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AN EXELON COMPANY

LANDSIDE (OPERABLE UNIT 1)
FEASIBILITY STUDY

Benning Road Facility
3400 Benning Road, NE
Washington, DC 20019

LANDSIDE OPERABLE UNIT 1 FEASIBILITY STUDY

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3400 Benning Road, N.E.
Washington, DC 20019

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Acronyms

µg/kg	micrograms per kilogram
µg/L	micrograms per liter
ALM	asphalt latex membrane
ARARs	applicable or relevant and appropriate requirements
ARSP	Anacostia River Sediment Project
AST	aboveground storage tank
BERA	Baseline Ecological Risk Assessment
bgs	below ground surface
BHHRA	Baseline Human Health Risk Assessment
BMPs	best management practices
BTV	background threshold value
CCTV	closed-circuit television
CEA	Classification Exception Areas
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	Code of Federal Regulations
CM	composite membrane
COC	Chemical of Concern
COIs	Constituents of Interest
COPC	Chemical of Potential Concern
CSM	conceptual site model
CTE	central tendency exposure
CVOC	chlorinated volatile organic compound
CY	cubic yards
DC	District of Columbia
DCE	dichloroethene
DCMR	District of Columbia Municipal Regulations
DO	dissolved oxygen
DOEE	Department of Energy and the Environment
EDL	estimated detection limit
DRO	diesel range organics
ERD	Enhanced Reductive Dichlorination
EVO	emulsified vegetable oil
EVOH	ethylene vinyl alcohol
FFS	Focused Feasibility Study
FS	Feasibility Study
g	grams
GAC	Granular Activated Carbon
gpm	gallons per minute
GRA	General Response Action
GRO	gasoline range organics
HDPE	high-density polyethylene

Acronyms (continued)

HI	Health Index
IC	institutional control
$KMnO_4$	potassium permanganate
KMY	Kenilworth Maintenance Yard
KPS	Kenilworth Park South
LIA	Landside Investigation Area
LLDPE	Linear low-density polyethylene
LWZ	lower water-bearing zone
MCL	Maximum Contaminant Level
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MNA	Monitored Natural Attenuation
MnO_2	manganese dioxide
MnO_4^-	permanganate ion
MS4	municipal separate storm sewer system
MTBE	methyl tert-butyl ether
mV	millivolts
NA	not applicable
$NaMnO_4$	sodium permanganate
NAVD88	North American Vertical Datum of 1988
NCP	National Contingency Plan
ng/L	nanograms per liter
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
O&M	operation and maintenance
OMB	Federal Office of Management and Budget
ORP	oxidation-reduction potential
OSHA	Occupational Safety and Health Administration
OU	Operable unit
OWS	Oil-water separator
PAH	polycyclic aromatic hydrocarbons
PCBs	polychlorinated biphenyls
PCE	perchloroethylene
PECS	potential environmental cleanup sites
Pepco	Potomac Electric Power Company
pg/L	picograms per liter
PMP	PCB Minimization Plan
POTW	publicly owned treatment works
PPE	personal protective equipment
ppm	parts per million
PRB	permeable reactive barrier
PRG	preliminary remediation goals

Acronyms (continued)

PSLs	Project Screening Levels
PTSM	Principal Threat Source Material
PVC	polyvinyl chloride
RAA	Remedial Action Alternatives
RAO	Remedial Action Objectives
RBTC	risk-based target concentrations
RDL	representative detection limit
RI	Remedial Investigation
River	Anacostia River
RME	reasonable maximum exposure
ROD	Record of Decision
RSL	risk screening level
Site	3400 Benning Road NE, Washington, DC
SMP	Soil Management Plan
TBC	To Be Considered
TCE	trichloroethylene
TM	thermoplastic membrane
TSCA	Toxic Substances Control Act
TSS	total suspended solids
UCL	upper confidence limit
USEPA	U.S. Environmental Protection Agency
UST	underground storage tank
UWZ	upper water-bearing zone
VC	vinyl chloride
VOC	volatile organic compound
WIA	Waterside Investigation Area
WMATA	Washington Metropolitan Area Transit Authority
WRA	Well Restriction Area
ZVI	zero-valent iron

1 Introduction

This Feasibility Study (FS) Report describes the development and evaluation of landside remedial alternatives based on the findings from the Remedial Investigation (RI) completed by Potomac Electric Power Company (Pepco) at its Benning Road Facility located at 3400 Benning Road NE, Washington, DC (Site) and a segment of the Anacostia River (River) adjacent to the Site.

Pepco is conducting the RI/FS for the Benning Road Facility pursuant to the requirements of a consent decree with the District of Columbia (DC) that was approved by the U.S. District Court on December 1, 2011 (Consent Decree). The RI/FS is conducted consistent with the requirements of Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP).

The location of the Site is depicted in **Figure 1-1**. The study areas encompassed for the RI/FS are shown on **Figure 1-2**. The Study Area for the RI/FS consists of a “Landside Investigation Area (LIA)” focused on the Site itself, and a “Waterside Investigation Area (WIA)” focused on the shoreline and sediments in the segment of the Anacostia River in close proximity to the Site. The Site is one of 15 upland properties along the tidal Anacostia River currently identified by District Department of Energy and Environment (DOEE) as potential environmental cleanup sites (PECSs) within the study area for the Anacostia River Sediment Project (ARSP) (**Figure 1-3**).

DOEE determined that the most expeditious approach for completing the Feasibility Study would be to divide the Site into two separate “Operable Units” for the purpose of evaluating, selecting, and implementing remedial actions. The landside area has been designated “Operable Unit 1 (OU1),” and the waterside area has been designated “Operable Unit 2 (OU2).” The decision to manage the Site through two separate operable units reflects the fact that the remedial actions being evaluated for the landside area are distinct from the remedial actions being evaluated for the waterside area and the remedial actions for each operable unit can be implemented independently. This approach also aligns better with the different remedial objectives for each operable unit – the landside remedy is intended to be the final remedy, whereas the waterside remedy is intended to be an interim remedy, with the need for possible additional remedial action to be evaluated based on the results of the interim action pursuant to the same adaptive management approach adopted for the rest of the Anacostia River under the ARSP. This document addresses remedial alternative for the landside area (OU1). A separate Focused Feasibility Study is being prepared for the waterside area (OU2).

1.1 Purpose and Scope

The purpose of the Benning Road Facility RI/FS is to: (a) characterize environmental conditions within the Study Area, (b) investigate whether and to what extent past or current conditions at the Site have caused or contributed to contamination of River sediments, (c) assess current and potential risk to human health and the environment posed by conditions within the Study Area, and (d) develop and evaluate potential remedial actions, as may be warranted. The Final Remedial Investigation Report (Final RI Report) for the Benning Road Site was submitted to DOEE on February 28, 2020 (AECOM, 2020), and was approved by DOEE on March 2, 2020. The Final RI Report addressed the first three objectives outlined above, and this FS Report is prepared to address the development and evaluation of potential remedial actions for the landside area.

A substantial portion of the RI focused on field sampling and data analysis to define the nature and extent of chemicals of potential concern (COPCs) in groundwater, soils, and Anacostia River sediment and surface water. Extensive RI data were collected during two phases of investigation, extending from 2013 to 2018, to document the presence and general distribution of COPCs (AECOM, 2020). A number of different organic and inorganic constituents were detected in these environmental media, and potential risks associated with exposure to these constituents were evaluated in a Site-specific Baseline Human Health Risk Assessment (BHHRA) and a Site-specific Baseline Ecological Risk Assessment (BERA). Potential human health risks were evaluated using conservative risk analysis tools and an extensive Site-specific data set in accordance with U.S. Environmental Protection Agency (USEPA) and DOEE guidance.

This FS evaluates potential remedial actions for all areas of the Landside Investigation Area where risks exceed the cancer risk threshold of 1E-05 (a target risk selected for the Site consistent with the ARSP target risk level) and/or the non-cancer hazard index (HI) threshold of 1. It is anticipated that the remedy to be selected by DOEE based on this Landside Feasibility Study, following public comment on a Proposed Plan, and then documented in a Record of Decision issued by DOEE, will represent the final action for OU1.

Based on current and baseline conditions presented in the RI, the objectives of this FS report include the following:

- Provide a comprehensive list of applicable or relevant and appropriate requirements (ARARs) to be considered or attained for remedial actions.
- Establish specific Remedial Action Objectives (RAOs) that are protective of human health and the environment.

- Develop preliminary remediation goals (PRGs) to achieve the RAOs consistent with the selected risk thresholds.
- Develop general response actions that will satisfy RAOs.
- Estimate areas and volumes of contaminated media that must be addressed.
- Identify and screen remedial technologies and process options so that only applicable technologies are retained for remedial alternatives evaluation.
- Develop remedial alternatives from the retained remedial technologies and process options.
- Evaluate selected remedial alternatives against the nine criteria defined in the NCP.
- Conduct a comparative assessment of the remedial alternatives selected for detailed evaluation.

1.2 Report Organization

This FS report is organized into the following sections:

Section 1 – Introduction

Section 2 – Site Conditions

Section 3 – ARARs, Remedial Action Objectives, and Preliminary Remediation Goals

Section 4 – General Response Actions, Technologies, and Process Options Screening

Section 5 – Description and Screening of Assembled Remedial Alternatives

Section 6 – Detailed Analysis of Alternatives

Section 7 – Comparative Analysis of Remedial Alternatives

Section 8 – References

2 Site Conditions

This section provides a brief overview of both historical and current Site conditions to provide relevant and sufficient background to understand the formulation and evaluation of remedial alternatives. The information provided in this section includes: a brief site description and history; a summary of pre-RI investigations, cleanups, and closures; RI/FS activities; study area characteristics; an updated conceptual site model (CSM); and a summary of baseline risk assessments. Additional details can be found in the Final Remedial Investigation Report (AECOM, 2020).

2.1 Site Description

The 77-acre Site is bordered by a District of Columbia Solid Waste Transfer Station to the north, Kenilworth Maintenance Yard (KMY) (which is owned by the National Park Service [NPS]) to the northwest, a narrow area of land and shoreline (which is part of Anacostia Park managed by NPS) to the west between the Site and the Anacostia River, Benning Road to the south, and residential areas to the east and south across Benning Road (**Figure 1-2**). The Site topography slopes generally toward the west and reaches a topographic high point in the south-central area of the Site along Benning Road. Surface elevations range from about 11 ft North American Vertical Datum of 1988 (NAVD88) near the River along the western Site perimeter to about 36 ft NAVD88 on the east side of the Site, and the topographic high (36 ft NAVD88) is along the southern Site boundary (AECOM, 2020). The geographic coordinates for the approximate center of the Site are 38.898° north latitude and 76.959° west longitude.

Most of the Site is occupied by the Benning Service Center, which houses activities related to construction, operation, and maintenance of Pepco's electric power transmission and distribution system serving the Washington, DC area. The Service Center occupies the largest part of the property and accommodates approximately 700 Pepco employees. Service Center employees are engaged in maintenance and construction of Pepco's electric transmission and distribution system; system engineering; vehicle fleet maintenance and refueling; and central warehousing for all the materials, supplies, and equipment needed to operate the Pepco electrical distribution system. Three active substations are located on the Site, one in the eastern portion (Substation #7), one in the northern portion (Substation #41), and one in the western portion (Substation #45). Since the 1960s, the area located in the southeast corner of the Facility has been used as a transformer shop for the service and repair of transformers and other electrical equipment. Currently, these activities are conducted in and around Building 56 and Building 57. The center of the Site is occupied by buildings used for office space, fleet services maintenance, stores, and waste management. Areas located outside of the buildings are used for storage of equipment and materials. A vehicle fueling facility is located in the western portion of the Site. The Site is fully enclosed by a fence with two guarded entrances. The main guard station at 3400 Benning Road is staffed 24 hours a day, 7 days a week. The second entrance is also guarded during all times when it is open. The current physical layout of the facility is presented in **Figure 2-1**.

The majority of the Site is covered by impervious material such as concrete or asphalt, as shown on **Figure 2-2**. The majority of the stormwater runoff from the service center areas is conveyed through a 48/54 inch main storm drainpipe to the Anacostia River at Outfall 013. Outfall 013 discharges to the Cove in the Waterside Investigation Area along with five other non-Pepco outfalls **(Figure 2-1)** and potential overflow from a silt pond located on the Kenilworth Park South (KPS) landfill site just to the north of the Cove. Outfall 013 drains stormwater runoff from the majority of the Site to the east of the former power plant location. A smaller drainage area of the site to the west of the former generating station drains stormwater to the Anacostia River at Outfall 101 (**Figure 1-2 and Figure 2-1**). Outfall 101 also historically received stormwater collected in secondary containment basins for transformers associated with the power plant. The transformers and their containment structures were removed as part of the power plant demolition in 2015, eliminating the secondary containment discharges to Outfall 101 (AECOM, 2020). Pepco employs a number of best management practices (BMPs), stormwater inlet controls and treatment measures to control pollutants in Site stormwater discharges. Stormwater discharges from the Site to the Anacostia River at Outfalls 013 and 101 are authorized by the facility's National Pollutant Discharge Elimination System (NPDES) Permit (No. DC0000094) issued by the USEPA.

2.2 Former Site Operations

The former Benning Road Power Plant was located on the westernmost portion of the Site (**Figure 2-3**). The power plant was built in 1906 and provided Pepco's first system-wide electricity supply to the District of Columbia and nearby Maryland suburbs. Over the years, the power plant operated and subsequently retired several different generating units, reflecting advances in technology and operating on different types of fuel. Beginning in the early 1970s, the power plant operated an average of 10 to 15 days annually to meet peak demands. The power plant was permanently shut down on June 1, 2012. Structures associated with the power plant included the boiler buildings, four fuel oil aboveground storage tanks (ASTs), two cooling towers, station transformers (located in a "transformer row" to the west of the power plant building) and various auxiliary buildings[1]. The four ASTs were demolished in early 2013, and the superstructures of the two cooling towers were demolished in early 2014.

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[1] Former Building 33 and clarifier house buildings associated with the cooling towers.

Demolition of the main power plant structure and auxiliary structures began in mid-2014 and was completed in April of 2015. Backfilling and site restoration activities were completed at the end of May 2015. The two remaining cooling tower concrete basins were further investigated and removed, along with adjacent areas of contaminated soil, as described below in Section 2.3.

A number of areas on Site were historically used as equipment laydown areas and for material storage. These historical operational areas are identified on **Figure 2-4**. Readers are referred to the Conceptual Site Model (CSM) Technical Memorandum (AECOM, 2016) for further details.

Several underground storage tanks (USTs) ranging in capacities from 250 to 20,000 gallons existed on Site to support two former fueling stations (Kenilworth Fueling Island and Benning Fueling Island) and for the storage of waste oil and new transformer oil. All of the USTs were removed from the Site beginning in the 1980s with the last remaining UST removed in 2020. Sampling or corrective action was conducted following the tank removals and UST closures were approved by DOEE in each case, with the exception of the last UST removed from the Site in 2020. This was a 15,000-gallon double-walled tank used to hold new non-polychlorinated biphenyl (PCB) transformer oil located within the paved yard surrounded by Buildings 54, 56 and 57. Closure of this UST case remains under DOEE review.

2.3 Historical Investigation and Remediation Activities

Several documented historical environmental investigations and response actions were conducted by Pepco and the USEPA on the Site. A summary of these activities is provided in the following paragraphs. Detailed descriptions of these activities are provided in the Final RI Report (AECOM, 2020).

- Several documented instances of releases of fuel oils occurred between 1989-2013 and several documented releases of materials containing PCBs occurred between 1985 and 2022. These releases are summarized in **Table 2-1** and **Table 2-2**, respectively. Pepco promptly cleaned up the releases in accordance with applicable legal requirements. In all of the cases, the release was contained on landside and did not reach the Anacostia River except for the June 2013 fuel oil spill. A 10-gallon spill of No.4 fuel oil in June 2013 resulted in the discharge of oil via Outfall 013, but the oil did not contain PCBs.
- USEPA conducted a multi-media inspection at the Site in 1997 in connection with the renewal of Pepco's NPDES permit (USEPA, 1997). Residue samples collected from the storm drain system indicated PCB and metal concentrations that exceeded USEPA Sediment Quality Guidelines.
- USEPA conducted a Site Inspection at Pepco's Benning Road Site under the CERCLA program in 2008 and issued a report in 2009 (USEPA, 2009) which linked PCBs and inorganic constituents detected in Anacostia River sediments to potential historical discharges from the Site. The USEPA

2009 Site Investigation Report also stated that the Site was properly managed and that any spills or leaks of hazardous substances were quickly addressed and, if necessary, properly remediated.

- A May 2010 lightning strike on a rooftop transformer (located on the rooftop of the former Power Plant Building) released 4 quarts of dielectric fluid with >500 parts per million of PCBs. Drainage and containment systems prevented the release of oil or PCB contaminated water to the river. Water and oil collected from the containment systems were sent to an off-site facility for disposal.
- Soil removal was conducted in connection with several UST closures that took place between the 1980s and 2020.
- Two former cooling towers (referred to as Cooling Tower #15 and Cooling Tower #16) were constructed at the Site in 1969 and 1970, respectively. In 1995, Pepco sampled the caulking used in the cooling tower basin expansion joints and determined that the caulk contained PCBs. Following several phases of investigation and remediation (2004, 2012 – 2015), the cooling tower basins and surrounding soils which had been contaminated by PCBs from the caulk were removed from the Site in 2017 in accordance with a cleanup plan approved by the USEPA and DOEE. Approximately 9,923 tons of soil and 6,666 tons of concrete debris contaminated with PCBs were removed from the site and disposed of at an approved off-site disposal facility (AECOM, 2017).
- Following a closed-circuit television (CCTV) camera inspection in 2015, a total of approximately 47 cubic yards (CY) of sediment was removed from the Site storm drains. Pepco conducted a second CCTV camera inspection of the storm drains in 2018, at which time 9.5 tons of sediment and debris were removed from the storm drain system. During June 2019, a third sediment removal was conducted removing an additional 4.72 tons of sediments and debris. The PCB Aroclor results for these three rounds of sediment cleaning showed a reduction in PCB concentration in the accumulated sediment from 636 µg/kg of total PCB Aroclors in July 2015 to non-detect in June 2019.

2.4 RI/FS Activities

2.4.1 Remedial Investigation

The RI field program consisted of two phases of investigation: Phase I field activities were conducted between January 25, 2013, and December 31, 2014, and Phase II field activities were conducted between December 1, 2017, and July 9, 2018. To help guide the LIA activities, the RI identified a total of 20 Target Areas and seven historical Operational Areas (which in most cases overlap with the Target Areas). These Target Areas and Operational Areas were based on historical investigations and remediation, UST closures, and the locations of former and current Site operations. The identified LIA Operational Areas and Target Areas are shown on **Figure 2-4 and Figure 2-5**, respectively.

Both the Landside and Waterside Investigation Areas were well characterized during the RI, which included the collection and analysis of nearly 2,000 field samples from multiple environmental media. Pepco also completed a background sampling program to establish Site-specific background conditions for soil, groundwater, Anacostia River surface water, and Anacostia River sediment. On-site samples collected from the LIA are shown in **Figure 2-6**. Relevant data collected by DOEE as part of the ARSP RI sampling effort were also evaluated in the BHHRA and BERA, as well as the background evaluation. Relevant findings of the RI are discussed in Sections 2.7 through 2.10.

2.4.2 Supplemental PCE Sampling

During the Remedial Investigation, perchloroethylene (PCE) was detected in groundwater in the southern portion of the Site. The extent of on-site groundwater contamination of PCE was investigated and delineated during RI Phase 1 and Phase 2 activities. Although chlorinated solvent use was documented in the power plant area of the Site, there were no known releases of this material and no evidence of an on-site "source area" was found during the subsurface investigations on-site. The possibility of off-site source(s) was strongly suggested by the concentration patterns observed along the southern border of the Site, which are highest at the property boundary and decline with distance toward the interior of the property. However, the groundwater level and flow data density along the southern property boundary were insufficient to confirm an off-site source. Given these uncertainties, as noted in the final RI Report, a post-RI field investigation was completed in July 2021 to collect additional data regarding groundwater levels and flow directions along the southern boundary to help determine the source(s).

A technical memorandum documenting the results of the PCE data gap investigation was approved by DOEE on February 27, 2023 (AECOM, 2023). The results of the data gap investigation are summarized below. Please refer to **Appendix A** for the technical memo.

Groundwater flow is generally to the west toward the Anacostia River which is consistent with regional groundwater flow. During the 2021 PCE data gap investigation, PCE concentrations at the Site ranged between non-detect to 390 µg/L. The highest PCE concentrations were detected at the southern boundary along Benning Road and range from 55 to 390 µg/L. PCE concentrations decline sharply toward the interior of the Site and range between non-detected to 1.4 µg/L. PCE was also detected off-site in the upper water-bearing zone (UWZ) at concentrations of 17 µg/L and 15 µg/L, respectively. There were no PCE or other chlorinated volatile organic compound (CVOC) detections in the lower water-bearing zone (LWZ) off-site samples during the 2021 monitoring round for the PCE data gap investigation. Additionally, there were no PCE detections in the LWZ on-site samples with the exception of low concentrations (<1 µg/L) detected at two monitoring wells at southern boundary of the site. This trend is consistent with historical observations wherein highest PCE concentrations were detected at sampling locations along the southern property boundary and the concentrations uniformly and rapidly declined toward the interior of Pepco property.

There is no evidence that Pepco used chlorinated solvent vapor degreasers or stored chlorinated solvents in sumps or large tanks on-site. Chlorinated solvents were only used in small quantities for parts cleaning. In summary, the absence of evidence of any available site historical records of on-site source areas or releases of PCE suggests an off-site source, but the available data regarding PCE concentrations and groundwater migration patterns do not support a definitive conclusion as to whether the PCE detected in groundwater originated from on-site or off-site sources. Additional discussion on PCE source evaluation is provided in Section 2.9.

2.5 PCB Minimization Plan Implementation

The Site discharges stormwater to the nearby Anacostia River (the River) under a National Pollutant Discharge Elimination System (NPDES) permit issued by USEPA (No. DC0000094). This discharge has been regulated under the facility's NPDES permit since 1976. The permit was last re-issued effective June 01, 2021. The permit requires Pepco to monitor PCB concentrations in the stormwater discharged at the two Anacostia River outfalls (Outfall 013 and Outfall 101) and the six (6) Municipal Separate Storm Sewer System (MS4) outfalls (Outfall 005, Outfall 006, Outfall 014, Outfall 015, Outfall 016, and Outfall 401). The effluent discharged at these outfalls has consistently complied with the "no discharge" limitation on PCBs specified in the permit, as determined according to testing of discharge samples using EPA Method 608. EPA Method 608 follows the current version as per 40 CFR Part 136, Appendix A, and reports PCB Aroclors.

The permit also requires outfall monitoring via Method 1668 for PCB congeners. The 2021 permit added a requirement for the development of a PCB Minimization Plan (PMP) if PCBs are detected using Method 1668. The initial round of Method 1668 sampling under the 2021 permit was conducted in the third quarter of 2021. The sample results showed PCBs above Method 1668 detection limits at the permitted outfalls, triggering the preparation and implementation of the PMP. The plan includes a detailed schedule, with milestones, and appropriate BMPs to achieve the DOEE's Water Quality Standard for PCBs (AECOM, 2022).

During the March 2022 PMP sampling effort, stormwater samples were collected from a total of 22 locations targeting historical PCB hotspots and specific drainage areas or portions of the Site where PCBs are/were handled. Two of the samples consisted of rainwater collected on roof tops prior to contacting any surfaces to measure background concentrations. Total PCB concentrations (as sum of congeners) for the other 20 site stormwater samples ranged from 1,820 pg/L (detected at Inlet 53, I-53) to 85,000 pg/L (detected at I-54). PCBs were detected in the two background rainwater samples at 251 pg/L and 797 pg/L, respectively. All locations were also sampled for total suspended solids (TSS). Although the PCB and TSS correlation is weak, lower PCB concentrations generally appear to be associated with lower TSS levels and the PCB levels appear to increase with increasing TSS concentrations. All of the PCB concentrations detected are below the drinking water Maximum Contaminant Level (MCL) of 500 ng/L. Five of the 20 samples (I-30, I-54, I-87, I-97, and SF-4) exceeded the DOEE eco-based water quality standard of 14 ng/L, with 75% of the locations reporting below this standard. All of the sampled locations (including the background locations) exhibited concentrations above the fish-consumption based DOEE water quality standard of 0.064 ng/L. Tables and figures summarizing the PMP sampling results are provided as **Appendix B**.

Achieving the fish consumption-based water quality standard of 0.064 ng/L in Site stormwater discharges may not be possible due to technology limitations and background concentrations in rainwater. However, in accordance with the NPDES permit, Pepco intends to follow an adaptive management approach that involves iterative implementation of control measures focusing first on the sources or controls expected to have the largest impact on water quality coupled with a monitoring plan to assess progress toward attainment of the water quality standards. Several Phase 1 BMPs recommended in the PMP have been implemented. Resampling of PMP locations (Phase 2) was conducted in Fall 2022. Results from the most recent outfall samples are included in **Appendix B**. Results from Phase 2 sampling are being evaluated to determine the need for additional controls. The PMP implementation is being conducted as part of the NPDES Program under regulatory oversight by EPA.

2.6 LIA Environmental Setting

2.6.1 Land and Groundwater Use

The Site is located in Ward 7 in the District of Columbia, within the 20019 zip code. Minnesota Avenue is zoned for commercial use in the vicinity of the Site. In addition, a commercial light manufacturing corridor exists along the Kenilworth Avenue/Metrorail tracks. Property along Benning Road across from the Site is largely commercial in use. All other surrounding areas are largely residential. The Site use itself is commercial/industrial and that use is expected to continue into the foreseeable future.

According to a USEPA 2009 Site Inspection Report, there are no drinking water intakes located within 15 miles of the Site. Based on a review of the Environmental Data Resources report dated August 2023, no public water supply wells are located within a 1 mile radius of the Site. DC Water provides drinking water to the surrounding area by drawing raw water from intakes located at Great Falls and Little Falls on the Potomac River, upstream from the confluence of the Potomac River with the Anacostia River (https://www.dcwater.com/drinking-water). Groundwater in DC is not currently being used as a source of drinking water. However, groundwater underneath the site is classified by DOEE as a Class G1 aquifer (i.e., of drinking water quality) and is subject to Title 21 of the District of Columbia Municipal Regulations (DCMR).

2.6.2 Geology and Hydrogeology

The subsurface beneath the Site consists of three geologic units: (1) historical fill material used to level the Site, (2) the Patapsco Formation underlying the fill, and (3) Arundel Clay underlying the Patapsco Formation. Fill material thickness averages about 5 to 8 feet across much of the Site, and up to 20 feet along subsurface utilities. The artificial fill material at the Site primarily consists of infrastructure (utilities and structures), historical fill material (silts and sands with occasional wood or brick fragments) used to level the Site, and relatively impermeable pavement (asphalt and concrete). Areas with thicker layers of fill material include the former sludge dewatering area and areas where subterranean tunnels and storm drains exist (AECOM, 2020). The Patapsco Formation consists of a variegated mixture of brown and gray clays, silts, sands, and gravels. The Arundel Clay is a distinct regional confining layer, composed of very stiff, fat, mottled maroon, and dark gray clay. The Arundel Clay underlies the Site at a depth of between 45 and 85 feet below ground surface (bgs), and the top of this unit at the Site generally dips toward the west. Regionally, formations comprising the Potomac Group dip towards the east/southeast (Koterba et al., 2010). **Figure 2-7** shows the locations of geologic cross sections for the site. Hydrogeologic cross sections of the subsurface, identified in **Figure 2-7**, are provided in **Figure 2-8** to **Figure 2-10**.

