Palermo Wellfield Superfund Site
Operable Unit 2 Proposed Plan

Tumwater, Washington **April 2024**

U.S. Environmental Protection Agency, Region 10

Proposed Plan for Public Comment

1. INTRODUCTION

The U.S. Environmental Protection Agency (EPA) invites the public to review and comment on this Proposed Plan to amend the Record of Decision (ROD) for the cleanup of tetrachloroethene, a chlorinated solvent also known as perchloroethene (PCE), at the Palermo Wellfield Superfund Site ("Site") located in Tumwater, Washington (**Figure 1**).

The Site has been administratively divided into two Operable Units (OUs) based on the contaminants of concern. OU-2, which is the subject of this Proposed Plan, addresses the release of PCE from former operations at the Southgate Dry Cleaners.

OU-1 is associated with the separate releases of trichloroethene (TCE) at testing materials laboratories owned by the Washington State Department of Transportation (WSDOT). A separate ROD Amendment to revise the Site's remedy and address TCE contamination will be issued for OU-1.

This Proposed Plan provides background information on the Site, describes the cleanup alternatives that were evaluated, and identifies the EPA's Preferred Alternative to amend the Site's remedy to contain and treat PCE contamination at OU-2.

INSIDE THIS PROPOSED PLAN

Public Comment Period:
April 9 through May 11, 2024

Public Meeting Details:
EPA will be holding an in-person public meeting on April 23, 2024. For more information, visit the Palermo Wellfield Superfund Site webpage.

Tuesday, April 23, 2024
5:00 to 6:00 p.m. – Open House
6 p.m – Presentation and Public Comment
Best Western Olympia-Tumwater Inn
5188 Capitol Blvd SE, Tumwater, WA 98501

Where to review the Proposed Plan:
The Administrative Record, which contains the Proposed Plan and other documents that support the basis for the Preferred Alternative, are available for public review at the following locations:

- **Tumwater Timberland Library**
  7023 New Market Street, SW,
  Tumwater, WA, 98501,
  (360) 943-7790
  Open 9 AM till 6 PM.
- **Online** at the Palermo Wellfield Superfund Site webpage.

How to Comment on the Proposed Plan:
Written comments may be submitted at any time during the public comment period by U.S. mail or email to the following recipient:

- **U.S. Mail**: James Hall, Remedial Project Manager, Site Cleanup Section 3,
  U.S. EPA
  Superfund Emergency Management Division
  1200 6th Avenue, Suite 155
  Seattle, WA 98101-3188
- **Email**: hall.james@epa.gov

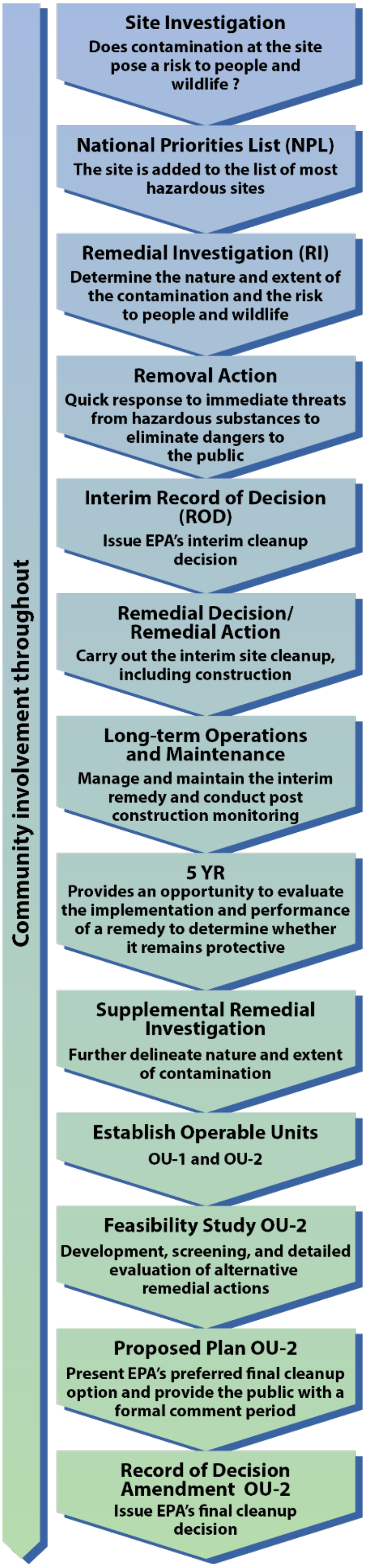

Figure 2. Steps in the Superfund Process

The EPA is releasing this Proposed Plan as part of its public participation requirements under Section 117(a) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), commonly known as Superfund, and Section 300.430(f)(2) of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP).

The EPA is seeking comments on this Proposed Plan, the Preferred Alternative, the other alternatives considered, and the supporting analyses and information. This information can be reviewed online at the Palermo Wellfield Superfund Site webpage.

The Superfund Process

The Superfund process, as established by CERCLA and the NCP, is structured to guide the investigation and cleanup of contaminated sites. The process includes various steps, illustrated by **Figure 2**, starting with the discovery of a site, and continuing through investigation, remedy selection, remedy implementation, post-remedy evaluation, and site completion.

The NCP provides procedures, expectations, substantive requirements, and program management principles for the CERCLA remedial process. In addition, the EPA has developed technical guidance and policy on a range of issues to ensure that decisions are based on well-established science and cleanup actions that are protective of human health and the environment consistent with CERCLA and the NCP.

The EPA is seeking comment on this Proposed Plan. After considering public comments, the EPA anticipates issuing its decision on the selected remedial alternative in a ROD Amendment which will provide the rationale for its decision. The ROD Amendment will also include a responsiveness summary, which will include the EPA's response to public comments received during the public comment period.

The EPA may modify the Preferred Alternative or select another cleanup alternative for OU-2 after consideration of comments received on this Proposed Plan. The public is encouraged to review and comment on any or all alternatives presented in this Proposed Plan and the Focused Feasibility Study, which are available as part of the administrative record.

Summary of Preferred Alternative

The EPA's Preferred Alternative to treat contamination of PCE at OU-2 includes soil vapor extraction (SVE) to treat soil and soil vapor beneath the Southgate Mall building and in situ sequestration, along with in situ chemical reduction (ISCR) to treat PCE in groundwater. An outline of the Preferred Alternative is provided below. Additional details on these selected technologies are provided on pages 11 and 12.

SVE, a technology that uses wells and an applied vacuum to remove soil vapor from the subsurface, is proposed to remediate PCE in soil and soil gas near the PCE release at the Southgate Dry Cleaners in the Southgate Shopping Center. Institutional and engineering controls would be implemented as needed to mitigate exposure due to soil gas migrating into enclosed building spaces.

In situ sequestration with ISCR, a technology that employs injections of carbon and zero valent iron in the aquifer to contain and treat contaminants, is proposed to remediate contaminants in groundwater. This involves the delivery of liquid activated carbon to sequester and retard the spread of contaminants in groundwater. Zero-valent iron (ZVI) is used to facilitate the transformation of PCE to acetylene and ethane, which are dissolved gasses in groundwater that are non-toxic at low concentrations.

The existing subdrain in the Palermo neighborhood will remain in place to capture shallow groundwater at the base of the bluff. The existing treatment lagoon will continue to operate and treat water discharged from the subdrain. The air strippers installed at the Palermo Wellfield will continue to operate to reduce contamination in groundwater before entering the City's water distribution system. Institutional and engineering controls will be implemented to limit exposure to contaminants in soil and groundwater until cleanup goals are achieved.

2. SITE BACKGROUND

The City of Tumwater (City) first detected PCE and TCE in three drinking water supply wells in 1993. PCE and TCE are both chlorinated solvents and common environmental contaminants. Chlorinated solvent concentrations were above safe levels in one of these wells. The City temporarily removed the affected wells from service and has since added treatment. The City and the Washington State Department of Ecology (Ecology) performed investigations between 1988 and 1993 and identified a plume of TCE and PCE in groundwater originating from sources upgradient of the Palermo Wellfield.

The EPA listed the Site on the Superfund program's National Priorities List in April 1997. Between 1997 and 1999, the EPA collected samples of soil, groundwater, ponded water in residential crawl spaces, and surface water as part of the Remedial Investigation (RI), which indicated that contamination was present. The EPA completed ecological and human health risk assessments and determined that contaminant concentrations associated with groundwater, surface water, soil and indoor air at the Site posed unacceptable risks to human health.

Figure 1. Site Location

The Southgate Dry Cleaners, located in the Southgate Shopping Center, is the source of PCE contamination. Investigations at Southgate Dry Cleaners resulted in the discovery of a 55-gallon drum used as a sump beneath the floor of the facility where spent PCE was stored. The drum was likely placed during the initial construction of the cleaners in the 1970s and was removed in 1994 (GeoEngineers, 2021; Jacobs, 2021). In 1998 and 1999, the EPA completed Removal Actions to address the PCE contamination in soil and to add treatment to the Palermo Wellfield, which included installing an SVE system to treat soil contamination beneath the Southgate Dry Cleaners, and the installation of air strippers to treat groundwater at the Palermo Wellfield.

The ROD was completed for the Site in 1999. As part of the remedy presented in the ROD, a subdrain and lagoon treatment system were installed to lower the water table within the Palermo neighborhood (EPA, 1999a).

In 2007, the EPA entered into a settlement with the owners of the Southgate Dry Cleaners. As a result, the EPA is responsible for the remediation of the PCE contamination. The sources of TCE are the former and current materials testing laboratories owned by WSDOT, who is the Responsible Party at the Site for the TCE contamination.

