfilled Waste Oil UST Excavation
- Existing Concrete Grease Trap
- Existing Catch Basin
- Existing Storm Drain
- Existing Gas Line
- Existing Sewer Line
- Existing Water Line
- Electric Utility
- Extent PCE > 5 ug/L in Groundwater
- Proposed Soil Excavation Area
- Proposed Performance/Compliance Monitoring Well
- Proposed Replacement Performance/Compliance Monitoring Well
- Inferred Groundwater Flow Direction (Wet Season)
- Inferred Groundwater Flow Direction (Dry Season)

N W E S

50 0 50
Feet

Notes:
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Data Source: Aerial from King County dated 2019 and street centerlines. Vertical Datum: NAVD 88. Projection: NAD83 Washington State Planes, North Zone, US Foot.

Cleanup Action Alternative 1 Source Removal with Capping and Monitored Natural Attenuation

Former Alderwood Laundry and Dry Cleaners
Lynnwood, Washington

GeoEngineers

Figure 11

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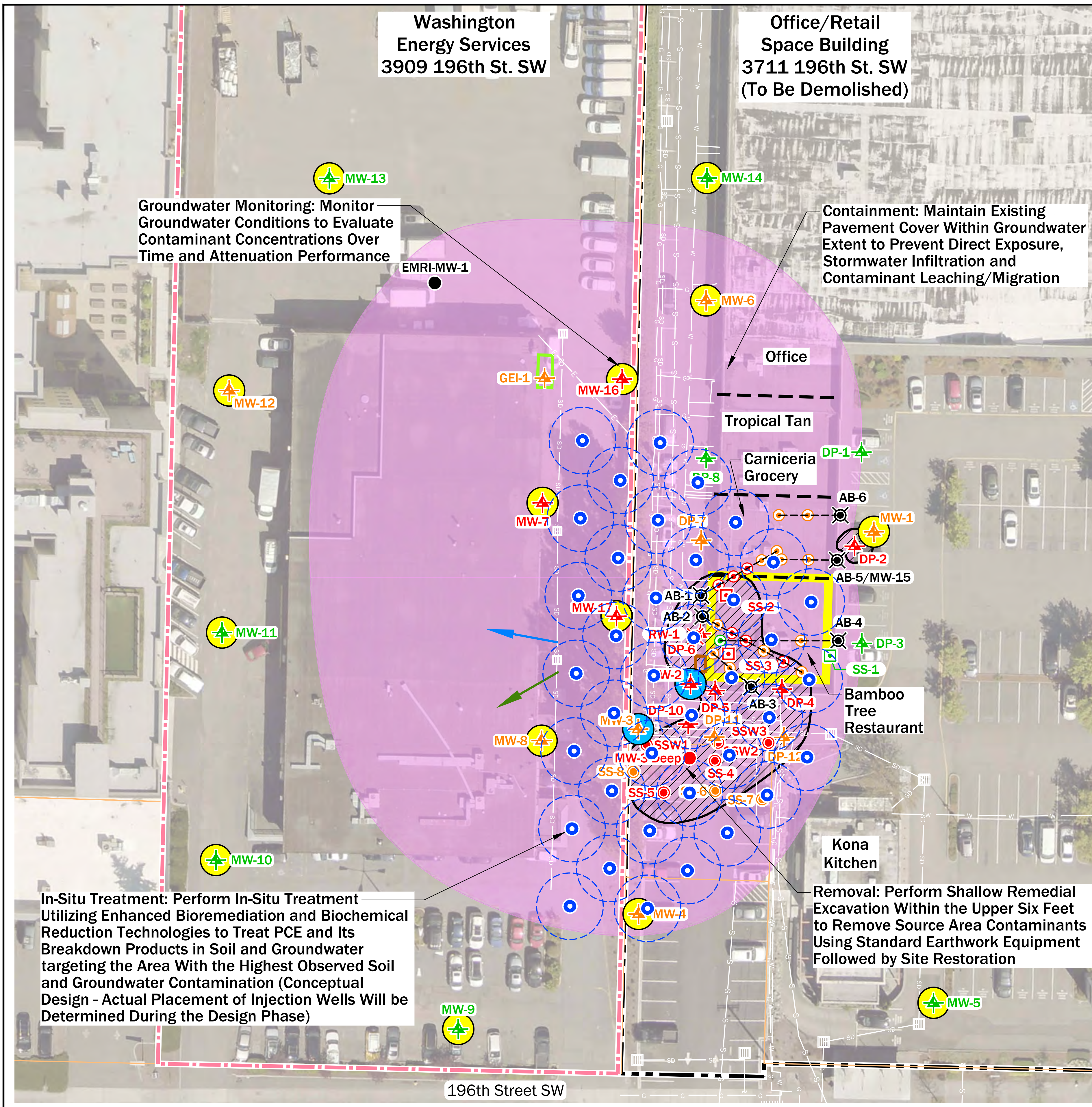

Legend

- DP-6/MW-2 — Exploration - MTCA Method A Cleanup Levels Exceedance for PCE/TCE in Soil
- DP-7/MW-4 — Exploration - HVOCs detected less than MTCA Method A Cleanup Levels in Soil
- DP-1/MW-9 — Exploration - HVOCs Not Detected
- AB-1 — Angled Boring by GeoEngineers, Inc.
- EMRI-MW-1 — Groundwater Monitoring Well by EMRI (1999)
- Soil Sample with PCE detection greater than MTCA Method A Cleanup Level
- Soil Sample with HVOC detections less than MTCA Method A or B Cleanup Levels
- Soil Sample with HVOCs Not Detected
- SSW1 — Confirmation Soil Sample
- MW-3-Deep — Deep Groundwater Assessment Boring with PCE/TCE detection greater than MTCA Method A Cleanup Level
- RW-1 — Pilot Study Injection Well with PCE/TCE detection greater than MTCA Method A Cleanup Level
- SS-2 — Sub Slab Soil Data April 2021 with PCE detection greater than MTCA Method A Cleanup Level
- SS-1 — Sub Slab Soil Data April 2021 with HVOCs Not Detected
- Lynnwood Public Facilities District Property Boundary
- West Adjoining Property Boundary
- Parcel Boundary
- Approximate Footprint of Former Alderwood Laundry & Dry Cleaners
- Backfilled Waste Oil UST Excavation
- Existing Concrete Grease Trap
- Existing Catch Basin
- Existing Storm Drain
- Existing Gas Line
- Existing Sewer Line
- Existing Water Line
- Electric Utility
- Extent PCE > 5 ug/L in Groundwater
- Proposed Soil Excavation Area
- Proposed Performance/Compliance Monitoring Well
- Proposed Replacement Performance/Compliance Monitoring Well
- Proposed In-Situ Injection Point
- Estimated Zone of Influence
- Inferred Groundwater Flow Direction (Wet Season)
- Inferred Groundwater Flow Direction (Dry Season)

N W E S

50 0 50
Feet

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Data Source: Aerial from King County dated 2019 and street centerlines. Vertical Datum: NAVD 88. Projection: NAD83 Washington State Planes, North Zone, US Foot.