The subsurface investigation identified a silt-clay semi-confining layer underlying much of the Site and dividing the Patapsco Formation into an upper water-bearing zone (UWZ) and a lower water-bearing zone (LWZ). The top of the silt-clay layer was encountered between 25 and 40 feet bgs, and the layer averaged about 6 feet in thickness.

The top of the UWZ generally ranges from 9 to 16 feet bgs. The piezometric surface of the LWZ at the Site generally averages 0 to 2 feet deeper than the UWZ. Groundwater elevation measurements at the Site indicate that the direction of groundwater flow in both water-bearing zones is generally toward the River to the west, with slight local variations (**Figure 2 to 8, Appendix A**). Horizontal hydraulic gradients ranged from approximately 0.0008 to 0.01 in the UWZ, and approximately 0.002 to 0.02 in the LWZ.

Evidence of tidal influence in groundwater at the Site was apparent in both the upper and lower water-bearing zones. The greatest influence was observed at monitoring well MW-01 in the southwest corner of the Site, where groundwater levels in both the UWZ and LWZ varied by approximately 3 feet over a tidal cycle. Groundwater levels across the rest of the Site in both the UWZ and LWZ fluctuated by only 1 to 3 inches over a tidal cycle and exhibited less fluctuation with increasing distance from the River.

The results of testing conducted in eight well pairs distributed evenly across the Site indicate that hydraulic conductivities in the UWZ and LWZ range from approximately 10^{-6} to 10^{-5} meters per second, which is consistent with unconsolidated deposits of silty sands or fine sands.

2.7 Nature and Extent of Contamination

Extensive surface and subsurface characterization was performed for a wide range of analytes during the RI Phase I and Phase II investigations. Concentrations were compared to Project Screening Levels (PSLs) selected from generic, numeric screening levels such as USEPA Region III Regional Screening Levels, D.C. Surface Water Quality Criteria, and Groundwater Quality Criteria. The PSLs were originally developed in the Sampling and Analysis Plan dated February 2013 (AECOM, 2013) and were updated in Section 4.0 of the RI Report (AECOM, 2020). Individual PSLs and their sources are provided in Tables 4-1 through 4-39 in the RI Report. Analytes exceeding the PSLs were identified as Constituents of Interest (COIs) for further delineation and analysis. An iterative sampling approach was used to delineate the areas where analytes were detected above their screening levels in order to bound these exceedances horizontally and vertically. The results of this sampling are summarized below for each medium. COIs were further evaluated in the BHHRA, and only a subset were identified as potential chemicals of concern (COCs) based on the conclusions of the BHHRA. Section 2.9 provides a summary of the BHRHA and the selection of potential COCs. **Table 2-3** presents the full list of potential COCs identified in the BHHRA, and **Table 2-4** presents the potential COCs carried forward in the FS for the LIA for evaluation of remedial action alternatives.

2.7.1 COIs for LIA

<u>Surface and Subsurface Soil</u>

- Vanadium, polycyclic aromatic hydrocarbons (PAHs), diesel range organics (DRO), and PCBs were detected in surface and subsurface soils at concentrations exceeding screening levels and background levels in a number of the Target Areas.
- Dioxin concentrations exceeded screening levels in the surface and subsurface soils but were below background levels in the subsurface soils.
- Volatile organic compounds (VOCs), gasoline range organics (GRO) and pesticides were not detected in soils at concentrations in excess of screening levels at any of the Target Areas. All other COIs exceeded screening levels in soils but were consistent with the background levels.

As indicated in **Table 2-4**, only PCBs in the Transformer Shop area and vanadium in the Warehouse and Laydown area were identified as potential COCs to be carried forward in the FS.

Groundwater

- The investigation did not find any non-aqueous phase liquids in groundwater.
- Several metals were detected in the UWZ and LWZ at concentrations above screening levels but were consistent with or below background levels.
- PCBs, PAHs, and dioxins were not detected at concentrations above screening levels.
- One pesticide was detected at one location at concentrations slightly above screening levels.
- Two organic compounds, PCE and methyl tert-butyl ether (MTBE), were detected in groundwater at concentrations in excess of their screening levels.

As indicated in **Table 2-4**, only PCE and TCE were identified as potential COCs to be carried forward in the FS.

2.8 Fate and Transport of Landside Contaminants

Landside contaminants are not expected to migrate to adjacent properties but have the potential to migrate to the Anacostia River. There are only three pathways for contaminant transport from the Site to the river: via groundwater, via overland runoff, or via storm drains. Each of these pathways is evaluated in this section. Remedial actions to address Site-related impacts to the river will be evaluated in a separate feasibility study for OU2 (waterside area).

The groundwater pathway can contribute contaminants to the River via one of three possible routes: (1) direct discharge of groundwater to surface water; (2) groundwater to sediment pore water; and/or (3) groundwater infiltration into storm drains with eventual discharge to the river. Groundwater direct discharge calculations were documented in the Final RI Report and indicate that the estimated surface water concentrations were below applicable surface water quality criteria. Based on the volume of groundwater discharges and mass flux calculations, the potential for direct discharge of COIs via groundwater to surface water is deemed insignificant. While the CCTV inspections from 2014 indicated inferred groundwater infiltration, recent CCTV inspections of the storm drain system have not indicated any active groundwater infiltration but have indicated conditions indicative of possible historical infiltration at isolated locations. No dry weather flows (other than process flows allowed under the permit) were ever observed at the end of Outfall 013. Although the system may not always have been sealed against all groundwater infiltration, the foregoing observations indicate that the groundwater-to-storm drains pathway is not significant (AECOM, 2020). The analytical results of COIs detected in Site and background pore water samples were similar and all Site porewater concentrations were below the applicable surface water quality criteria for ecological risks. Porewater concentrations at the Site are a result of contact with the contaminated sediments rather than upwelling of contaminated groundwater, given the low concentrations in groundwater (AECOM, 2020). Therefore, the groundwater pathway is an insignificant contributor to the contamination observed in the WIA.

Most of the Site surface is paved or otherwise stabilized; therefore, erosion and migration of eroded soils is not identified as a significant transport mechanism under existing Site conditions. A very small portion of the Site along the western boundary may drain by overland runoff onto adjacent Anacostia Avenue and beyond. Results of sampling at the Anacostia Park property (located between the River and Anacostia Avenue downgradient of the Site) during the RI indicated that overland runoff from the Site is not a significant pathway for migration of contaminants from the Site to the river.

The storm drain system at the Site discharges to the River via two outfalls, Outfall 013 and Outfall 101, and therefore represents a potential pathway for the movement of contaminants from the Site to surface water.

2.8.1 Outfall 101

Outfall 101 serves a very small drainage area of the Site to the west of the former power plant and discharges to the River at a location just downstream of the Benning Road bridge. There are no identified Site sources likely to have contributed significant concentrations of PCBs to stormwater discharged at Outfall 101. Total PCB concentrations are below the threshold for compliance with National Pollutant Discharge Elimination System (NPDES) permit's "no discharge" limit for PCBs. However, concentrations measured during some historical monitoring events (AECOM, 2022) are above the National Recommended Water Quality Criteria for aquatic life (14 ng/L) and for human health from fish tissue consumption (0.064 ng/L). In addition to the wet weather flows, the initial NPDES permit issued for the power plant in May 1976 also authorized the discharge to the river at Outfall 101 of certain process wastewater streams associated with the operation of generating Units 10 to 14, including non-contact cooling water, boiler blowdown, and dirty water sumps. The units in question ceased operating shortly after the issuance of the initial NPDES permit in 1976, and these wastewater streams were no longer included among the authorized discharges when the permit was next renewed in 1990. There is no information available regarding volume or quality of these historical process water discharges at Outfall 101. However, the power plant operations in question would not be expected to have contributed PCBs to these effluent streams beyond those that may have been present in the makeup water withdrawn from the river. Outfall 101 also received stormwater collected in secondary containment basins for transformers associated with the former power plant. The transformers and their containment structures were demolished and removed as part of the power plant demolition in 2015, eliminating the secondary containment discharges to Outfall 101. Following the power plant demolition several storm drain inlets that previously discharged to Outfall 101 were closed. Inlet 87 is the only inlet that is currently active in the area to the west of the former power plant building. Inlet-87 receives stormwater runoff from the former generating station gravel area, where legacy PCB-impacted surfaces or soils may be present. Although no known PCBs source is present in the area, legacy operations in this area included a transformer row and other station transformers. Stormwater runoff can pick up PCBs from the ground surface before entering Inlet-87 (AECOM, 2022). As per the drainage areas delineated in **Figure 3-1** of the March 2022 PCB Minimization Plan report (AECOM, 2022), total drainage area served by Outfall 101 is 5.56 acres, while that for Outfall 013 is 57.2 acres. The stormwater flow from Outfall 101 is thus expected to be lower than the flow from Outfall 013. While PCB concentrations in Outfall 101 have been higher than those in Outfall 013 in several instances between 2009 and 2021 (AECOM, 2022), due to lower flow in Outfall 101, the total mass of PCBs discharged to the Cove from Outfall 101 is expected to be lower compared to the PCB mass discharged from Outfall 013. Based on the foregoing, Outfall 101 is not considered to represent a significant pathway in terms of PCB mass, in comparison to Outfall 013, for transport of PCBs from the Site to the River.

2.8.2 Outfall 013

Outfall 013 historically discharged both wet-weather flows (stormwater) and dry-weather flows (process wastewater) to the Cove. This outfall served as the final discharge point for a number of internal outfall points designated under the Facility's NPDES permit. In addition to the wet weather flows, these permitted discharges included:

- Dry weather batch discharges from an oil-water separator (via Internal Outfall 003) that was used to treat oil/water mixtures pumped from manhole vaults within the Pepco distribution system;
- Dry weather discharges of demineralization effluent and boiler blow down (via Internal Outfall 201) from power plant operations;
- Cooling tower blowdown water (Internal Outfalls 202 and 203); and
- A onetime accidental discharge of 8,000-gallons of PCB impacted water from remediation activities.

Beginning in 1990, the NPDES permit included an authorized discharge (designated Outfall 010) from a "sludge drying pit" or "sludge dump pit." The pit, located near inlet 54 south of Substation 7, was used to hold sediments pumped from manholes within the Pepco electric distribution system. Thickened sludge was removed for off-site landfill disposal upon evaporation and removal of any supernatant water. A line connecting the pit to the main underground storm drain was controlled by a valve to allow manual discharge; however, it does not appear that the contents of the drying pit were ever discharged via Outfall 010. Available records show no discharges from this outfall, and USEPA observed that there was no discharge and the valve was locked during a 1997 site inspection (USEPA, 1997). Instead, any water that accumulated in the pit was removed and treated in the on-site oil-water separator (OWS) prior to discharge through Outfall 003. The connection to the storm drain was later permanently closed, and Outfall 010 was removed from the permit upon its reissuance in 2009 (USEPA, 2009).

Concentrations of several metals, PAHs, total petroleum hydrocarbons, PCBs, and low levels of pesticides were detected in storm drain residue and stormwater samples from the Outfall 013 drainage system. Concentrations of COIs in storm drain samples were mostly below background threshold values (BTVs) and are consistent with typical industrial runoff. Storm drain residues sampled during the RI reflect accumulated sediments over a period of several decades. The presence of PCBs in storm drain residues in some locations suggests historical discharges from Outfall 013 may have contributed to PCB impacts in the Cove. Accumulated sediments were removed from the storm drains subsequent to the RI sampling and therefore do not represent a current potential source of contamination to the River. The Site currently employs various BMPs to control sediments and contaminants in stormwater discharged from the Site. Furthermore, process discharges to Outfall 013 have been eliminated during the most recent renewal of the NPDES permit limiting the discharges solely to stormwater runoff.

2.8.3 Outfall Pathway Summary

Due to control measures implemented over the years, Pepco's stormwater discharges from the Site are currently in compliance with the NPDES discharge requirements. In addition, outfall discharges are largely below the drinking water MCL and the District's eco-based water quality standards for PCBs. Several outfalls still exhibit PCB concentrations above the most stringent fish consumption-based water quality standard of 0.064 ng/L. As described in Section 2.5 above, Pepco has prepared and is implementing a PMP following an adaptive management approach that involves iterative implementation of control measures coupled with a monitoring plan to assess progress toward attainment of the water quality standards. While the stormwater discharges from the Site thus represent an ongoing discharge pathway, the concentrations are very low compared to upstream background and in compliance with NPDES permit limits.

Based on the foregoing discussion, groundwater migration and direct overland surface runoff are insignificant PCB transport pathways at the Site. Outfall 101 is not considered to represent a significant pathway in terms of PCB mass, in comparison to Outfall 013, for transport of PCBs from the Site to the river. The most likely pathway for the transport of PCBs from the Site to the river is via storm drain discharges at Outfall 013, and possibly Piney Branch, which flowed through the Site from the southeast corner toward the Cove before the storm drains were installed in the 1950s.

2.9 PCE Source Evaluation Summary

Groundwater, soil, and related monitoring data from the Remedial Investigation and the supplemental PCE investigation was reviewed to evaluate whether any sources of PCE exist on-site. Multiple lines of evidence support the conclusion that the PCE plume did not originate on-site and that no continuing PCE sources to groundwater are present on-site. A summary of the source evaluation assessment is presented below.

2.9.1 Limited Quantities of Chlorinated Solvents Used On-Site

As described in the post-RI PCE Data Gap Investigation Report (AECOM, 2023), there is no evidence that Pepco used chlorinated solvent vapor degreasers or stored chlorinated solvents in sumps or large tanks on-site. Chlorinated solvents were only used in small quantities for parts cleaning. Information obtained during the RI indicated that only a single product used on-site contained PCE (SS-25), and no products used contained TCE. The SS-25 product was reportedly used only in the former power plant building and Building 65, both located in the western area of the Site, downgradient and well removed from the PCE plume in the DP-09 area, and its use was discontinued in the 1980s.

During a recent environmental audit of the Benning facility, Pepco discovered occasional use of CRC Brakleen® aerosol cans containing PCE. This product is used for cleaning of brake parts and typically the solvent is sprayed on the part surface to be cleaned and it is either air dried or wiped off with a cloth. In this operation, PCE is applied as a fine spray mist. This small quantity of solvent generally evaporates quickly, and the use of this aerosol product would not be expected to be source of soil or groundwater contamination at the Site.

Although chlorinated solvent use was documented in the power plant area of the Site, there were no known releases of this material and no evidence of an on-Site “source area” was found during the subsurface investigations on-Site.

2.9.2 Groundwater Sampling Data Not Indicative of Existing On-Site PCE Source

2.9.2.1 Dimensions of PCE Plume Are Stable

Groundwater sampling data dating back to 2014 indicate that the dimensions of the PCE plume are generally stable and thus not indicative of the presence of an ongoing source of PCE to groundwater. Most wells showing non-detect for PCE in the initial sampling event have continued to show no detection in subsequent sampling, and several downgradient wells (MW01A, MW01B, MW02A, MW05A) have shown decreasing concentrations in sampling events from 2014, 2016, and 2021, including non-detect at MW01A, MW01B, and MW02A in 2021.

2.9.2.2 Groundwater Concentrations not Indicative of Presence of DNAPL Source Zones

As per EPA (1992) guidelines, dense non-aqueous phase liquid (DNAPL) is suspected to be present when the concentration of a chemical in ground water is greater than one percent of its pure-phase solubility. For example, when the concentration of PCE is greater than 2,000 µg/L in the dissolved phase (1 percent of its pure-phase solubility of 200,000 µg/L), PCE is inferred to be present as a DNAPL. This approach is known as the “one percent of solubility” rule-of-thumb or simply as the “one percent rule” (EPA 1992). The table below shows the on-site groundwater sampling data for individual VOCs measured in the Upper Water Bearing Zone (UWZ) compared to the respective pure-phase and 1% solubility thresholds (EPA, 2004). The maximum concentrations of PCE in on-site UWZ groundwater was nearly a factor of five lower than the respective 1% aqueous solubility threshold, while maximum concentrations of daughter products were between four to six orders of magnitude lower than the respective 1% aqueous solubility threshold. These concentrations, therefore, do not indicate the presence of DNAPL source zones.

Compound	Aqueous Solubility at 298 K (EPA, 2004) (µg/L)	1% of Aqueous Solubility at 298 K (µg/L)	Maximum concentration measured on-site in UWZ Groundwater (µg/L)
PCE	200,000	2,000	470
TCE	1,472,000	14,720	49
cis-1,2-DCE	3,500,000	35,000	23
trans-1,2-DCE	6,300,000	63,000	0.22
1,1-DCE	2,250,000	22,500	0.72
Vinyl Chloride	8,800,000	88,000	5.30

2.9.2.3 No VOCs Detected in Soil Samples Within or Adjacent to the Plume

A sub-surface soil sample was collected from 14.5 to 15.5 ft below grade at SUSDP09, located within the PCE plume. The concentrations of PCE and daughter products in the soil sample from the 14.5-15.5 ft. interval from this location were all below the respective detection limits, as summarized in below.

Compound	SUSDP09 (14.5 TO 15.5 ft) (µg/kg)
PCE	< 5.5 U
TCE	< 5.5 U
cis-1,2-DCE	< 5.5 U
trans-1,2-DCE	< 5.5 U
1,1-DCE	< 5.5 U
Vinyl Chloride	< 5.5 U

2.9.2.4 PID Readings of “Zero” for Most Sample Locations within the PCE Plume

Continuous photoionization detector (PID) reading were collected as part of the drilling programs during the Remedial Investigation. PID readings were “zero” for most sample locations (DPB-7, MW-09, DPA-4, DPB-

5, DPB-3, DPC4, TP-01A, and TP-04) within the onsite PCE plume during the RI and subsequent subsurface sampling. Copies of the boring logs for these locations can be found in the RI (AECOM, 2020) and in the PCE data gap investigation memo (AECOM, 2023).

The maximum total VOC concentration in the UZW groundwater on-site was recorded at MW-09 and DPB7 (460 µg/L and 520 µg/L, respectively), with PCE concentrations of 390 and 470 µg/L, respectively. At DPB7, the maximum PID reading recorded in the soil boring log was 0.2 ppm at the 31-32 ft. interval, while all other PID readings, up to depths of 55 ft., were zero. At MW-09, all PID readings were zero.

Groundwater samples from the UWZ at DPA4 and DPB5 locations exhibited total VOC concentrations > 200 µg/L. However, PID readings from boring logs for both locations were "zero" at all depths. Other groundwater sampling locations within the 5 ppb total VOC plume (DPB3 and DPC4,) also exhibited PID readings of "zero" at all depths.

Additional borings installed in 2021 within the total VOC plume exhibit similar results for the PID readings. The TP-01A location adjacent to DPB5 exhibited PCE and TCE concentration of 220 µg/L and 14 µg/L, respectively, in the UWZ groundwater in 2021 (AECOM, 2023). However, all PID readings for the soil boring (boring depth of 33 ft.) from this location were "zero". At TP-04, PCE and TCE concentrations in groundwater were 55 and 5.8 µg/L, respectively. Similar to TP-01A, all PID readings for the soil boring (boring depth of 35 ft.) exhibited "zero" readings.

All soil intervals from the SUSDP09 boring exhibited PID readings below 1 ppm, with maximum PID reading of 0.9 ppm observed in the 5-6 ft. interval, and majority of the intervals exhibiting "zero" reading.

2.9.3 Conclusion

The foregoing discussion evaluated chlorinated solvent use on-site, concentrations of VOCs in groundwater (which are one to six orders of magnitude below the EPA's threshold for DNAPL occurrence), and sub-surface soil PID screening and VOC analytical data. Each of these multiple lines of evidence supports the conclusion that the PCE plume did not originate on-site and that no continuing PCE sources to groundwater are present on-site.

2.10 Risk Assessment Summary

The baseline human health risk assessment conducted as part of the Remedial Investigation (AECOM, 2020, Appendix AA) evaluated potential cancer risks and non-cancer hazards to human health based on potential receptors' exposures to soil and groundwater in the LIA. Consistent with guidance, reasonable maximum exposure (RME) and central tendency exposure (CTE) scenarios were evaluated to provide information on a range of potential exposures and risks. As requested by DOEE, the BHHRA identified potential COCs as those COPCs which pose a potential excess lifetime cancer risk greater than 1 x 10^{-6} or a target endpoint hazard index above 1 for the RME receptor scenario. An ecological risk assessment was not conducted for the LIA due to the limited habitat. A summary of the risk assessment findings for the Landside (BHHRA) Areas of Investigation is presented below.

2.10.1 Summary of Landside BHHRA Findings

Based on the CSM and consideration of current and future conditions in the LIA, contact with on-Site media is unlikely under the current use scenario. Groundwater is not used for drinking water, and direct contact with soil is unlikely based on the limited Site access, tight security, and presence of pavement and hard-packed gravel cover across most of the Site. The existing operational and institutional controls (ICs) in place will continue to provide effective exposure prevention measures in the future. As discussed in the approved BHHRA (AECOM, 2020, Appendix AA), the vapor intrusion pathway is incomplete under the current scenario as there are no occupied buildings in areas where chlorinated volatile organic chemicals are present in the subsurface. However, the BHHRA was conducted based on the assumption that conditions may change in the future, and that receptors may be potentially exposed to on-Site media. The BHHRA evaluated eight landside exposure areas for soil and groundwater based on current Site use, as indicated in **Figure 2-11**.

Based on the human health CSM developed for the LIA, the following potential receptors and exposure pathways were identified in the BHHRA:

- **Current/future construction workers** who may be exposed via incidental ingestion of and/or dermal contact with soil (0 to 16 feet bgs) via inhalation of fugitive dust derived from soil, and via inhalation of vapors from groundwater in an excavation trench.
- **Future outdoor industrial workers** who may be exposed via incidental ingestion of and/or dermal contact with surface soil (0 to 1 foot bgs) and via inhalation of fugitive dust derived from surface soil.
- **Future indoor industrial workers** who may be exposed to VOCs in indoor air resulting from groundwater vapor intrusion, should a building be constructed in an area with volatile COPCs in the future.
- **Hypothetical future recreational visitors** who may be exposed via incidental ingestion of and/or dermal contact with surface soil (0 to 1 foot bgs) and via inhalation of fugitive dust derived from surface soil.

COPCs were selected for quantitative evaluation in the BHHRA based on comparisons to screening levels. The majority of total potential carcinogenic risk and noncarcinogenic hazards for landside receptor scenarios were within or below the USEPA target cancer risk range of 10^{-6} to 10^{-4} and below a noncarcinogenic target endpoint HI of 1, as indicated in **Figure 2-12** and **Figure 2-13**. Additionally, the levels of PCE and trichloroethylene (TCE) detected in two off-site wells (TP-10A and TP-11A) are below residential vapor intrusion screening levels calculated using USEPA's screening tool at a 10^{-6} risk level and hazard index of 1. Potential COCs[2] were identified in the BHHRA as any COPC posing a potential cancer risk greater than 10^{-6} or a target endpoint hazard index greater than 1. The BHHRA identified arsenic, 2,3,7,8-tetrachlorodibenzo(p)dioxin-toxicity equivalents, total PCBs, and vanadium as potential COCs in landside soil, and chloroform, PCE, TCE, and vinyl chloride (VC) as potential COCs in landside groundwater. However, arsenic in soil was eliminated as a potential COC because the background evaluation (Appendix W of the Final RI Report) found that arsenic concentrations in soil were consistent with background. The remaining potential COCs, including chemicals posing potential cancer risks greater than 10^{-6} but less than 10^{-5} are summarized in **Table 2-4**. In the ARSP Focused Feasibility Study (FFS), only those potential COCs posing risks greater than 10^{-5} were carried forward to the development of PRGs (TetraTech, 2019). Using the same 10^{-5} risk threshold for the LIA, the potential COCs carried forward to the development of PRGs for the Landside FS are: PCBs in Transformer Shop soil, vanadium in Warehouse and Laydown Area soil, and PCE and TCE in Southern Boundary groundwater.

2.10.2 Summary of Potential COCs and Media Addressed by Remedial Action

Table 2-4 summarizes the potential COCs and media carried forward in the FS for the LIA for evaluation of remedial action alternatives.

2.11 Revised Conceptual Site Model

The CSM is an integrated functional description of: (1) the major constituents of concern, based on previous Site investigations and the history of Site operations; (2) the potential on-Site and off-Site sources of these constituents; and (3) the possible exposure pathways of these constituents to potential human health and ecological receptors.

The CSM for the landside area has been updated following the completion of the Final RI Report to reflect the fate and transport analyses, exposure pathways and receptors based on the selected 10^{-5} target cancer risk and HI of 1. The updated CSM is presented as **Figure 2-14** and **Figure 2-15** for On-

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[2] The term "potential COC" was established as the term for COPCs with potential excess lifetime cancer risk greater than 1 x 10^{-6} or a target endpoint hazard index above 1 in Pepco's response to DOEE comments in August 2015. The term is used in the Final BHHRA (February 2020). Therefore, the term "potential COC" is used in this FS report to maintain consistency with the BHHRA.

site Sources and Off-site Sources, respectively. Magenta indicates an unacceptable risk pathway based on the BHHRA. General pictorial representations of the Landside CSM are presented as **Figure 2-16**.

Key elements of the landside CSM include the following:

- The majority of the Site is paved or covered by impermeable surfaces and stormwater is captured in storm drains minimizing infiltration of water through soils that may be impacted.
- Groundwater is not used for drinking water at or in the vicinity of the Site. However, 21 DCMR 1150 regulations classify all District groundwater as Class G1, meaning the aquifer is viewed as a future potential resource.
- Direct contact with soil is unlikely based on the limited Site access, perimeter fence, guarded entrances, and presence of pavement or gravel across the majority of the Site.
- The existing operational controls that are in place at the Site provide effective exposure prevention. However, if these controls were discontinued in the future, on-Site workers may potentially contact surface soil, and construction workers may contact subsurface soil via incidental ingestion, dermal contact, and inhalation of volatiles or dust derived from soil.
- A vapor intrusion pathway evaluation indicated no current exposure; however, vapor controls may be necessary for future buildings constructed over areas where PCE/TCE contamination is present in the groundwater. PCE and TCE levels detected in two off-site wells are below residential vapor intrusion screening levels.

3 ARARs, Remedial Action Objectives and Preliminary Remediation Goals

3.1 ARARs

In accordance with the NCP, applicable CERCLA guidance documents, and applicable District laws and regulations, response actions must comply with all "Applicable or Relevant and Appropriate Requirements" or "ARARs." The NCP (40 Code of Federal Regulations [CFR] 300.5) defines "Applicable Requirements" and "Relevant and Appropriate Requirements" as follows:

- ***Applicable Requirements*** - "are those clean-up standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal or [District of Columbia] environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site."
- ***Relevant and Appropriate Requirements*** - "are those clean-up standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal or [District of Columbia] 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 the CERCLA site that their use is well suited to the particular site."