Table 1. Palermo Wellfield History

Action at Palermo Wellfield Superfund Site	**Date**
Palermo Wellfield Superfund Site listed on National Priorities List.	1997
Remedial investigation/Feasibility Study	1997-1999
Removal Actions – SVE System and Wellhead Treatment	1998-1999
Record of Decision	1999
Remedial Design/Remedial Action – Subdrain and Treatment Lagoon	1999-2001
Long-Term Monitoring and Operation and Maintenance	2002 to Present
Five-Year Review of Remedy – Cleanup Measures Reviewed every Five Years	2003 2008 2013 2018 2023
Supplemental Remedial Investigations	2013 - 2023
Two Operable Units (OUs) Established OU-1 Trichloroethene (TCE) Plume OU-2 Tetrachloroethene (PCE) Plume	2023
OU-2 Feasibility Study	2023
OU-2 Proposed Plan	2024
OU-2 Record of Decision Amendment – upcoming	2024-2025

In January 2023, the EPA administratively separated the Site into two OUs. The sources of TCE and its associated groundwater contamination were designated as OU-1. PCE soil and groundwater contamination were designated as OU-2. The areas where the PCE and TCE plume are comingled, including the subdrain and treatment lagoon in the Palermo neighborhood, are considered part of OU-1. These two OUs were not differentiated in the ROD. The EPA intends to issue individual ROD Amendments for each OU.

Concentrations of PCE in groundwater and soil currently remain above the cleanup levels set in the ROD. The EPA determined that additional remedial action is necessary to treat remaining contamination at OU-2 and is now revising the remedy through a ROD Amendment.

To support the Proposed Plan, a Supplemental Remedial Investigation (SRI) was completed in 2023 (EA, 2023a) that summarized historical and recent investigations completed at OU-2.

A Focused Feasibility Study (FFS) was also completed in 2023 (EA, 2023b). The FFS developed and screened remedial options and evaluated the alternatives using seven of the nine criteria specified in Section 300.430(f)(5)(i) of the NCP (see pages 15 through 17 of this Proposed Plan).

Removal and Remedial Actions

A Removal Action was completed to treat PCE in 1997, in which a SVE system was installed at Southgate Dry Cleaners. The system operated from 1998 to 2000 and removed approximately 400 pounds of PCE from soil (EPA, 1999a).

The cleanup plan selected in the ROD included continued operation of the SVE system at the Southgate Dry Cleaners and the wellhead treatment systems at the Palermo Wellfield. The ROD also included the construction of a subdrain designed to intercept contaminated groundwater and lower the water table elevation in the Palermo neighborhood, and the construction of a treatment lagoon to reduce contaminant concentrations.

The ROD also established Remedial Action Objectives (RAOs) and Remediation Goals (RGs), which describe cleanup criteria for the Site.

The following Remedial Actions have been implemented at the Site:

- Removal of the sump/drum that was used for solvent storage from beneath the floor at the Southgate Dry Cleaners in 1994, following the identification of the dry cleaner as a potential source area.
- Installation and operation of a SVE system to extract PCE in soil vapor from beneath the Southgate Dry Cleaners facility and its immediate vicinity. The SVE system consisted of six vertical wells with all but one well located in front of the Southgate Dry Cleaners. Although the SVE system removed approximately 400 pounds of PCE between 1998 and 2000, contamination remained beneath the Southgate Dry Cleaners.
- Installation of air strippers at the Palermo Wellfield to treat the TCE present in the drinking water.
- Installation of an interceptor subdrain to capture shallow groundwater and divert it to a treatment lagoon. The purpose of the subdrain is to prevent groundwater from surfacing beneath residences and reduce the potential for vapor intrusion in the western portion of the Palermo neighborhood.

The EPA has conducted Five Year Reviews at the Site since 2002 to evaluate the effectiveness of the remedy. In 2011, the EPA completed an Optimization Evaluation to identify opportunities to improve remedy protectiveness, effectiveness, and cost efficiency, and to facilitate progress toward site remedy completion (EPA, 2018). The Optimization Evaluation concluded that:

- The TCE and PCE groundwater plumes were not well-defined.
- Plume capture by the subdrain and well field may not be complete.
- Vapor intrusion remains a concern.
- Historical TCE and PCE sources may be ongoing sources for groundwater contamination.

As a result, SRIs were conducted at both OUs to better define the groundwater plume, evaluate vapor intrusion concerns, and assess source area contamination. The following summarizes impacts to soil, soil vapor, and groundwater, as well as the fate and transport of PCE contamination present at OU-2.

3. SITE CHARACTERISTICS

The Site is in western Washington in the City of Tumwater, approximately 60 miles south of Seattle. The 150-acre Site is in a light commercial and residential area. The western part of the Site is an uplands area and is bisected by Interstate 5. The uplands area contains the Southgate Shopping Center and Southgate Dry Cleaners facility, restaurants and other small businesses. The current and former WSDOT materials testing laboratories are located west of the freeway. A 60-foot bluff separates the uplands area from the lowland part of the Site in the Deschutes River Valley. Immediately below the bluff is the eastern part of the Site that includes the Palermo neighborhood, consisting of approximately 50 houses and the Palermo Wellfield. The north-flowing Deschutes River is located immediately east of the Site (**Figure 3**).

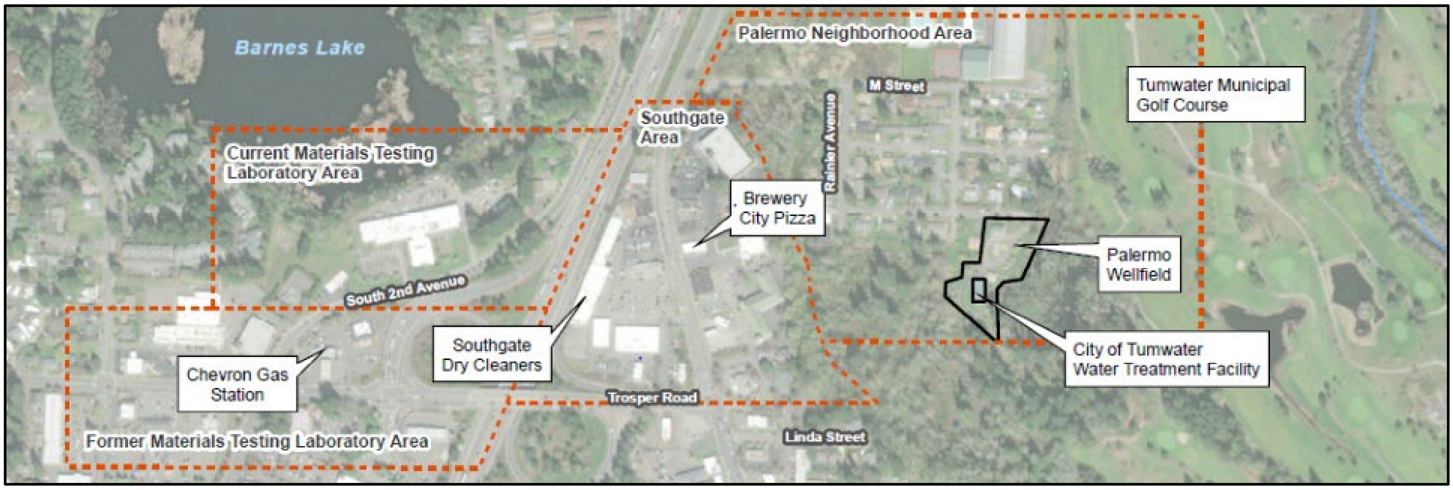

Figure 3. Site Vicinity

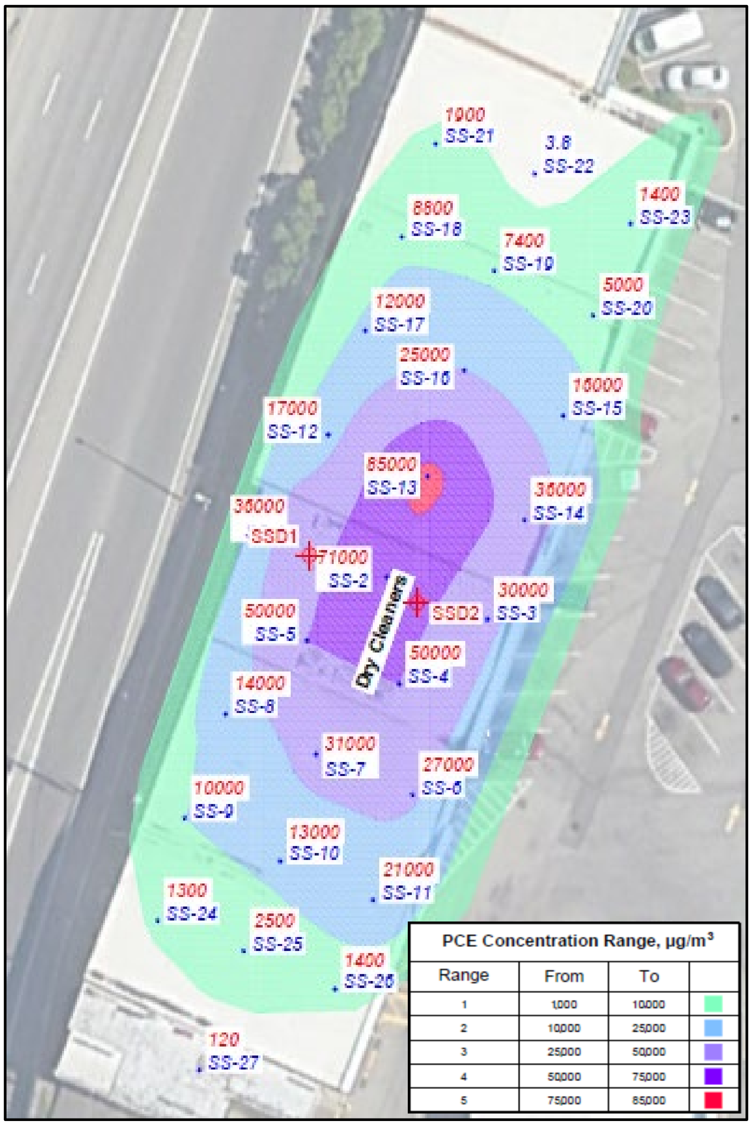

Figure 4. 2018 and 2023 Sub-Slab Soil Vapor PCE Concentrations in Micrograms per Cubic Meter

Groundwater flows to the east-northeast in the upland area of the Site and trends toward the City wellfield in the Palermo neighborhood. Recent depths to groundwater water observed in monitoring wells in the upland area of the Site range from approximately 25 to 60 feet below ground surface (ft. bgs) (EA, 2023a). The water table is found near ground surface at the base of the bluff, and the water table extends to a depth of approximately 7 ft. bgs in the eastern portion of the Palermo neighborhood. Artesian conditions have been observed in several wells in this area during wetter conditions in the winter and spring.