Alternative 2 - Source Removal with Capping and In-Situ Enhanced Bioremediation/ Biochemical Reduction

Former Alderwood Laundry and Dry Cleaners
Lynnwood, Washington

GEOENGINEERS

Figure 12

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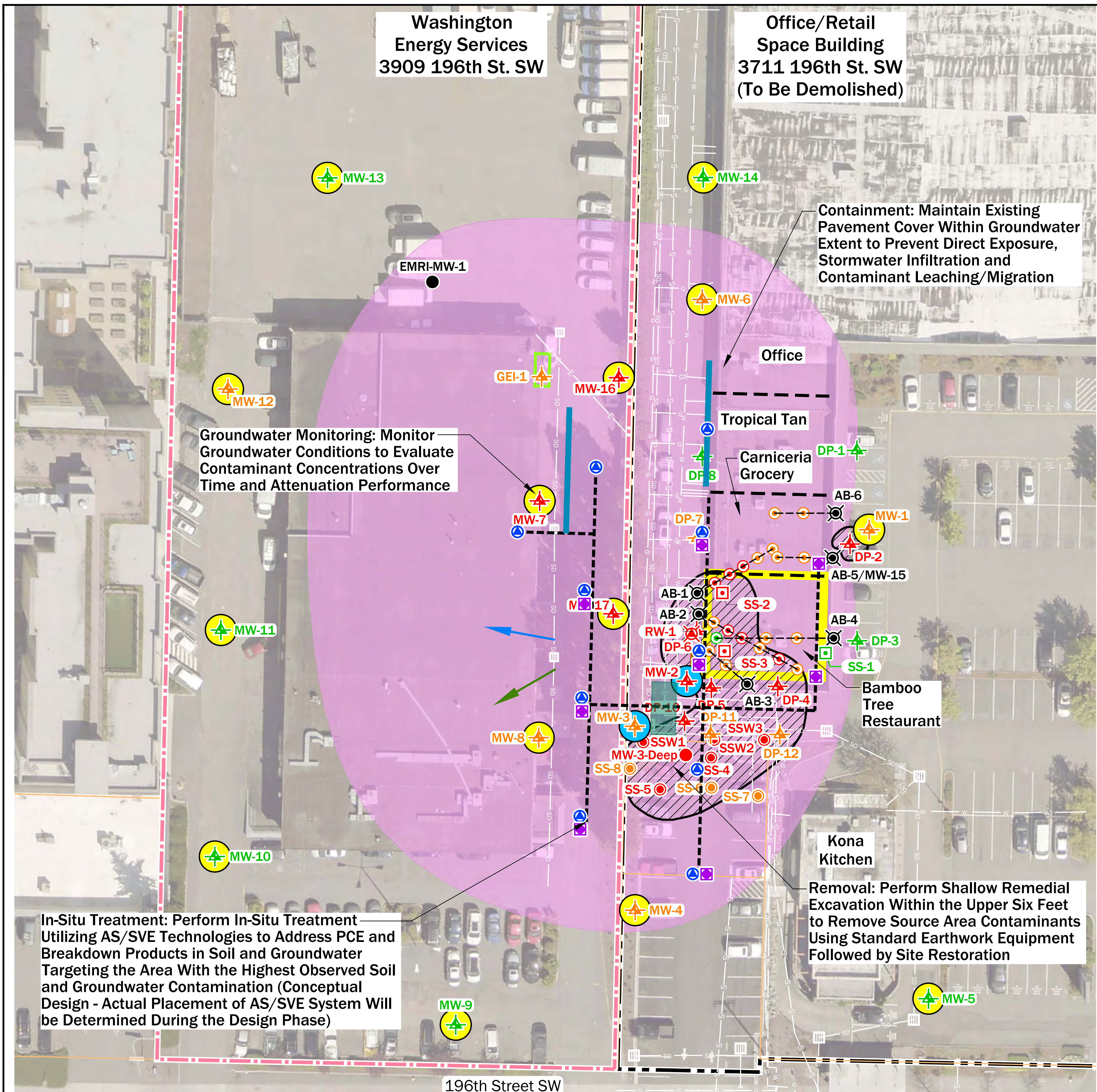

Legend

- DP-6/MW-2 — Exploration - MTCA Method A Cleanup Levels Exceedance for PCE/TCE in Soil
- DP-7/MW-4 — Exploration - HVOCs detected less than MTCA Method A Cleanup Levels in Soil
- DP-1/MW-9 — Exploration - HVOCs Not Detected
- AB-1 — Angled Boring by GeoEngineers, Inc.
- EMRI-MW-1 — Groundwater Monitoring Well by EMRI (1999)
- Soil Sample with PCE detection greater than MTCA Method A Cleanup Level
- Soil Sample with HVOC detections less than MTCA Method A or B Cleanup Levels
- Soil Sample with HVOCs Not Detected
- SSW1 — Confirmation Soil Sample
- MW-3-Deep — Deep Groundwater Assessment Boring with PCE/TCE detection greater than MTCA Method A Cleanup Level
- RW-1 — Pilot Study Injection Well with PCE/TCE detection greater than MTCA Method A Cleanup Level
- SS-2 — Sub Slab Soil Data April 2021 with PCE detection greater than MTCA Method A Cleanup Level
- SS-1 — Sub Slab Soil Data April 2021 with HVOCs Not Detected
- Lynnwood Public Facilities District Property Boundary
- West Adjoining Property Boundary
- Parcel Boundary
- Approximate Footprint of Former Alderwood Laundry & Dry Cleaners
- Backfilled Waste Oil UST Excavation
- Existing Concrete Grease Trap
- Existing Catch Basin
- Existing Storm Drain
- Existing Gas Line
- Existing Sewer Line
- Existing Water Line
- Electric Utility
- Extent PCE > 5 ug/L in Groundwater
- Proposed Soil Excavation Area
- Proposed Performance/Compliance Monitoring Well
- Proposed Replacement Performance/Compliance Monitoring Well
- Treatment Compound
- Vapor Extraction Trench
- Conveyance Piping
- Proposed Soil Vapor Extraction (SVE) Well
- Proposed Air Sparging (AS) Well
- Inferred Groundwater Flow Direction (Wet Season)
- Inferred Groundwater Flow Direction (Dry Season)

N W E S

50 0 50

Feet

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Data Source: Aerial from King County dated 2019 and street centerlines. Vertical Datum: NAVD 88. Projection: NAD83 Washington State Planes, North Zone, US Foot.