The determination that a requirement is relevant and appropriate is a two-step process: (1) determination if a requirement is relevant and (2) determination if a requirement is appropriate. In general, this involves consideration of a number of site-specific factors, including the characteristics of the remedial action, the hazardous substances present at the site, or the physical circumstances of the site, to those addressed by the statutory or regulatory requirements. In some cases, a requirement may be relevant, but not appropriate, given site-specific circumstances; such a requirement would not be an ARAR for the site. In addition, it is possible for only part of a requirement to be considered relevant and appropriate in a given case. When the analysis determines that a requirement is both relevant and appropriate, such a requirement must be satisfied to the same degree as if it were applicable.

Remedial actions also may be evaluated with reference to an additional category of requirements, referred to as "To Be Considered" (TBC). This category encompasses non-promulgated advisories or guidance issued by the federal or the District government that are not legally binding and do not have the status of ARARs. While TBCs are not promulgated or enforceable, TBCs may be consulted to interpret ARARs or to establish PRGs when ARARs do not exist for particular contaminants or do not sufficiently eliminate identified risks.

The identification of ARARs is site-specific and depends on the chemical contaminants, site/location characteristics, and remedial actions being considered. Each of these three types of ARARs is described further in the following sections.

3.1.1 Chemical Specific ARARs

Chemical-specific ARARs are numeric values that define concentrations of specific contaminants deemed to be protective of human health and the environment under site-specific exposure conditions. The potential chemical-specific ARARs for the Benning Road Site are described in **Table 3-1** and provide a basis for the numerical values used to develop Site PRGs in Section 3.3.

3.1.2 Location Specific ARARs

Location-specific ARARs serve to protect individual characteristics, resources, and specific environmental features on a site, such as wetlands, water bodies, floodplains, and sensitive ecosystems. Location-specific ARARs may affect or restrict remediation and site activities. The general types of location-specific requirements that may be applied to the Benning Road Site include water resources and floodplain regulations. The potential location-specific ARARs and TBCs that apply to the Benning Road Site are described in **Table 3-1**.

3.1.3 Action Specific ARARs

Action-specific ARARs are technology- or activity-based requirements that govern activities or processes that may be implemented on a site, including storage, transportation, and disposal methods of hazardous substances as well as construction of facilities or treatment processes. The potential action-specific ARARs and TBCs that apply to the Benning Road Site are described in **Table 3-1**. Because action-specific ARARs and TBCs depend on the components of a particular remedial action, they are discussed further as appropriate for each remedial alternative as part of the detailed evaluation of alternatives.

Federal and District permits may be required for the implementation of remedial action. Permitting requirements generally fall under the action-specific ARARs. D.C. Code § 8-634.01(c) provides an exemption from some permitting requirements for remedial activities conducted on-site. Where this permitting exemption applies, remedial actions conducted on site need to comply only with the substantive aspects of ARARs and not with the corresponding administrative requirements.

3.2 Remedial Action Objectives

Remedial Action Objectives (RAOs) are a foundational consideration in the development and evaluation of remedial alternatives. RAOs are narrative statements that serve as a basis for developing numerical remediation goals and remedial alternatives to protect human health and the environment. RAOs and remedial goals evolve over the course of an RI/FS and become final when the Record of Decision (ROD) for the response action is signed. RAOs are specific to the areas and media where the risk assessments identified unacceptable risks, as summarized in Section 2.9. Unacceptable risk for the purpose of this FS is defined as any risk exceeding an excess life-time cancer risk of 1.0E-05 and a non-cancer HI of 1. These end points are appropriate for the current and anticipated future industrial/commercial use of the Site and are consistent with the risk targets used for the ARSP.

The following RAOs have been established for the FS:

- **RAO 1 - Remove and/or treat PCB contaminated soils identified as Principal Threat Source Material (PTSM) posing an excess human health lifetime cancer risk exceeding 10^{-3} in the Transformer Shop Area.** The BHHRA identified an unacceptable cancer risk of 2.0E-3 to a future outdoor industrial worker exposed to PCBs in surface soils (0 to 1 foot) in the Transformer Shop Area under the conservative RME scenario (AECOM, 2020, Appendix AA). This risk is driven by elevated PCB concentration (8,800 mg/kg) at a single location in the surface soil (SUSDP21-3G). This soil constitutes a Principal Threat Source Material (PTSM) (USEPA, 1991). As per 40 CFR § 300.430(a)(1)(iii)(A), principal threats are expected to be addressed through treatment. This RAO can be achieved by removal and treatment of the PTSM.

- **RAO 2 – Reduce excess human health lifetime cancer risks to less than 10^{-5} and non-cancer hazard index to less than 1 from direct contact exposure to PCBs in soil in the Transformer Shop area of the Landside Investigation Area.** The BHHRA identified an unacceptable cancer risk of 2.0E-3 to a future outdoor industrial worker exposed to PCBs in surface soils (0 to 1 foot) in the Transformer Shop Area under the conservative RME scenario (AECOM, 2020, Appendix AA). The BHHRA also indicated an unacceptable non-cancer HI of 1.6 for a current/future construction worker exposed to PCBs in subsurface soils (0-16 feet) in the Transformer Shop area.

  These conservative risk calculations do not account for the fact that potential exposure pathways for on-Site surface and subsurface soils are currently incomplete due to perimeter fencing, 24-hour Site security, and the presence of overlying pavement. These site controls are expected to remain in effect into the foreseeable future. The excess cancer risk and non-cancer hazard can be mitigated by reducing PCB concentrations in soil or continued measures to prevent exposure to PCBs in soil. Therefore, this RAO can be achieved through remedial action and/or implementation of institutional controls.

- **RAO 3 - Reduce human health non-cancer hazard index to less than 1 from direct contact exposure to vanadium in soil in the Warehouse and Laydown area of the Landside Investigation Area.** The BHHRA identified an unacceptable non-cancer hazard of 3.0 to a current/future construction worker exposed to vanadium in combined surface and subsurface soils (0-16 feet) in the Warehouse and Laydown area under the conservative RME scenario (AECOM, 2020, Appendix AA). This conservative risk calculation did not account for the fact that potential exposures to on-Site surface and subsurface soils are currently incomplete due to perimeter fencing, 24-hour Site security, and the presence of gravel cover. These site controls are expected to remain in effect into the foreseeable future. The non-cancer hazard can be mitigated by reducing vanadium concentrations in soil or continued measures to prevent exposure to vanadium in soil. Therefore, this RAO can be achieved through remedial action and/or implementation of institutional controls.

- **RAO 4 - Reduce concentrations of PCE and daughter products in Site groundwater to the District of Columbia Water Quality Standards for Groundwater, or to the lowest concentration levels feasible**. According to the NCP, "EPA expects to return usable ground waters to their beneficial use wherever practicable within a timeframe that is reasonable given the particular circumstances of the site." The groundwater at the Site is classified by DOEE as a Class G1 aquifer. PCE and TCE were detected in groundwater at concentrations in excess of the G1 groundwater standards as per Title 21 of DCMR (District of Columbia Municipal Regulations, 2017). However, groundwater is not currently used as a drinking water source and the Patapsco formation underneath the LIA is unlikely to produce sufficient water to be a viable water resource. Monitoring data shows that the plume is stable, that some natural attenuation is occurring on site, and there no evidence of continuing on-site source or the source (likely off-site) is depleted. No human or ecological receptors for impacted groundwater are present on-site. This RAO can be achieved through a combination of implementation of ICs, natural attenuation, and/or degradation of contaminants or removal and treatment of contaminated groundwater.

- **RAO 5 - Mitigate the potential for vapor intrusion risks from PCE and daughter products in future buildings overlying the PCE groundwater plume in the southern portion of the**

Landside Investigation Area. The BHHRA identified unacceptable cancer risks arising from uncontrolled PCE and TCE vapor intrusion from groundwater to indoor air space of future buildings constructed within the PCE and TCE plume footprint in the southern portion of the Site (AECOM, 2020, Appendix AA). Currently there are no buildings overlying the PCE plume. The future vapor intrusion risks from PCE, TCE, and daughter products, such as cis-1,2-dichloroethene (cis-1,2-DCE), trans-1,2-dichloroethene (trans-1,2-DCE, 1,1-dichloroethene (1,1-DCE), and vinyl chloride (VC), can be mitigated by either reducing the concentrations of these chemicals in groundwater or preventing vapors from entering the buildings. Therefore, this RAO can be achieved through groundwater remediation or incorporating vapor intrusion barriers into future buildings. This RAO will be triggered only when: (a) a building is constructed over the groundwater plume in the future; and (b) potential COC concentrations in groundwater remain above the vapor intrusion thresholds prior to completion of remedial actions to meet RAO 4.

3.3 Preliminary Remediation Goals for Landside Investigation Area

For the LIA, PRGs are needed for PCBs in soil in the Transformer Shop area and vanadium in soil in the Warehouse and Laydown Area and for PCE and TCE in groundwater in the DP-09 area near the southern boundary of the Site. A PRG is the specific chemical concentration in an environmental medium (e.g., soil or groundwater) that is protective of human health and/or the environment given site-specific exposure conditions. PRGs are developed based on ARARs and risk-based target concentrations (RBTCs) with consideration of background concentrations. In the absence of ARARs, PRGs may reflect TBCs. PRGs are then used in the evaluation of remedial alternatives to meet the RAOs.

3.3.1 Potential Risk-Based PRGs

RBTCs were derived for total PCBs in surface soil (0 to 1 foot bgs) for the outdoor worker scenario and for total PCBs and vanadium in combined surface and subsurface soil for the construction worker scenario. RBTCs were also derived for PCE and TCE in groundwater for the vapor intrusion to indoor air scenario. The soil RBTCs were derived using the same toxicity and exposure assumptions that were used in the approved BHHRA (AECOM, 2020, Appendix AA), except for changes to the construction worker noncancer averaging time, PCB and vanadium subchronic reference doses, and PCB volatilization factor for the outdoor worker, as directed by DOEE. The same risk equations were re-arranged to calculate the concentration that would result in a specific target risk level or HI. The RBTC, calculated in this way, equates to the exposure point concentration (EPC) that would meet the specified target risk level/HI. The RBTC equations, inputs, and calculations for soil are provided in **Appendix C** of this report. The vapor intrusion RBTCs were derived using USEPA's Vapor Intrusion Screening Level Calculator (USEPA, 2020); the output is provided in **Appendix C**.

For the cancer evaluation, RBTCs were derived for risk levels of 10^{-4}, 10^{-5}, and 10^{-6} (i.e., one in 10,000, 100,000, and 1,000,000 increased chances that a person will develop cancer over a lifetime), consistent with USEPA's acceptable risk range of 10^{-6} to 10^{-4} (USEPA, 1991, 1994). As previously noted in Section 3.2, a risk level of 10^{-5} was selected for the Benning Road Facility FS, consistent with DOEE's selection of 10^{-5} for establishing river-wide remedial goals for the ARSP. A target HI of 1 was used for the non-cancer evaluation.

3.3.2 Potential ARAR-Based PRGs

This section discusses the potential use of chemical-specific ARARs as PRGs. Potential chemical-specific ARARs were identified for soil and groundwater, as discussed below.

3.3.2.1 Soil

The USEPA regulations implementing the Toxic Substances Control Act (TSCA) provide several chemical-specific ARARs for PCBs in soil, including those related to PCB storage, disposal, site characterization and cleanup, decontamination, and record keeping. These requirements are found at 40 CFR Part 761, Subpart D (Sections 761.50 to 761.79), which governs storage and disposal of PCBs.

40 CFR Section 761.61 specifies two alternate approaches to remediation: (a) self-implementing cleanup [§ 761.61(a)]; and (b) risk-based cleanup [§ 761.61(c)]. Consistent with this flexible character of the rule, either approach may be used in applying these regulations as an ARAR for purposes of determining the PRG for PCBs in soil at the site. Given the extensive risk analysis already conducted as part of the approved RI and the associated risk-based concentrations derived for PCBs in site soils, Pepco is electing to use the risk-based approach under the TSCA regulations, rather than defaulting to the self-implementing approach which is designed to streamline cleanup for sites where site-specific risk analysis is not available and which therefore relies on conservative exposure assumptions to ensure that the cleanup is protective of human health.

The risk-based option under TSCA requires an approval from EPA based on a finding that the conditions following cleanup will not present an unreasonable risk of injury to health or the environment. Remedial alternatives involving the risk-based option will include preparation of necessary documentation, i.e. a corrective action plan, to obtain EPA approval prior to implementation to comply with this ARAR. The required documentation would be prepared and submitted during the remedial design phase.

In addition, any excavated soils exceeding 50 mg/kg of PCBs must be disposed of as TSCA remediation waste at an approved facility in accordance with 40 CFR 761.

3.3.2.2 Groundwater

Section 1150 of Title 21 of the DCMR (District of Columbia Municipal Regulations, 2017) establishes classes, criteria, and monitoring requirements for groundwater within the District. Groundwater adjacent to the waterfront at the Site is classified by DOEE as G1 as both the upper and lower water bearing zones are connected to the river, although the groundwater at the Site is not used for drinking purposes. As per Title 21 of DCMR, Class G1 groundwater standards for PCE are set at 5 µg/L, while standards for associated daughter products TCE, cis-1,2-DCE, trans-1,2-DCE, 1,1-DCE, and VC are set at 5 µg/L, 70 µg/L, 100 µg/L, 7 µg/L, and 2 µg/L, respectively. However, Section 1155.5(c) of the regulation indicates that enforcement standards shall be based on the best available scientific knowledge including, but not limited to, background water quality, USEPA water quality criteria and Health Advisories, other states' water quality criteria, and risk assessment calculations. Technological and economic factors may also be considered.

3.3.3 Potential Background Based PRGs

A site-specific background evaluation was presented in the RI Report (AECOM, 2020, Appendix W) . Site-specific BTVs were derived for constituents in landside soil, including total PCBs and vanadium. BTVs were also derived for Site groundwater; however, PCE and TCE were not detected in the groundwater background dataset and BTVs were not derived for these constituents. The background evaluation included a statistical analysis to determine whether the surface and subsurface soil datasets were sufficiently similar to group them and develop a single BTV, or if separate BTVs were needed. The results of the statistical analysis indicated that vanadium and PCB concentrations in surface and subsurface soil are not significantly different from one-another. For the purposes of calculating BTVs, surface and subsurface soil data were combined and the following BTVs were carried forward for consideration in the FS for the LIA:

- Total PCBs: 15.1 µg/kg (as Aroclors)
- Vanadium: 37.8 mg/kg

3.3.4 Laboratory Reporting Limits

This section identifies the nominal analytical quantification limitations for potential COCs to ensure that PRGs can be achieved. Selected PRG values must be technically measurable in laboratories based on analytical detection limits, method detection limits, and laboratory reporting limits. For vanadium in soil matrices, the representative detection limit (RDL) was used to identify analytical quantification limits and ranged 0.097 mg/kg to 0.15 mg/kg, based on samples for which the dilution factor was 1. For PCB Aroclors in soil matrices measured using EPA 8082LL, for a dilution factor of 1, the quantification limit ranged from 0.83 µg/kg to 1.2 µg/kg. For PCB congeners measured using EPA 1668 method, the estimated detection limit (EDL) for each congener was considered to be the representative detection limit. Based on a dilution factor of 1 and nominal sample mass of 10 g of soil, EDLs ranged from 0.07 ng/g (PCB-131) to 2.6E-05 ng/g (PCB-54).

For both PCE and TCE in groundwater, the reporting limits were identified to be 1 µg/L for method EPA 8260D.

3.3.5 Selection of Landside PRGs

Table 3-2 compares the ARARs, BTVs, and RBTCs, identifies the selected PRG for each chemical addressed by one or more RAO and explains the basis for selection. The selected landside PRGs are summarized below:

Chemical	Transformer Shop Area	Warehouse and Laydown Area	Southern Boundary	
	Outdoor Worker/ Construction Worker	Construction Worker	Indoor Worker	
	Combined Surface and Subsurface Soil (0-16 ft) (mg/kg)	Combined Surface and Subsurface Soil (0-16 ft) (mg/kg)	Groundwater (Vapor Intrusion) (µg/L)	Groundwater Protection (µg/L)
Total PCBs	7 (a, b)	NA	NA	NA
Vanadium	NA	277	NA	NA
PCE	NA	NA	242	5
TCE	NA	NA	22	5
cis-1,2-DCE	NA	NA	NA	70
trans-1,2-DCE	NA	NA	NA	100
1,1-DCE	NA	NA	NA	7
Vinyl Chloride	NA	NA	NA	2

Notes:

a) For PCBs in the Transformer Shop Area, the lowest of the calculated RBTCs, 7 mg/kg, is selected as the overall PRG for soil. This PRG corresponds to a target hazard index of 1 and is based on the construction worker scenario. For the construction worker, the soil RBTC based on non-cancer effects is more stringent than the cancer-based RBTC corresponding to a risk level of 10^{-5} (see Appendix C). The baseline cancer risk presented in the BHHRA for the construction worker was less than 10^{-5}.

b) For purposes of evaluating risk solely to outdoor workers, the surface soil RBTC of 10.5 mg/kg is selected, which corresponds to a cancer risk level of 10^{-5} and is based on the outdoor worker scenario.

3.4 Impact Areas and Volumes

3.4.1 PCBs in Transformer Shop Area Soil

PCBs were identified as a potential COC in Transformer Shop Area soil **(Figure 3-1)**. **Table 3-3** presents a comparison of surface soil (0-1 ft. bgs) concentrations to the outdoor worker RBTC of 10.5 mg/kg. **Table 3-4** presents a comparison of combined soil (0-16 ft. bgs) concentrations to the PRG of 7 mg/kg. **Figure 3-2 and Figure 3-4** present PCB concentrations in surface and subsurface soil samples, respectively, compared to the PRG of 7 mg/kg.

PCBs in surface soil in one location within the Transformer Shop Area (surface soil at SUSDP21-3G with a concentration of 8,800 mg/kg, **Table 3-3**) pose a risk greater than 1E-03 to the outdoor worker, thus constituting a Principal Threat Waste (USEPA, 1991). The volume of surface soil that constitutes this Principal Threat Source Material (PTSM) was assumed to be the entire polygon or 1.8 CY across approximately 48 sq feet.

PCBs in surface soil (0-1 foot bgs) exceeded the PRG of 7 mg/kg at six locations (SUSDPGD21-D1, SUSDP21-1C, SUSDPGD21-G1, SUSDP21-3M, SUS21-2J, and SUSDP21-3G) (see **Table 3-4**; **Figure 3-2 and Figure 3-3**). PCBs in subsurface soil (> 1 foot bgs) exceeded the selected risk-based PRG of 7 mg/kg in three depth intervals at one location (SUSDPGD21-G1) and in the 1-2 ft. interval at several locations (see **Table 3-4**; **Figure 3-4 and Figure 3-5**). The maximum depth interval at which PCBs in soil exceeded 7 mg/kg occurred in the 4-5 ft. interval in the SUSDPGD21-G1 polygon. Based on Thiessen polygon analysis, the total volume of soil with PCBs > 7 mg/kg in the 0-5 ft. interval was estimated to be 132 CY **(Table 3-5)**. Additional samples will be collected during the pre-design investigation or remedial design phase to further delineate the horizontal and vertical extent of the proposed excavation areas to further refine these volume estimates. These investigations will be designed to collect sufficient data to understand the post-excavation conditions and thus eliminating the need for post-excavation sampling. This will help expedite the excavation and restoration process to minimize impacts on on-site operations.

3.4.2 Vanadium in Warehouse and Laydown Area Soil

Vanadium was identified as a potential COC in soil in the Warehouse and Laydown Area. **Table 3-6** presents a comparison of soil data collected in this area to the selected PRG (277 mg/kg). Vanadium concentrations exceeded the PRG at 18 locations in surface soil (0-1 ft. bgs) and at 4 locations in sub-surface (1-2 ft. bgs) in a portion of the Warehouse and Laydown Area overlapping with the former coal pile area and Target Area 1, as summarized in **Table 3-6,** and shown in **Figure 3-6** and **Figure 3-7**. The volume of soil in the 0-2 ft. interval with vanadium at concentrations greater than the PRG of 277 mg/kg was calculated using a Thiessen polygon analysis to be approximately 4000 CY across 2.11 acres (as shown in **Figure 3-8**). Additional samples may be collected during the pre-design investigation or the remedial design phase to refine this volume estimate.

3.4.3 PCE and TCE in Southern Boundary Groundwater

Groundwater PRGs were developed for the vapor intrusion pathway for potential COCs in groundwater within the UWZ at the southern property boundary. All monitoring data from 2014 to 2021 from monitoring wells, temporary wells, and direct push samples was used to delineate extent of the impacted groundwater plume. PCE concentrations exceeding the PRG of 242 µg/L are presented in **Table 3-6** and depicted on **Figure 3-10**. TCE concentrations exceeding the PRG of 22 µg/L are presented in **Table 3-6** and depicted on **Figure 3-11**. The approximate surface area of the impacted groundwater plume is 43,759 sq. ft. (PCE) and 22,231 sq. ft. (TCE) (**Figure 3-10** and **Figure 3-11)**. **Figures 3-10** and **3-11** also clearly show the plume is underneath a parking lot and that there are no permanent buildings/structures within the footprint of the 242 µg/L PCE plume that are occupied. While some office trailers can be seen in **Figure 3-10** and **Figure 3-11**, these trailers are elevated above the ground surface and do not have sub-surface foundations, thus eliminating any potential exposure to PCE and TCE vapors in indoor air originating from groundwater in the UWZ. There are no human receptors for vapor intrusion risks within the plume footprint and thus, the plume does not currently present a potential hazard.

PCE and TCE concentrations in groundwater exceeded the Title 21 DCMR standards **(Appendix A** and **Table 3-7)**, while daughter products cis-1,2-DCE, trans-1,2-DCE, 1,1-DCE, and VC were either not detected or if detected, were below the DCMR standards. However, as per RAO 4 (groundwater restoration), the remedial alternative also needs to incorporate PCE and its daughter products. As a result, for development of remedial alternatives for RAO4, the extent of the groundwater plume was delineated based on concentration of total VOCs, representing the sum of PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, 1,1-DCE, and VC.

Using all data from 2014 to 2021 **(Table 3-8)**, with maximum total VOC concentration measured at each well across the years used to delineate the plume extents, results in three separate plumes for total VOCs **(Figure 3-12)**. The total area of the three plumes with total VOC concentration exceeding 5 µg/L was calculated to be 222,643 sq. ft. The largest plume (145,593 sq. ft.) is located near the southern property boundary, while two smaller secondary plumes are located to the west of the larger plume. One of these secondary plumes (50,066 sq. ft.) is located to the west of Substation 45 and centered around the MW-05A well. This plume results primarily from the maximum PCE concentration of 15 µg/L measured at MW-05 in 2016. Other VOCs detected in the groundwater at this well were cis-1,2-DCE and TCE, and were both below their respective groundwater standards. In the most recent sampling event in 2021 (AECOM, 2023), PCE was detected in this well at a concentration of 1.5 µg/L, below the groundwater standard of 5 µg/L, while TCE and all daughter products were not detected.

The other secondary total VOC plume (26,984 sq. ft.) is located near the western boundary of the property, and is driven by maximum PCE, TCE, and cis-1,2-DCE concentrations exceeding 5 µg/L at MW-01A, TA19C1, TA19C2, and TA19C3 during some of the monitoring events between 2014 and 2017. However, the most recent sampling event in 2021 did not detect any PCE and daughter products at either MW-01A or at the adjacent MW-02A monitoring well (AECOM, 2023).

The low levels of PCE (below the groundwater standard of 5 ug/L) and non-detection of daughter products in the UWZ monitoring wells located within or adjacent to the secondary plumes during the 2021 sampling event shows that elevated concentrations of VOCs are not currently present within these secondary plumes. Thus, remedial alternatives for groundwater restoration were only focused on the primary plume adjacent to the southern property boundary. Monitoring data from 2014 and 2016 for the LWZ around the MW-01B and MW-05B monitoring wells showed PCE concentrations at both wells exceeding the groundwater standard (18 to 110 µg/L). TCE concentration measured at MW-01B was 25 and 48 µg/L in 2014 and 2016, respectively, exceeding the 5 µg/L standard. However, the most recent monitoring data from 2021 showed no detections of PCE and any daughter products at MW-01B and at the adjacent MW-02B monitoring well. At MW-05B, only PCE was detected (0.88 µg/L) but was well below the groundwater standard, while no PCE or daughter products were detected in the adjacent TP-08B location (AECOM, 2023).

The low levels of PCE (below the groundwater standard of 5 ug/L) and non-detection of daughter products in the LWZ monitoring wells, MW-01B and MW-05B, during the 2021 sampling event shows that elevated concentrations of VOCs in the LWZ groundwater are not currently present around these locations.

Thus, remedial alternatives for groundwater restoration were only focused on the primary UWZ plume adjacent to the southern property boundary.

4 General Response Actions, Technology and Process Option Screening

This section presents the General Response Actions (GRAs) and identifies and screens available technologies and process options under each GRA for each medium at the LIA with actionable risk. Technologies are described and then evaluated and screened relative to effectiveness, implementability and cost, following EPA's *Guidance for Conducting RI/FS Under CERCLA* (USEPA, 1988). Technologies retained are then assembled into specific alternatives for each medium. Detailed evaluation of the assembled alternatives is discussed in Section 5.0.

4.1 General Response Actions

GRAs are broad categories of remedial actions that may satisfy the remedial action objectives set forth in Section 3.0. General response actions include no action, ICs, containment, removal, treatment, disposal, or a combination of these actions. Similar to RAOs, GRAs are medium-specific. The GRAs identified for each medium are summarized below.

4.1.1 GRAs for LIA Soils

The following potential GRAs have been identified for PCBs in soils in the Transformer Shop area (TA 12) and for vanadium in the soils in the Warehouse and Laydown Yard area (TA 1 and former coal pile area):

GRA	Description
No Action	No actions are taken under this GRA. While the No Action GRA will not satisfy any RAOs, the NCP and CERCLA require consideration of the "no action" alternative as a baseline for comparison of the other GRAs/alternatives.
Institutional Controls	Measures such as Soil Management Plans, fences, security, land use restrictions, and deed notices to minimize human exposures to potential COCs and/or protect the integrity of an implemented remedy.
Containment	Installation of surface caps or cover materials to prevent direct human contact with underlying impacted soils. Existing asphalt and concrete pavement at the Site could be included in this GRA depending on the condition and thickness of the existing asphalt and concrete pavement.
Treatment	Treatment of potential COCs either in place or ex-situ through the various physical, chemical, biological, or thermal treatment technologies.
Removal and Disposal/Reuse	The physical removal or excavation of impacted soils/sediments, followed by on-site reuse or off-site disposal.