Soil and Soil Vapor

Contamination in subsurface soil and soil vapor is localized under the existing commercial buildings in the Southgate Shopping Center. The former SVE system removed the bulk of the PCE contamination in soil and soil gas beneath the Southgate Dry Cleaners; however, there is residual contamination in subsurface soil and soil gas.

Approximately 22,000 cubic yards of contaminated soil is estimated to remain beneath the Southgate Dry Cleaners building. The highest detected PCE concentrations measured in soil gas from 2018 to 2023 were beneath the building foundation north of Southgate Dry Cleaners (**Figure 4**).

Groundwater

The PCE groundwater plume extends vertically from 50 to 80 ft. bgs in the upland area of the Site and has migrated approximately 1000 feet laterally eastward toward the bluff. The majority of the PCE groundwater plume that passes through the bluff is captured by the subdrain. The plume with concentrations between 5 and 10 µg/L encompasses 120,000 square feet. The plume with concentrations greater than 10 µg/L encompasses 30,000 square feet. The highest concentrations of PCE in groundwater are found near MW-DG-11 (**Figure 5**) in the upland area, where concentrations exceed 50 µg/L.

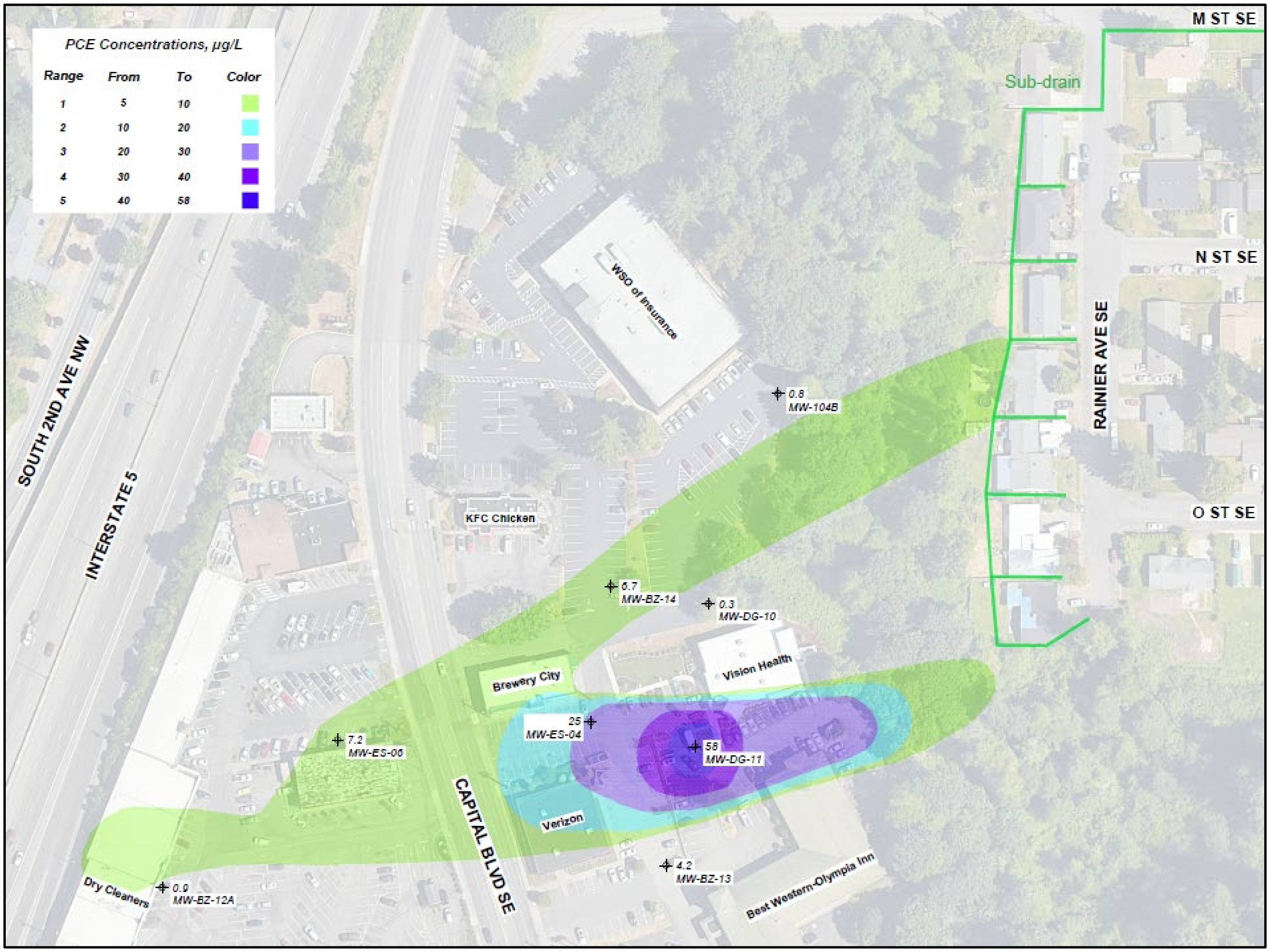

Figure 5. PCE Groundwater Plume and Sub-Drain – Spring 2021

Fate and Transport

Key transport pathways at OU-2 are PCE moving through subsurface soil into groundwater, PCE movement within groundwater, volatilization into soil gas, intrusion of soil gas into crawlspaces and buildings, and potential soil gas movement into groundwater.

No surface soil contamination has been observed at OU-2. PCE was historically released into the subsurface beneath the Southgate Dry Cleaners, where spent solvent was stored in a below-ground drum that was leaking into subsurface soil.

Residual PCE in subsurface soil exceeds the remediation goal (**Table 2**) and thus may be a continuing source of PCE migrating to groundwater and volatilizing to soil gas.

Contaminated groundwater has migrated horizontally downgradient to the northeast for approximately 1,000 feet. Based on 2021 groundwater elevations, the gradient is 0.02 to 0.03 feet per foot and the hydraulic conductivity is 0.2 to 12.5 feet per day (GeoEngineers, 2021). Contaminated groundwater has migrated vertically within depths of 25 feet below the water table. The PCE plume does not appear to be expanding, and PCE concentrations at individual groundwater monitoring wells are either stable or show decreasing concentrations since sampling began in the 1990s.

PCE concentrations in soil gas samples beneath the Southgate Dry Cleaners and adjacent businesses currently potentially pose unacceptable risk to human health through migration into indoor air. There is also residual contamination in subsurface soil beneath the building. Volatile organic compounds in soil can migrate to ambient air, where they can pose a threat to human health. Vapor intrusion of COCs into residences and local businesses can accumulate in closed spaces.

The Conceptual Site Model and exposure pathways for both OU-1 (TCE) and OU-2 (PCE) are shown on **Figure 6**.