Alternative 3 - Source Removal with Capping and In-Situ AS/SVE Treatment

Former Alderwood Laundry and Dry Cleaners
Lynnwood, Washington

GeoEngineers

Figure 13

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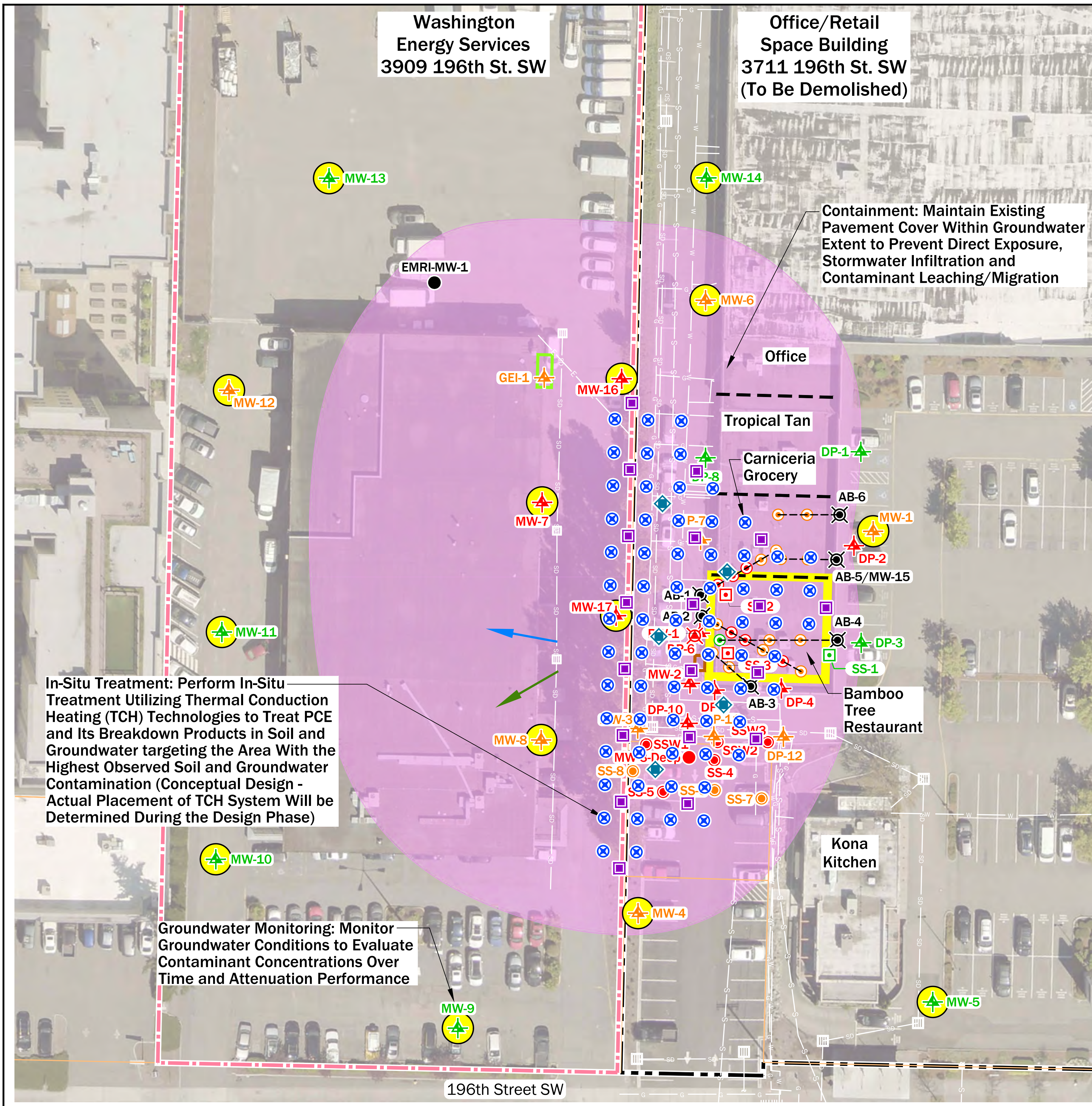

Legend

DP-6/MW-2	Exploration - MTCA Method A Cleanup Levels Exceedance for PCE/TCE in Soil
DP-7/MW-4	Exploration - HVOCs detected less than MTCA Method A Cleanup Levels in Soil
DP-1/MW-9	Exploration - HVOCs Not Detected
AB-1	Angled Boring by GeoEngineers, Inc.
EMRI-MW-1	Groundwater Monitoring Well by EMRI (1999)
	Soil Sample with PCE detection greater than MTCA Method A Cleanup Level
	Soil Sample with HVOC detections less than MTCA Method A or B Cleanup Levels
	Soil Sample with HVOCs Not Detected
SSW1	Confirmation Soil Sample
MW-3-Deep	Deep Groundwater Assessment Boring with PCE/TCE detection greater than MTCA Method A Cleanup Level
RW-1	Pilot Study Injection Well with PCE/TCE detection greater than MTCA Method A Cleanup Level
SS-2	Sub Slab Soil Data April 2021 with PCE detection greater than MTCA Method A Cleanup Level
SS-1	Sub Slab Soil Data April 2021 with HVOCs Not Detected

- Lynnwood Public Facilities District Property Boundary
- West Adjoining Property Boundary
- Parcel Boundary
- Approximate Footprint of Former Alderwood Laundry & Dry Cleaners
- Backfilled Waste Oil UST Excavation
- Existing Concrete Grease Trap
- Existing Catch Basin
- Existing Storm Drain
- Existing Gas Line
- Existing Sewer Line
- Existing Water Line
- Electric Utility

- Extent PCE > 5 ug/L in Groundwater
- Proposed Performance/Compliance Monitoring Well
- Proposed Thermal Treatment Point
- Proposed Soil Vapor Extraction Well
- Proposed Temperature Monitoring Point
- Inferred Groundwater Flow Direction (Wet Season)
- Inferred Groundwater Flow Direction (Dry Season)

N W E S

50 0 50

Feet

Notes:

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Data Source: Aerial from King County dated 2019 and street centerlines. Vertical Datum: NAVD 88. Projection: NAD83 Washington State Planes, North Zone, US Foot.

Alternative 4 - Thermal Conduction Heating and Soil Vapor Extraction with Capping

Former Alderwood Laundry and Dry Cleaners
Lynnwood, Washington

GEOENGINEERS

Figure 14

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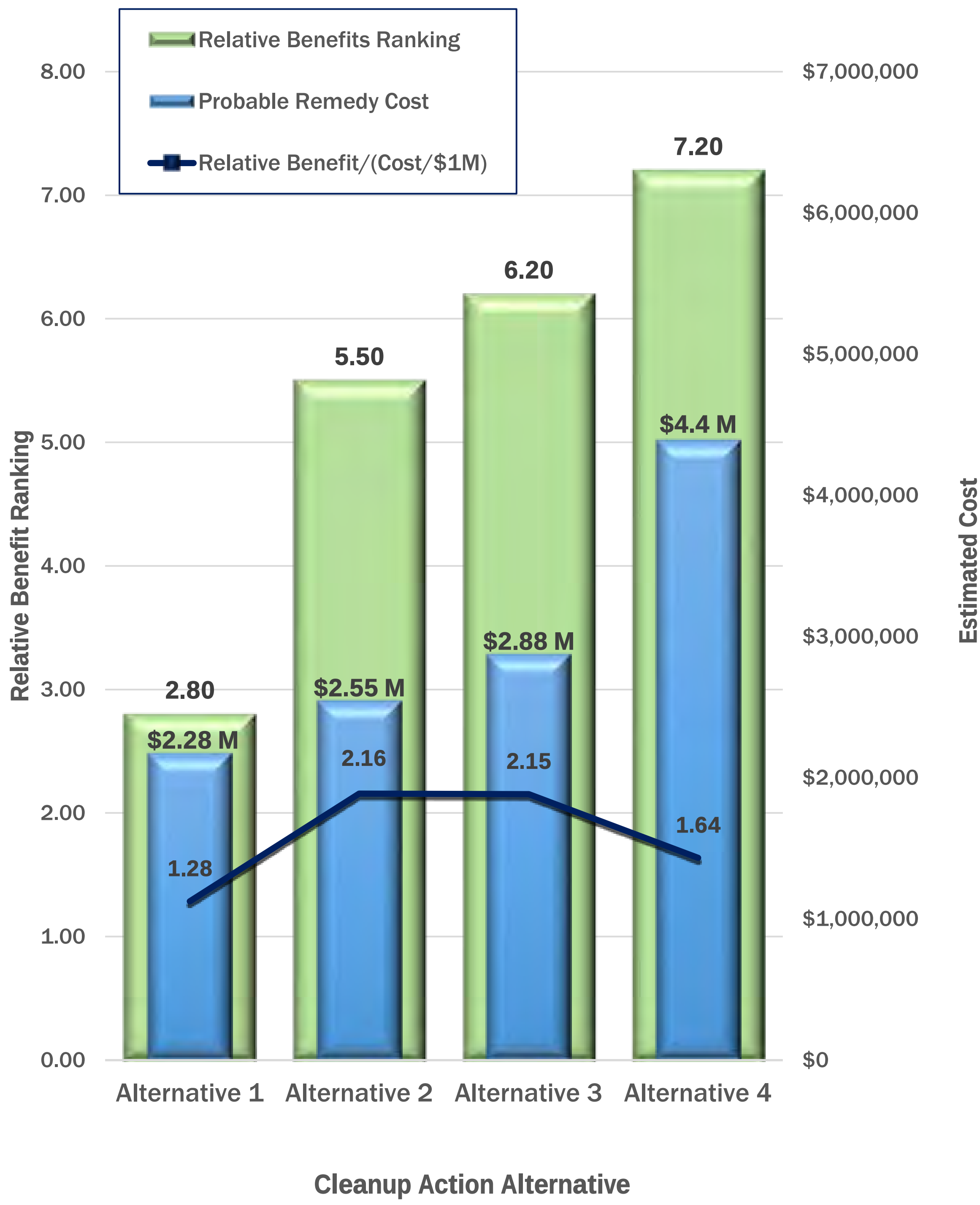

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Data Source: Former Alderwood Laundry and Dry Cleaners Feasibility Study Table 6.