4.1.2 GRAs for LIA Groundwater (Vapor Intrusion)

The following potential GRAs have been identified for addressing vapor intrusion risks from PCE and TCE in the UWZ groundwater near the southern property boundary:

GRA	Description
No Action	No actions are taken under this GRA. While the No Action GRA will not satisfy any RAOs, the NCP and CERCLA require consideration of the "no action" alternative as a baseline for comparison of the other GRAs/alternatives.
Institutional Controls	Measures such site security, fencing, groundwater use restrictions, and general land use and deed restrictions to minimize human exposures to potential COCs and/or protect the integrity of an implemented remedy.
Monitored Natural Attenuation (MNA)	Reduction in potential COC concentrations though natural fate and transport processes including biotic and abiotic degradation. MNA is monitored for efficacy. Efficacy is evaluated based on monitored rates of attenuation.
Containment	Installation of horizontal barriers to prevent vapor intrusion into buildings
	Installation of active or passive venting systems within buildings (typically in combination with horizontal barriers) to collect sub-slab vapors and release them to the atmosphere

4.1.3 GRAs for LIA Groundwater (Groundwater Restoration)

The following potential GRAs have been identified for restoration of PCE and TCE-impacted groundwater in the UWZ near the southern property boundary:

GRA	Description
No Action	No actions are taken under this GRA. While the No Action GRA will not satisfy any RAOs, the NCP and CERCLA require consideration of the "no action" alternative as a baseline for comparison of the other GRAs/alternatives.
Institutional Controls	Measures such site security, fencing, groundwater use restrictions, and general land use and deed restrictions to minimize human exposures to potential COCs and/or protect the integrity of an implemented remedy.
Monitored Natural Attenuation (MNA)	Reduction in potential COC concentrations though natural fate and transport processes including biotic and abiotic degradation. MNA is monitored for efficacy. Efficacy is evaluated based on monitored rates of attenuation.
Containment	Installation of vertical and horizontal barriers to prevent groundwater plume migration, vapor migration, or as a means to channel groundwater through an in-situ treatment zone.
Collection and Discharge	Collection of groundwater on-site via interceptor trenches or extraction wells, followed by off-site disposal.
Treatment	Treatment of potential COCs in place through the various physical, chemical, biological, or thermal treatment technologies.
Collection, Treatment, and Discharge	Extraction of contaminated groundwater by pumping from a series of extraction wells, treating the water aboveground to remove potential COCs, followed by permitted discharge of treated water.

4.2 Ancillary Technologies

Ancillary technologies are those that will be needed to support the implementation of GRAs, and they will be considered in the development of the remedial alternatives discussed in **Section 5.0**. These processes are not screened because they are integral to the implementation of many of the GRAs. The applicable ancillary technologies are described below:

- Erosion and Sedimentation Control Best Management Practices – Best management practices are guidelines on the design, installation, and maintenance of controls to prevent erosion or sedimentation at sites where the ground is disturbed or used for soil stockpiling. Erosion and sediment control will be implemented per 21 DCMR Chapter 5 **(Table 3-1)** and will be reviewed and approved during the remedial design.
- Wastewater Management Technologies – Excavation dewatering, equipment decontamination, and other onsite activities result in the production of wastewater. These waters are potentially impacted by potential COCs and must be managed accordingly. There are options for wastewater management technologies including treatment and discharge into the municipal sewer system, and transportation and disposal at an approved facility. The applicability of each of the technologies will be reviewed in the design phase of the selected remedial alternative.
- Excavation Stability Technologies – Excavations may require additional stabilization based on depth, proximity to structures, and other physical constraints. Some excavation stability technologies include shoring, sloping, and benching.
    - Shoring – The installation of physical supports to allow deep excavation without structural collapse of the soils. Structural design may be required.
    - Sloping – When sidewalls are cut at an angle based on soil composition to prevent structural collapse of soils. Increases excavation footprint.
    - Benching – When sidewalls are cut in steps to prevent structural collapse of soils. Increases excavation footprint.

4.3 Technology/Process Option Screening

The development of remedial alternatives commences with the identification, screening and evaluation of potentially applicable remedial technologies and associated process options. Remedial technologies are general technology options under a GRA. Each technology type can have multiple process options. For this landside FS, technologies and process options are discussed together. A number of technologies were identified for each medium of concern under each potential GRA. These technologies are then evaluated on the basis of effectiveness in meeting the RAOs, technical (constructability) and regulatory (meeting ARAR) implementability, and cost. Evaluation for cost at this screening stage is based on qualitative criteria (low, moderate, and high). Detailed costs are presented in **Section 5.0**.

The technology screening/evaluation is summarized in **Table 4-1** (PCB-contaminated soil in LIA), **Table 4-2** (vanadium-contaminated soil in LIA), and **Table 4-3** and **Table 4-4** (PCE and TCE impacted groundwater). Based on this evaluation, one or more representative technologies/process options were retained for each GRA.

The following is a summary of Retained GRAs, and associated technologies/process options:

GRA	Technology	Process Option
Applicable to PCB and Vanadium-Contaminated Soils in LIA		
No Action	No Action	No Action
Institutional Controls	Engineering Controls	Existing Fencing
		Existing Site Security
	Administrative Controls	Soil Management Plan
		Signage
	Legal Controls	Land Use Restrictions
		Permit Limits
		Deed Restrictions
PCB-Contaminated Soil in LIA		
Containment	Single-Layer Cap	Asphalt Cap
Treatment	Ex-Situ Treatment	Incineration (off-site)
Removal and Disposal/Re-use	Excavation and On-Site Reuse or Off-site Disposal	Excavation and Off-Site Disposal
		Excavation and On-Site Reuse
Vanadium-Contaminated Soil in LIA		
Containment	Single-Layer Cap	Gravel Cover
Removal and Disposal	Excavation and Off-site/On-Site Disposal	Excavation and Off-Site Disposal

GRA	Technology	Process Option
LIA Groundwater (Vapor Intrusion)		
No Action	No Action	No Action
Institutional Controls	Engineering Controls	Existing Fencing
		Existing Site Security
	Administrative Controls	Classification Exception Areas (CEA) / Well Restriction Area (WRA)
		Signage
	Legal Controls	Land Use Restrictions
		Deed Restrictions
MNA	Attenuation via Physical, Biological, or Chemical Processes	Reduction of Potential COC Concentrations Through Physical Processes
		Reduction of Potential COC Concentrations Through Biological Degradation[3]
		Reduction of Potential COC Concentrations Through Chemical Degradation
Containment	Horizontal Containment with Sub-Slab Venting System	Asphalt Latex Membranes with Passive Venting System
		Thermoplastic Membranes with Passive Venting System
		Composite Membrane Barriers with Passive Venting System

[3] Geo-chemical results at the site indicate that conditions in the sub-surface are not favorable for complete biological dechlorination but can be potentially enhanced by substrate addition and bioaugmentation (AECOM, 2023).

GRA	Technology	Process Option
LIA Groundwater (Groundwater Restoration)		
No Action	No Action	No Action
Institutional Controls	Engineering Controls	Existing Fencing
		Existing Site Security
	Administrative Controls	Classification Exception Areas (CEA) / Well Restriction Area (WRA)
		Signage
	Legal Controls	Land Use Restrictions
		Deed Restrictions
MNA	Attenuation via Physical, Biological, or Chemical Processes	Reduction of Potential COC Concentrations Through Physical Processes
		Reduction of Potential COC Concentrations Through Biological Degradation[4]
		Reduction of Potential COC Concentrations Through Chemical Degradation
Treatment	In-Situ Treatment	Chemical Oxidation via Permanganate Injection
		Zero Valent Iron (ZVI) Injection
		In-Situ Enhanced Bioremediation
Collection, Treatment, and Discharge	Groundwater Extraction, Ex-Situ Treatment, and Discharge	Groundwater extraction, treatment via adsorption on Granular Activated Carbon (GAC), and discharge

4.4 Summary of Assembled Remedial Alternatives

Combinations of the retained GRAs and associated technologies/process options for different media provided in Section 4.3 are considered in assembling media-specific remedial alternatives.

Remedial Action Alternatives for PCB-Contaminated Soils

- **LSS-PCB-1:** No Action
- **LSS-PCB-2:** Removal with Off-Site Treatment and Disposal of PTSM, and ICs

[4] Geo-chemical results at the site indicate that conditions in the sub-surface are not favorable for complete biological dechlorination but can be potentially enhanced by substrate addition and bioaugmentation (AECOM, 2023).

- **LSS-PCB-3:** Removal with Off-Site Treatment/Disposal of PTSM, Surface Soils with PCBs > 7 mg/kg, and Select Sub-Surface Soils (1-4 ft.), and ICs
- **LSS-PCB-4:** Removal with Off-Site Treatment/Disposal of PTSM, Surface Soils with PCBs > 7 mg/kg, and Select Sub-Surface Soils (1-2 ft.), and ICs
- **LSS-PCB-5:** Removal with Off-Site Treatment/Disposal of PTSM and Soils (0-2 ft.) with PCBs > 7 mg/kg, and ICs

Remedial Action Alternatives for Vanadium-Contaminated Soils

- **LSS-V-1:** No Action
- **LSS-V-2:** Institutional Controls
- **LSS-V-3:** Excavation with Off-Site Disposal, and ICs

Remedial Action Alternatives for Addressing Vapor Intrusion Risks from PCE and TCE in Groundwater

- **LGW-VB-1:** No Action
- **LGW-VB-2:** Asphalt Latex Membrane Vapor Barriers with Passive Venting System
- **LGW-VB-3:** Thermoplastic Membrane Vapor Barriers with Passive Venting System
- **LGW-VB-4:** Composite Membrane Vapor Barriers with Passive Venting System

Remedial Action Alternatives for Groundwater Restoration RAO

- **LGW-GR-1:** No Action
- **LGW-GR-2:** MNA, Groundwater Monitoring, and ICs
- **LGW-GR-3:** Treatment via Permanganate Injection, with MNA and ICs
- **LGW-GR-4:** Treatment via ZVI Injection, with MNA and ICs
- **LGW-GR-5:** Treatment via Biowalls and ZVI Injection, with MNA and ICs
- **LGW-GR-6:** Groundwater Extraction and Treatment using GAC, with MNA and ICs

5 Description and Screening of Assembled Remedial Alternatives

The assembled remedial alternatives summarized in Section 4.4 were further screened using the following criteria: effectiveness, implementability, and cost as per EPA's RI/FS guidance (USEPA, 1988).

Effectiveness

This criterion evaluates the effectiveness of the assembled remedial alternative for protecting human health and the environment.

Implementability

This criterion evaluates the technical and administrative feasibility of construction, operation, and maintenance of the assembled remedial alternatives.

Cost

This criterion evaluates the costs of remedial alternatives and is intended to be within -50% to 100% of the detailed evaluation cost estimate. Costs include both capital costs and operation and maintenance (O&M) costs. Due to uncertainties in the screening-level cost estimates, this criterion is used as a comparative metric and is not being used to screen out any alternative.

5.1 Key ICs Applicable to Remedial Alternatives for LIA

Several ICs have been identified for the LIA, including the areas with impacted soil and groundwater. These ICs would be implemented in conjunction with respective remedial alternatives for vanadium and PCB-impacted soils, and PCE-impacted groundwater. Key aspects of these ICs are discussed below.

5.1.1 Engineering Controls

The entire Site, including the Transformer Shop area, Warehouse and Laydown area, and the southern area of the site encompassing the PCE plume, is surrounded by a fence and round-the-clock security restricting access by unauthorized persons. These measures prevent exposure of target populations to potential COCs at the site. Implementation of these engineering controls would be enforced through a deed restriction.

Pepco is considering the sale and potential redevelopment of an approximately 10-acre parcel on the western portion of the property where the former generating station was located **(Figure 2-3)**. No potential COCs were identified in the soil in the former generating station area, thus no fencing is needed in this part of the Site. If this parcel is sold, fencing and security will continue to be maintained in the remainder of the Site.

5.1.2 Administrative Controls

Administrative controls for the Landside area would include signage to identify risks to inform target populations about areas impacted by potential COCs, the preparation and implementation of a Soil Management Plan (SMP), and the implementation of appropriate health and safety measures (such as PPE, dust suppression, or air monitoring) in connection with construction or maintenance activities that may pose the risk of exposure of outdoor workers or construction workers to contaminated media at the Site. Signs would be placed at the Transformer Shop and at the Warehouse and Laydown areas, identifying the potential COCs at each of these areas, the impacted media and its depth, and precautions that visitors and workers in each of these areas should follow to avoid exposure to the potential COCs. Similarly, signs would be placed near the PCE plume identifying potential COCs in the groundwater and specifying restrictions on the use of groundwater as documented in the deed restrictions (see "Legal Controls" below). Pepco is in the process of preparing a SMP which is a post-remedy institutional control for activities such as excavation/construction that may impact the integrity of the remedy. The SMP will describe (i) procedures for conducting excavation activities for utility or construction work in areas where uncontrolled exposure could pose unacceptable risks, (ii) procedures for managing soil brought to the surface during construction activities, (iii) requirements for stockpiling, testing, and disposing excavated soil, (iv) health and safety controls for workers, (v) best management practices for preventing environmental impacts during excavations, (vi) soil management, and (vii) restoration of surface to pre-excavation condition. The SMP would be applicable to the entire site, including the western parcel identified for possible sale and redevelopment, to protect against possible exposures to both identified COCs and possible unidentified areas of contamination. The SMP would include protocols for construction workers who may conduct ground disturbance work within the Site in the future. The SMP would also include specific protocols and procedures for any ground disturbance activities adjacent to the PCE plume which may potentially impact any ongoing groundwater treatment remedy. The SMP would be implemented through a work clearance process and enforced through a deed notice.

5.1.3 Legal Controls

Legal controls would include deed restrictions enforceable by DOEE that would: (a) limit use of the Site to commercial and /or industrial operations; (b) prohibit use of groundwater at the Site; (c) require implementation of the engineering controls and the SMP; and (d) require vapor barriers and venting systems in buildings constructed within the PCE plume until the PRGs for vapor intrusion have been achieved. In addition, deed restrictions will also include documentation of the location and type of known contaminants remaining in soil, and any requirements for compliance monitoring and reporting.

5.2 Screening of Assembled Alternatives for PCB-Impacted Soil

5.2.1 Alternative LSS-PCB-1: No Action

This alternative does not include any remedial action or implementation of any ICs for addressing risks from PCB-impacted soil in the Transformer Shop area.

Effectiveness: This alternative would not be effective in achieving the RAOs as no remedial action would be implemented to reduce risk from on-site soils with PCB concentrations exceeding PRGs.

Implementability: This alternative would be easy to implement from both technical and administrative standpoints as no remedial actions would be carried out and no ICs would be implemented.

Cost: There is no cost associated with this alternative as no remedial actions would be carried out and no ICs would be implemented.

Conclusion

Although LSS-PCB-1 would not be effective in achieving the RAOs, it has been retained for detailed analysis to serve as a baseline for comparison with other remedial alternatives.

5.2.2 Alternative LSS-PCB-2: Removal with Off-Site Treatment and Disposal of PTSM, and ICs

This alternative involves excavation, off-site treatment (via incineration), and off-site disposal of 1.8 CY of PTSM in the Transformer Shop area. Excavation of PTSM would reduce the residual risk on-site while incineration of the PTSM would permanently destroy PCBs. The excavated area would be backfilled with clean soil and asphalt pavement over the excavated area would be restored for operational and personnel safety. Because surface soil with PCBs exceeding the outdoor worker RBTC of 10.5 mg/kg would remain on-site, the asphalt pavement (existing as well as that installed over backfilled areas) will be maintained as part of the O&M activities under this alternative to prevent exposure of outdoor workers to surface soil in this area.

This alternative also would include ICs, as described in Section 5.1. In the event of any construction activities, implemented ICs, such as SMP, health and safety plans, and signage, would manage any residual impacts and prevent exposure of outdoor workers or construction worker to potential COCs in soil.

For feasibility evaluation purposes, it is assumed that all the soil in the 0-1 ft. interval of SUSDP21-3G polygon would be excavated **(Figure 5-1)**. Additional samples will be collected during the pre-design investigation or remedial design phases to refine the excavation area.

Effectiveness: Post-excavation risk assessment results **(Appendix D)** show that removal of PTSM (i.e., soils with PCB concentration of 8,800 mg/kg) reduces the surface soil EPC (for future outdoor worker) to 11.3 mg/kg, which is higher than the outdoor worker RBTC of 10.5 mg/kg and overall PRG of 7 mg/kg but reduces the excess lifetime cancer risks for the outdoor worker to 1E-05. Removal of PTSM under this alternative also reduces the combined soil EPC (for current/future construction worker) to 75 mg/kg, representing a 40% reduction over the current EPC of 126 mg/kg for combined soils. Overall, this alternative would remove approximately 21.3 kg of PCBs, in the form of PCB-impacted soil, from the site. The asphalt pavement (existing as well as that installed over backfilled areas) would isolate remaining surface soil from human receptors. The thickness of the existing asphalt pavement over soils in the Transformer Shop area ranges from 0.5 ft. to 0.83 ft. based on the geotechnical boring logs from the RI (AECOM, 2020). The asphalt pavement is currently in good condition and is maintained regularly and repaired as needed. The ICs, including the SMP, would protect against exposures to subsurface soil.

Implementability: This alternative would be moderately implementable from both technical and administrative standpoints. Only a small volume of soil would be excavated and treated. Incineration has been used at several Superfund sites to treat PCB waste and is a well-established technology. Implementation of ICs included in this alternative is expected to be easy from an administrative perspective. Materials, methods, and services required for this alternative are generally available. Due to excavation of PTSM in tight spaces and handling of PTSM and TSCA-level soil, this alternative is regarded as moderately implementable.

Cost: Costs for implementation of this remedy are anticipated to be low. Capital costs for this alternative would be associated with excavation, processing, transportation, treatment, and disposal of PTSM, and implementation of ICs. O&M costs after remedy implementation are anticipated to be low to moderate and would primarily consist of asphalt cap maintenance and periodic reviews.

Conclusion

Based on the effectiveness and implementability screening evaluation described above, alternative LSS-PCB-2 has been retained for detailed analysis.

5.2.3 Alternative LSS-PCB-3: Removal with Off-Site Treatment/Disposal of PTSM, Surface Soils with PCBs > 7 mg/kg, and Select Sub-Surface Soils (1-4 ft.), and ICs

This alternative involves a combination of the following remedial actions: a) excavation, treatment (via incineration), and off-site disposal of 1.8 CY of PTSM; b) excavation and disposal of 42 CY of soil in the 0-1 ft. interval with PCB concentrations > 7 mg/kg; c) excavation and disposal of 7 CY soil in the 1-4 ft. interval with PCB concentration > 100 mg/kg; and d) backfilling and restoration of excavated areas in the Transformer Shop area. Overall, approximately 51 CY of soil with PCBs > 7 mg/kg would be removed from site.

PTSM removal would involve excavation of 1.8 CY of soil from the SUSDP21-3G polygon, followed by off-site incineration and subsequent disposal. In addition, all surface soil would be excavated from five polygons (SUSDPGD21-D1, SUS21-2J, SUSDSGD21-G1, SUSDP-3M, and SUSDP21-1C) covering an area of approximately 1132 sq. ft., totaling 42 CY of soil, and representing all surface soil in the Transformer Shop area exceeding a PCB concentration of 7 mg/kg.

Finally, sub-surface soil would be excavated from the 1-4 ft. intervals of the SUSDPGD21-G1 polygon where PCB concentrations measured were 450 mg/kg (1-2 ft.), 77 mg/kg (2-3 ft.), and 180 mg/kg (3-4 ft.). This would remove 7 CY of sub-surface soil, representing all subsurface soil in the Transformer Shop area exceeding a PCB concentration of 100 mg/kg.

Non-PTSM excavated soils with PCBs > 50 mg/kg (11 CY) would be disposed at a TSCA-approved landfill. Remaining excavated soils (38 CY) would be disposed of at a permitted landfill authorized to accept PCB-contaminated soil with concentrations below 50 parts per million (ppm).

Excavated areas would be backfilled with clean soil and asphalt pavement over the excavated area would be restored for operational and personnel safety. However, asphalt pavement is not an active component of this alternative because:

1) This alternative removes all surface soil with PCBs > 7 mg/kg, resulting in a surface soil EPC that is lower than the outdoor worker surface soil RBTC of 10.5 mg/kg **(Appendix D)**. As a result, asphalt pavement is not needed to achieve the outdoor worker RBTC for surface soil.

2) While sub-surface soil with PCBs > 100 mg/kg would remain in some locations, any excavation activities that might result in exposure of outdoor workers or construction workers to sub-surface soil would necessarily involve removal of the asphalt pavement. As such, the asphalt pavement would not reduce or prevent exposure of outdoor workers or construction workers to PCBs in sub-surface soil.

This alternative also would include ICs as described in Section 5.1, including SMP, health and safety plans, and signage to manage any residual impacts and prevent exposure of outdoor workers or construction workers to potential COCs in soil.

For feasibility evaluation purposes, it is assumed that all soil in the 0-1 ft. interval of SUSDPGD21-D1, SUS21-2J, SUSDSGD21-G1, SUSDP-3M, and SUSDP21-1C polygons, and in the 1-4 ft. interval of SUSDPGD21-G1 polygon would be excavated and disposed **(Figure 5-2)**. Additional samples will be collected during the pre-design investigation or remedial design phases to refine the excavation area.

Effectiveness: By removing all surface soil (including PTSM) with PCBs > 7 mg/kg, this alternative would reduce the surface soil EPC to below the PRG as well as reduce the excess lifetime cancer risk for the outdoor worker to 1E-05. In addition, as discussed in **Appendix D,** this alternative is predicted to reduce the combined soil EPC to 22 mg/kg, representing an 83% reduction to the existing combined soil EPC of 126 mg/kg. Overall, this alternative would remove approximately 25.1 kg of PCBs, in the form of PCB-impacted soil, from the site. Risk to both outdoor workers and construction workers related to exposure to remaining PCBs in subsurface soil would be managed through the implementation of ICs.

Implementability: Materials, methods, and services required for this alternative are generally available. Incineration has been used at several Superfund sites to treat PCB waste and is a well-established technology. Implementation of ICs included in this alternative is expected to be easy from an administrative perspective. However, some of the soil excavation would need to be performed in a tight space between Building 57 and the Kenilworth Avenue retaining wall. This alternative also involves handling of PTSM and TSCA-level soil. Sub-surface excavation up to a depth of 4 ft. minimum would be required next to the Kenilworth Avenue retaining wall. This excavation depth may be at or below the depth of the wall foundation, in which case additional shoring of the foundation, along with consultation with DC Department of Transportation (DDOT), and subsequent permitting is likely to be required to maintain integrity of the retaining wall. In addition, various sub-surface utilities are present within the excavation area which are also expected to pose implementation challenges. Thus, this alternative is regarded as difficult to implement.

Cost: Costs for implementation of this remedy are anticipated to be high. Capital costs for this alternative would be associated with excavation, processing, transportation, treatment, and/or disposal of excavated soil (including PTSM), and implementation of ICs, with additional costs for foundation shoring which is anticipated to be expensive. O&M costs after remedy implementation are anticipated to be low to moderate and would primarily consist of periodic reviews.

Conclusion

Based on the implementability issues discussed above, alternative LSS-PCB-3 has not been retained for detailed analysis.

5.2.4 Alternative LSS-PCB-4: Removal with Off-Site Treatment/Disposal of PTSM, Surface Soils with PCBs > 7 mg/kg, and Select Sub-Surface Soils (1-2 ft.), and ICs

This alternative involves a combination of the following remedial actions: a) excavation, treatment (via incineration), and off-site disposal of 1.8 CY of PTSM; b) excavation and disposal of 42 CY of soil in the 0-1 ft. interval with PCB concentrations > 7 mg/kg; c) excavation and disposal of 31 CY soil in the 1-2 ft. interval with PCB concentration > 7 mg/kg; and d) backfilling and restoration of excavated areas in the Transformer Shop area. Overall, 75 CY of soil with PCBs > 7 mg/kg would be removed from site.

PTSM removal would involve excavation of 1.8 CY of soil from the SUSDP21-3G polygon, followed by off-site incineration and subsequent disposal. In addition, all surface soil would be excavated from five additional polygons (SUSDPGD21-D1, SUSDPGD21-G1, SUSDP-3M, SUSDP21-1C, and SUS21-2J) covering an area of approximately 1,132 sq. ft., totaling 42 CY of soil, and representing all surface soil in the Transformer Shop area exceeding a PCB centration of 7 mg/kg.

Due to implementation challenges associated with sub-surface excavation near the Kenilworth Avenue retaining wall discussed under alternative LSS-PCB-3 (Section 5.2.3), subsurface excavation in the area between Building 57 and the retaining wall would be limited to the 1-2 ft. interval in the SUSDPGD21-G1 polygon which exhibited the second highest PCB concentration in soil (450 mg/kg) within the Transformer Shop area as discussed below.

Excavation of non-PTSM sub-surface soil also would be conducted in the 1-2 ft. intervals of SUSDP-21C (PCBs: 17 mg/kg), and SUSDP21 (PCBs: 7.2 mg/kg) polygons. Within the SUSDP21 polygon, PCB concentration in the surface soil is below 1 mg/kg (0.52 mg/kg). However, as concentration in the 1-2 ft. interval within this polygon exceeds 7 mg/kg, both the surface soil and sub-surface soil would need to be excavated. Thus, overall, a total of 48 CY of sub-surface soil would be excavated, of which 31 CY would be disposed with the remaining 17 CY reused as backfill.

Non-PTSM excavated soils with PCBs > 50 mg/kg (6.3 CY) would be disposed at a TSCA-approved landfill. Remaining excavated soils (67 CY) would be disposed of at a permitted landfill authorized to accept PCB-contaminated soil with concentrations below 50 parts per million (ppm).

Excavated areas would be backfilled with excavated soil (with PCBs < 1 mg/kg) and clean soil. However, asphalt pavement is not an active component of this alternative because:

1) This alternative removes all surface soil with PCBs > 7 mg/kg, resulting in a surface soil EPC that is lower than the outdoor worker surface soil RBTC of 10.5 mg/kg **(Appendix D)**. As a result, asphalt pavement is not needed to achieve the outdoor worker RBTC for surface soil.

2) While sub-surface soil with PCBs > 100 mg/kg would remain in some locations, any excavation activities that might result in exposure of outdoor workers or construction workers to sub-surface soil would necessarily involve removal of the asphalt pavement. As such, the asphalt pavement would not reduce or prevent exposure of outdoor workers or construction workers to PCBs in sub-surface soil.

This alternative also would include ICs as described in Section 5.1, including SMP, health and safety plans, and signage to manage any residual impacts and prevent exposure of onsite workers and construction worker to potential COCs in soil.

For feasibility evaluation purposes, it is assumed that all soil in the 0-1 ft. interval of SUSDPGD21-D1, SUSDPGD21-G1, SUSDP21-3M, SUSDP21-3G, SUSDP21-1C, and SUS21-2J polygons, and in the 1-2 ft. interval of SUSDPGD21-G1, SUSDP21-1C, and SUSDP21 polygons would be excavated and disposed **(Figure 5-3)**. Additional samples will be collected during the pre-design investigation or remedial design phases to refine the excavation area.