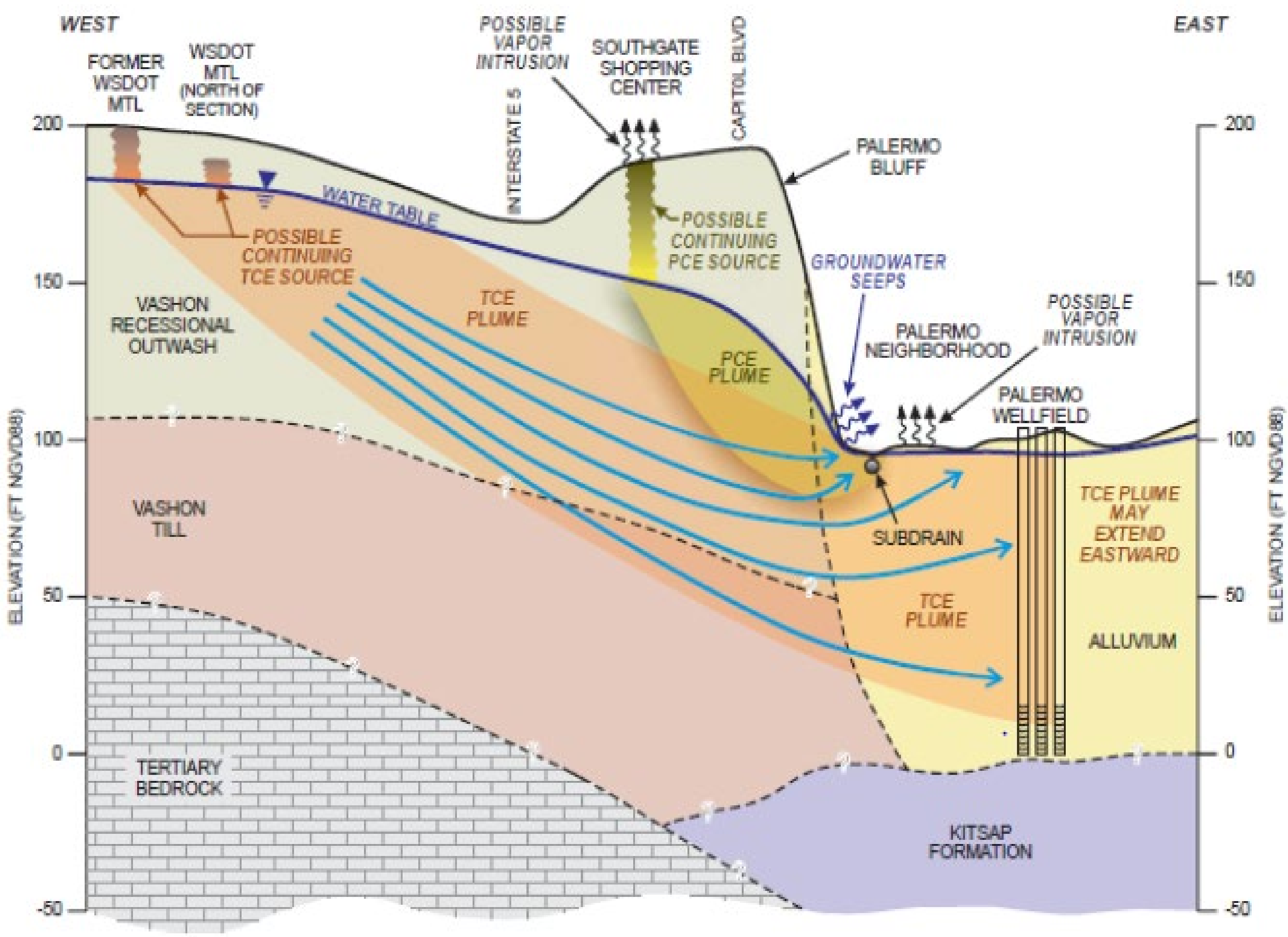

Figure 6. OU-1 (TCE) and OU-2 (PCE) Conceptual Site Model

4. SUMMARY OF SITE RISKS

In 1999, the EPA completed a baseline Ecological Risk Assessment and Human Health Risk Assessment as part the RI. These assessments serve as a baseline to indicate risks that could exist if no action were taken (EPA, 1999a).

The Ecological Risk Assessment determined that exposure pathways for aquatic receptors to contaminated surface water are unlikely to be complete. The following risk scenarios were evaluated in the Human Health Risk Assessment:

- Exposure to PCE and TCE from using contaminated groundwater as a source of drinking water and for showering or bathing
- Exposure to PCE and TCE via dermal contact and incidental ingestion of surface water in the ditch located in the Palermo neighborhood
- Exposure to PCE and TCE via inhalation of PCE and TCE vapors intruding into residential indoor air from crawlspaces

The results from the Human Health Risk Assessment informed the Site's remedy selected in the ROD. The EPA is now revising the remedy as the cleanup goals established in the ROD remain unmet.

5. REMEDIAL ACTION OBJECTIVES AND CLEANUP LEVELS

Remedial Action Objectives (RAOs) describe what the site cleanup is expected to accomplish to protect human health and the environment. RAOs help focus the development and evaluation of remedial alternatives and are developed to address unacceptable risks associated with each COC, exposure pathway, exposure route, and receptor. Cleanup levels represent the long-term contaminant concentrations that need to be achieved by the remedial alternatives in order to meet the narrative goals stated in the RAOs.

Table 2 on the following page summarizes the RAOs and the cleanup levels for OU-2.

Table 2. Summary of Remedial Action Objectives and Remediation Goals

Matrix	Remedial Action Objectives	COC	Cleanup Level	Basis	Monitoring Location
Groundwater	Restore groundwater to drinking water standards within a reasonable timeframe.	PCE	5 µg/L	Federal Safe Drinking Water Act MCLs	Groundwater throughout the aquifer
	Prevent exposure to contaminants in groundwater containing carcinogens in excess of MCLs.	PCE	5 µg/L		Palermo Wellfield wellheads
Surface Water	Prevent discharge of groundwater containing COCs to the Deschutes River at concentrations in excess of ARARs or resulting in ecological hazard index greater than 1.	PCE	2.4 µg/L	Revision of certain Federal water quality criteria applicable to Washington[a]	Point of discharge to Deschutes River
Soil	Prevent PCE in soil from leaching to groundwater that would result in a concentration greater than the MCL.	PCE	0.002 mg/kg	Protection of groundwater based on the MCL as a target concentration in groundwater.	Entire soil column with potential exposure to groundwater or precipitation
Indoor Air	Prevent exposure of building occupants to PCE vapors in indoor air at concentrations that pose unacceptable risk.	PCE	47 µg/m^3 in occupational buildings 11 µg/m^3 in residential buildings	EPA Regional Screening Level (RSL) for Composite Worker and Residential Ambient Air	Commercial and residential indoor air

Notes:

[a] 40 CFR 131.45

mg/kg: Milligrams per kilogram

µg/m^3: Micrograms per cubic meter

µg/L: Micrograms per liter

ARARs = Applicable or Relevant and Appropriate Requirements

MCL = Maximum Contaminant Level

6. REMEDIAL ALTERNATIVES

This section discusses the common components for all alternatives proposed for OU-2, provides a description of the technologies applied to alternatives, and presents the six alternatives evaluated for OU-2. **Figures 7-11** present general layouts for Alternatives 2-6 and are provided at the end of this document.

Common Components for All Alternatives

All alternatives include monitoring, institutional controls (ICs), and engineering controls (ECs). Monitoring refers to the collection of data after the remedy is in place in order to evaluate the remedy's performance and effectiveness. ICs are non-engineered instruments, such as administrative and legal controls, which help minimize the potential for human exposure to contamination and protect the integrity of a remedy by limiting land or resource use. ECs are physical means to preclude exposure to contamination and may include the use of sub-slab ventilation systems, vapor barriers, and fences to preclude exposure to contamination.

Currently, a substantial amount of the downgradient portion of the comingled PCE and TCE plume is hydraulically contained by the subdrain after passing through the bluff. The groundwater captured by the subdrain is subsequently treated by aeration at the treatment lagoon. This comingled portion of the plume, including the subdrain and treatment lagoon, are considered part of OU-1. The subdrain and treatment lagoon remain operational and monitoring the point of compliance near the Deschutes River will continue. As part of the OU-1 cleanup, the EPA will evaluate this portion of the remedy to determine if the existing aeration treatment is an effective means to reach the surface water cleanup levels. The EPA may implement additional treatment or optimization of this portion of the remedy if necessary based on this monitoring data.

Technologies Applied to Alternatives

Soil Vapor Extraction (SVE): SVE is technology used to remove volatile organic compounds such as PCE and TCE from below ground for treatment aboveground (EPA, 2021b). SVE extracts vapors from the soil above the water table using extraction wells installed in soil connected to an above-ground blower. The above-ground blower creates a vacuum and vapors are conveyed from the extraction wells to ground surface. Typically, soil vapors are treated with carbon before being discharged to the atmosphere.

SVE is considered a presumptive remedy by the EPA, meaning it is a technology that the EPA believes, based upon its experience, generally will be the most appropriate remedy for a specified type of site. SVE was implemented at the Site following the 1999 ROD and was effective in removing approximately 400 lbs of PCE from soil beneath the Southgate Dry Cleaners. This technology is feasible at OU-2 due to the sandy soils underlying the Southgate Dry Cleaners and Southgate Mall. It is anticipated that horizontal extraction wells would be installed beneath the Southgate Mall from the exterior to minimize disturbance to the building and tenants.

Monitored Natural Attenuation (MNA): MNA is a remedial approach that allows natural processes to decrease or "attenuate" concentrations in soil or groundwater to clean up groundwater without enhancement or treatment (EPA, 1999b). Natural attenuation processes are physical, chemical, or biological processes that reduce the mass, or concentration of contaminants in the groundwater under favorable conditions.

Examples of natural attenuation processes include biodegradation, a biotic process in which naturally occurring microbes in the subsurface ingest contaminate mass, and dilution, a process in which concentrations of contaminants decrease as they move through the aquifer and mix with clean groundwater.

Site conditions must be evaluated to determine what attenuation processes may be occurring. Long-term monitoring is necessary to evaluate the effectiveness of the MNA process. Monitoring typically involves collecting soil and groundwater samples to analyze them for the presence of contaminants and other site characteristics. MNA may be used in conjunction with other remediation technologies and may be implemented after other remediation measures have concluded. MNA may be used for a portion of a groundwater plume or subset of contaminants.

In Situ Chemical Oxidation (ISCO): ISCO is a remedial technology that uses chemicals called oxidants to help change contaminants into less toxic byproducts (EPA, 2012). It is commonly referred to as "in situ" because it is conducted in place, without having to pump out groundwater for aboveground treatment. To treat groundwater, oxidants such as potassium permangate are injected into the aquifer through wells. The oxidants mix with contaminated groundwater and react with contaminants. Another oxidizing agent, ozone, may be injected into the aquifer as a gas. The ozone reacts with contaminants and the byproducts are treated with SVE. ISCO is a common technology for source treatment of PCE in groundwater and can, in some cases, be used to treat dissolved plumes.

In Situ Biogeochemical Reductive Dechlorination (BiRD): In situ BiRD is a remedial technology that entails the injection of amendments including sulfate, iron, electron donor (carbon substrate), and bacteria into the subsurface to treat groundwater (EA, 2023b). Amendments are typically added within a remediation compound, injected, and extracted, and recirculated. These injections promote the biogeochemical cycling of sulfate reduction and produces iron sulfides. This process reduces PCE concentrations without generating secondary contaminants. The greatest challenge is creating and sustaining reducing conditions in the aquifer to facilitate BiRD reactions without producing undesirable degradation products. In addition, this alternative may temporarily dissolve and mobilize metals that are naturally occurring in the aquifer as precipitates (not present in water) under oxidizing conditions. Therefore, a treatability study is recommended to refine design elements.

In Situ Sequestration: In situ sequestration is a remedial technology that entails the delivery of an amendment into the aquifer to sequester and retard the propagation of contaminants (EA, 2023b). Micron-scale injectable liquid activated carbon is typically used as the sequestration agent. The activated carbon is injected into the saturated zone to form barriers that allow groundwater passage and sorption under natural hydraulic gradients. This technology does not destroy contaminants.