Disproportionate Cost Analysis

Former Alderwood Laundry and Dry Cleaners
Lynnwood, Washington

GeoEngineers

Figure 15

GeoEngineers

APPENDIX A
Cleanup Action Cost Estimate

Table A-1

Cleanup Action Alternative 1 (Source Area Removal, Capping with Monitored Natural Attenuation and Institutional Controls) Cost Estimate

Former Alderwood Laundry and Dry Cleaners

Lynnwood, Washington

Item No.	Item Description	Estimated Quantity[1]	Unit Cost[2] (2021$)	Unit	Estimated Cost	Notes/ Assumptions
Construction						
1	Mobilization/Demobilization	1	$35,000	LS	$35,000	Includes mobilization to the site, installation of temporary site controls including temporary traffic, and erosion and sediment controls (as applicable), and demob from the site.
2	Asphalt Demolition	670	$20	SY	$13,400	Includes removal of existing asphalt surface and portion of top course surfacing material in source areas. Assumes removal depth to 6" below ground surface.
3	Demolition Debris Recycling/Disposal	201	$25	TON	$5,025	Includes loading and transportation of demolished asphalt debris to permitted recycling facility.
4	Monitoring Well Decommissioning by Licensed Driller	5	$3,500	LS	$17,500	Decommission MW-2, 3, 3D, 15 and RW-1 prior to construction.
5	Excavation Dewatering, Treatment and Disposal	1	$35,000	LS	$35,000	Unit cost based on similar projects.
6	Soil Removal, Handling and Loading	1,400	$15	CY	$21,000	Assume in-place volume. Cost includes excavation, handling, stockpile and loading.
7	Contaminated Soil Transport and Disposal	2,520	$100	TON	$252,000	Assume 1.8 ton/cy (in-place). Assumes that the material generated will be transported and disposed at a RCRA Subtitle D landfill.
8	Utility Protection and/or Temporary Relocation and Restoration	1	$35,000	LS	$35,000	Protect utilities and/or temporarily reroute and restore to facilitate remedial excavation activities.
9	Purchase, Place and Compact Backfill Material	2,520	$30	TON	$75,600	Cost includes purchase, filling and compaction.
10	Surveying	1	$5,000	LS	$5,000	Unit cost based on similar projects.
11	Placement of Asphalt Pavement to Restore Source Area Excavation	1,250	$35	SY	$43,750	Assumes placement of 5 inches of base course and 4 inches of asphalt; no new stormwater system installation; and stormwater runoff flows to existing drainage structures or match existing drainage pattern. Does not include footprint of existing strip mall building.
12	Monitoring Well Installation by Licensed Driller	2	$4,500	LS	$9,000	Replacement wells for MW-2 and MW-3.
13	Construction Contingency	1	20	%	$109,455	Covers unknowns, unforeseen circumstances, or unanticipated conditions associated with construction activities.
				Total Construction Cost	**$656,730**	
Performance and Compliance Monitoring						
14	Soil Removal Confirmation Sample Analysis	30	$150	EA	$4,500	Verification sidewall and base samples to confirm the limits of soil removal activities. Assumes one sample per 40 linear feet of sidewall and one sample per 625 square feet of base and 10 % duplicate samples.
15	Post-Construction Groundwater Sampling and Reporting	4	$15,000	EVNT	$60,000	Post-construction monitoring will be completed on a quarterly basis for up to one year utilizing the existing/new network of wells. Assumes up to sixteen wells will be sampled per monitoring event and preparation of annual monitoring reports summarizing results for Ecology submittal.

Item No.	Item Description	Estimated Quantity[1]	Unit Cost[2] (2021$)	Unit	Estimated Cost	Notes/ Assumptions
16	Post-Construction Groundwater Sample Analysis	4	$10,000	EVNT	$40,000	Includes chemical analysis of PCE and breakdown products at each of the selected monitoring well locations including duplicate sample per sampling event.
17	Long-Term Compliance Groundwater Sampling and Reporting	10	$15,000	EVNT	$370,000[3]	Long-term groundwater monitoring utilizing the existing/new network of wells. It is assumed that groundwater monitoring would be completed once per Ecology Five Year Periodic Review period for up to 50 years following completion of the post-construction monitoring period. Assumes up to sixteen wells will be sampled per monitoring event and preparation of an annual monitoring reports summarizing results for Ecology submittal.
18	Long-Term Compliance Groundwater Sample Analysis	10	$10,000	EVNT	$247,000[3]	Includes chemical analysis of PCE and breakdown products at each of the selected monitoring well locations including duplicate sample per sampling event.
19	Long-Term Vapor Sampling and Reporting	10	$7,500	EVNT	$185,000[3]	Perform long-term subslab and indoor vapor monitoring. It is assumed that vapor monitoring would be competed once per Ecology Five Year Periodic Review period for up to 50 years following completion of the post-construction monitoring period. Assumes up to 10 sample point per monitoring event and preparation of an annual monitoring reports summarizing results for Ecology submittal.
20	Long-Term Vapor Sample Analysis	10	$3,500	EVNT	$87,000[3]	Includes chemical analysis of PCE and breakdown products at each of the selected monitoring locations including duplicate sample per sampling event.
21	Purge Water Testing and Disposal	14	$275	EVNT	$8,000[3]	Disposal fee for purge water generated during each monitoring event. Assumes one 55-gallon drum per monitoring event will be generated for disposal.
22	Performance and Compliance Monitoring Contingency	1	20	%	$200,300	Covers unknowns, unforeseen circumstances, or unanticipated conditions associated with performance and contingency monitoring activities.
				Total Compliance Monitoring Cost	**$1,201,800**	
Professional/Administrative Support						
23	Pre-Construction Soil Characterization and Contained-In Waste Disposal Support	1	$50,000	LS	$50,000	Pre-construction support to characterize material for waste disposal and to support an Ecology Contain-In determination.
24	Project Planning, Design, Permitting and Construction Management Support	1	$75,000	LS	$75,000	Includes project planning and management to support implementation of the remedial action.
25	Engineering Design Report and Compliance Monitoring Plan	1	$50,000	LS	$50,000	Engineering Design Report will detail the plans and procedures that will be used for cleanup of the Site. The Compliance Monitoring Plan will detail the groundwater performance, confirmational and long-term monitoring to verify the effectiveness of the cleanup action.
26	Cleanup Action Report	1	$50,000	LS	$50,000	Cleanup Action Report will detail the soil removal, verification sampling and restoration activities completed during construction.
27	Institutional Controls Monitoring and Maintenance Plan	1	$35,000	LS	$35,000	Prepare Institutional Controls Monitoring and Maintenance Plan to identify the controls that will be utilized at the Site, and to provide guidelines for the monitoring, maintenance, handling and disposal of soil and groundwater encountered during future Site maintenance and/or development activities.
28	Voluntary Cleanup Program (VCP) and Regulatory Closure Support	1	$30,000	LS	$30,000	Includes VCP and regulatory coordination and communications, and project closeout support.
29	Professional/Administrative Support Contingency	1	10	%	$29,000	Covers unknowns, unforeseen circumstances, or unanticipated conditions associated with professional/administrative support.
				Total Professional/Administrative Services	**$319,000**	
				Cleanup Alternative Total[4]	**$2,180,000**	Accuracy of the total remedial alternative cost is considered -30 to +50 % based on EPA's Guide to Developing and Documenting Cost Estimates During the Feasibility Study.