<u>Effectiveness:</u> As with LSS-PCB-3, LSS-PCB-4 would reduce the surface soil EPC to below the PRG as well as reduce the excess lifetime cancer risk for the outdoor worker below 1E-05. In addition, as discussed in **Appendix D,** this alternative is predicted to reduce the combined soil EPC to 29 mg/kg, representing a 77% reduction to the existing combines soil EPC of 126 mg/kg. Overall, this alternative would remove approximately 24.8 kg of PCBs, in the form of PCB-impacted soil, from the site.

<u>Implementability:</u> Materials, methods, and services required for this alternative are generally available. Incineration has been used at several Superfund sites to treat PCB waste and is a well-established technology. Implementation of ICs included in this alternative is expected to be easy from an administrative perspective. However, some of the soil excavation would need to be performed in a tight space between Building 57 and the Kenilworth Avenue retaining wall. This alternative also involves handling of PTSM and TSCA-level soil. Sub-surface excavation down to 2 feet would be required next to the Kenilworth Avenue retaining wall which is expected to pose moderate implementation challenges. In addition, various sub-surface utilities are present within the excavation area which are also expected to pose implementation challenges for sub-surface excavations. Thus, this alternative is regarded as moderately implementable.

<u>Cost:</u> Costs for implementation of this remedy are anticipated to be moderate. Capital costs for this alternative would be associated with excavation, processing, transportation, treatment, and/or disposal of

excavated soil (including PTSM), and implementation of ICs. O&M costs after remedy implementation are anticipated to be low to moderate and would primarily consist of periodic reviews.

Conclusion

Based on the effectiveness and implementability screening evaluation described above, alternative LSS-PCB-4 has been retained for detailed analysis.

5.2.5 Alternative LSS-PCB-5: Removal with Off-Site Treatment/Disposal of PTSM and Soils (0-2 ft.) with PCBs > 7 mg/kg, and ICs

This alternative involves a combination of the following remedial actions: a) excavation, treatment (via incineration), and off-site disposal of 1.8 CY of PTSM; b) excavation and disposal of 125 CY of soil in the 0-2 ft. interval with PCB concentrations > 7 mg/kg; and c) backfilling and restoration of excavated areas in the Transformer Shop area. Overall, approximately which 126 CY of soil with PCBs > 7 mg/kg would be removed from site.

PTSM removal would involve excavation of 1.8 CY of soil from the SUSDP21-3G polygon, followed by off-site incineration and subsequent disposal. In addition, all soil would be excavated from the 0-2 ft. interval across 17 polygons, representing all soil within this interval with a PCB concentration exceeding 7 mg/kg. Overall, 179 CY of soil non-PTSM soil would be excavated. Excavated soil with PCBs < 1 mg/kg (approximately 55 CY), would be reused as backfill, while remaining 125 CY would be disposed in appropriate landfill facilities.

Of the 125 CY of soil to be disposed, 9.9 CY of non-PTSM excavated soils with PCBs > 50 mg/kg would be disposed at a TSCA-approved landfill, while 115 CY would be disposed of at a permitted landfill authorized to accept PCB-contaminated soil with concentrations below 50 parts per million (ppm).

Excavated areas would be backfilled with excavated soil (with PCBs < 1 mg/kg) and clean soil. The asphalt pavement over the excavated area would be restored for operational and personnel safety. However, asphalt pavement is not an active component of this alternative because:

1) This alternative removes all surface soil with PCBs > 7 mg/kg, resulting in a surface soil EPC that is lower than the outdoor worker surface soil RBTC of 10.5 mg/kg **(Appendix D)**. As a result, asphalt pavement is not needed to achieve the outdoor worker RBTC.

2) While sub-surface soil with PCBs > 100 mg/kg would remain in some locations, the asphalt pavement would be removed or excavated into during construction activities. As such, the asphalt pavement would not reduce or prevent exposure of construction worker to PCBs in sub-surface soil.

This alternative also would include ICs as described in Section 5.1. In the event of any construction activities, implemented ICs, such as SMP, health and safety plans, and signage, would manage any residual impacts and prevent exposure of construction worker to potential COCs in soil.

For feasibility evaluation purposes, it is assumed that all soil in the 0-2 ft. interval of the highlighted polygons shown in **Figure 5-4** would be excavated. Additional samples will be collected during the pre-design investigation or remedial design phases to refine the excavation area.

Effectiveness: LSS-PCB-5 involves excavation of all surface and sub-surface soil (including PTSM) with PCBs > 7 mg/kg. Thus, this alternative would reduce the surface soil EPC to below the PRG as well as reduce the excess lifetime cancer risk for the outdoor worker below 1E-05. In addition, as discussed in **Appendix D,** this alternative is predicted to reduce the combined soil EPC to 7.1 mg/kg, representing a 94% reduction to the existing combined soil EPC of 126 mg/kg. This EPC is also nearly meets the combined soil PRG of 7 mg/kg, and results in a potential hazard index of 1 for the construction worker. Overall, this alternative would remove approximately 25.6 kg of PCBs, in the form of PCB-impacted soil, from the site. Risk to both outdoor workers and construction workers related to exposure to remaining PCBs in subsurface soil would be managed through the implementation of ICs.

Implementability: Materials, methods, and services required for this alternative are generally available. Incineration has been used at several Superfund sites to treat PCB waste and is a well-established technology. Implementation of ICs included in this alternative is expected to be easy from an administrative perspective. However, some of the subsurface soil excavation would need to be performed in a tight space between Building 57 and the Kenilworth Avenue retaining wall. This alternative also involves handling of PTSM and TSCA-level soil. Sub-surface excavation up to a depth of 2 ft. minimum would be required along nearly the entire length of retaining wall. This excavation depth would likely require additional shoring of the foundation, along with consultation with DC Department of Transportation (DDOT), and subsequent permitting, to ensure integrity of the retaining wall. In addition, various sub-surface utilities are present within the excavation area which are also expected to pose implementation challenges. Thus, this alternative is regarded as difficult to implement.

Cost: Costs for implementation of this remedy are anticipated to be very high. Capital costs for this alternative would be associated with excavation, processing, transportation, treatment, and/or disposal of excavated soil (including PTSM), and implementation of ICs, as well as additional costs for foundation shoring along a large portion of the retaining wall, which is anticipated to be expensive. O&M costs after remedy implementation are anticipated to be low to moderate and would primarily consist of periodic reviews.

Conclusion

Alternative LSS-PCB-5 has been retained for detailed analysis.

5.3 Screening of Assembled Alternatives for Vanadium-Impacted Soil

5.3.1 Alternative LSS-V-1: No Action

This alternative does not include any remedial action or implementation of any ICs for addressing risks from vanadium-impacted soil in the Warehouse and Laydown area.

Effectiveness: This alternative would not be effective in achieving the RAOs as no remedial action would be implemented to reduce risk from on-site soils with vanadium concentrations exceeding PRGs.

Implementability: This alternative would be easy to implement from both technical and administrative standpoints as no remedial actions would be carried out and no ICs would be implemented.

Cost: There is no cost associated with this alternative as no remedial actions would be carried out and no ICs would be implemented.

Conclusion

Although LSS-V-1 would not be effective in achieving the RAOs, it has been retained for detailed analysis to serve as a baseline for comparison with other remedial alternatives.

5.3.2 Alternative LSS-V-2: Institutional Controls

This alternative relies on ICs described in Section 5.1 to reduce vanadium exposure to current or future construction workers. ICs such as preparation and implementation of an SMP, and implementation of appropriate health and safety measures would prevent exposure to vanadium-contaminated soil during construction or maintenance activities. Signage would be placed at the Warehouse and Laydown area identifying the potential COC (vanadium), the impacted media and its depth, and precautions that visitors and workers in each of these areas should follow to avoid exposure to the potential COC (vanadium). In addition, legal controls would be implemented via deed restrictions will also include documentation of the location, type, and concentration of known contaminants remaining in soil, and any requirements for compliance monitoring and reporting. Further details on relevant ICs can be found in Section 5.1.

While gravel cover is currently in place and is expected to remain so for operational purposes, maintenance of gravel cover is not included as an institutional control under this alternative. The potentially unacceptable risk identified in the BHHRA was for the construction worker scenario only, primarily associated with inhalation during excavation. Since gravel cover would be removed or excavated into during construction activities, the gravel cover would not prevent inhalation or contact with vanadium by a construction worker.

In the event of any construction activities, implemented ICs, such as SMP, health and safety plans, and signage, would manage any residual impacts and prevent exposure of construction worker to potential COCs in soil.

Effectiveness: This alternative would be effective in achieving the RAOs. While vanadium concentrations exceeding PRGs would remain on site, ICs would be implemented to manage any residual impacts and prevent construction worker exposure to contaminated soil.

Implementability: This alternative would be easily implementable from both technical and administrative standpoints.

Cost: Costs for implementation of this remedy are anticipated to be low. Capital costs for this alternative would be associated with implementation of ICs. O&M costs after remedy implementation are anticipated to be low and would consist of periodic reviews.

Conclusion

Based on the effectiveness, implementability, and cost screening evaluation described above, Alternative LSS-V-2 has been retained for detailed analysis.

5.3.3 Alternative LSS-V-3: Excavation with Off-Site Disposal, and ICs

This alternative involves excavation and disposal of approximately 1530 CY of soil in the Warehouse and Laydown area to achieve the RAOs. Under this alternative, surface soils (up to 1 ft. bgs) would be removed from ten polygons where concentrations of vanadium in soil exceed 277 mg/kg. These polygons comprise an area of 0.95 acres and are shown in **Figure 5-5**. Concentrations of vanadium in these ten polygons range from 1,400 mg/kg (SUS08-2N) to 42,000 mg/kg (TA1E1). Excavated soil would be disposed as non-hazardous waste at a permitted landfill and excavated areas would be backfilled with clean soil. While gravel cover is currently in place and is expected to be restored for operational safety, it is not required for managing risks under this alternative and is thus not an active component of this remedy. This alternative also would include ICs as described in Section 5.1.

For feasibility evaluation purposes, it is assumed that all the soil in the 0-1 ft. interval in ten polygons will be excavated. Additional samples will be collected during the pre-design investigation or remedial design phases to refine the excavation area.

Effectiveness: Post-excavation risk assessment calculations **(Appendix D)** show that excavation of the soils in the polygons included in this alternative reduces the EPC to 258 mg/kg, which is lower than the PRG of 277 mg/kg, while the corresponding hazard index is reduced to 0.9 from the current hazard index of 16. Thus, this alternative would be effective in achieving the RAOs.

Implementability: This alternative would be moderately difficult to implement due to presence of aboveground and underground structures and utilities within the excavation polygons.

Cost: Costs for implementation of this remedy are anticipated to be high. Capital costs for this alternative would be associated with excavation, processing, transportation, and disposal of excavated soil, and implementation of ICs. O&M costs after remedy implementation are anticipated to be low and would primarily consist of periodic reviews. Gravel cover maintenance is not included under O&M costs as the gravel cover is not an active component of the remedy.

Conclusion

Alternative LSS-V-3 has been retained for detailed analysis.

5.4 Screening of Assembled Alternatives for Reducing Vapor Intrusion Risks in Future Buildings from PCE and TCE in Groundwater

The following alternatives are only relevant if a building is built over the PCE plume before the vapor intrusion PRGs are achieved.

5.4.1 Alternative LGW-VB-1: No Action

This alternative does not include any remedial action or implementation of any ICs for addressing vapor intrusion risks in future buildings due to the PCE and TCE-impacted groundwater plume. However, as **Figures 3-10** and **3-11** show, the plume is underneath a parking lot and that there are no permanent buildings/structures that are occupied within the footprint of the PCE and TCE plumes. As there are no human receptors within the plume footprint, the plume does not currently pose vapor intrusion risks. PCE and TCE plume would pose vapor intrusion risks if a building were to be constructed in the future while PCE and TCE concentrations exceeding respective PRGs remain on-site. However, there are no plans for construction of a building in this area for the foreseeable future.

Effectiveness: This alternative would not be effective in achieving the RAOs as PCE and TCE concentrations exceeding PRGs would remain on-site and would pose risks in future buildings constructed over the extent of the plume.

Implementability: This alternative would be easy to implement from both technical and administrative standpoints as no remedial actions would be carried out and no ICs would be implemented.

Cost: There is no cost associated with this alternative as no remedial actions would be carried out and no ICs would be implemented.

Conclusion

Although LGW-VB-1 would not be effective in achieving the RAO unless contaminant concentrations have been reduced below the PRGs before construction of a hypothetical future building within the plume footprint, it has been retained for detailed analysis to serve as a baseline for comparison with other remedial alternatives.

5.4.2 LGW-VB-2: Asphalt Latex Membrane Vapor Barriers with Passive Venting System

This alternative addresses vapor intrusion risks from the impacted groundwater plume through a combination of an asphalt latex membrane (ALM) vapor barrier and a passive venting system in hypothetical future buildings constructed in the vicinity of the plume. The vapor barrier can be applied in a continuous, seamless layer using a spray-on asphalt latex material. ALMs are typically applied to a base layer made of a geotextile or a composite membrane (CM) (ITRC, 2020).

This alternative would also include annual post-construction indoor vapor monitoring to be conducted in any hypothetical future building in which the ALM vapor barrier is installed to confirm effectiveness of the vapor barrier and passive venting system at protecting human health.

This alternative would be a contingent remedial action implemented through an institutional control in the form a deed restriction. The deed restriction would require the installation of a vapor barrier and a passive venting system and specify any indoor air monitoring requirements in any new building constructed in the area of the groundwater contamination plume until such time as contaminant concentrations are reduced below the PRGs. Exact composition and specification of the CM material would be decided during the design phase should implementation of this remedy be required for a hypothetical future building.

However, as **Figures 3-10** and **3-11** show, the plume is underneath a parking lot and that there are no permanent buildings/structures that are occupied within the footprint of the PCE and TCE plumes. While some office trailers can be seen in **Figure 3-10** and **Figure 3-11**, these trailers are elevated above the ground surface and do not have sub-surface foundations, thus eliminating any potential exposure to PCE and TCE vapors in indoor air originating from UWZ groundwater. As there are no human receptors within the plume footprint, the plume does not currently pose vapor intrusion risks. PCE and TCE plume would pose vapor intrusion risks if a building were to be constructed in the future while PCE and TCE concentrations exceeding respective PRGs remain on-site. However, there are no plans for construction of a building in this area for the foreseeable future.

<u>Effectiveness:</u> ALMs are generally chemically resistant and have low permeability for VOCs, although to a lesser extent than thermoplastic membrane vapor barriers. ALM vapor barriers in combination with a passive venting system would thus be effective in achieving the RAOs by reducing intrusion of PCE and

TCE vapors from the impacted groundwater plume into indoor air, thereby reducing human exposure in hypothetical future buildings constructed over the plume.

Implementability: This alternative would be easy to implement from an administrative standpoint as vapor barriers and passive venting systems are well-established technologies and can be incorporated into new construction. From a technical perspective, ALMs are easier to install than other vapor barriers such as thermoplastic membranes and composite membranes because use of ALMs eliminates the need for mechanical fastening and caulking at penetrations and terminations and provides a seamless barrier thereby reducing risk of membrane failure at seams. However, installation of ALMs would also require installation of an additional geotextile layer on top to protect the ALM from construction damage (ITRC, 2020). Application of multiple layers of spray-on asphalt latex may be needed to achieve minimum thickness. Time needed to complete installation may be longer than other methods as each layer needs to off-gas before the next one can be applied. ALMs are also harder to patch or repair (USEPA, 2008).

Cost: The capital cost associated with this alternative is anticipated to be moderate due to the costs of ALMs which are typically more expensive than geomembrane vapor barriers made from polymers such as HDPE. Periodic costs (including O&M and annual indoor air monitoring) are anticipated to be low.

Conclusion

ALMs are generally not as effective as other vapor barriers such as thermoplastic membranes and composite membranes, while also being harder to patch or repair than these other vapor barriers. As a result, alternative LGW-VB-2 has not been retained for further evaluation.

5.4.3 LGW-VB-3: Thermoplastic Membrane Vapor Barriers with Passive Venting System

This alternative addresses vapor intrusion risks from the impacted groundwater plume through a combination of thermoplastic membranes (TM) as a vapor barrier and a passive venting system in hypothetical future buildings constructed in the vicinity of the plume. TM vapor barriers are typically made from high-density polyethylene (HDPE), linear low-density polyethylene (LLDPE), and polyvinyl chloride (PVC) (ITRC, 2020). Thermoplastic membranes generally have relatively higher level of chemical resistance as compared to vapor barrier materials such as ALMs. Membranes less than 30 mil thick (0.762 mm) are not durable enough to withstand damage during placement of reinforcing steel and concrete and are not recommended for use in sub-slab applications. For HDPE membranes, a 40 to 60 mil minimum thickness is recommended by USEPA (USEPA, 2008). HDPE membranes, however, can be difficult to handle in tight spaces, and may present issues with sealing. Other materials such as LLDPE are more flexible and have comparable chemical and permeation resistance as HDPE.

The TM vapor barrier would be used in conjunction with a passive sub-slab venting system that relies on convective flow of warmed air upward in a vent pipe to draw air from beneath the slab. This alternative would also include annual post-construction indoor vapor monitoring to be conducted in any hypothetical future building in which the TM vapor barrier is installed to confirm effectiveness of the vapor barrier and passive venting system at protecting human health.

This alternative would be a contingent remedial action implemented through an institutional control in the form a deed restriction. The deed restriction would require the installation of a vapor barrier and a passive venting system and specify any indoor air monitoring requirements in any new building constructed in the area of the groundwater contamination plume until such time as contaminant concentrations are reduced below the PRGs. Exact composition and specification of the TM material would be decided during the design phase should implementation of this remedy be required in a hypothetical future building.

However, as **Figures 3-10** and **3-11** show, the plume is underneath a parking lot and that there are no permanent buildings/structures that are occupied within the footprint of the PCE and TCE plumes. While some office trailers can be seen in **Figure 3-10** and **Figure 3-11**, these trailers are elevated above the ground surface and do not have sub-surface foundations, thus eliminating any potential exposure to PCE and TCE vapors in indoor air originating from UWZ groundwater. As there are no human receptors within the plume footprint, the plume does not currently pose vapor intrusion risks. PCE and TCE plume would pose vapor intrusion risks if a building were to be constructed in the future while PCE and TCE concentrations exceeding respective PRGs remain on-site. However, there are no plans for construction of a building in this area for the foreseeable future.

<u>Effectiveness:</u> TM barriers have high chemical resistance and low permeance to VOCs. TMs generally exhibit higher chemical resistance and lower permeability to VOCs than ALMs. TM vapor barriers in combination with a passive venting system would thus be effective in achieving the RAOs by reducing intrusion of PCE and TCE vapors from the impacted groundwater plume into indoor air, thereby reducing human exposure in hypothetical future buildings constructed over the extent of the plume.

<u>Implementability:</u> This alternative would be easy to implement from an administrative standpoint as vapor barriers and passive venting systems are well-established technologies. From a technical standpoint, TMs can be incorporated into new construction, exhibit higher puncture resistance, and are less prone to being damaged during the construction process. However, installation of TMs is labor intensive as heat-welded seams, mechanical fastening, and sealing at penetrations and terminations is necessary to prevent leaks. Thicker membranes may be difficult to install (ITRC, 2020).

Cost: The capital cost associated with this alternative is anticipated to be moderate. Although the material cost of TMs is lower than that of ALMs, installation costs for TMs are higher than those for ALMs (ITRC, 2020). Periodic costs (including O&M and annual indoor air monitoring) are anticipated to be low.

Conclusion

Based on the effectiveness, implementability, and cost screening evaluation described above, alternative LGW-VB-3 has been retained to be included as a contingency measure.

5.4.4 LGW-VB-4: Composite Membrane Vapor Barriers with Passive Venting System

This alternative addresses vapor intrusion risks from the impacted groundwater plume through a combination of CM vapor barrier and a passive venting system in hypothetical future buildings constructed in the vicinity of the plume. CMs incorporate a variety of passive barriers to create a multilayer system designed to improve chemical resistance, constructability, and durability. Examples of CM vapor barriers include ethylene vinyl alcohol (EVOH) embedded between layers of polyethylene, and advanced CMs that include metallized films or foils to achieve improved chemical resistance (ITRC, 2020). CMs such as Geo-Seal®-100 (EPRO Services, Inc.) combine the high chemical resistance and very low permeability of HDPE with the constructability and low cost of ALMs by encapsulating the ALMs in HDPE.

The CM vapor barrier would be used in conjunction with a passive sub-slab venting system that relies on convective flow of warmed air upward in a vent pipe to draw air from beneath the slab. This alternative would also include annual post-construction indoor vapor monitoring to be conducted in any hypothetical future building in which the CM vapor barrier is installed to confirm effectiveness of the vapor barrier and passive venting system at protecting human health.

This alternative would be a contingent remedial action implemented through an institutional control in the form a deed restriction. The deed restriction would require the installation of a vapor barrier and a passive venting system and specify any indoor air monitoring requirements in any new building constructed in the area of the groundwater contamination plume until such time as contaminant concentrations are reduced below the PRGs.

Exact composition and specification of the CM material would be decided during the design phase should implementation of this remedy be required in a hypothetical future building.

However, as **Figures 3-10** and **3-11** show, the plume is underneath a parking lot and that there are no permanent buildings/structures that are occupied within the footprint of the PCE and TCE plumes. While some office trailers can be seen in **Figure 3-10** and **Figure 3-11**, these trailers are elevated above the ground surface and do not have sub-surface foundations, thus eliminating any potential exposure to PCE and TCE vapors in indoor air originating from UWZ groundwater. As there are no human receptors within the plume footprint, the plume does not currently pose vapor intrusion risks. PCE and TCE plume would pose vapor intrusion risks if a building were to be constructed in the future while PCE and TCE concentrations exceeding respective PRGs remain on-site. However, there are no plans for construction of a building in this area for the foreseeable future.

Effectiveness: CMs incorporate a variety of passive barriers to create a multilayer system designed to improve chemical resistance, constructability, and durability and lower the permeability. CM vapor barriers in combination with a passive venting system would thus be effective in achieving the RAOs by reducing intrusion of PCE and TCE vapors from the impacted groundwater plume into indoor air, thereby reducing human exposure to occupants in hypothetical future buildings constructed over the extent of the plume.

Implementability: This alternative would be easy to implement from a technical perspective as vapor barriers and passive venting systems are well-established technologies. From a technical standpoint, CMs can be incorporated into new construction. Products such as GEO-100® which consist of outer layer of HDPE would also be expected to exhibit high puncture resistance and be less prone to damage during the construction process. However, installation of CMs, especially smooth CMs may be challenging due to lack of adhesion to concrete surfaces and may need mechanical fastening and sealing at penetrations and terminations to prevent leaks. Thicker membranes may be difficult to install. Some thinner CMs (< 30 or 40 mil) may require regulatory approval prior to installation (ITRC, 2020). Minimum thickness requirements for vapor barrier membranes would likely present similar installation challenges as those identified for TM vapor barriers.

Cost: The capital cost associated with this alternative is anticipated to be moderate. Periodic costs (including O&M and annual indoor air monitoring) are anticipated to be low.

Conclusion

TMs have been widely used in vapor barrier installations for vapor intrusion risks from PCE and TCE. The relatively low levels of PCE and TCE in groundwater can be sufficiently addressed using TMs. CMs would not provide any additional benefits over TMs with regards to reducing vapor intrusion risks from relatively low levels of PCE and TCE. As a result, alternative LGW-VB-4 has not been retained for further evaluation.

5.5 Screening of Assembled Alternatives for Restoration of PCE-Impacted Groundwater in UWZ

5.5.1 Alternative LGW-GR-1: No Action

This alternative does not include any remedial action or implementation of any ICs for restoring groundwater impacted by PCE and TCE. Furthermore, no monitoring of groundwater would be carried out under this alternative.

Effectiveness: This alternative would not be effective in achieving the RAOs as PCE and TCE concentrations exceeding DCMR Title 21 standards would remain on-site.

Implementability: This alternative would be easy to implement from both technical and administrative standpoints as no remedial actions would be carried out and no ICs would be implemented.

Cost: There is no cost associated with this alternative as no remedial actions would be carried out and no ICs would be implemented.

Conclusion

Although LGW-GR-1 would not be effective in achieving the RAOs, it has been retained for detailed analysis to serve as a baseline for comparison with other remedial alternatives.

5.5.2 Alternative LGW-GR-2: MNA, Groundwater Monitoring, and ICs

As discussed in Section 2.9, various lines of evidence support the conclusion that there are no continuing PCE sources present on-site and that the plume is stable. Concentrations of chlorinated VOCs in the UWZ groundwater are one to six orders of magnitude below the DNAPL threshold, indicating that the PCE source (likely to be off-site) is depleted.

Prior RI investigations thoroughly investigated and delineated the extent of on-site groundwater contamination of PCE, which included direct push groundwater samples collected during 2013 and 2014, and sample collection from on-site monitoring wells during 2014 and 2016. During these events, PCE and associated CVOCs were detected in the UWZ at DP-09/MW-09A and several nearby locations along the southern border of the Site. PCE also was previously detected in the both the UWZ and LWZ at MW-1 in the southwest corner of the site. However, during the post-RI investigation (AECOM, 2023), chlorinated VOCs including PCE were no longer detected in the UWZ or LWZ in this area of the Site. Historically, the highest PCE concentrations were detected at sampling locations along the southern property boundary and the concentrations uniformly and rapidly declined toward the interior of Pepco property. Several downgradient wells (MW01A, MW01B, MW02A, MW05A) have shown decreasing concentrations in sampling events from 2014, 2016, and 2021, including non-detect at MW01A, MW01B, and MW02A in 2021.

PCE daughter products were observed at some of the locations sampled at the Site. In the 2021, sampling, daughter products up to cis-DCE were observed in three wells (TP-04A, MW-09A, and MW-9B). Degradation to TCE was observed in three wells one on site well (TP-01A) and two off-site wells (TP-10A and 11A).

The above results indicate that natural attenuation is gradually occurring at the site. Natural attenuation may be occurring via a combination of physical (such as dilution, dispersion, and diffusion), biological, and chemical processes. As documented in the PCE Data Gap Investigation (AECOM, 2023), dissolved oxygen levels < 1 mg/L (indicative of anaerobic conditions) were observed in several wells in the UWZ and LWZ. PCE daughter products (up to cis-1,2-DCE) were observed in two UWZ wells, while degradation of PCE to TCE was observed in one on-site UWZ well. ORP levels of -200 to -250 mV as typically required for complete biological degradation to ethene were only observed in the one well in the LWZ. These observations indicate that conditions in the sub-surface are not favorable for complete biological dechlorination.

Groundwater in DC is not currently being used as a source of drinking water. Based on a review of the Environmental Data Resources report dated August 2023, no public water supply wells are located within a one-mile radius of the Site, and a USEPA 2009 Site Inspection Report documented that there are no drinking water intakes located within 15 miles of the Site. These reports provide strong evidence to support that groundwater in the vicinity of the Site is not used for drinking water purposes. The primary economic water-producing aquifer in this area is the Patuxent aquifer located beneath the Arundel formation. sands in the Patapsco Formation, which comprises the UWZ at the site, are typically thin and do not produce sufficient water to be locally considered an aquifer (D.C. Water Resources Research Center, 1995). It is therefore unlikely that the water in the UWZ (located above Arundel Clay) could ever be developed as a viable water resource due quality and yield concerns. Potential risks to human health from exposure to on-site groundwater are therefore unlikely and can be addressed using ICs.