In Situ Chemical Reduction (ISCR): ISCR is a remedial technology that uses chemicals called "reducing agents" to treat contaminant mass (EA, 2023b). Zero-valent iron is an effective reducing agent used to treat chlorinated solvents including PCE. ISCR reduces PCE and creates ethene as a final product. Supplemental treatments may be necessary due to the short-term effectiveness, typically 2 to 3 years, of ZVI. Organic carbon sources, electron donors, and bioaugmentation are often combined with ISCR to facilitate treatment. Iron, arsenic, manganese, and other metals become soluble under reducing conditions and precipitate as conditions become oxidizing. Rather than create PCE breakdown products such as DCE or vinyl chloride, this methodology produces acetylene and ethane as PCE breakdown products. ISCR may be used in conjunction with in situ sequestration.

Summary of Alternatives

The EPA has developed the following remedial alternatives to meet the RAOs for OU-2. These alternatives were developed following the requirements established in CERCLA and the NCP. A summary of the evaluated remedial alternatives is presented below. More detailed evaluation can be found in the FFS (EA, 2023b).

ALTERNATIVE 1: NO ACTION

- Estimated Capital Cost: **$0**
- Total Operation and Maintenance (O&M) Cost: **$1.4M**
- Estimated Total Present Worth Cost: **$1.4M**

The No Action alternative represents the remedy currently in place for the Site.

ALTERNATIVE 2: SVE AND MONITORED NATURAL ATTENUATION (MNA)

- Estimated Capital Cost: **$1.9M**
- Total (O&M) Cost: **$5.3M**
- Estimated Total Present Worth Cost: **$7.2M**

Alternative 2 consists of SVE in the area beneath the Southgate Dry Cleaners and adjacent business, and ex situ treatment using granular activated carbon, and MNA for the groundwater contaminant plume. The proposed areal extent of the SVE system is approximately 20,000 square feet, with an estimated thickness of 30 feet. The proposed horizontal SVE well layout is shown on Figure 7.

This alternative also includes MNA of the groundwater plume. Additional monitoring points will be needed if the remedy is implemented for the entire plume. The Alternative 2 conceptual design for MNA is provided on Figure 8.

The estimated time to achieve RAOs using this alternative is over 20 years.

ALTERNATIVE 3: SVE AND IN SITU CHEMICAL OXIDATION (ISCO)

- Estimated Capital Cost: **$3.9M to $5.8M** (Depending on Well Configuration)
- Total O&M Cost: **$3M**
- Estimated Total Present Worth Cost: **$6.9M to $8.8M** (Depending on Well Configuration)

Alternative 3 consists of SVE at the Southgate Dry Cleaners and adjacent businesses as described in Alternative 2, and a combination of ISCO and MNA to remediate the groundwater plume. If ozone is selected as the ISCO reagent, it will be coupled with SVE (independent of the SVE associated with the Southgate Dry Cleaners). The estimated capital cost varies depending on the configuration of injection wells, as shown in Table 3.

Alternative 3 relies on the introduction of an ISCO reagent via vertical or horizontal injection wells to facilitate in situ remediation within the PCE plume greater than 10 g/L. Permanganate or ozone reagents are the preferred ISCO amendments. Figure 9 provides the conceptual horizontal axial well layout for Alternative 3.

The estimated time to achieve RAOs using this alternative is approximately three (3) years.

ALTERNATIVE 4: SVE AND IN SITU BIOGEOCHEMICAL REDUCTIVE DECHLORINATION (BIRD)

- Estimated Capital Cost: **$3.4M to $5.6M** (Depending on Well Configuration)
- Total O&M Cost: **$4M**
- Estimated Total Present Worth Cost: **$7.3M to $9.2M** (Depending on Well Configuration)

Alternative 4 consists of SVE at the Southgate Dry Cleaners and adjacent businesses as described in Alternative 2, and in situ BiRD combined with MNA for the groundwater plume.

Amendments would be added within a remediation compound, injected upgradient, and extracted downgradient within a closed loop recirculation system. BiRD would be applied within the plume where PCE concentrations are greater than 10 μg/L. The estimated capital cost varies depending on the configuration of injection wells, as shown in Table 3. Figure 10 provides the conceptual vertical layouts for Alternative 4.

The estimated time to achieve RAOs using this alternative is approximately four (4) years.

ALTERNATIVE 5: SVE AND IN SITU SEQUESTRATION

- Estimated Capital Cost: **$4.7M**
- Total O&M Cost: **$4M**
- Estimated Total Present Worth Cost: **$8.8M**

Alternative 5 consists of SVE at the Southgate Dry Cleaners and adjacent businesses as described in Alternative 2, and in situ sequestration to address the groundwater plume.

In situ sequestration entails the delivery of micron-scale injectable liquid activated carbon to sequester and retard the propagation of contaminants but does not destroy contaminants. The activated carbon is injected into the saturated zone to form barriers that allow groundwater passage and sorption under natural hydraulic gradients. The length of time to meet RAOs is higher compared to other alternatives because Alternative 5 relies on groundwater flow to move contaminants toward the barriers. The COCs would no longer be present in the groundwater after passing through the barrier. The COCs will be sorbed to solids deep below the subsurface, reducing exposure pathways. Implementation and monitoring may require extended periods and multiple injection events.

In situ sequestration may be applied across the entire plume, or only where PCE concentrations are greater than 10 μg/L. The proposed barrier layout for Alternative 5 is presented on Figure 11.

The estimated time to achieve RAOs using this alternative is approximately 10 years.

ALTERNATIVE 6: SVE AND IN SITU SEQUESTRATION WITH IN SITU CHEMICAL REDUCTION (ISCR)

- Estimated Capital Cost: **$5.3M**
- Total O&M Cost: **$4M**
- Estimated Total Present Worth Cost: **$9.3M**

Alternative 6 consists of SVE at the Southgate Dry Cleaners and adjacent businesses as described in Alternative 2, and in situ sequestration as described for Alternative 5, with the addition of ISCR to address the groundwater plume. Sequestration and treatment with ZVI may be applied across the entire plume or only the portion of the plume with PCE concentrations greater than 10 µg/L. ZVI may be added to all barrier locations or placed selectively. The costs presented are for the entire plume. The proposed barrier layout for Alternative 6 is presented on Figure 11.

Sequestration and treatment with ZVI has been pilot tested at OU-1 and demonstrated to be effective.

The estimated time to achieve RAOs using this alternative is approximately 10 years.

7. COMPARATIVE ANALYSIS OF ALTERNATIVES

Under CERCLA and Section 300.430(f)(5)(i) of the NCP, the EPA evaluated remedial alternatives using the following nine criteria:

Threshold Criteria

These criteria must be met by each alternative:

1. **Overall protection of human health and the environment.** Evaluates whether an alternative adequately protects human health and the environment by eliminating, reducing, or controlling unacceptable risks posed by exposures to hazardous substances, pollutants, or contaminants.
2. **Compliance with ARARs.** Evaluates whether the alternative meets Federal and state environmental statutes, regulations, and other requirements that pertain to the site, or whether a waiver of any such requirements is justified.

Balancing Criteria

These criteria represent technical considerations upon which the detailed analysis is based:

3. **Long-term effectiveness and permanence**. Considers the ability of a remedial alternative to maintain the protection of human health and the environment over time and the reliability of such protection.
4. **Reduction of toxicity, mobility, or volume through treatment**. Evaluates using treatment to reduce the harmful effects of contaminants and the ability of contaminants to move in the environment, and the amount of contamination present.
5. **Short-term effectiveness**. Considers both the length of time required to implement a remedial alternative and the risk that constructing and maintaining the remedy would pose to workers, residents, and the environment until cleanup levels are achieved.
6. **Implementability**. Considers the technical and administrative feasibility of implementing a remedial alternative, such as the relative availability of goods and services.
7. **Cost**. Considers both estimated capital costs and long-term operations and maintenance costs. Cost estimates are expected to be accurate within a range of +50 and -30 percent.

Modifying Criteria

Modifying criteria are evaluated at the end of the public review and comment period; they are not discussed in this Proposed Plan:

8. **State and Tribal acceptance**. Considers whether the state and tribes support the EPA's analyses and recommendations of the FFS report and the Proposed Plan.
9. **Community acceptance**. Considers whether the local community agrees with the EPA's analyses and recommendations of the FFS report and the Proposed Plan.

Overall Protection of Human Health and the Environment

Alternatives 2 through 6 are protective of human health and the environment. Alternative 6 provides protection by sequestering contaminants using liquid activated carbon barriers and destruction of contaminants by ZVI, resulting in the remediation of the PCE contaminant plume to RAOs. Alternative 5 is comparable to Alternative 6 but does not include the destruction of contaminants by ZVI. Operational level-of-effort is greater for Alternative 3 and Alternative 4 due to active remediation for BiRD or ozone, or repeated injections in the case of permanganate. Alternative 2 will require the longest time frame to meet RAOs and additional monitoring would be required to determine if this remedy is appropriate.

Pilot testing at OU-1 has indicated that in situ sequestration, proposed in Alternative 5 and 6, is an effective groundwater remedy for cleanup. The in situ chemical reduction component proposed in Alternative 6 treats contaminants, and there is minimal site activity and disturbance between injections.

Because Alternative 1 is not protective of human health and the environment, it was eliminated from consideration under the remaining eight criteria.

Compliance with ARARs

Preliminary ARARs are presented in the FS report (EA, 2023b). The identification of ARARs is an iterative process which will continue until final ARAR determinations are made by the EPA in the ROD Amendment. Alternative 2 will comply with chemical- and action-specific ARARs, while location-specific ARARs do not apply. Alternative 3 will comply with chemical-, and action-specific ARARs. Pilot testing would be required for Alternative 3 if the permanganate oxidant is selected to ensure that migration to surface water does not occur and to ensure that this alternative complies with location-specific ARARs. Alternatives 4, 5, and 6 will comply with chemical-, location- and action-specific ARARs.