Notes:

[1] Concept design level.

[2] Unit costs based on a combination construction cost estimates solicited from applicable vendors and contractors; review of actual costs incurred during similar, applicable projects; and professional judgment. Unit costs are based on 2021 dollars.

[3] Cost for long-term monitoring and/or operation and maintenance (O&M) calculated using the following formula (where applicable). FV = PV (1+r)n, where FV = 2021 Unit Cost, PV = Past Unit Cost, r = annual inflation rate (3%), n = number of periods inflation held.

[4] Total Remedial Action Alternative Costs are rounded up to the nearest $10,000.

LS = lump sum

CY = cubic yard

EA = each

EVNT = event

Table A-2

Cleanup Action Alternative 2 (Source Area Removal, Capping with In-Situ Enhanced Bioremediation, Biochemical Reduction, and Institutional Controls) Cost Estimate

Former Alderwood Laundry and Dry Cleaners
Lynnwood, Washington

Item No.	Item Description	Estimated Quantity[1]	Unit Cost[2] (2021$)	Unit	Estimated Cost	Notes/ Assumptions
Construction						
1	Mobilization/Demobilization	1	$35,000	LS	$35,000	Includes mobilization to the site, installation of temporary site controls including temporary traffic, and erosion and sediment controls (as applicable), and demob from the site.
2	Asphalt Demolition	670	$20	SY	$13,400	Includes removal of existing asphalt surface and portion of top course surfacing material in source areas. Assumes removal depth to 6" below ground surface.
3	Demolition Debris Recycling/Disposal	201	$25	TON	$5,025	Includes loading and transportation of demolished asphalt debris to permitted recycling facility.
4	Monitoring Well Decommissioning by Licensed Driller	5	$3,500	LS	$17,500	Decommission MW-2, 3, 3D, 15 and RW-1 prior to construction.
5	Excavation Dewatering, Treatment and Disposal	1	$35,000	LS	$35,000	Unit cost based on similar projects.
6	Soil Removal, Handling and Loading	1,400	$10	CY	$14,000	Assume in-place volume. Cost includes excavation, handling, stockpile and loading.
7	Contaminated Soil Transport and Disposal	2,520	$100	TON	$252,000	Assume 1.8 ton/cy (in-place). Assumes that the material generated will be transported and disposed at a RCRA Subtitle D landfill.
8	Utility Protection and/or Temporary Relocation and Restoration	1	$35,000	LS	$35,000	Protect utilities and/or temporarily reroute and restore to facilitate remedial excavation activities.
9	Purchase, Place and Compact Backfill Material	2,520	$30	TON	$75,600	Cost includes purchase, filling and compaction.
10	Surveying	1	$5,000	LS	$5,000	Unit cost based on similar projects.
11	Placement of Asphalt Pavement to Restore Source Area Excavation	1,250	$35	SY	$43,750	Assumes placement of 5 inches of base course and 4 inches of asphalt; no new stormwater system installation; and stormwater runoff flows to existing drainage structures or match existing drainage pattern. Does not include footprint of existing strip mall building.
12	Monitoring Well Installation by Licensed Driller	2	$4,500	LS	$9,000	Decommission MW-2, 3, 3D, 15 and RW-1 prior to construction.
13	Construction Contingency	1	20	%	$108,055	Covers unknowns, unforeseen circumstances, or unanticipated conditions associated with construction activities.
				Total Construction Cost	**$648,330**	
In-Situ Enhanced Bioremediation and Biochemical Reduction						
14	Pilot Study	1	$35,000	LS	$35,000	Pilot scale study is currently underway to evaluate this remedial technology. Unit cost based on contractor quote.
15	Mobilization/Demobilization	2	$4,500	LS	$9,000	Includes mobilization to the site, installation of temporary site controls including temporary traffic, and erosion and sediment controls (as applicable), and demob from the site.
16	Drilling, Mixing and Injection of Reagents	76	$4,500	EACH	$342,000	Includes drilling of temporary injection points using sonic or hollow-stem auger drilling methods. Borings would be completed to depths of 30 to 50 feet bgs targeting shallow perched and deeper saturated zones for reagent injection.

Item No.	Item Description	Estimated Quantity[1]	Unit Cost[2] (2021$)	Unit	Estimated Cost	Notes/ Assumptions
17	Purchase of Reagents	2	$90,000	LS	$180,000	Unit cost based on Regenesis quote for 3-D Microemulsion, BDI Plus and CRS solutions purchase price.
18	Transport and Disposal of Drill Cuttings	228	$375	Drum	$85,500	Assume 3x55-gallon drum of investigation waste generated per boring (38 borings total). Assumes that the material generated will be transported and disposed at a RCRA Subtitle D landfill.
19	In-Situ Enhanced Bioremediation and Biochemical Reduction Contingency	1	20	%	$130,300	Covers unknowns, unforeseen circumstances, or unanticipated conditions associated with in-situ injection including completion of a secondary round of injection to address residual PCE contamination and its breakdown products.
				Total Construction Cost	**$781,800**	
Performance and Compliance Monitoring						
20	Soil Removal Confirmation Sample Analysis	30	$150	EA	$4,500	Verification sidewall and base samples to confirm the limits of soil removal activities. Assumes one sample per 40 linear feet of sidewall and one sample per 625 square feet of base and 10 % duplicate samples.
21	Performance Groundwater Sampling and Reporting	18	$15,000	EVNT	$266,000[3]	Performance monitoring utilizing the existing/new network of wells. It is assumed that groundwater monitoring would be initially completed on a quarterly basis for one year followed by 7 years of semi-annual monitoring. Assumes up to sixteen wells will be sampled per monitoring event and preparation of an annual monitoring reports summarizing results for Ecology submittal.
22	Performance Groundwater Sample Analysis	18	$10,000	EVNT	$178,000[3]	Includes chemical analysis of PCE and breakdown products at each of the selected monitoring well locations including duplicate sample per sampling event.
23	Long-Term Compliance Groundwater Sampling and Reporting	3	$15,000	EVNT	$75,000[3]	Long-term groundwater monitoring utilizing the existing/new network of wells. It is assumed that groundwater monitoring would be completed once per Ecology Five Year Periodic Review period for up to 15 years following completion of the performance monitoring period. Assumes up to sixteen wells will be sampled per monitoring event and preparation of an annual monitoring reports summarizing results for Ecology submittal.
24	Long-Term Compliance Groundwater Sample Analysis	3	$10,000	EVNT	$50,000[3]	Includes chemical analysis of PCE and breakdown products at each of the selected monitoring well locations including duplicate sample per sampling event.
25	Long-Term Vapor Sampling and Reporting	3	$7,500	EVNT	$38,000[3]	Perform long-term subslab and indoor vapor monitoring. It is assumed that vapor monitoring would be competed once per Ecology Five Year Periodic Review period for up to 15 years following completion of the performance monitoring period. Assumes up to 10 sample point per monitoring event and preparation of an annual monitoring reports summarizing results for Ecology submittal.
26	Long-Term Vapor Sample Analysis	3	$3,500	EVNT	$18,000[3]	Includes chemical analysis of PCE and breakdown products at each of the selected monitoring locations including duplicate sample per sampling event.
27	Purge Water Testing and Disposal	21	$275	EA	$7,000[3]	Disposal fee for purge water generated during each monitoring event. Assumes one 55-gallon drum per monitoring event will be generated for disposal.
28	Performance and Compliance Monitoring Contingency	1	20	%	$127,300	Covers unknowns, unforeseen circumstances, or unanticipated conditions associated with performance and contingency monitoring activities.
				Total Compliance Monitoring Cost	**$763,800**	
Professional/Administrative Support						
29	Pre-Construction Soil Characterization and Contained-In Waste Disposal Support	1	$50,000	LS	$50,000	Pre-construction support to characterize material for waste disposal and to support an Ecology Contain-In determination.
30	Project Planning, Design, Permitting and Construction Management Support	1	$100,000	LS	$100,000	Includes project planning and management to support implementation of the remedial action.