No ecological receptors for groundwater were identified in the LIA. Furthermore, simulations of on-site groundwater discharge to the Anacostia River conducted as part of the ARSP groundwater modeling report (Tetra Tech, 2019) predicted the maximum PCE porewater concentration to be below 1 µg/L, which is at least two orders of magnitude lower than the 4-day surface water criterion (800 µg/L). Based on these modeling results, the report predicted no adverse impacts to surface sediment biota from discharge of PCE-containing groundwater from the Site to the Anacostia River.

Based on the above discussion, this alternative relies natural attenuation occurring within the subsurface to reduce the chlorinated VOC concentrations over time. It includes implementing a groundwater monitoring program and ICs to manage risks from chlorinated VOCs in groundwater.

MNA with long-term groundwater monitoring would be implemented along with ICs to ensure groundwater plume does not impact any human or ecological receptors. A long-term groundwater monitoring plan would be prepared as part of the Remedial Design following the selection of groundwater remedy. This plan would describe an approach to evaluate the progress of MNA at the site by measuring groundwater parameters such as:

- Field parameters (such as DO, ORP, pH, temperature, and conductivity)
- Concentrations of PCE and daughter products,
- Geochemical parameters for evaluating MNA (such as nitrate, sulfate, dissolved iron, total organic carbon)
- Biological parameters (to confirm presence and activity of PCE-dechlorinating microorganisms).
- Other analytes (such as dissolved gases, volatile fatty acids) for evaluating MNA

Six additional monitoring wells would be installed in the UWZ (to a maximum depth of 25 to 30 ft.) and monitoring data would be used to: (a) confirm that no on-site PCE source exists; (b) evaluate whether plume is stable or shrinking; (c) confirm that no risks to human and ecological receptors are anticipated; (d) evaluate whether concentrations of PCE and daughter products continue to exhibit downward trends; and (e) evaluate the progress of MNA in reducing CVOC concentrations in on-Site groundwater.

Effectiveness: While PCE and TCE concentrations exceeding DCMR Title 21 standards would remain on-site, long-term groundwater monitoring and ICs would be implemented to confirm that the existing conditions, for which no risks to human or ecological receptors are identified, would continue to be maintained. Groundwater monitoring results indicate that natural attenuation is gradually occurring at the Site.

Implementability: This alternative would be easy to implement from both technical and administrative standpoints.

Cost: The cost for this alternative is anticipated to be moderate and would be primarily for installation of additional monitoring wells, implementation of ICs, permits, preparation of monitoring plan, remedial design, long-term groundwater monitoring and analysis, as well as five-year reviews and periodic reporting.

Conclusion

LGW-GR-2 been retained for detailed analysis.

5.5.3 Alternative LGW-GR-3: Treatment via Permanganate Injection, with MNA and ICs

This alternative relies on delivery of a chemical oxidant, in the form of potassium or sodium permanganate ($KMnO_4$ and $NaMnO_4$, respectively), to the impacted groundwater in the UWZ to destroy PCE and associated daughter products (TCE, DCE, and VC) and convert them to non-hazardous products (carbon dioxide and water). The reactive species is the permanganate ion, MnO_4^-, which reacts with PCE and daughter products to convert them to CO_2 and water with MnO_2 as a by-product, and without formation of toxic intermediates such as DCE isomers and VC (USEPA, 2006). In this alternative, aqueous solutions of $KMnO_4$ or $NaMnO_4$ would be delivered to the impacted groundwater plume via a series of injection wells.

Additional monitoring wells would be installed in the UWZ (to a maximum depth of 25 to 30 ft.), and groundwater would be monitored for PCE, degradation products, and performance parameters. Additional injections would be performed as necessary until groundwater standards are achieved. Post-remedy monitoring for rebounding of PCE and daughter products would be implemented. This alternative also would include ICs as described in Section 5.1.

Effectiveness: Permanganate oxidation is highly effective for degrading PCE and daughter products. Permanganate is long-lasting in the aquifer and can persist and react with potential COCs several months after injections are complete (USEPA, 2006). However, bench-scale and pilot-scale treatability studies would be needed to evaluate applicability of this process options for on-site groundwater and its effectiveness in achieving the groundwater standards for respective potential COCs. Effectiveness would also depend upon the extent to which proper distribution of the permanganate solution can be achieved in the sub-surface. Additionally, organic and inorganic constituents in soil and groundwater can impose a background oxidant demand due to reaction of permanganate with these constituents, thus reducing its efficacy (U.S. Department of Energy, 1999; USEPA, 2006).

Implementability: Chemical oxidation via permanganate injection is a well-developed technology, materials and methods needed are readily available, and it has been applied successfully at several sites for treating PCE and TCE in groundwater. The sub-surface geology in the UWZ consists of sand/gravel and intermixed clay, silt, and sand, which would be somewhat favorable for injection of permanganate. Permanganate oxidation can work under a wide pH range of 3.5 to 12 and is independent of pH in the range of 4 to 8 (USEPA, 2006), which would be suitable for the site as groundwater pH ranges between 4.41 to 6.54 (AECOM, 2023). However, depending upon extent of distribution of the oxidant in the sub-surface, multiple injections may be needed which may impact surrounding on-site activities. Chemical oxidation of PCE and TCE does not lead to formation of toxic intermediates such as DCE isomers and VC. Reaction by-product, MnO_2, is an insoluble precipitate and can reduce the permeability of the aquifer (ITRC, 2005). Permanganate injection can also impact the existing redox conditions and pH in the sub-surface, leading to mobilization of metals. Background oxygen demand is anticipated to be high, which would require injection of large quantities of oxidant into the sub-surface to effectively treat PCE and TCE. Use of permanganate impart a purple color to the groundwater, which can be observed in connected surface water bodies and wells if permanganate distribution is not controlled (USEPA, 2006). This alternative can thus be regarded as being moderately difficult to implement.

Cost: Due to the large plume footprint, the quantity of oxidant required to overcome the natural (background) oxidant demand is expected to be high, thereby resulting in high implementation costs. Capital costs for this alternative would be associated with material costs for sodium permanganate, injection of oxidant into the sub-surface, preparation of long-term groundwater monitoring plan, permitting costs, and implementation of

ICs. O&M costs after remedy implementation are anticipated to be moderate and would primarily consist of periodic reviews and groundwater sampling.

Conclusion

Due to issues surrounding the implementability of chemical oxidation via permanganate and anticipated high costs, alternative LGW-GR-3 is not retained for detailed evaluation.

5.5.4 Alternative LGW-GR-4: Treatment via ZVI Injection, with MNA and ICs

ZVI is an amendment capable of facilitating the electrochemical reduction of chlorinated compounds such as PCE, TCE, DCE, and VC to ethane and ethene. While ZVI is typically used in permeable reactive barriers (PRB) for in-situ remediation of impacted groundwater plumes, it can also be directly injected into the sub-surface as a slurry. Several commercial products such as S-MicroZVI® (REGENESIS Bioremediation Products), Ferox Flow and Ferox Plus eZVI (both from Hepure), EHC® Liquid Reagent and EHC® Plus (both from Evonik Active Oxygens), and CleanER™ iZVI (Cascade Environmental) are available and have been used for remediation of PCE-impacted groundwater. Another potential product is BOS 100® (Remediation Products, Inc.), which uses carbon impregnated with metallic iron, and can be injected as a slurry into the sub-surface.

In this alternative, a commercially available ZVI product would be used to treat PCE and daughter products in groundwater. Within the 300 ppb total VOC plume, referred to as “MW-09 Treatment Zone” **(Figure 5-6)**, ZVI would be injected into the sub-surface via direct push methods at a ZVI-to-soil dose of 0.25%. This zone was selected for direct ZVI injection because it encompasses several locations with the highest total VOC concentration such as DPB7 (520 µg/L), MW09A (460 µg/L), DPB6 (370 µg/L), DPA4 (340 µg/L), and DPA3 and DPA5 (300 µg/L each).

Downgradient of the MW-09 Treatment Zone, ZVI would be injected into the sub-surface via direct push methods (at a ZVI-to-soil dose of 0.63%) along a transect to create a ZVI “curtain”. This ZVI “curtain” would treat PCE and daughter products in the groundwater flowing through the curtain. Additional monitoring wells would be installed in the UWZ (to a maximum depth of 25 to 30 ft.) and groundwater would be monitored for PCE, degradation products, and performance parameters. Within the MW-09 Treatment Zone, two ZVI injections are assumed to be sufficient. The conceptual approach for implementation of this alternative is shown in **Figure 5-6**.

Under optimal sub-surface conditions (such as ORP < -400 mV), use of ZVI minimizes formation of toxic daughter products such as DCE and VC via degradation of PCE and TCE. However, in the absence of sufficiently reducing conditions, partial dechlorination of PCE and TCE can occur, resulting in formation and accumulation of DCE and VC in the sub-surface (Gavaskar et al., 2005). Thus, addition of sufficient ZVI amendment to create strongly reducing conditions suitable for ensuring complete dechlorination, along with monitoring of groundwater conditions, PCE and daughter products is critical. Post-remedy monitoring for rebounding of PCE would be implemented. This alternative also would include ICs as described in Section 5.1.

Effectiveness: ZVI has been demonstrated to be highly effective for degradation of PCE and daughter products. Bench- and pilot-scale treatability studies would be needed to evaluate applicability of this process option for on-site groundwater and its effectiveness in achieving the groundwater standards for potential COCs. Effectiveness would also depend upon the extent to which proper distribution of the ZVI slurry can be achieved in the sub-surface. Larger ZVI particles generally have lower reactivity than smaller (micro or nano-sized) but have longer stability (Labeeuw, 2013). Thus, effectiveness of the alternative would also depend upon particle size of the selected commercial product and would need to be evaluated in bench-scale studies.

Implementability: In-situ chemical reduction of PCE and daughter products using ZVI is a well-developed technology with several commercial products available and which have been used at multiple sites for remediation of impacted groundwater. The sub-surface geology in the UWZ consists of sand/gravel and intermixed clay, silt, and sand, which would be somewhat favorable for injection of ZVI slurry. Depending upon the reactivity and stability of the ZVI particles, multiple rounds of injection may be needed which may impact surrounding on-site activities. Existing conditions in several on-site wells, such as dissolved oxygen levels < 1 mg/L and low values of oxidation-reduction potential (ORP) observed at a few monitoring wells, are somewhat favorable for reductive dechlorination as evidenced by presence of daughter products TCE and cis-1,2-DCE in some of the on-site wells (AECOM, 2023). However, conditions are not favorable for complete dechlorination of PCE and TCE to ethene and ethane but may be enhanced by injection of sufficient quantities of ZVI. Sufficiently reducing conditions (ORP < -400 mV) are typically required to prevent formation and accumulation of DCE and VC. Degradation reactions for PCE and TCE in presence of ZVI are faster at lower pH values than at higher pH values, and degradation is significantly retarded at pH of 8.1 and above (Cook, 2009). The site groundwater exhibits pH range 4.41 to 6.54 (AECOM, 2023) and thus, would be potentially suitable for treatment via ZVI. The implementability of this alternative can thus be regarded as moderate.

Cost: Cost of implementing this alternative is anticipated to be moderate. Capital costs for this alternative would be associated with procurement of ZVI, injection of ZVI into the sub-surface, preparation of long-term groundwater monitoring plan, permitting costs, and implementation of ICs. O&M costs after remedy implementation are anticipated to be moderate and would primarily consist of periodic reviews and groundwater sampling.

Conclusion

Alternative LGW-GR-4 is being retained for detailed evaluation.

5.5.5 Alternative LGW-GR-5: Treatment via Biowalls and ZVI Injection, with MNA and ICs

This alternative would treat PCE and daughter products in groundwater using a combination of bioremediation and ZVI. Bioremediation involves application of substrates, nutrients, and/or microbes via injection wells, in conjunction with injectable reactive media, to enhance biodegradation of PCE and TCE in groundwater via reductive dechlorination process. Injectable reactive media such as ZVI can be used to further enhance the reductive dechlorination process. The mechanism for dechlorination via ZVI was discussed under Alternative LGW-GR-4 above. This alternative thus combines biotic and abiotic dechlorination processes to degrade PCE and daughter products in the groundwater.

Existing conditions in several on-site wells, such as dissolved oxygen levels < 1 mg/L and low values of ORP, are somewhat favorable for reductive dechlorination as evidenced by presence of daughter products TCE and cis-1,2-DCE in some of the on-site wells (AECOM, 2023). This alternative would enhance the dechlorination process to enable degradation of PCE and daughter products to ethene. Typical substrates include sodium lactate, methanol, ethanol, molasses, high fructose corn syrup, etc. which are fast-release substrates. Slow-release substrates include vegetable oils, vegetable oil emulsions, and whey (USEPA, 2013). Bioaugmentation may be necessary if the on-site soils do not have sufficient or sufficiently active population of halorespirers. Native or injected microbial population of halorespirers use substrates as electron donors and in the process, sequentially dechlorinate PCE to ethene, via formation of TCE, cis-1,2-DCE, and vinyl chloride as intermediate reaction products. However, the groundwater pH ranges from 4.41 to 6.54 at the site, which is not conducive for survival and growth of microbial populations.

To account for the above conditions, bioremediation under this alternative would be implemented using underground trenches filled with a mixture of limestone and mulch, typically referred to “permeable mulch biowalls (Parsons, 2008)”. The limestone would increase the pH of the groundwater as it passes through the biowalls. Within each biowall, mulch would serve as a slow-release substrate to stimulate growth of native dechlorinating bacteria. Emulsified vegetable oil (EVO), an additional substrate, would be injected into the biowall using PVC pipes installed along the length of the biowall. Some bioaugmentation may be necessary at the beginning of the treatment.

The conceptual approach for implementation of this alternative is shown in **Figure 5-7**.

Overall, three biowalls would be constructed along the length of the plume. These are designated as “Biowall A” (close to the eastern edge of the plume), “Biowall B” (downstream of Biowall A), and “Biowall C” (close to the western edge of the plume).

Due to the presence of underground utilities within the plume footprint, Biowall #B and Biowall #C in the western half of the plume cannot be constructed across the entire width of the plume. At these two locations, biowalls would be constructed up to a safe offset distance from the underground utility lines running east to west. The plume areas between the edge of the plume and biowalls containing the utility lines would be treated by injecting ZVI at a dose of 0.25% (ZVI-to-soil) to create ZVI "curtains." These curtains would treat PCE and daughter products in the groundwater passing through them.

Downgradient of the biowalls, ZVI would be injected into the sub-surface via direct push methods (at a ZVI-to-soil dose of 0.63%) along a transect to create a ZVI "curtain". The ZVI curtain would be created just beyond the western edge of the plume to treat any remaining PCE and daughter products in the groundwater flowing through the curtain.

Additional monitoring wells would be installed in the UWZ (to a maximum depth of 25 to 30 ft.) and groundwater would be monitored for PCE, degradation products, and performance parameters. Anaerobic reductive dechlorination of PCE results in formation of toxic intermediates such as TCE, DCE and its isomers, or vinyl chloride. Thus, ensuring that conditions suitable for complete dechlorination continue to exist in the sub-surface is necessary and monitoring of PCE and degradation by-products is critical. Post-remedy monitoring for rebounding of PCE would be implemented. This alternative also would include ICs as described in Section 5.1.

<u>Effectiveness:</u> Enhanced reductive dechlorination and ZVI are demonstrated technologies for effective treatment of PCE and daughter products. Bench-scale studies would be needed to evaluate applicability of this process option for on-site groundwater and its effectiveness in achieving the groundwater standards. As discussed earlier, existing conditions are not suitable for biotic dechlorination pathway and would require amendments such as limestone, substrates, and possibly bioaugmentation to achieve the conditions necessary for this remedy to be effective. Effectiveness would also depend upon the extent to which proper distribution of the substrates, microbes, and ZVI can be achieved in the sub-surface. Anaerobic reductive dechlorination of PCE may result in accumulation of toxic intermediates such as TCE, cis-1,2-DCE, and vinyl chloride. However, when properly implemented, this remedial alternative can fully degrade PCE and these intermediates to ethene.

<u>Implementability:</u> In-situ dechlorination of PCE and daughter products using enhanced bioremediation and ZVI is a well-developed technology that has been applied at several sites for remediation of PCE-impacted groundwater. The sub-surface geology in the UWZ consists of sand/gravel and intermixed clay, silt, and sand, which would be somewhat favorable for injection of substrates, nutrients, ZVI, and microbial amendments. Existing conditions in several on-site wells, such as dissolved oxygen levels < 1 mg/L and low values of ORP, are somewhat favorable for partial reductive dechlorination as evidenced by presence of

daughter products TCE and cis-1,2-DCE in some of the on-site wells (AECOM, 2023). The groundwater pH is not conducive for survival and growth of microbial populations but can be raised by incorporating limestone within the biowalls. Overall, conditions are not favorable for complete dechlorination of potential COCs to ethene and but may be enhanced using appropriate substrates. Depending upon the conditions in the aquifer, multiple rounds of injection may be needed which may impact surrounding on-site activities. Due to the presence of underground utilities within the plume footprint, challenges to construction of underground trenches are anticipated. Maintaining the conditions necessary for dechlorination processes, such as pH, ORP, and sufficient concentration of electron donors in the sub-surface, until PRGs are achieved (likely to require several years) is expected to be difficult. The implementability of this alternative can thus be regarded as difficult.

Cost: Cost of implementing this alternative is anticipated to be moderate to high. Capital costs for this alternative would be associated with cost of trenching, procurement of reagents (ZVI, substrates, bioaugmentation culture), injection of reagents into the sub-surface, disposal of soil excavated from trenches, preparation of long-term groundwater monitoring plan, permitting costs, and implementation of ICs. O&M costs after remedy implementation are anticipated to be moderate and would primarily consist of periodic reviews and groundwater sampling.

Conclusion

Alternative LGW-GR-5 is being retained for detailed evaluation.

5.5.6 Alternative LGW-GR-6: Groundwater Extraction and Treatment using GAC, with MNA and ICs

This alternative would extract the groundwater to remove PCE and daughter products by adsorption on GAC. This system is typically referred to as a “pump and treat” system.

Under this alternative, groundwater extraction wells would be installed within the plume footprint. The conceptual approach for implementation of this alternative is shown in **Figure 5-8**. Extracted groundwater would be pumped to a treatment building consisting of two GAC vessels in series, in which PCE and daughter products in the groundwater would be removed via adsorption on GAC. The treated water would be discharged to a publicly owned treatment works (POTW) or the MS4 system under appropriate permits.

Additional monitoring wells would be installed in the UWZ (to a maximum depth of 25 to 30 ft.) and groundwater would be monitored for PCE, degradation products, and performance parameters. This alternative also would include ICs as described in Section 5.1.

Effectiveness: GAC is a commonly used and highly effective adsorbent for removal of PCE and daughter products in pump and treat systems. Bench scale studies can be used to select appropriate GAC product suitable for on-site groundwater. Effectiveness of the system may be limited by low yields from the aquifer. Aquifer tests are needed to determine long-term groundwater extraction rates that can be sustained at the site and the time required for achieving the RAOs.

Implementability: Pump and treatment systems with GAC have been used at many sites for treatment of groundwater impacted with PCE and daughter products. Materials, methods, and services required for pump and treat systems are thus readily available. Implementability of this alternative may be limited by low groundwater yields from the aquifer. Additionally, groundwater pumping creates risk of drawing unknown off-site contaminants on to the Site. The implementability of this alternative can thus be regarded as moderate to difficult.

Cost: Cost of implementing this alternative is anticipated to be moderate to high. Capital costs for this alternative would be associated with installation of extraction wells, pipelines, treatment building, material costs (GAC, bag filters, chemical amendments to reduce precipitation of metals), preparation of long-term groundwater monitoring plan, permitting costs, and implementation of ICs. O&M costs after remedy implementation are anticipated to be high mainly due to costs related to GAC replacement and system operation over the lifetime of the remedy.

Conclusion

Alternative LGW-GR-6 is being retained for detailed evaluation.

5.6 Summary of Assembled Remedial Alternatives Retained for Detailed Evaluation

Based on the additional screening of assembled alternatives in Section 5.1 to 5.4, the following alternatives are being retained for detailed evaluation. Description and screening of assembled remedial alternatives is summarized in **Tables 5-1** to **5-4**.

Remedial Action Alternatives for PCB-Contaminated Soils

- **LSS-PCB-1:** No Action
- **LSS-PCB-2:** Removal with Off-Site Treatment and Disposal of PTSM, and ICs
- **LSS-PCB-4:** Removal with Off-Site Treatment/Disposal of PTSM, Surface Soils with PCBs > 7 mg/kg, and Select Sub-Surface Soils (1-2 ft.), and ICs

- **LSS-PCB-5:** Removal with Off-Site Treatment/Disposal of PTSM and Soils (0-2 ft.) with PCBs > 7 mg/kg, and ICs

Remedial Action Alternatives for Vanadium-Contaminated Soils

- **LSS-V-1:** No Action
- **LSS-V-2:** ICs
- **LSS-V-3:** Excavation with Off-Site Disposal, and ICs

Remedial Action Alternatives for Addressing Vapor Intrusion Risks from PCE and TCE in UWZ Groundwater

- **LGW-VB-3**: Thermoplastic Membrane Vapor Barriers with Passive Venting System[5]

Remedial Action Alternatives for Restoration of PCE-Impacted Groundwater in UWZ

- **LGW-GR-1:** No Action
- **LGW-GR-2:** MNA, Groundwater Monitoring, and ICs
- **LGW-GR-4:** Treatment via ZVI Injection, with MNA and ICs
- **LGW-GR-5:** Treatment with Biowalls and ZVI, with MNA and ICs
- **LGW-GR-6:** Groundwater Extraction and Treatment using GAC, with MNA and ICs

[5] LGW-VB-3 was the only alternative retained for addressing vapor intrusion risks from PCE and TCE in UWZ groundwater. This alternative would be considered for implementation should a building be constructed over the plume before the PRGs for vapor intrusion are met. There are no plans for any such building within this area at present time.

6 Detailed Analysis of Alternatives

The Remedial Action Alternatives (RAAs) described in Section 5.6 for different site media are subjected to detailed analysis in this section. The RAAs use combinations of active remedial approaches (e.g., excavation, in-situ groundwater remediation, etc.) and passive approaches (e.g., ICs, MNA) to achieve RAOs in the areas with actionable risk. In this section, the individual RAAs are evaluated against CERCLA evaluation criteria.

6.1 CERCLA Evaluation Criteria

The NCP and USEPA RI/FS Guidance (USEPA, 1988) require consideration of nine evaluation criteria in the detailed analysis of remedial alternatives. These nine criteria fall into three distinct categories: threshold criteria, primary balancing criteria, and modifying criteria. The two “threshold criteria” are protection of human health and the environment, and compliance with the ARARs. RAAs that meet the “threshold criteria” are then evaluated according to the five “primary balancing criteria,” which include (i) long-term effectiveness and permanence, (ii) reduction of toxicity, mobility, or volume through treatment, (iii) short-term effectiveness, (iv) implementability, and (v) cost. The final two remedy evaluation criteria are “modifying criteria” and include regulatory agency acceptance and community acceptance.

Each alternative is evaluated individually and comparatively against the first seven evaluation criteria. The “modifying criteria” are assessed following the review of the FS by DOEE and public comment on DOEE’s Proposed Plan. Agency and public comments are fully addressed in the Record of Decision. Descriptions of each of the nine remedy evaluation criteria are provided below.

1. Overall Protection of Human Health and the Environment: This criterion evaluates whether each alternative provides adequate protection of human health and the environment. This criterion also examines how each alternative manages the site risks in accordance with the RAOs.
2. Compliance with ARARs: This criterion evaluates whether each alternative complies with ARARs identified in **Table 3-1**. All RAAs that undergo detailed evaluation are designed to comply with the ARARs through permitting and regulatory reviews of the proposed remedial action.
3. Long-Term Effectiveness and Permanence: This criterion evaluates the magnitude of residual risk that may remain after implementation of an alternative, as well as the adequacy and reliability of controls that may be required to manage the residual risk. This criterion also evaluates long-term monitoring and maintenance requirements.
4. Reduction of Toxicity, Mobility, or Volume Through Treatment: This criterion is used to assess the degree to which an RAA reduces toxicity, mobility, or volume through treatment.

5. Short-Term Effectiveness: This criterion evaluates the effects on human health and the environment during the construction and implementation phase. This criterion also evaluates protection of the community and workers, potential environmental impacts, and planned mitigation until the RAOs are achieved.

6. Implementability: This criterion evaluates the technical and administrative feasibility of implementing each alternative. Technical feasibility relates to the ability of an alternative to be constructed and operated, the reliability of the technology, and whether it can accommodate phased implementation or modifications based on ongoing monitoring. Administrative feasibility considers ability and time required to obtain the necessary approvals and permits and the activities requiring coordination with other services (including off-site treatment, storage, and disposal facilities), equipment, specialists, services, materials, and prospective technologies.

7. Cost: This criterion evaluates the cost of each alternative. Typically, these cost estimates are expected to provide an accuracy of +50 to -30% and are prepared using available data. They do not represent actual construction cost estimates or real costs at completion. The cost estimates include capital and annual/periodic O&M costs with a 30% contingency. Professional/technical services are estimated as a percentage of the direct capital cost consistent with the USEPA feasibility-study guidance (USEPA, 1988) and include project management and agency review and oversight. Long-term costs are estimated over a 30-year period, and net present worth costs are calculated using a 3% discount rate (determined by Pepco[6]). Key assumptions used for developing cost estimates are provided in **Appendix E**.

8. Regulatory Agency Acceptance: This criterion evaluates the technical and administrative issues and comments that the regulatory agency may have regarding each of the alternatives. This criterion is evaluated during the preparation of the Proposed Plan.

9. Community Acceptance: This criterion evaluates the issues and concerns the public may have regarding each of the alternatives. This criterion is addressed in the ROD once comments on the Proposed Plan have been received.

A No Action alternative is evaluated for each remedial action. The No Action alternatives do not include any remedial activities or ICs and would not achieve RAOs in a reasonable timeframe, but the NCP and

[6] For commercial entities and for profit corporations, the discount rate will be company-specific as it is related to how the company gets its funds. It is the rate of return that the investors expect or the cost of borrowing money. Pepco determined their company-specific discount rate to be used in the present worth calculations to be 3%. This is also in line with the long-term average published by OMB.

CERCLA require consideration of the “No Action” alternative as a baseline for comparison of the other GRAs/alternatives. Since the No Action alternatives do not meet the threshold criteria (Overall Protection of Human Health and the Environment, and Compliance with ARARs), No Action alternatives are not evaluated for balancing criteria.

6.2 Site-Specific Considerations

This section provides an evaluation of site-specific conditions as they apply to the evaluation criteria. This section includes a compilation of site-specific considerations based on the information collected during the RI.