Long-Term Effectiveness and Permanence

Alternative 3 complements existing aerobic and oxidizing geochemical conditions present in the aquifer. Alternative 3 and 4 would require treatability studies before the alternative could be implemented. A treatability study has already been conducted for liquid activated carbon and nano-scale ZVI (Alternatives 5 and 6) at OU-1 and was shown to be effective. Alternative 6 also has the addition of a nano scale ZVI that provides a destruction mechanism; however, maintaining ZVI reactivity would require periodic injections since the amendment longevity is limited. Once properly designed and in place, the activated carbon barriers provide long-term effectiveness with contaminant sorption and retardation.

Reduction of Toxicity, Mobility, and Volume through Treatment

Alternatives 2, 5 and 6 would reduce contaminant mass through capture by the subdrain and treatment via the aeration lagoon. Alternatives 3, 4, and 6 would reduce contaminant mass within the treatment zone. Alternative 3 and Alternative 4 would require pilot testing to demonstrate efficacy of the approach.

Short-Term Effectiveness

Short-term effectiveness evaluates the time needed to implement the remedy and considers adverse impacts to workers, the community, and the environment. All alternatives have some risk to the community and workers because they require action at the Site. Alternative 3 may result in adverse effects to fish and wildlife if permanganate is used as an oxidant and if release to surface water occurs. The construction period for all alternatives may expose the community to potential risks that can be mitigated with engineered controls and proper safety measures. Site access will be limited during remediation for all alternatives.

Alternative 2 will take the longest time to meet RAOs. Alternative 3 will provide the shortest time to restore the aquifer; however, Alternative 3 and Alternative 4 require treatability/pilot tests in support of remedial design activities and to ensure that there are no adverse effects to fish and wildlife. Treatability/pilot tests can delay implementation until the efficacy of the approach is demonstrated. Alternatives 5 and 6 may take longer than Alternatives 3 and 4, but less time than Alternative 2 to meet RAOs.

Implementability

All Alternatives are implementable using typical construction methods and equipment. Alternatives 3 and 4 could potentially be implemented using horizontal wells which would minimize surface disturbance and disruption to businesses. The construction footprint of Alternatives 5 and Alternative 6 would cause the largest surface disturbance and disruption to businesses. However, injection using a direct-push method for Alternatives 5 and 6 would allow the application of greater injection pressures, and the ability to target discrete intervals of the highest mass flux for better delivery and distribution of the amendments.

Alternative 3 and Alternative 4 require treatability studies prior to implementation to determine the efficacy of the technology. Alternative 4 would require installation, operation, and maintenance of the remediation system, as would Alternative 3 if ozone is used as an oxidant. O&M efforts would be the least for Alternative 2, Alternative 5, and Alternative 6.

It is expected that Alternative 3, with permanganate used as an oxidant, will face significant hurdles with state, Tribal and community acceptance due to its potential for toxicity to fish and wildlife.

Alternative 5 and Alternative 6 rank as the most satisfactory because of the limited onsite work and constructability, low O&M, and expected ease of approval from other agencies. Alternative 5 and Alternative 6 require bench testing to determine the potential for mobilization of metals and the generation of degradation products.

Cost

Estimated total costs are highest for Alternative 6 at $9.3M (EA, 2023b). The costs for Alternatives 3 and 4 vary depending on the injection well configuration. Cost estimates range from $6.9M to $8.8M for Alternative 3 and from $7.3M to $9.2M for Alternative 4. The estimated total cost for Alternative 2 is $7.2M. Cost summaries can be found on the following page in Table 3.

Table 3. Comparative Cost Estimate Summary

Description	Capital Costs (Present Value)	O&M and LTM Timeframe (years)	O&M, LTM, and Periodic Costs (Present Value)	Total Costs (Present Value)
Alternative 1: No Action	$0	30	$1.4	$1.4M
Alternative 2: SVE and MNA	$1.9M	20	$5.3M	$7.2M
Alternative 3: SVE and ISCO	$3.9M to $5.8M	3	$3M	$6.9M to $8.8M
Alternative 4: SVE and BiRD	$3.4M to $5.6M	4	$4M	$7.3M to $9.2M
Alternative 5: SVE and In Situ Sequestration	$4.7M	10	$4M	$8.8M
Alternative 6: SVE and In Situ Sequestration with ISCR	$5.3M	10	$4M	$9.3M

Notes:

ICs, ECs, and monitoring are common elements between Alternatives 2-6

BiRD = Biogeochemical Reductive Dechlorinaton

EC = Engineering control

IC = Institutional control

ISCO = In situ chemical oxidation

ISCR = In situ chemical reduction

LTM = Long-term monitoring

M = Millions

MNA = Monitored natural attenuation

O&M = Operations and maintenance

SVE = Soil vapor extraction

State, Tribal, and Community Acceptance

These criteria cannot be evaluated until the state and community have reviewed and commented on the alternatives presented in this Proposed Plan.

8. SUMMARY OF THE EPA'S PREFERRED ALTERNATIVE

The EPA's Preferred Alternative for OU-2 is Alternative 6, SVE and In Situ Sequestration with ISCR.

The EPA's Preferred Alternative employs SVE to clean up soil and soil vapor in the area of the PCE release at the Southgate Dry Cleaners and surrounding businesses. The SVE system will include horizontal wells that will allow for better access to soil contamination beneath the building than the historical vertical SVE well system that operated from 1998 to 2000. The extracted vapors will be treated using granular activated carbon. Soil vapor concentrations will be monitored during cleanup and ICs and ECs will be in place to limit exposure to soil and soil vapors.

The EPA's Preferred Alternative employs in situ sequestration with the addition of ZVI as a mechanism to treat PCE in groundwater. This remedial technology was pilot tested at OU-1, and results indicate that in situ sequestration is an effective groundwater remedy for cleanup at the Site. The activated carbon barriers and usage of ZVI as a mechanism to treat PCE provide long-term effectiveness with contaminant sorption and retardation. MNA may be used in conjunction with this alternative for the dilute plume as a cost savings measure.

Based on the current data and information available at this time, the EPA has determined that the Preferred Alternative meets the threshold criteria and provides the best balance of tradeoffs among the alternatives, with respect to the balancing and modifying criteria. The EPA expects the Preferred Alternative to satisfy the following statutory requirements of CERCLA §121(b): (1) be protective of human health and the environment; (2) comply with ARARs; (3) be cost-effective; (4) utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable; and (5) satisfy the preference for treatment as a principal element, or explain why the preference for treatment will not be met.

The EPA may modify the Preferred Alternative based on information received during the public comment period.

Additional resources are available online at:

U.S. EPA Region 10 Palermo Wellfield Superfund Site
https://cumulis.epa.gov/supercpad/cursites/csitinfo.cfm?id=1001761

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GLOSSARY

Applicable or Relevant and Appropriate Requirements (ARARs): Applicable requirements, as defined in 40 CFR § 300.5, are those clean-up standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, Remedial Action, location, or other circumstance found at a CERCLA site. Only those state standards that are identified by the state in a timely manner and that are more stringent than federal requirements may be applicable.

Relevant and appropriate requirements, as defined in 40 CFR § 300.5, means those clean-up standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, Remedial Action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at a CERCLA site that their use is well suited to the particular site. Only those state standards that are identified by the state in a timely manner and that are more stringent than federal requirements may be relevant and appropriate.

Contaminants of Concern (COCs): Site-specific chemicals/contaminants that are identified for evaluation in the site assessment process that pose unacceptable human health or ecological risks.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA): A federal law, commonly referred to as the "Superfund" Program. CERCLA provides clean-up and emergency response in connection with existing inactive hazardous waste disposal sites that endanger public health and safety or the environment.

Engineering controls: a physical method to eliminate or reduce exposure to residual contamination on a property. Examples include but are not limited to caps, covers, vapor mitigation systems, horizontal or vertical barriers, and hydraulic control of groundwater.

Exposure pathway: The pathway for a chemical from the source of contamination to the exposed individual or receptor, such as dermal contact, ingestion, or inhalation.

Feasibility Study (FS): A comprehensive process to screen, develop, and evaluate potential alternatives for remediating contamination.

Groundwater: Subsurface water that occurs in fully saturated soil and geologic formations.

Institutional Controls: Non-engineered controls, such as administrative and legal controls, help minimize human exposure to contamination and/or protect the integrity of the remedy.

In Situ Biogeochemical Reductive Dechlorination (BiRD): This remedial technology entails an injection of sulfate, iron, electron donor (carbon substrate), and bacteria into the target zone to promote the biogeochemical cycling of sulfate reduction and the creation of iron sulfides that react and destroy PCE without generating secondary toxic contaminants. BiRD amendments may be injected through vertical wells or horizontal wells that are parallel (axial) or perpendicular (transverse) to the plume. The greatest challenge is creating and sustaining reducing conditions to facilitate BiRD reactions without producing undesirable degradation products: TCE, dichloroethane, or vinyl chloride.

In Situ Chemical Reduction (ISCR): ISCR is a remedial technology that utilizes reducing agents to treat contaminants. The reducing reagents effective for chlorinated solvents include zero-valent iron (ZVI). ISCR reduces PCE, creating ethene as a final product. Supplemental treatments may be necessary due to the short-term effectiveness, typically 2 to 3 years, of ZVI. Organic carbon sources, electron donors, and bioaugmentation are often combined with ISCR. Iron, arsenic, manganese, and other metals become soluble under reducing conditions and precipitate as conditions become oxidizing. Groundwater becomes reducing and may affect color, smell, or taste and may not be acceptable for domestic or potable uses.