Item No.	Item Description	Estimated Quantity[1]	Unit Cost[2] (2021$)	Unit	Estimated Cost	Notes/ Assumptions
31	Engineering Design Report and Compliance Monitoring Plan	1	$50,000	LS	$50,000	Engineering Design Report will detail the plans and procedures that will be used for cleanup of the Site. The Compliance Monitoring Plan will detail the groundwater performance, confirmational and long-term monitoring to verify the effectiveness of the cleanup action.
32	Cleanup Action Report	1	$50,000	LS	$50,000	Cleanup Action Report will detail the soil removal, verification sampling and restoration activities completed during construction.
33	Institutional Controls Monitoring and Maintenance Plan	1	$35,000	LS	$35,000	Prepare Institutional Controls Monitoring and Maintenance Plan to identify the controls that will be utilized at the Site, and to provide guidelines for the monitoring, maintenance, handling and disposal of soil and groundwater encountered during future Site maintenance and/or development activities.
34	Voluntary Cleanup Program (VCP) and Regulatory Closure Support	1	$30,000	LS	$30,000	Includes VCP and regulatory coordination and communications, and project closeout support.
35	Professional/Administrative Support Contingency	1	10	%	$31,500	Covers unknowns, unforeseen circumstances, or unanticipated conditions associated with professional/administrative support.
				Total Professional/Administrative Services	$346,500	
				Cleanup Alternative Total[4]	$2,550,000	Accuracy of the total remedial alternative cost is considered -30 to +50 % based on EPA's Guide to Developing and Documenting Cost Estimates During the Feasibility Study.

Notes:

[1] Concept design level.

[2] Unit costs based on a combination construction cost estimates solicited from applicable vendors and contractors; review of actual costs incurred during similar, applicable projects; and professional judgment. Unit costs are based on 2021 dollars.

[3] Cost for long-term monitoring and/or operation and maintenance (O&M) calculated using the following formula (where applicable). FV = PV (1+r)n, where FV = 2021 Unit Cost, PV = Past Unit Cost, r = annual inflation rate (3%), n = number of periods inflation held.

[4] Total Remedial Action Alternative Costs are rounded up to the nearest $10,000.

LS = lump sum

CY = cubic yard

EA = each

EVNT = event

Table A-3

Cleanup Action Alternative 3 (Source Area Removal, Capping with Air Sparging and Soil Vapor Extraction, and Institutional Controls) Cost Estimate

Former Alderwood Laundry and Dry Cleaners
Lynnwood, Washington

Item No.	Item Description	Estimated Quantity[1]	Unit Cost[2] (2021$)	Unit	Estimated Cost	Notes/ Assumptions
Construction						
1	Mobilization/Demobilization	1	$35,000	LS	$35,000	Includes mobilization to the site, installation of temporary site controls including temporary traffic, and erosion and sediment controls (as applicable), and demob from the site.
2	Asphalt Demolition	670	$20	SY	$13,400	Includes removal of existing asphalt surface and portion of top course surfacing material in source areas. Assumes removal depth to 6" below ground surface.
3	Demolition Debris Recycling/Disposal	201	$25	TON	$5,025	Includes loading and transportation of demolished asphalt debris to permitted recycling facility.
4	Monitoring Well Decommissioning by Licensed Driller	5	$3,500	LS	$17,500	Decommission MW-2, 3, 3D, 15 and RW-1 prior to construction.
5	Excavation Dewatering, Treatment and Disposal	1	$35,000	LS	$35,000	Unit cost based on similar projects.
6	Soil Removal, Handling and Loading	1,400	$10	CY	$14,000	Assume in-place volume. Cost includes excavation, handling, stockpile and loading.
7	Contaminated Soil Transport and Disposal	2,520	$100	TON	$252,000	Assume 1.8 ton/cy (in-place). Assumes that the material generated will be transported and disposed at a RCRA Subtitle D landfill.
8	Utility Protection and/or Temporary Relocation and Restoration	1	$35,000	LS	$35,000	Protect utilities and/or temporarily reroute and restore to facilitate remedial excavation activities.
9	Purchase, Place and Compact Backfill Material	2,520	$30	TON	$75,600	Cost includes purchase, filling and compaction.
10	Surveying	1	$5,000	LS	$5,000	Unit cost based on similar projects.
11	Placement of Asphalt Pavement to Restore Source Area Excavation	1,250	$35	SY	$43,750	Assumes placement of 5 inches of base course and 4 inches of asphalt; no new stormwater system installation; and stormwater runoff flows to existing drainage structures or match existing drainage pattern. Does not include footprint of existing strip mall building.
12	Monitoring Well Installation by Licensed Driller	2	$4,500	LS	$9,000	Decommission MW-2, 3, 3D, 15 and RW-1 prior to construction.
13	Construction Contingency	1	20	%	$108,055	Covers unknowns, unforeseen circumstances, or unanticipated conditions associated with construction activities.
				Total Construction Cost	**$648,330**	
AS/SVE System Installation and Operation						
14	Pilot Study	1	$35,000	LS	$35,000	Pilot scale study to evaluate full-scale design. Unit cost based on similar projects.
15	Mobilization/Demobilization	1	$15,000	LS	$15,000	Includes mobilization to the site, installation of temporary site controls including temporary traffic, and erosion and sediment controls (as applicable), and demob from the site.
16	Asphalt Demolition	125	$20	SY	$2,500	Includes removal of existing asphalt surface and portion of top course surfacing material in source areas. Assumes removal depth to 6" below ground surface.

Item No.	Item Description	Estimated Quantity[1]	Unit Cost[2] (2021$)	Unit	Estimated Cost	Notes/ Assumptions
17	Demolition Debris Recycling/Disposal	38	$25	TON	$938	Includes loading and transportation of demolished asphalt debris to permitted recycling facility.
18	Treatment Well Installation	1	$200,000	LS	$200,000	Includes installation of AS and SVE treatment wells by a licensed driller, field oversight, IDW disposal and project management. Assumes collection and analysis of up to 20 additional soil samples to further characterize soil conditions within the treatment area.
19	Transport and Disposal of Drill Cuttings	60	$375	Drum	$22,500	Assume 3x55-gallon drum of investigation waste generated per boring (20 borings total). Assumes that the material generated will be transported and disposed at a RCRA Subtitle D landfill.
20	Trenching and Installation of conveyance piping and system connections	1	$15,000	LS	$15,000	Unit cost based on contractor quote.
21	Transport and Disposal of Contaminated Soil Generated During Trenching	180	$75	TON	$13,500	Disposal of soil generated from trenching activities to connect AS/SVE wells to the treatment compound. Assume 1.8 ton/cy (in-place). Assumes that the material generated will be transported and disposed at a RCRA Subtitle D landfill.
22	Purchase, Place and Compact Backfill Material	180	$30	TON	$5,400	Cost includes purchase, filling and compaction.
23	Installation AS/SVE Monuments	1	$3,500	LS	$3,500	Unit cost based on contractor quote.
24	Surveying of AS/SVE Monuments	1	$5,000	LS	$5,000	Unit cost based on similar projects.
25	Installation of AS/SVE Treatment Compound	1	$75,000	LS	$75,000	Unit cost based on contractor quote.
26	Pressure testing and System Startup	1	$15,000	LS	$15,000	Unit cost based on contractor quote.
27	Treatment System Operation and Maintenance	7	$45,000	YR	$356,000[3]	Includes program management, electricity for treatment compound, carbon vessel changeout and general system inspections and maintenance.
28	Decommissioning of AS/SVE Treatment Wells	18	$3,500	EACH	$63,000	Unit cost based on contractor quote.
29	Decommissioning of AS/SVE Treatment Compound	1	$25,000	LS	$25,000	Unit cost based on contractor quote.
30	AS/SVE Installation, Startup and Operation and Maintenance Contingency	1	20	%	$170,468	Covers unknowns, unforeseen circumstances, or unanticipated conditions associated with AS/SVE installation, startup and operation and maintenance activities.
				Total Construction Cost	**$1,022,805**	
Performance and Compliance Monitoring						
31	Soil Removal Confirmation Sample Analysis	30	$150	EA	$4,500	Verification sidewall and base samples to confirm the limits of soil removal activities. Assumes one sample per 40 linear feet of sidewall and one sample per 625 square feet of base and 10 % duplicate samples.
32	Performance Groundwater Sampling and Reporting	18	$15,000	EVNT	$266,000[3]	Performance monitoring utilizing the existing/new network of wells. It is assumed that groundwater monitoring would be initially completed on a quarterly basis for one year followed by 7 years of semi-annual monitoring. Assumes up to sixteen wells will be sampled per monitoring event and preparation of an annual monitoring reports summarizing results for Ecology submittal.
33	Performance Groundwater Sample Analysis	18	$10,000	EVNT	$178,000[3]	Includes chemical analysis of PCE and breakdown products at each of the selected monitoring well locations including duplicate sample per sampling event.