6.2.1 Landside Features

The Site is entirely secured by a fence with two guarded entrances. The main guard station at 3400 Benning Road is staffed 24 hours a day, 7 days a week. The second entrance is also guarded during all times when gates are open (i.e., during business hours). Thus, the Site access is restricted to personnel authorized by Pepco. As a result, only on-site workers and construction workers are subject to exposure to landside risks. Existing pavement and gravel cover further reduce exposure of on-site workers to Site soils. Pepco will prepare an SMP as part of the ICs described in Section 5.1 above. As discussed below, the SMP will be a key element of the landside RAAs.

Numerous aboveground and underground utilities exist on Site and may act as preferential pathways for injected chemicals. Elevated, at-grade, and underground metro rail infrastructure operated by Washington Metropolitan Area Transit Authority (WMATA) and associated easements exist along the southern boundary of the Site. Infrastructure setback requirements may limit certain activities. A retaining wall exists along the southern boundary near the Transformer Shop area. This retaining wall supports Kenilworth Avenue and may limit excavation activities in this area.

6.2.2 Groundwater Conditions and PCE Natural Attenuation

Field parameters collected in March 2021 as part of the PCE investigation were examined to understand the subsurface environmental conditions (AECOM, 2021b). A total of 13 wells in the UWZ were monitored (with one of the wells going dry). Groundwater was slightly acidic, with UWZ pH levels ranging from 4.41 to 6.68. Several wells in both the UWZ and LWZ indicated dissolved oxygen (DO) concentrations of less than 1.0 mg/L, a level that is generally associated with anaerobic conditions. Another important field parameter is the ORP which indicates whether the subsurface is characterized by oxidizing conditions (higher positive values) or reducing conditions (lower negative values). Oxidative and reductive potentials were observed in both the UWZ and LWZ; the highest ORP was found in the UWZ, while the lowest ORP was found in the LWZ. Degradation of PCE to TCE was observed in one on-site well and two off-site wells. Anaerobic conditions below an ORP of 500 mV are generally conducive to initiate the reductive dichlorination by halorespirers. ORP levels of -200 to -250 mV are conducive to complete dechlorination of PCE to ethene under favorable environmental conditions and when sufficient microbial populations are present. ORP levels within this range were only observed in one location in the LWZ where all CVOC concentrations were non-detects. Based on this information, it appears that the current conditions in the subsurface are not favorable to complete dechlorination within most areas of the PCE plume but can be potentially enhanced by substrate addition and bioaugmentation. MNA through biological and chemical degradation pathways is limited at this site and MNA would rely mostly on physical degradation processes.

6.3 Detailed Analysis of RAAs for PCB-Contaminated LIA Soil

6.3.1 Alternative LSS-PCB-1: No Action

This alternative does not include any remedial activities or ICs and would not achieve RAOs in a reasonable timeframe. This alternative serves as a baseline condition against which other remedial alternatives are compared. Following is a summary of the evaluation of this alternative:

<u>Overall Protection of Human Health and the Environment</u>: No remedial actions are proposed as part of this alternative and PCBs exceeding PRGs would remain in soil; therefore, potential human health risks are not mitigated. This alternative is not protective of human health. No ecological risks were identified for the LIA.

<u>Compliance with ARARs</u>: This alternative would not reduce human health risks posed by PCBs in soil. Therefore, this alternative does not comply with the ARARs.

Since the No Action alternative does not meet the threshold criteria (Overall Protection of Human Health and the Environment, and Compliance with ARARs), it is not evaluated for balancing criteria.

6.3.2 Alternative LSS-PCB-2: Removal with Off-Site Treatment and Disposal of PTSM, and ICs

This alternative relies on excavation and treatment of PTSM in the Transformer Shop area to achieve the RAOs. Approximately 1.8 CY of PTSM would be excavated and treated via incineration at an off-site facility. The excavated area would be backfilled with clean soil. DOEE regulations require that the clean fill comply with EPA industrial risk screening levels (RSLs). Specific criteria for clean fill will be finalized at the remedial design stage. The asphalt pavement over the excavated area would be restored for operational and personnel safety. The asphalt pavement (existing as well as that installed over backfilled areas) would isolate remaining soil from human receptors. The thickness of the existing asphalt pavement over soils in the Transformer Shop area ranges from 0.5 ft. to 0.83 ft. based on the geotechnical boring logs from the RI (AECOM, 2020). The asphalt pavement is currently in good conditions and is maintained regularly and repaired as needed.

In addition, as described in Section 5.1, the ICs for this alternative will help to minimize the potential for exposure to contaminated media by controlling activities that may disturb the existing asphalt pavement. The following is a summary of the evaluation of this alternative:

Overall Protection of Human Health and the Environment: Post-excavation risk assessment results **(Appendix D)** show that removal of PTSM (i.e., soils with PCB concentration of 8,800 mg/kg) reduces the surface soil EPC (for future outdoor worker) to 11.3 mg/kg, which is greater than the overall PRG of 7 mg/kg, but reduces the excess lifetime cancer risks to 1E-05. Removal of PTSM under this alternative also reduces the combined soil EPC (for current/future construction worker) to 75 mg/kg, representing a 40% reduction over the current EPC of 126 mg/kg for combined soils. The asphalt pavement (existing as well as that installed over backfilled areas) would isolate remaining soil from human receptors. No ecological risks were identified for the LIA. ICs, including fencing and security, signage, a deed notice and an SMP, would be implemented to inform target populations about risks, limit exposures to soil impacted by potential COCs, and manage any residual impacts by controlling construction in the area. Therefore, this alternative is protective of human health and the environment.

Compliance with ARARs: This alternative would be implemented pursuant to the risk-based option under TSCA. This alternative also meets the EPA expectation of treatment of Principal Threat Material. Therefore, this alternative meets this threshold criterion of compliance with ARARs.

Long-Term Effectiveness and Permanence: Excavation and treatment of PTSM would be a permanent measure that removes soils with elevated PCB levels from the site. The asphalt pavement (existing as well as that installed over backfilled areas) would provide long-term protection from exposure to remaining PCBs in soil. An SMP would be implemented to control unauthorized excavations limiting exposure. Future changes in land use will be addressed by the deed restrictions proposed as part of the ICs. These measures would ensure long-term protectiveness and permanence of the remedy.

Reduction of Toxicity, Mobility, or Volume Through Treatment: Under this alternative, 1.8 CY of PTSM would be removed and treated via incineration. Removal of PTSM would remove approximately 21.3 kg of PCBs from the Site and is expected to reduce EPC for remaining on-site soils by 40%. Overall, a substantial reduction in toxicity of residual on-site soils would be achieved with this alternative, with minor reduction in the volume of PCB-containing soils on site.

Short-term Effectiveness: Removal and treatment of 1.8 CY of PTSM is expected to substantially reduce EPC associated with residual soil and can be achieved in a short timeframe. An asphalt pavement is in place in the vicinity of the Transformer Shop area within the LIA. The asphalt pavement over the excavation area would need to be removed but can be re-installed in a short timeframe. ICs can be implemented within a relatively short time period. Short-term risks to the community, workers, and the environment are possible during pavement removal and replacement and excavation of PTSM via generation of dust and soil erosion. Short-term risks could be mitigated through implementation of dust suppression measures, site control measures, use of personal protective equipment (PPE) by workers, implementation of soil erosion control measures, a soil management plan and air monitoring. Pepco will develop and implement an air monitoring plan and mitigation measures for any construction/excavation activities associated with remedy implementation. The air monitoring plan is prepared as part of the remedial design and will be compliant with Occupational Safety and Health Administration (OSHA) requirements. Due to the small quantity of soil to be excavated under this alternative, impacts to surrounding community from traffic and movement of trucks associated with transportation of excavated material are anticipated to be minimal.

Implementability: The technologies and methods required to implement this alternative are well established. Equipment and materials (e.g., asphalt, clean fill, soil erosion and control materials, etc.) needed are readily available. While the work areas are already cleared and the asphalt pavement is currently in place, excavation of PTSM would need to be performed in a limited space between Building 57 and the Kenilworth Avenue retaining wall. Any paving temporarily removed for PTSM excavation would be replaced. Parking areas and/or building entrances and egress points may be temporarily inaccessible to current occupants during construction. However, alternative parking areas and/or building access/egress points could be established during construction. Closest EPA-approved incineration facilities, as per EPA (2022), are located in LaPorte, TX (approximately 1400 miles from the Site), Tonkawa, OK (approximately 1300 miles from the Site), and Port Arthur, TX (approximately 1300 miles from the Site). This alternative assumes transportation and incineration of PTSM at Port Arthur (TX). Incineration facility to be used would be finalized during the remedial design process. Due to limited space available between Building 57 and the retaining wall, as well as handling of PTSM and TSCA-level excavated soil required, this alternative is regarded as moderately implementable.

Cost: The capital cost for this alternative, consisting of costs for professional/technical services, excavation, management, transportation, treatment, and disposal of PTSM, asphalt cover removal and replacement, backfill placement, deed notice, and SMP preparation are estimated to be $132,000. O&M costs over 30 years include costs associated with periodic reviews. Net present value of O&M costs (comprising periodic reviews and asphalt pavement maintenance) is estimated to be $121,000. The total present worth cost of this alternative is $253,000 (**Table 6-1**). Key assumptions used for developing cost estimates are provided in **Appendix E**.

6.3.3 Alternative LSS-PCB-4: Removal with Off-Site Treatment/Disposal of PTSM, Surface Soils with PCBs > 7 mg/kg, and Select Sub-Surface Soils (1-2 ft.), and ICs

This alternative involves a combination of the following remedial actions: a) excavation, treatment (via incineration), and off-site disposal of 1.8 CY of PTSM; b) excavation and disposal of 42 CY of soil in the 0-1 ft. interval with PCB concentrations > 7 mg/kg; c) excavation and disposal of 31 CY soil in the 1-2 ft. interval with PCB concentration > 7 mg/kg; and d) backfilling and restoration of excavated areas in the Transformer Shop area. Overall, 75 CY of soil with PCBs > 7 mg/kg would be removed from site.

PTSM removal would involve excavation of 1.8 CY of soil from the SUSDP21-3G polygon, followed by off-site incineration and subsequent disposal. In addition, all surface soil would be excavated from five additional polygons (SUSDPGD21-D1, SUSDPGD21-G1, SUSDP-3M, SUSDP21-1C, and SUS21-2J) covering an area of approximately 1,132 sq. ft., totaling 42 CY of soil and representing all surface soil in the Transformer Shop area exceeding a PCB concentration of 7 mg/kg.

Due to implementation challenges associated with sub-surface excavation near the Kenilworth Avenue retaining wall discussed under alternative LSS-PCB-3 (Section 5.2.3), excavation of subsurface soil in the area between Building 57 and the retaining wall would be limited to the 1-2 ft. interval in the SUSDPGD21-G1 polygon which exhibited the second highest PCB concentration in soil (450 mg/kg) within the Transformer Shop area as discussed below.

Excavation of non-PTSM sub-surface soil also would be conducted in the 1-2 ft. intervals of SUSDP-21C (PCBs: 17 mg/kg), and SUSDP21 (PCBs: 7.2 mg/kg) polygons. Within the SUSDP21 polygon, PCB concentration in the surface soil is below 1 mg/kg (0.52 mg/kg). However, as concentration in the 1-2 ft. interval within this polygon exceeds 7 mg/kg, both the surface soil and sub-surface soil would need to be excavated. Thus, overall, a total of 48 CY of sub-surface soil would be excavated, of which 31 CY would be disposed with the remaining 17 CY reused as backfill.

Non-PTSM excavated soils with PCBs > 50 mg/kg (6.3 CY) would be disposed at a TSCA-approved landfill. Remaining excavated soils (67 CY) would be disposed of at a permitted landfill authorized to accept PCB-contaminated soil with concentrations below 50 parts per million (ppm).

Excavated areas would be backfilled with excavated soil (with PCBs < 1 mg/kg) and clean soil. DOEE regulations require that the clean fill comply with EPA industrial RSLs. Specific criteria for clean fill will be finalized at the remedial design stage. The asphalt pavement over the excavated area would be restored for operational and personnel safety. However, asphalt pavement is not an active component of this alternative for reasons outlined in Section 5.2.4 and thus, maintenance of the asphalt pavement is not part of the O&M activities under this alternative.

Other component of this alternative includes implementing ICs such as fencing and security, signage, a deed notice and an SMP as described in Section 5.1.

For feasibility evaluation purposes, it is assumed that all soil in the 0-1 ft. interval of SUSDPGD21-D1, SUSDPGD21-G1, SUSDP21-3M, SUSDP21-3G, SUSDP21-1C, and SUS21-2J polygons, and in the 1-2 ft. interval of SUSDPGD21-G1, SUSDP21-1C, and SUSDP21 polygons would be excavated and disposed. Additional samples will be collected during the pre-design investigation or remedial design phases to refine the excavation area.

Following is a summary of the evaluation of this alternative.

Overall Protection of Human Health and the Environment: LSS-PCB-4 involves excavation of all surface soil (including PTSM) with PCBs > 7 mg/kg from several additional locations as compared to LSS-PCB-2. This alternative would reduce the surface soil EPC to below the RBTC of 10.5 mg/kg for the on-site worker as well as reduce the excess lifetime cancer risks below 1E-05. As discussed in **Appendix D,** this alternative is predicted to reduce the combined soil EPC to 29 mg/kg, representing a 77% reduction in the EPC compared to the present EPC of 126 mg/kg. No ecological risks were identified for the LIA. ICs, including fencing and security, signage, a deed notice and an SMP, would be implemented to inform target populations about risks, limit use of areas impacted by potential COCs, and manage any residual impacts by controlling construction in the area. Therefore, this alternative is protective of human health and the environment.

Compliance with ARARs: This alternative would be implemented pursuant to the risk-based option under TSCA. This alternative also meets the EPA expectation of treatment of Principal Threat Material. Therefore, this alternative meets this threshold criterion of compliance with ARARs.

Long-Term Effectiveness and Permanence: Excavation of soils would be a permanent measure that removes soils with elevated PCB levels from the site. An SMP and other ICs would be implemented to control exposures to remaining PCBs in soil in connection with construction activities. Future changes in land use will be addressed by the deed restrictions proposed as part of the ICs. These measures would ensure long-term protectiveness and permanence of the remedy.

Reduction of Toxicity, Mobility, or Volume Through Treatment: This alternative would remove 75 CY of soil with PCBs > 7 mg/kg from the site, representing approximately 24.8 kg of PCBs, and is expected to reduce the EPC associated with remaining site soils by 77%. Overall, large reduction in toxicity of on-site soils and a moderate reduction in volume of PCB-impacted soil would be achieved under this alternative.

Short-Term Effectiveness: Removal of PTSM and surface soil under this alternative is expected to substantially reduce the EPC associated with residual soil and can be achieved in a timeframe of 6 to 8 months. The asphalt pavement over the excavation area would need to be removed but can be re-installed in a short timeframe. ICs can be implemented within a relatively short time period. Short-term risks to the community, workers, and the environment are possible during pavement removal and replacement and partial excavation of PCB-impacted soils via generation of dust and soil erosion. Short-term risks could be mitigated through implementation of dust suppression measures, site control measures, use of PPE by workers, implementation of soil erosion control measures, a soil management plan and air monitoring. Pepco will develop and implement an air monitoring plan and mitigation measures for any construction/excavation activities associated with remedy implementation. The air monitoring plan is prepared as part of the remedial design and will be compliant with OSHA requirements. Due to the relatively small quantity of soil to be excavated under this alternative, impacts to the surrounding community from traffic and movement of trucks associated with transportation of excavated material are anticipated to be minor and temporary.

Implementability: The technologies and methods required to implement this alternative are well established. Equipment and materials (e.g., asphalt, clean fill, soil erosion and control materials, etc.) needed are readily available. While the work areas are already cleared and the asphalt pavement is currently in place, excavation of PTSM, and surface and sub-surface soil would need to be performed in a limited space between Building 57 and the Kenilworth Avenue retaining wall. Presence of a major underground sewer line owned by DC Water and Sewer south of Building 57 may present challenges to sub-surface excavation. Any paving temporarily removed for PTSM excavation would be replaced. Parking areas and/or building entrances and egress points may be temporarily inaccessible to current occupants during construction. However, alternative parking areas and/or building access/egress points could be established during construction. Closest EPA-approved incineration facilities, as per EPA (2022), are located in LaPorte, TX (approximately 1400 miles from the Site), Tonkawa, OK (approximately 1300 miles from the Site), and Port Arthur, TX (approximately 1300 miles from the Site). This alternative assumes transportation and incineration of PTSM at Port Arthur (TX). Incineration facility to be used would be finalized during the remedial design process. Non-PTSM excavated soils with PCBs > 50 mg/kg (6.3 CY) would be disposed at a TSCA-approved landfill (assumed to be Model City, New York). Remaining excavated soils (67 CY) would be disposed of at a permitted landfill. Potential disposal options for permitted landfills include US Ecology's facility in York, PA (https://www.usecology.com/location/us-ecology-york) and WM's King George landfill facility in King George, VA (https://www.wmsolutions.com/locations/details/id/237), which are approximately 95 miles and 71 miles away, respectively, from the site. Incineration and landfill facilities would be finalized during the remedial design process. Due to limited space available south of Building 57, handling of PTSM and TSCA-level excavated soil required, and presence of underground sewer line in the excavation area, this alternative is regarded as moderately implementable.

Cost: The capital cost for this alternative, consisting of costs for professional/technical services, partial excavation and off-site disposal, deed notice, and SMP, are estimated to be $454,000. O&M costs over 30 years include costs associated with periodic reviews. Net present value of O&M costs is estimated to be $37,000. The total present worth cost of this alternative is $502,000 (**Table 6-2**). Key assumptions used for developing cost estimates are provided in **Appendix E**.

6.3.4 Alternative LSS-PCB-5: Removal with Off-Site Treatment/Disposal of PTSM and Soils (0-2 ft.) with PCBs > 7 mg/kg, and ICs

This alternative involves a combination of the following remedial actions: a) excavation, treatment (via incineration), and off-site disposal of 1.8 CY of PTSM; b) excavation and disposal of 125 CY of soil in the 0-2 ft. interval with PCB concentrations > 7 mg/kg; and c) backfilling and restoration of excavated areas in the Transformer Shop area. Overall, approximately 126 CY of soil with PCBs > 7 mg/kg would be removed from site.

PTSM removal would involve excavation of 1.8 CY of soil from the SUSDP21-3G polygon, followed by off-site incineration and subsequent disposal. In addition, all soil would be excavated from the 0-2 ft. interval across 17 polygons, representing all soil within this interval with a PCB concentration exceeding 7 mg/kg. Overall, 179 CY of soil non-PTSM would be excavated. Excavated soil with PCBs < 1 mg/kg (approximately 55 CY), would be reused as backfill, while remaining 125 CY would be disposed in appropriate landfill facilities.

Of the 125 CY of soil to be disposed, 9.9 CY of non-PTSM excavated soils with PCBs > 50 mg/kg would be disposed at a TSCA-approved landfill, while 115 CY would be disposed of at a permitted landfill authorized to accept PCB-contaminated soil with concentrations below 50 parts per million (ppm).

Excavated areas would be backfilled with excavated soil (with PCBs < 1 mg/kg) and clean soil. DOEE regulations require that the clean fill comply with EPA industrial RSLs. Specific criteria for clean fill will be finalized at the remedial design stage. The asphalt pavement over the excavated area would be restored for operational and personnel safety. However, asphalt pavement is not an active component of this alternative for reasons outlined in Section 5.2.5 and thus, maintenance of the asphalt pavement is not part of the O&M activities under this alternative.

For feasibility evaluation purposes, it is assumed that all soil in the 0-2 ft. interval of the highlighted polygons shown in **Figure 5-4** would be excavated. Additional samples will be collected during the pre-design investigation or remedial design phases to refine the excavation area.

Other component of this alternative includes implementing ICs such as fencing and security, signage, a deed notice and an SMP as described in Section 5.1.

Following is a summary of the evaluation of this alternative.

<u>Overall Protection of Human Health and the Environment</u>: LSS-PCB-5 involves excavation of all soil within the 0-2 ft. interval in the Transformer Shop area (including PTSM) with PCBs > 7 mg/kg. This alternative would reduce the surface soil EPC to below the PRG as well as reduce the excess lifetime cancer risks below 1E-05. As discussed in **Appendix D,** this alternative is predicted to reduce the combined soil EPC to 7.1 mg/kg, representing a 94% reduction in the EPC compared to the present EPC of 126 mg/kg. This EPC is also nearly meet the combined soil PRG of 7 mg/kg, and results in a potential hazard index of 1. No ecological risks were identified for the LIA. ICs, including fencing and security, signage, a deed notice and an SMP, would be implemented to inform target populations about risks, limit use of areas impacted by potential COCs, manage any residual impacts as well as protect the integrity of the pavement by controlling construction in the area. Therefore, this alternative is protective of human health and the environment.

<u>Compliance with ARARs</u>: This alternative would be implemented pursuant to the risk-based option under TSCA. This alternative also meets the EPA expectation of treatment of Principal Threat Material. Therefore, this alternative meets this threshold criterion of compliance with ARARs.

<u>Long-Term Effectiveness and Permanence</u>: Excavation of soils would be a permanent measure that removes soils with elevated PCB levels from the site. A SMP and other ICs would be implemented to control exposures to remaining PCBs in soil in connection with construction activities. Future changes in land use will be addressed by the deed restrictions proposed as part of the ICs. These measures would ensure long-term protectiveness and permanence of the remedy.

<u>Reduction of Toxicity, Mobility, or Volume Through Treatment</u>: This alternative would remove 126 CY of soil with PCBs > 7 mg/kg, representing approximately 25.6 kg of PCBs, and is expected to reduce the EPC associated with remaining site soils by 94%. Overall, a large reduction in toxicity of on-site soils and a moderate reduction in volume of PCB-impacted soil would be achieved under this alternative.

<u>Short-Term Effectiveness</u>: Removal of PTSM and remaining soil under this alternative is expected to substantially reduce EPC associated with residual soil and can be achieved in a timeframe of 10-12 months. The asphalt pavement over the excavation area would need to be removed but can be re-

installed in a short timeframe. ICs can be implemented within a relatively short time period. Short-term risks to the community, workers, and the environment are possible during pavement removal and replacement and partial excavation of PCB-impacted soils via generation of dust and soil erosion. Short-term risks could be mitigated through implementation of dust suppression measures, site control measures, use of PPE by workers, implementation of soil erosion control measures, a soil management plan and air monitoring. Pepco will develop and implement an air monitoring plan and mitigation measures for any construction/excavation activities associated with remedy implementation. The air monitoring plan is prepared as part of the remedial design and will be compliant with OSHA requirements. Some impacts to the surrounding community from traffic and movement of trucks are possible from construction activities and transportation of excavated material but are anticipated to be temporary in nature.

Implementability: The technologies and methods required to implement this alternative are well established. Equipment and materials (e.g., asphalt, clean fill, soil erosion and control materials, etc.) needed are readily available. While the work areas are already cleared and the asphalt pavement is currently in place, excavation of PTSM, and surface and sub-surface soil would need to be performed in a limited space between Building 57 and the Kenilworth Avenue retaining wall. Sub-surface excavation up to a depth of 2 ft. minimum would be required along nearly the entire length of retaining wall. This excavation depth would likely need additional shoring of the foundation, along with consultation with DDOT, and subsequent permitting, to ensure integrity of the retaining wall. Presence of a major underground sewer line owned by DC Water and Sewer between Building 57 and retaining wall may present also challenges to sub-surface excavation in this area. Additionally, several underground utilities are present in the remaining excavation area and are likely to pose implementation challenges for sub-surface excavation. Any paving temporarily removed for PTSM excavation would be replaced. Parking areas and/or building entrances and egress points may be temporarily inaccessible to current occupants during construction. However, alternative parking areas and/or building access/egress points could be established during construction. Closest EPA-approved incineration facilities, as per EPA (2022), are located in LaPorte, TX (approximately 1400 miles from the Site), Tonkawa, OK (approximately 1300 miles from the Site), and Port Arthur, TX (approximately 1300 miles from the Site). This alternative assumes transportation and incineration of PTSM at Port Arthur (TX). Incineration facility to be used would be finalized during the remedial design process. Non-PTSM excavated soils with PCBs > 50 mg/kg (9.9 CY) would be disposed at a TSCA-approved landfill (assumed to be Model City, New York). Potential disposal options for permitted landfills include US Ecology's facility in York, PA (https://www.usecology.com/location/us-ecology-york) and WM's King George landfill facility in King George, VA (https://www.wmsolutions.com/locations/details/id/237), which are approximately 95 miles and 71 miles away, respectively, from the site. Remaining excavated soils (115 CY) would be disposed of at a permitted landfill. Incineration and landfill facilities would be finalized during the remedial design process. Due to limited space available between Building 57 and the retaining wall, handling of PTSM and TSCA-level excavated soil required, and presence of underground utilities in the excavation area, this alternative is regarded as difficult to implement.

Cost: The capital cost for this alternative, consisting of costs for professional/technical services, partial excavation and off-site disposal, deed notice, and SMP, are estimated to be $928,000. O&M costs over 30 years include costs associated with periodic reviews. Net present value of O&M costs is estimated to be $37,000. The total present worth cost of this alternative is $976,000 (**Table 6-3**). Key assumptions used for developing cost estimates are provided in **Appendix E**.

6.3.5 Summary

A summary of the detailed analysis performed for the three alternatives for PCB-contaminated soil is presented in **Table 6-4**. A comparative analysis of these alternatives is discussed in Section 7.0.

6.4 Detailed Analysis of RAAs for Vanadium-Contaminated LIA Soil

6.4.1 Alternative LSS-V-1: No Action

This alternative does not include any remedial activities or ICs and would not achieve RAOs in a reasonable timeframe. This alternative serves as a baseline condition against which other remedial alternatives are compared. Following is a summary of the evaluation of this alternative:

Overall Protection of Human Health and the Environment: No actions are proposed as part of this alternative and vanadium exceeding PRGs would remain in soil; therefore, potential human health risks are not mitigated. This alternative is not protective of human health. No ecological risks were identified for the LIA.

Compliance with ARARs: This alternative would not reduce human health risks posed by vanadium concentration in soil. Therefore, this alternative does not comply with the ARARs.

Since the No Action alternative does not meet the threshold criteria (Overall Protection of Human Health and the Environment, and Compliance with ARARs), it is not evaluated for balancing criteria.

6.4.2 Alternative LSS-V-2: Institutional Controls

This alternative relies on ICs described in Section 5.1 to reduce vanadium exposure to current or future construction workers. ICs such as preparation and implementation of an SMP, and implementation of appropriate health and safety measures would prevent exposure to vanadium-contaminated soil during construction or maintenance activities. Signage would be placed at the Warehouse and Laydown area identifying the potential COC (vanadium), the impacted media and its depth, and precautions that visitors and workers in each of these areas should follow to avoid exposure to the potential COC (vanadium). In addition, legal controls would be implemented via deed restrictions will also include documentation of the location and type of known contaminants remaining in soil, and any requirements for compliance monitoring and reporting. ICs for this alternative will help to minimize the potential for exposure to impacted soil by controlling activities that may disturb the soil. Further details on relevant ICs can be found in Section 5.1.