In Situ Chemical Oxidation (ISCO): ISCO is a technology whereby an oxidant, such as potassium permanganate or ozone, are used to degrade organic compounds into less toxic compounds. ISCO is a proven technology for source treatment of PCE and can, in some cases, be used to treat dissolved plumes.

In Situ Sequestration: In situ sequestration entails the delivery of micron-scale injectable liquid activated carbon to sequester and retard the propagation of contaminants, but does not destroy contaminants. The activated carbon is injected into the saturated zone to form barriers that allow groundwater passage and sorption under natural hydraulic gradients.

Monitored Natural Attenuation (MNA): MNA is a remedial approach that allows natural processes to achieve RAOs without enhancement or treatment. The natural attenuation processes that are at work in such a remediation approach are physical, chemical, or biological processes that reduce the mass, or concentration of contaminants in the groundwater under favorable conditions. The processes may include biodegradation (aerobic or anaerobic), dispersion, or dilution. Conditions for MNA of volatile organic compounds in groundwater through biodegredation and reductive dechlorination may be favorable if there are reducing conditions in the aquifer and sufficient electron donors and electron acceptors are available. MNA may be used for a portion of a groundwater plume or subset of contaminants and can be utilized in conjunction with active remediation measures.

Operation and Maintenance (O&M): Activities conducted after the Remedial Action to maintain the effectiveness of the response action.

Proposed Plan: A plan for site Remedial Action or other action that is available to the public for comment.

Record of Decision (ROD): A legal document that describes the clean-up action or alternative selected for a site, the basis for choosing that alternative, and public comments on the selected alternative.

Remedial Action Objectives (RAOs): Specific goals for protecting human health and the environment. RAOs are developed by evaluating ARARs protective of human health and the environment and the results of remedial investigations and risk assessments.

Remedial Investigation (RI): Extensive technical study conducted to characterize the nature and extent of contamination and the risks posed by contaminants present at a site.

Soil Vapor Extraction (SVE): SVE is a presumptive remedy to treat volatile organic compounds such as PCE and TCE within the vadose zone. SVE entails the use of vertical or horizontal subsurface extraction wells connected to an aboveground blower to induce a vacuum and extract soil vapor. Extracted soil vapor is conveyed through pipes and passed through an emission control system before being discharged to the atmosphere. Typically, vapor-phase carbon absorption is used to treat extracted soil vapor prior to discharge to the atmosphere.

U.S. Environmental Protection Agency (EPA): The federal agency responsible for the administration and enforcement of CERCLA (and other environmental statutes and regulations), and with final approval authority for the selected remedial alternative.

Zero-valent Iron (ZVI): A metal used in in situ reduction (ISCR) to treat contaminants in groundwater. ZVI is a reducing agent that treats contaminants like PCE through dechlorination. ZVI can be injected into the sub-surface at various nano- or micro-scale particle sizes and coupled with other amendments to form permeable reactive barriers.

ABBREVIATIONS AND ACRONYMS

µg/L	Microgram(s) per liter
ARAR	Applicable or Relevant and Appropriate Requirement
BiRD	Biogeochemical Reductive Dechlorination
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	Contaminant of concern
EC	Engineering control
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ERA	Ecological Risk Assessment
FFS	Focused Feasibility Study
FS	Feasibility Study
IC	Institutional control
ISCR	In Situ Chemical Reduction
MCL	Maximum Contaminant Level
mg/kg	Milligram(s) per kilogram
MTCA	Washington State Model Toxics Control Act
MNA	Monitored natural attenuation.
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
O&M	Operation and maintenance
OU	Operable Unit
PCE	Tetrachloroethene
RI	Remedial Investigation
ROD	Record of Decision
site	Palermo Wellfield Superfund Site
SVE	Soil vapor extraction
TCE	Trichloroethene
TMV	Toxicity, mobility, or volume
WSDOT	Washington State Department of Transportation
ZVI	Zero-valent iron