Item No.	Item Description	Estimated Quantity[1]	Unit Cost[2] (2021$)	Unit	Estimated Cost	Notes/ Assumptions
23	Long-Term Compliance Groundwater Sampling and Reporting	3	$15,000	EVNT	$75,000[3]	Long-term groundwater monitoring utilizing the existing/new network of wells. It is assumed that groundwater monitoring would be completed once per Ecology Five Year Periodic Review period for up to 15 years following completion of the performance monitoring period. Assumes up to sixteen wells will be sampled per monitoring event and preparation of an annual monitoring reports summarizing results for Ecology submittal.
24	Long-Term Compliance Groundwater Sample Analysis	3	$10,000	EVNT	$50,000[3]	Includes chemical analysis of PCE and breakdown products at each of the selected monitoring well locations including duplicate sample per sampling event.
25	Long-Term Vapor Sampling and Reporting	3	$7,500	EVNT	$38,000[3]	Perform long-term subslab and indoor vapor monitoring. It is assumed that vapor monitoring would be competed once per Ecology Five Year Periodic Review period for up to 15 years following completion of the performance monitoring period. Assumes up to 10 sample point per monitoring event and preparation of an annual monitoring reports summarizing results for Ecology submittal.
26	Long-Term Vapor Sample Analysis	3	$3,500	EVNT	$18,000[3]	Includes chemical analysis of PCE and breakdown products at each of the selected monitoring locations including duplicate sample per sampling event.
27	Purge Water Testing and Disposal	21	$275	EA	$7,000[3]	Disposal fee for purge water generated during each monitoring event. Assumes one 55-gallon drum per monitoring event will be generated for disposal.
40	Performance and Compliance Monitoring Contingency	1	20	%	$127,300	Covers unknowns, unforeseen circumstances, or unanticipated conditions associated with performance and contingency monitoring activities.
				Total Compliance Monitoring Cost	$763,800	

Item No.	Item Description	Estimated Quantity[1]	Unit Cost[2] (2019$)	Unit	Estimated Cost	Notes/ Assumptions
Professional/Administrative Support						
41	Pre-Construction Soil Characterization and Contained-In Waste Disposal Support	1	$50,000	LS	$50,000	Pre-construction support to characterize material for waste disposal and to support an Ecology Contain-In determination.
42	Project Planning, Design, Permitting and Construction Management Support	1	$150,000	LS	$150,000	Includes project planning and management to support implementation of the remedial action.
43	Engineering Design Report and Compliance Monitoring Plan	1	$50,000	LS	$50,000	Engineering Design Report will detail the plans and procedures that will be used for cleanup of the Site. The Compliance Monitoring Plan will detail the groundwater performance, confirmational and long-term monitoring to verify the effectiveness of the cleanup action.
44	AS/SVE Installation/Operation and Maintenance Report	1	$35,000	LS	$35,000	Installation/Operation and Maintenance Plan will detail design parameters for the AS/SVE treatment system as well as identify the locations of wells, conveyance piping and treatment compound components, testing requirements and contingency plans.
45	Cleanup Action Report	1	$50,000	LS	$50,000	Cleanup Action Report will detail the soil removal, verification sampling and restoration activities completed during construction.
46	Institutional Controls Monitoring and Maintenance Plan	1	$35,000	LS	$35,000	Prepare Institutional Controls Monitoring and Maintenance Plan to identify the controls that will be utilized at the Site, and to provide guidelines for the monitoring, maintenance, handling and disposal of soil and groundwater encountered during future Site maintenance and/or development activities.
47	Voluntary Cleanup Program (VCP) and Regulatory Closure Support	1	$30,000	LS	$30,000	Includes VCP and regulatory coordination and communications, and project closeout support.
48	Professional/Administrative Support Contingency	1	10	%	$40,000	Covers unknowns, unforeseen circumstances, or unanticipated conditions associated with professional/administrative support.
				Total Professional/Administrative Services	**$440,000**	
				Cleanup Alternative Total[4]	**$2,880,000**	Accuracy of the total remedial alternative cost is considered -30 to +50 % based on EPA's Guide to Developing and Documenting Cost Estimates During the Feasibility Study.

Notes:

[1] Concept design level.

[2] Unit costs based on a combination construction cost estimates solicited from applicable vendors and contractors; review of actual costs incurred during similar, applicable projects; and professional judgment. Unit costs are based on 2021 dollars.

[3] Cost for long-term monitoring and/or operation and maintenance (O&M) calculated using the following formula (where applicable). FV = PV (1+r)n, where FV = 2021 Unit Cost, PV = Past Unit Cost, r = annual inflation rate (3%), n = number of periods inflation held.

[4] Total Remedial Action Alternative Costs are rounded up to the nearest $10,000.

LS = lump sum
CY = cubic yard
EA = each
EVNT = event

Table A-4

Cleanup Action Alternative 4 (Thermal Conduction Heating with Soil Vapor Extraction, Monitored Natural Attenuation and Institutional Controls) Cost Estimate