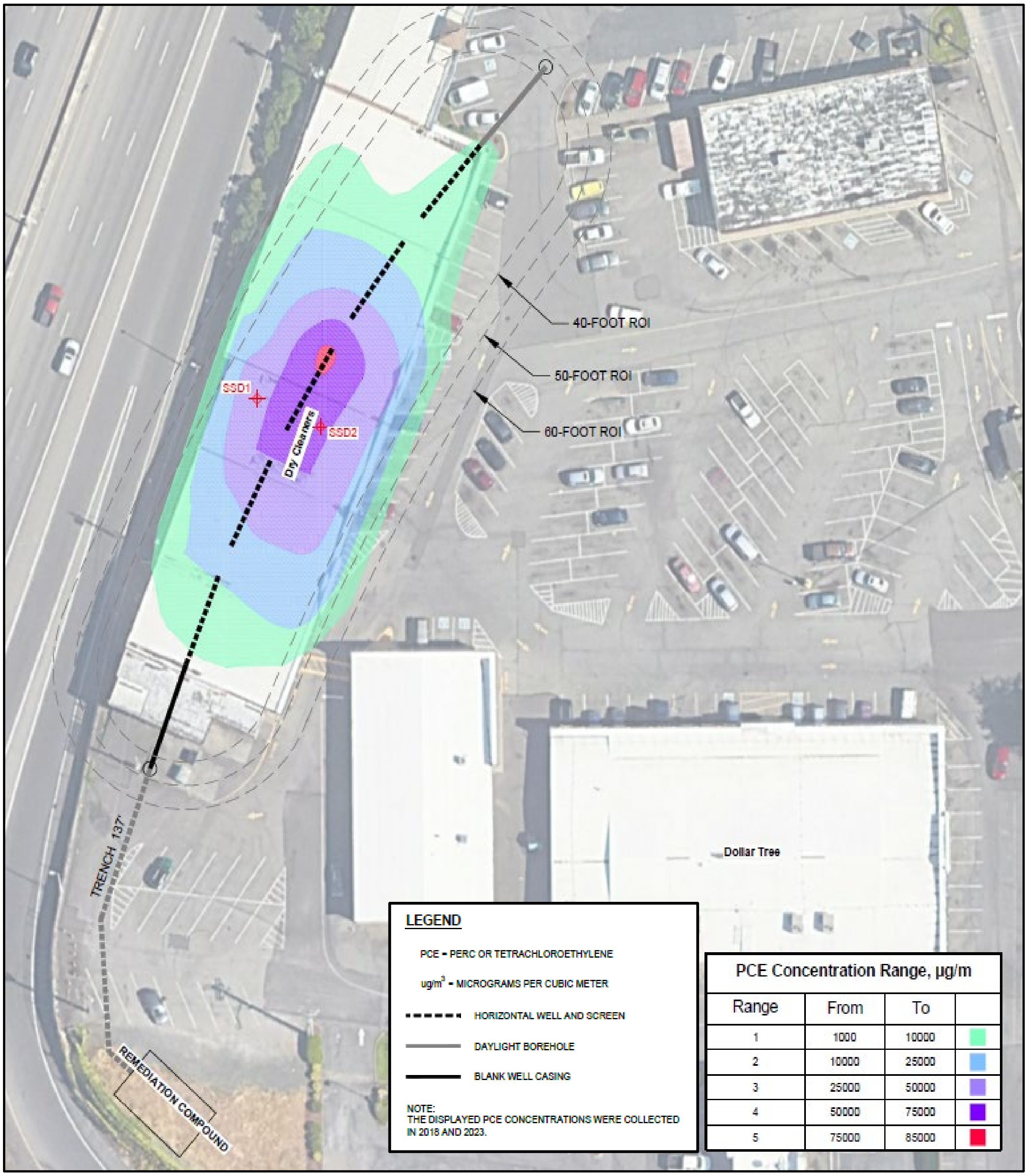

Figure 7. SVE Layout for Alternatives 2 - 6

Figure 8. Proposed Monitoring Well Network for Alternative 2: SVE and MNA

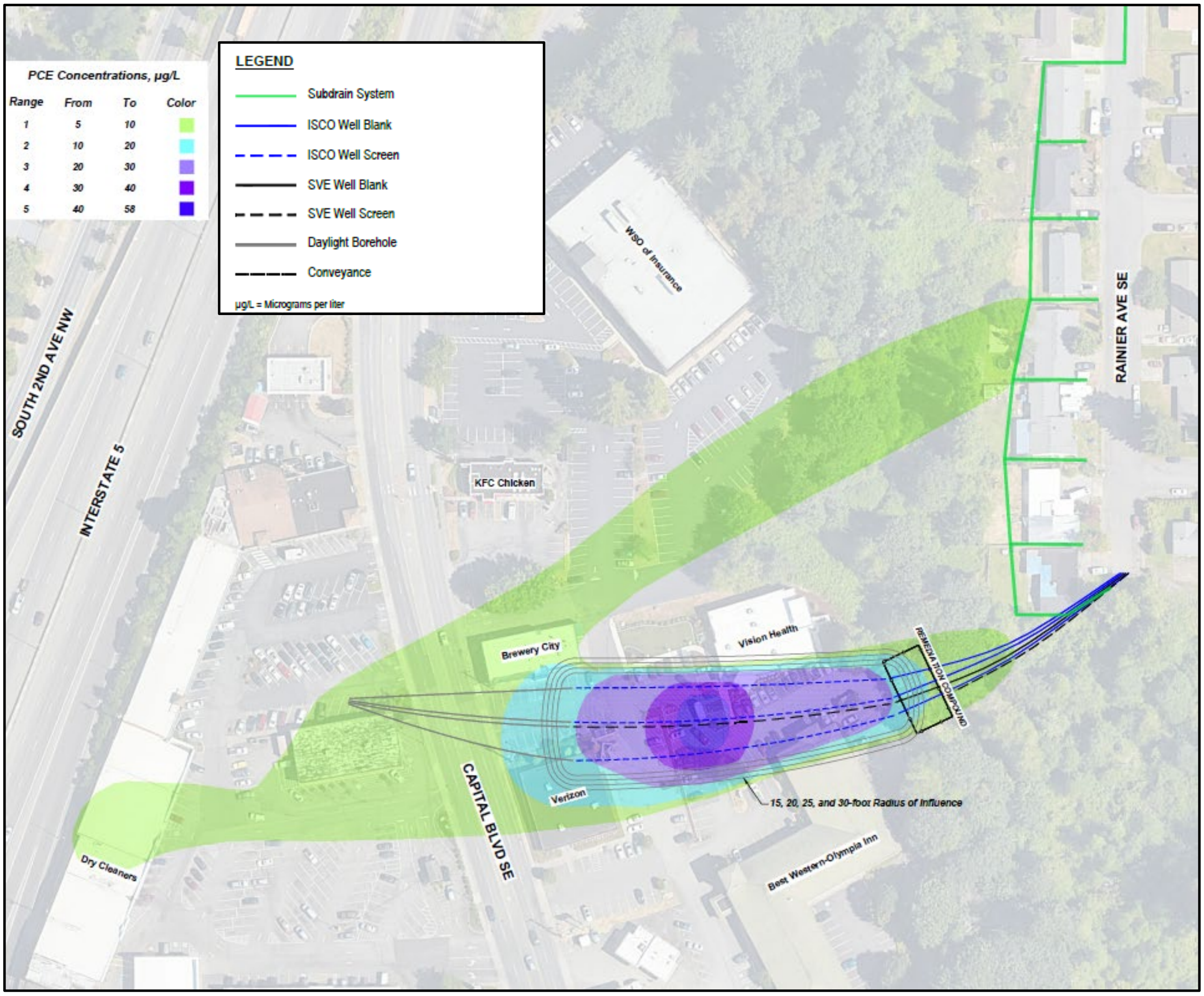

Figure 9. Conceptual Layout for Alternative 3: SVE and ISCO Injection Wells (Horizontal Axial Well Configuration)

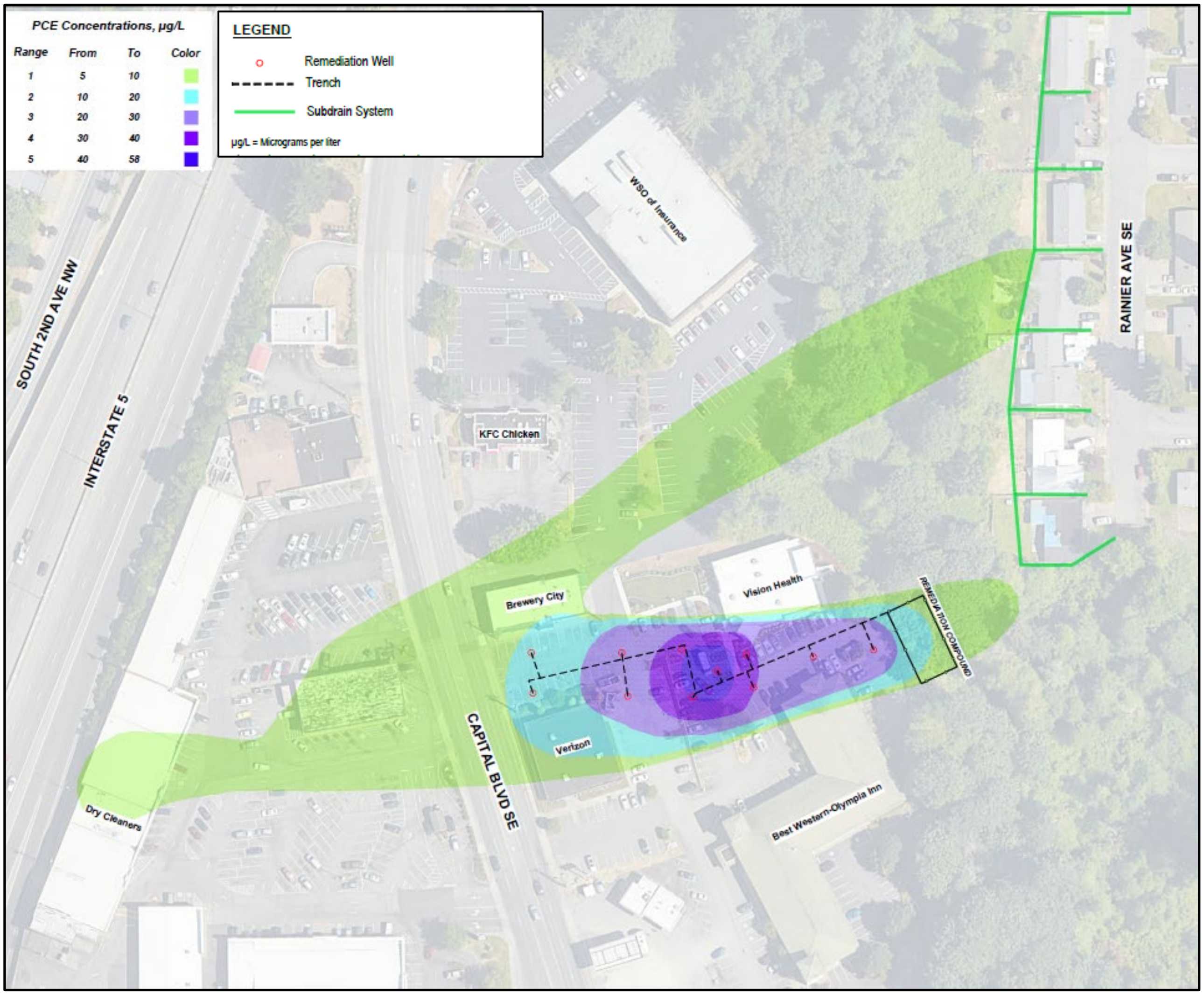

Figure 10. Conceptual Layout for Alternative 4: SVE and BiRD Injection Wells (Vertical Well Configuration)

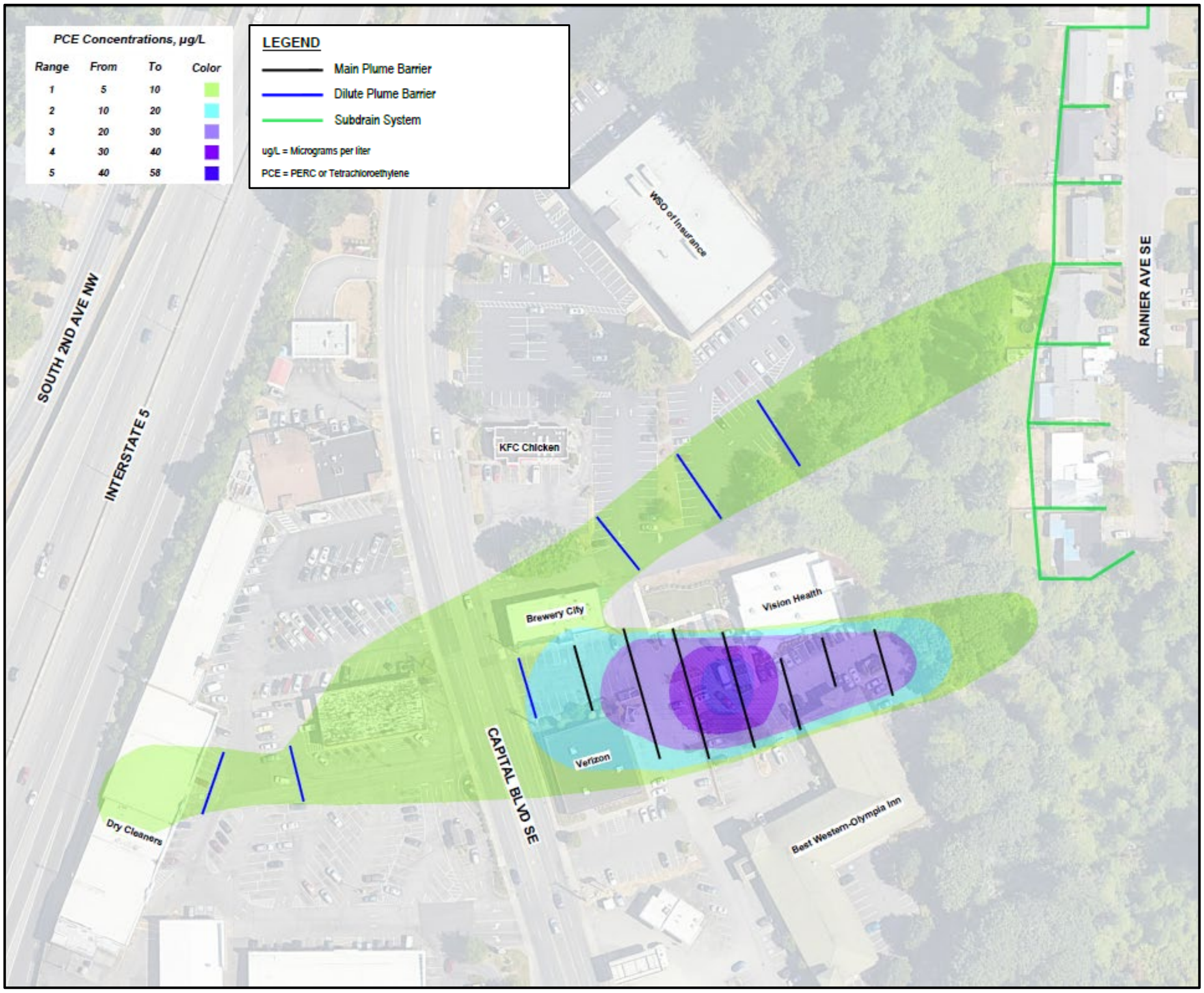

Figure 11. Conceptual Barrier Layout for Alternatives 5: SVE and In Situ Sequestration and Alternative 6: SVE and In Situ Sequestration with ISCR