Former Alderwood Laundry and Dry Cleaners
Lynnwood, Washington

Item No.	Item Description	Estimated Quantity[1]	Unit Cost[2] (2021$)	Unit	Estimated Cost	Notes/ Assumptions
TCH System Installation and Operation						
1	Pilot Study	1	$50,000	LS	$50,000	Pilot scale study to evaluate full-scale design. Unit cost based on similar projects.
2	Mobilization/Demobilization	1	$100,000	LS	$100,000	Includes mobilization to the site, installation of temporary site controls including temporary traffic, and erosion and sediment controls (as applicable), and demob from the site.
3	Monitoring Well Decommissioning by Licensed Driller	7	$2,500	LS	$17,500	Decommission MW-1, MW-2, MW-3, MW-3D, MW-15, MW-17 and RW-1 prior to construction.
4	Asphalt Demolition	1,450	$20	SY	$29,000	Includes removal of existing asphalt surface and portion of top course surfacing material in the thermal treatment area. Assumes removal depth to 6" below ground surface.
5	Demolition Debris Recycling/Disposal	435	$25	TON	$10,875	Includes loading and transportation of demolished asphalt debris to permitted recycling facility.
6	Installation of TCH, SVE, Temperature and Groundwater Monitoring Wells	1	$450,000	LS	$450,000	Unit cost based on contractor quote.
7	Transport and Disposal of Drill Cuttings	276	$375	Drum	$103,500	Assume 3x55-gallon drum of investigation waste generated per boring (92 borings total). Assumes that the material generated will be transported and disposed at a RCRA Subtitle D landfill.
8	Trenching between TCH, SVE and Temperature Monitoring Wells	1	$85,000	LS	$85,000	Assume in-place volume. Cost includes excavation, handling, stockpile and loading. Unit cost based on contractor quote.
9	Transport and Disposal of Contaminated Soil Generated During Trenching	450	$75	TON	$33,750	Assume 1.8 ton/cy (in-place). Assumes that the material generated will be transported and disposed at a RCRA Subtitle D landfill.
10	Installation of conveyance piping and system connections	1	$350,000	LS	$350,000	Unit cost based on contractor quote.
11	Purchase, Place and Compact Backfill Material	450	$30	TON	$13,500	Cost includes purchase, filling and compaction.
12	Placement of Asphalt Pavement to Restore Ground Surface	1,450	$35	SY	$50,750	Includes removal of existing asphalt surface and portion of top course surfacing material in the thermal treatment area. Assumes removal depth to 6" below ground surface.
13	Installation TCH, SVE, Temperature and Groundwater Well Monuments	1	$25,000	LS	$25,000	Unit cost based on contractor quote.
14	Surveying of TCH, SVE, Temperature and Groundwater Well Monuments	1	$5,000	LS	$5,000	Unit cost based on similar projects.
15	Installation of Treatment Compound	1	$400,000	LS	$400,000	Unit cost based on contractor quote.
16	System Startup	1	$35,000	LS	$35,000	Unit cost based on contractor quote.
17	Treatment System Operation and Maintenance	1	$700,000	YR	$700,000	Includes program management, electricity for treatment compound, carbon vessel changeout and general system inspections and maintenance.
18	Decommissioning of TCH Treatment System Wells	92	$3,500	WELL	$322,000	Decommission TCH system wells following treatment.
19	Decommissioning of TCH Treatment System Compound and Associated Components	1	$50,000	LS	$50,000	Decommission the TCH/SVE treatment compound including removal and disposal of spent carbons and other system controls following treatment.
20	TCH System Installation, Startup and Operation and Maintenance Contingency	1	20	%	$566,175	Covers unknowns, unforeseen circumstances, or unanticipated conditions associated with AS/SVE installation, startup and operation and maintenance activities.
				Total Construction Cost	**$3,397,050**	

Item No.	Item Description	Estimated Quantity[1]	Unit Cost[2] (2021$)	Unit	Estimated Cost	Notes/ Assumptions
Performance and Compliance Monitoring						
21	Performance Groundwater Sampling and Reporting	8	$12,500	EVNT	$100,000	Performance monitoring on a quarterly basis for up to one year utilizing the existing/new network of wells. Assumes up to twelve wells will be sampled per monitoring event and preparation of annual monitoring reports summarizing results for Ecology submittal.
22	Performance Groundwater Sample Analysis	8	$7,500	EVNT	$60,000	Includes chemical analysis of PCE and breakdown products at each of the selected monitoring well locations including duplicate sample per sampling event.
23	Long-Term Compliance Groundwater Sampling and Reporting	3	$15,000	EVNT	$65,000[3]	Long-term groundwater monitoring utilizing the existing/new network of wells. It is assumed that groundwater monitoring would be completed once per Ecology Five Year Periodic Review period for up to 15 years following completion of the performance monitoring period. Assumes up to sixteen wells will be sampled per monitoring event and preparation of an annual monitoring reports summarizing results for Ecology submittal.
24	Long-Term Compliance Groundwater Sample Analysis	3	$10,000	EVNT	$31,000[3]	Includes chemical analysis of PCE and breakdown products at each of the selected monitoring well locations including duplicate sample per sampling event.
25	Long-Term Vapor Sampling and Reporting	3	$7,500	EVNT	$24,000[3]	Perform long-term subslab and indoor vapor monitoring. It is assumed that vapor monitoring would be competed once per Ecology Five Year Periodic Review period for up to 15 years following completion of the performance monitoring period. Assumes up to 10 sample point per monitoring event and preparation of an annual monitoring reports summarizing results for Ecology submittal.
26	Long-Term Vapor Sample Analysis	3	$3,500	EVNT	$11,000[3]	Includes chemical analysis of PCE and breakdown products at each of the selected monitoring locations including duplicate sample per sampling event.
27	Purge Water Testing and Disposal	3	$275	EA	$4,000[3]	Disposal fee for purge water generated during each monitoring event. Assumes one 55-gallon drum per monitoring event will be generated for disposal.
30	Performance and Compliance Monitoring Contingency	1	20	%	$59,000	Covers unknowns, unforeseen circumstances, or unanticipated conditions associated with performance and contingency monitoring activities.
				Total Compliance Monitoring Cost	**$354,000**	
Professional/Administrative Support						
31	Pre-Construction Soil Characterization and Contained-In Waste Disposal Support	1	$35,000	LS	$35,000	Pre-construction support to characterize material for waste disposal and to support an Ecology Contain-In determination.
32	Project Planning, Design, Permitting and Construction Management Support	1	$300,000	LS	$300,000	Includes project planning and management to support implementation of the remedial action.
33	Engineering Design Report and Compliance Monitoring Plan	1	$75,000	LS	$75,000	Engineering Design Report will detail the plans and procedures that will be used for cleanup of the Site. The Compliance Monitoring Plan will detail the groundwater performance, confirmational and long-term monitoring to verify the effectiveness of the cleanup action.
34	Cleanup Action Report	1	$50,000	LS	$50,000	Cleanup Action Report will detail the soil removal, verification sampling and restoration activities completed during construction.
35	TCH System Installation/Operation and Maintenance Report	1	$60,000	LS	$60,000	Installation/Operation and Maintenance Plan will detail design parameters for the AS.SVE treatment system as well as identify the locations of wells, conveyance piping and treatment compound components, testing requirements and contingency plans.
36	Institutional Controls Monitoring and Maintenance Plan	1	$35,000	LS	$35,000	Prepare Institutional Controls Monitoring and Maintenance Plan to identify the controls that will be utilized at the Site, and to provide guidelines for the monitoring, maintenance, handling and disposal of soil and groundwater encountered during future Site maintenance and/or development activities.
37	Voluntary Cleanup Program (VCP) and Regulatory Closure Support	1	$30,000	LS	$30,000	Includes VCP and regulatory coordination and communications, and project closeout support.

Item No.	Item Description	Estimated Quantity[1]	Unit Cost[2] (2021$)	Unit	Estimated Cost	Notes/ Assumptions
38	Professional/Administrative Support Contingency	1	10	%	$58,500	Covers unknowns, unforeseen circumstances, or unanticipated conditions associated with professional/administrative support.
				Total Professional/Administrative Services	**$643,500**	
				Cleanup Alternative Total[4]	**$4,400,000**	Accuracy of the total remedial alternative cost is considered -30 to +50 % based on EPA's Guide to Developing and Documenting Cost Estimates During the Feasibility Study.

Notes:

[1] Concept design level.

[2] Unit costs based on a combination construction cost estimates solicited from applicable vendors and contractors; review of actual costs incurred during similar, applicable projects; and professional judgment. Unit costs are based on 2021 dollars.

[3] Cost for long-term monitoring and/or operation and maintenance (O&M) calculated using the following formula (where applicable). FV = PV (1+r)n, where FV = 2021 Unit Cost, PV = Past Unit Cost, r = annual inflation rate (3%), n = number of periods inflation held.

[4] Total Remedial Action Alternative Costs are rounded up to the nearest $10,000.

LS = lump sum
EA = each
CY = cubic yard
EVNT = event

GeoEngineers