While gravel cover is currently in place and is expected to remain so for operational purposes, maintenance of gravel cover is not included as an institutional control under this alternative. The potentially unacceptable risk identified in the BHHRA was for the construction worker scenario only, primarily associated with inhalation during excavation. Since gravel cover would be removed or excavated into during construction activities, the gravel cover would not prevent inhalation or contact with vanadium by a construction worker.

The following is a summary of the evaluation of this alternative:

Overall Protection of Human Health and the Environment: Under this alternative, ICs, including fencing and security, signage, a deed notice and an SMP, would be implemented to inform target populations about risks, limit use of potential COC-impacted areas, manage any residual impacts as well as reduce exposure to impacted soil by controlling construction in the area. No ecological risks were identified for the LIA. Therefore, this alternative is protective of human health and the environment.

Compliance with ARARs: All activities under this alternative would be implemented in accordance with relevant ARARs.

Long-Term Effectiveness and Permanence: Implementation of ICs such as an SMP would control unauthorized excavations, increasing the long-term effectiveness of this alternative. Future changes in land use will be addressed by the deed restrictions proposed as part of the ICs. This alternative would therefore provide long-term effectiveness and permanence.

Reduction of Toxicity, Mobility, or Volume Through Treatment: There would be no reduction in toxicity, mobility, or volume of vanadium-contaminated soil associated with this remedial alternative.

Short-Term Effectiveness: ICs can be implemented within a relatively short time period. No short-term risks to the community, workers, and the environment are expected during the implementation of this alternative.

Implementability: Implementability of ICs is anticipated to be easy.

Cost: There are no direct costs associated with this alternative. Indirect capital costs would be incurred for implementation of ICs such as deed notices and associated permitting, and the preparation of the SMP. O&M costs over 30 years consist of periodic reviews. Net present value of O&M costs is estimated to be $48,000. The total present worth cost of this alternative is $80,000 (**Table 6-5**). Key assumptions used for developing cost estimates are provided in **Appendix E**.

6.4.3 Alternative LSS-V-3: Excavation with Off-Site Disposal, and ICs

This alternative involves excavation and disposal of approximately 1530 CY of soil in the Warehouse and Laydown area to achieve the RAOs. Under this alternative, surface soils (up to 1 ft. bgs) would be removed from ten polygons where concentrations of vanadium in soil exceed 277 mg/kg. These polygons comprise an area of 0.95 acres and are shown in **Figure 5-5**. Concentrations of vanadium in these ten polygons range from 1,400 mg/kg (SUS08-2N) to 42,000 mg/kg (TA1E1). Excavated soil would be disposed as non-hazardous waste at a permitted landfill and excavated areas would be backfilled with clean soil.

ICs such as preparation and implementation of an SMP, and implementation of appropriate health and safety measures would reduce exposure to vanadium-contaminated soil during construction or maintenance activities. Signage would be placed at the Warehouse and Laydown area identifying the potential COC (vanadium), the impacted media and its depth, and precautions that visitors and workers in each of these areas should follow to avoid exposure to the potential COC (vanadium). In addition, legal controls would be implemented via deed restrictions will also include documentation of the location and type of known contaminants remaining in soil, and any requirements for compliance monitoring and reporting. ICs for this alternative will help to minimize the potential for exposure to impacted soil by controlling activities that may disturb the soil. Further details on relevant ICs can be found in Section 5.1. The following is a summary of the evaluation of this alternative:

Overall Protection of Human Health and the Environment: Post-excavation UCL calculations **(Appendix D)** show that excavation of the soils in the polygons included in this alternative would reduce the EPC to 258 mg/kg, which is lower than the PRG of 277 mg/kg. No ecological risks were identified for the LIA. ICs, including fencing and security, signage, a deed notice and an SMP, would be implemented to inform target populations about risks, limit use of potential COC-impacted areas, and manage any residual impacts as well as control construction in the area. Therefore, this alternative is protective of human health and the environment.

Compliance with ARARs: All actions planned under this alternative will be designed to comply with applicable ARARs.

Long-Term Effectiveness and Permanence: Removal of 1530 CY of soil with vanadium concentration exceeding PRG would be a permanent measure. Implementation of ICs such as an SMP would control unauthorized excavations, increasing the long-term effectiveness of the existing gravel cover. Future changes in land use will be addressed by the deed restrictions proposed as part of the ICs. This alternative would therefore provide long-term effectiveness and permanence.

Reduction of Toxicity, Mobility, or Volume Through Treatment: Post-excavation UCL calculations **(Appendix D)** show excavation under this alternative results in an EPC of 258 mg/kg for the remaining soils, which is lower than the PRG of 277 mg/kg. The post-excavation EPC of 258 mg/kg represents a 94% reduction compared to the current EPC of 4,510 mg/kg. Under this alternative, 1530 CY of soil with vanadium concentration exceeding the PRG would be permanently removed from site. Thus, a major reduction in both toxicity and volume of vanadium-contaminated soil is anticipated due to implementation of this remedial alternative.

Short-Term Effectiveness: ICs can be implemented within a relatively short time period. The time required for excavation the polygons is anticipated to moderate (10 – 12 months) due to the large extent of the excavation area (0.95 acres) and presence of aboveground structures and underground utilities within the excavation area. Short-term risks to the community, workers, and the environment are possible during excavation and backfilling via generation of dust and soil erosion due to the large quantity of soil being excavated. Short-term risks could be mitigated through implementation of dust suppression measures, site control measures, use of personal protective equipment PPE by workers, implementation of soil erosion control measures, a soil management plan and air monitoring. Pepco will develop and implement an air monitoring plan and mitigation measures for any construction/excavation activities associated with remedy implementation. The air monitoring plan is prepared as part of the remedial design and will be compliant with OSHA requirements. Some impacts to the surrounding community are anticipated due to traffic and movement of trucks associated with transportation of excavated material but would be temporary in nature.

Implementability: The technologies and methods required to implement this alternative are well established. Equipment, materials, and services are readily available. Site conditions are favorable for construction as the work areas are already cleared. However, some challenges are anticipated during excavation as several aboveground structures and underground utilities are present within the excavation area. Alternative routes are likely to be needed for movement of vehicles and machinery in the area during soil excavation and associated activities. Thus, this alternative is regarded as moderately difficult to implement.

Cost: The capital cost for this alternative, consisting of costs for professional/technical services, excavation, transportation, disposal, back-fill supply and placement, and preparation of the deed notice and SMP are estimated to be $620,000. O&M costs over 30 years include costs associated with periodic reviews. Net present value of O&M costs is estimated to be $48,000. The total present worth cost of this alternative is $670,000 (**Table 6-6**). Key assumptions used for developing cost estimates are provided in **Appendix E**.

6.4.4 Summary

A summary of the detailed analysis performed for the three alternatives for vanadium-impacted soil is presented in **Table 6-7**. A comparative analysis of these alternatives is discussed in Section 7.0.

6.5 Detailed Analysis of RAAs for Addressing Vapor Intrusion Risks from LIA Groundwater

6.5.1 Alternative LGW-VB-1: No Action

This alternative does not include any remedial action or implementation of any ICs for addressing vapor intrusion risks in future buildings due to the PCE and TCE-impacted groundwater plume. However, there are currently no buildings within the footprint of the PCE and TCE plumes and thus, the on-site groundwater presently does not pose any risks to human health from vapor intrusion.

Overall Protection of Human Health and the Environment: No actions are proposed as part of this alternative. Therefore, potential human health risks are not mitigated unless the PCE and TCE concentrations in groundwater have been reduced below the PRGs as a result of groundwater restoration actions before construction of a hypothetical building within the footprint of the plume. No ecological risks were identified for the LIA. However, there are currently no buildings within the footprint of the PCE and TCE plumes.

Compliance with ARARs: This alternative would not reduce vapor intrusion risks posed by PCE and TCE in groundwater if concentrations have not been reduced below the PRGs before a hypothetical building were to be constructed within the plume footprint. Therefore, this alternative does not comply with the ARARs.

Since the No Action alternative does not meet the threshold criteria (Overall Protection of Human Health and the Environment, and Compliance with ARARs), it is not evaluated for balancing criteria.

6.5.2 Alternative LGW-VB-3: Thermoplastic Membrane Vapor Barriers with Passive Venting System, MNA, and ICs

This alternative prevents contaminated vapor intrusion in potential future buildings constructed within the plume footprint by incorporating thermoplastic vapor barriers and a passive venting system in any such buildings. Thermoplastic vapor barriers consist of materials such as HDPE, LLDPE, and PVC, and are typically installed at the time of building construction. TM vapor barriers have excellent chemical resistance and very low permeability and would be effective barriers for reducing vapor mitigation into future buildings. EPA recommends minimum thickness range of 40-60 mil for HDPE barriers (USEPA, 2008). Selection of vapor barrier material and final thickness of the barrier would be selected during the remedial design phase.

Passive venting involves installation of piping beneath the slab connected to risers that run the building structure and vent to the atmosphere above the building. The passive venting system relies on upward flow of warm air through the pipes to draw air (and vapor-phase potential COCs) from underneath the slab, creating lower sub-slab air pressure relative to that of indoor air, and thereby preventing vapor intrusion into the building. While EPA does not specify the level of depressurization required for passive venting systems, active venting systems (such as use of fans to depressurize sub-slab) are required to achieve 4-10 Pa difference in the sub-slab (relative to indoor air pressure) over the entire building footprint (USEPA, 2008). Performance of passive venting systems is dependent upon weather conditions. System performance can be improved using wind-driven turbines in roof stacks to supplement the convective (temperature-driven) flow. Wind-turbines can also be solar powered to ensure consistent performance of the venting system during times of low wind speeds or ice/snow accumulation on the turbines (NJDEP, 2021). Passive venting systems can also be easily converted to active venting systems if required. The vapor barriers in combination with passive venting system will protect occupants of any such buildings from vapor risks.

While the on-site PCE plume spans approximately 43,760 sq. ft., not all of this area is suitable or available for construction of a building. About 12,900 sq. ft. of the plume along the southern boundary is underneath the DC Metro train tracks and is thus unavailable for building construction. The area between the office trailers and the DC Metro train tracks (approximately 5,150 sq. ft.) is narrow and not suitable for building construction due to the presence of train tracks, office trailers, and the retaining wall that supports Kenilworth Avenue. Including the area under the train tracks and the area between the train tracks and the office trailers, an estimated 18,050 sq. ft. of area is either unavailable or unsuitable for construction of any future hypothetical building. Thus, the maximum area available for future use within the plume is estimated to be 25,710 sq. ft. However, considering the need to offset the foundations of any hypothetical building from the retaining wall, and the underground utility lines present in the plume, the maximum possible footprint of the building is only expected to comprise 80% of the usable area, resulting in an estimated maximum possible building footprint of 20,568 sq. ft. Cost estimates for this alternative are thus based on assuming lining 20,568 sq. ft. with thermoplastic membrane vapor barriers.

Periodic vapor monitoring would be conducted to ensure that vapor barriers and passive venting system are functioning as intended and that concentrations of potential COCs inside the building do not exceed human health risk criteria. For the purposes of this evaluation, it is assumed that indoor air monitoring would be conducted twice a year for the first five years and once annually thereafter until vapor intrusion PRGs have been achieved. As described in Section 5.1, ICs for this alternative include groundwater use restrictions and deed restrictions requiring installation of vapor barriers and passive venting system for any building constructed within the area of the PCE plume prior to achieving the PRGs for vapor intrusion.

Overall Protection of Human Health and the Environment: This alternative is protective of human health. Thermoplastic vapor barriers, passive venting system, and ICs would be implemented to reduce human exposure to vapor intrusion risks from impacted groundwater and to prevent groundwater use.

Compliance with ARARs: All actions planned under this alternative will be designed to comply with applicable ARARs.

Long-term Effectiveness and Permanence: Use of vapor barriers to prevent vapor migration risks is a common practice and is effective in reducing indoor air concentrations. When properly designed and installed, vapor barriers can have longevity in excess of 30 years. TM vapor barriers are highly durable, chemically-resistant, and exhibit very low permeability for VOCs. Long-term effectiveness is also dependent on continued active implementation and enforcement of ICs.

Reduction of Toxicity, Mobility, or Volume Through Treatment: Treatment activities are not included in this alternative. Consequently, no reduction of toxicity, mobility, or volume of contamination would be achieved.

Short-term Effectiveness: Short-term risks to surrounding community, workers, or the environment during installation of vapor barriers and monitoring wells would be low. Engineering and health and safety controls can be implemented during construction phase to minimize short-term risks.

Implementability: This alternative is easily implemented. Equipment, materials, and services for installation of TMs are readily available. From a technical standpoint, TMs can be easily incorporated into new construction as they exhibit higher puncture resistance and are less prone to being damaged during the construction process. Installation of TMs can be labor intensive as heat-welded seams, mechanical fastening, and sealing at penetrations and terminations is necessary to prevent leaks. Thicker membranes may be difficult to install (ITRC, 2007). However, these issues can be easily addressed by using qualified contractors with experience in installation of vapor barriers.

Cost: The capital cost for this alternative, consisting of costs for professional/technical services including remedial design, vapor barrier and passive venting system installation, and ICs, is estimated to be $490,000. Periodic costs include annual indoor air monitoring, passive venting system O&M, and five-year reviews. Net present value of periodic costs over 30 years is estimated to be $188,000. The total present worth cost of this alternative is $680,000 (**Table 6-8**).

6.6 Detailed Analysis of RAAs for Restoration of LIA Groundwater

6.6.1 Alternative LGW-GR-1: No Action

This alternative does not include any remedial activities or ICs. Some natural attenuation may take place, but it would not be monitored. This alternative serves as a baseline condition against which other remedial alternatives are compared. Following is a summary of the evaluation of this alternative:

Overall Protection of Human Health and the Environment: No actions are proposed as part of this alternative to protect human health. No ecological risks were identified for LIA groundwater.

Compliance with ARARs: No actions would be taken to reduce PCE and TCE concentrations in groundwater to below chemical-specific ARARs (based on Title 21 DCMR groundwater standards). Therefore, this alternative does not comply with the ARARs.

Since the No Action alternative does not meet the threshold criteria (Overall Protection of Human Health and the Environment, and Compliance with ARARs), it is not evaluated for balancing criteria.

6.6.2 Alternative LGW-GR-2: MNA, Groundwater Monitoring, and ICs

As discussed in Section 2.9, various lines of evidence support the conclusion that there are no continuing PCE sources present on-site and that the plume is stable. Concentrations of chlorinated VOCs in the UWZ groundwater are one to six orders of magnitude below the DNAPL threshold, indicating that the PCE source (likely to be off-site) is depleted.

Prior RI investigations thoroughly investigated and delineated the extent of on-site groundwater contamination of PCE, which included direct push groundwater samples collected during 2013 and 2014, and sample collection from on-site monitoring wells during 2014 and 2016. During these events, PCE and associated CVOCs were detected in the UWZ at DP-09/MW-09A and several nearby locations along the southern border of the Site. PCE also was previously detected in the both the UWZ and LWZ at MW-1 in the southwest corner of the site. However, during the post-RI investigation (AECOM, 2023), chlorinated VOCs including PCE were no longer detected in the UWZ or LWZ in this area of the Site. Historically, the highest PCE concentrations were detected at sampling locations along the southern property boundary and the concentrations uniformly and rapidly declined toward the interior of Pepco property. Several downgradient wells (MW01A, MW01B, MW02A, MW05A) have shown decreasing concentrations in sampling events from 2014, 2016, and 2021, including non-detect at MW01A, MW01B, and MW02A in 2021.

PCE daughter products were observed at some of the locations sampled at the Site. In the 2021, sampling, daughter products up to cis-DCE were observed in three wells (TP-04A, MW-09A, and MW-9B). Degradation to TCE was observed in three wells one on site well (TP-01A) and two off-site wells (TP-10A and 11A).

The above results indicate that natural attenuation is gradually occurring at the site. Natural attenuation may be occurring via a combination of physical (such as dilution, dispersion, and diffusion), biological, and chemical processes. As documented in the PCE Data Gap Investigation (AECOM, 2023), dissolved oxygen levels < 1 mg/L (indicative of anaerobic conditions) were observed in several wells in the UWZ and LWZ. PCE daughter products (up to cis-1,2-DCE) were observed in two UWZ wells, while degradation of PCE to TCE was observed in one on-site UWZ well. ORP levels of -200 to -250 mV as typically required for complete biological degradation to ethene were only observed in the one well in the LWZ. These observations and results indicate that conditions in the sub-surface are not favorable for complete biological dechlorination.

Groundwater in DC is not currently being used as a source of drinking water. Based on a review of the Environmental Data Resources report dated August 2023, no public water supply wells are located within a 1 mile radius of the Site, and a USEPA 2009 Site Inspection Report documented that there are no drinking water intakes located within 15 miles of the Site. These reports provide strong evidence to support that groundwater in the vicinity of the Site is not used for drinking water purposes. The primary economic water-producing aquifer in this area is the Patuxent aquifer located beneath the Arundel formation. The sands in the Patapsco Formation, which comprises the UWZ at the site, are typically thin and do not produce sufficient water to be locally considered an aquifer (D.C. Water Resources Research Center, 1995). It is therefore unlikely that the water in the UWZ (located above Arundel Clay) could ever be developed as a viable water resource due quality and yield concerns. Potential risks to human health from exposure to on-site groundwater are therefore unlikely and can be effectively addressed using ICs.

No ecological risks for groundwater were identified in the LIA. Furthermore, simulations of on-site groundwater discharge to the Anacostia River conducted as part of the ARSP groundwater modeling report (Tetra Tech, 2019) predicted the maximum PCE porewater concentration to be below 1 µg/L, which is at least two orders of magnitude lower than the 4-day surface water criterion (800 µg/L). Based on these modeling results, the report predicted no adverse impacts to surface sediment biota from discharge of PCE-containing groundwater from the Site to the Anacostia River.

Based on the above discussion, long-term groundwater monitoring would be implemented along with ICs to ensure that the groundwater plume does not impact any human or ecological receptors. This alternative would also evaluate the progress of MNA at the Site by measuring the following parameters in groundwater:

- Field parameters (such as DO, ORP, pH, temperature, and conductivity)
- Concentrations of PCE and daughter products,
- Geochemical parameters for evaluating MNA (such as nitrate, sulfate, dissolved iron, total organic carbon)
- Biological parameters (to confirm presence and activity of PCE-dechlorinating microorganisms).
- Other analytes (such as dissolved gases, volatile fatty acids) for evaluating MNA

Six additional monitoring wells would be installed in the UWZ (to a maximum depth of 25 to 30 ft.) and monitoring data would be used to: (a) confirm that no on-site PCE source exists; (b) evaluate whether plume is stable or shrinking; (c) confirm that no risks to human and ecological receptors are anticipated; (d) evaluate whether concentrations of PCE and daughter products continue to exhibit downward trends; and (e) evaluate the progress of MNA in reducing CVOC concentrations in on-Site groundwater.

Long-term groundwater monitoring would comprise a total of 12 sampling events over 30 years: (a) five sampling events within the first 5 years (one event each year); (b) five sampling events over the next 15 years (one event every 3 years); and (c) two sampling events in the last 10 years (one event every 5 years). For purposes of the FS, each sampling event would include collection of 12 groundwater samples (10 from on-site wells + 2 for quality assurance/quality control). Each sampling event is estimated to require five days of labor. Data from each sampling event would be reported to DOEE (i.e., 12 reporting events over 30 years).

ICs implemented would include existing site security and fencing, signage identifying potential COCs in groundwater, groundwater use restrictions such as designation of the PCE plume area as Classification Exception Areas (CEA)/Well Restriction Area (WRA), and general land use and deed restrictions to minimize human exposures to potential COCs.

<u>Overall Protection of Human Health and the Environment</u>: As discussed above, risks to human health from consumption of groundwater impacted with PCE and TCE are not currently present as the groundwater on-site and within DC is not used as drinking water, and no public supply wells or drinking water intakes are present in the vicinity of the site. This scenario is not anticipated to change for the foreseeable future as water in the UWZ (located above Arundel Clay) is not a viable water resource due quality and yield concerns (D.C. Water Resources Research Center, 1995). No ecological risks were identified during the RI. The ARSP groundwater modeling study (Tetra Tech, 2019) predicts no impact

to biota in the surface sediment of the Anacostia River from discharge of PCE-containing groundwater from the site to the River. Groundwater monitoring and ICs would be implemented to ensure that the conditions preventing human health and ecological risks from exposure to on-site groundwater continue to persist to the extent possible. Thus, this alternative would be protective of human health and the environment.

Compliance with ARARs: Although the aquifer is designated as a Class G1 aquifer of drinking water quality, groundwater at the Site is not currently used as drinking water and does not pose any ecological risks. All actions planned under this alternative will be designed to comply with applicable ARARs.

Long-term Effectiveness and Permanence: Enforcement of implemented ICs would provide long-term effectiveness for this alternative. As discussed above, groundwater in the UWZ at the site is not a viable water resource and is unlikely to be developed as a drinking water resource in the future. Data from periodic groundwater monitoring under this alternative can be used to better quantify the long-term effectiveness in achieving the groundwater restoration RAO.

Reduction of Toxicity, Mobility, or Volume Through Treatment: There would be no reduction in toxicity, mobility, or volume through treatment under this alternative. However, decreasing concentrations of PCE and daughter products in several on-site wells, stable plume, and likely presence of a depleted off-site PCE source indicate that natural processes such as physical and biological degradation will be effective at reducing CVOC concentrations in groundwater over time.

Short-term Effectiveness: Actions planned under this alternative, such as ICs, groundwater monitoring plan, and groundwater sampling events can be implemented in a relatively short timeframe of 6-12 months. Short-term risks to the community, workers, and the environment are possible during well installation via generation of dust but would be temporary in nature. Short-term risks would be mitigated through implementation of dust suppression measures, site control measures, and use of PPE by workers. No impacts on workers or surrounding community are anticipated from other components of this alternative.

Implementability: This alternative would be easy to implement from both technical and administrative standpoints.

Cost: The capital cost for this alternative, consisting of installation of additional monitoring wells, implementation of ICs, remedial design, and preparation of monitoring plan are estimated to be $143,000. O&M costs over 30 years include a total of 12 sampling events over, with annual sampling events for the first 5 years, five sampling events over the next 15 years (one event every 3 years), and two sampling events in the last 10 years (one event every 5 years). For purposes of the FS, each sampling event would include collection of 12 groundwater samples (10 from on-site wells + 2 for quality assurance/quality control) from reviews every 5 years and annual groundwater sampling events (one event per year for first 5 years and one event every 5 years thereafter). Net present value of O&M costs is estimated to be $443,000. The total present worth cost of this alternative is $586,000 (**Table 6-10**). Key assumptions used for developing cost estimates are provided in **Appendix E**.

6.6.3 Alternative LGW-GR-4: Treatment via ZVI Injection, with MNA and ICs

This alternative relies on use of ZVI to facilitate the in-situ abiotic dechlorination of PCE and daughter products to ethene and ethane to achieve the groundwater standards in the UWZ. Under this alternative, ZVI is slowly oxidized and releases electrons. Chlorinated VOCs are chemically reduced (i.e., dechlorinated) by hydrogen ions and these electrons on the surface of ZVI. Hydrogen gas produced in reaction of ZVI with water can also contribute to the dechlorination of the VOCs. Dechlorination of PCE occurs via 2 mechanisms: i) Reductive β-elimination and ii) Hydrogenolysis. Reaction via reductive β-elimination pathway results in the formation of short-lived intermediates such as dichloroacetylene, chloroacetylene and acetylene, with ethene and ethane as the ultimate reaction products. Reaction via hydrogenolysis pathway proceeds via sequential removal of one chlorine atom from PCE, resulting in formation of TCE, which subsequently degrades to cis-1,2 DCE, then to VC, and ultimately to ethene and ethane. However, for ZVI, reductive β-elimination is the primary pathway provided the necessary sub-surface conditions are achieved, which minimizes formation of toxic intermediates such as cis,1,2-DCE and VC. These intermediates can be degraded further to ethene and ethane through further hydrogenolysis (Arnold & Roberts, 2000; Cook, 2009; Labeeuw, 2013).

Micro-scale and nano-scale ZVI particles are generally suitable for direct injections, while nano-scale ZVI can also be introduced into the sub-surface via injection wells (Przepiora & Roberts, 2016). Several commercial products such S-MicroZVI® (REGENESIS Bioremediation Products), Ferox Flow and Ferox Plus eZVI (both from Hepure), and CleanER™ iZVI (Cascade Environmental) are available and have been used for remediation of PCE-impacted groundwater. Selection of ZVI formulation to be used will be made during the remedial design phase based on results from bench-scale studies.

Under this alternative, within the 300 ppb total VOC plume (referred to as “MW-09 Treatment Zone”), ZVI would be injected into the sub-surface via direct push methods at a ZVI-to-soil dose of 0.25%. While the total footprint of the 300 ppb plume is estimated to be 35,381 sq. ft., approximately 12,315 sq. ft. of the plume area in underneath the DC Metro tracks. Direct injections within the area under the train tracks are not feasible. Thus, the direct injections of ZVI would cover an estimated 23,070 sq. ft. of the plume. Injection points would be spaced 20 ft apart within the MW-09 Treatment Zone. Two rounds of injection are assumed to be necessary for feasibility evaluation purposes, with plume extent being reduced to 50% of initial extent after first injection. A ZVI-to-soil dose of 0.25% is anticipated to be sufficient for achieving the PRGs within the MW-09 Treatment Zone. Both the dosage and the spacing of injection points may be revised based on results from bench- and pilot-scale studies.

Downgradient of the MW-09 Treatment Zone, ZVI would be injected into the sub-surface via direct push methods (at a ZVI-to-soil dose of 0.63%) along a transect to create a ZVI “curtain”. Injection points within each transect would be spaced 15 ft apart. The transect would border the western edge of the plume. This ZVI “curtain” would treat PCE and daughter products in the groundwater flowing through the curtain. Within the curtain, a ZVI-to-soil dose of 0.63% is anticipated to be sufficient for achieving the PRGs. Both the dosage and the spacing of injection points may be revised based on results from bench- and pilot-scale studies.

A conceptual approach for implementation of this alternative is shown in **Figure 5-6**.

For the purposes of this feasibility evaluation, installation of six additional monitoring wells is assumed, with maximum depth ranging between 25 to 30 ft bgs. Groundwater would be monitored for PCE, degradation products, and performance parameters. As described in Section 6.2, some natural attenuation appears to be taking place at the Site which should supplement the active remediation efforts. This alternative includes periodic groundwater monitoring to assess the effectiveness of both active remediation and natural attenuation.

As described in Section 5.1, ICs for this alternative include groundwater use restrictions and a requirement for vapor barriers and passive venting system for any building constructed within the area of the PCE plume prior to achieving the PRGs for vapor intrusion.

<u>Overall Protection of Human Health and the Environment</u>: Under LGW-GR-4, in situ abiotic dechlorination using ZVI would be implemented to achieve groundwater standards for PCE and associated daughter products such as TCE, DCE isomers, and VC. ICs are implemented to prevent groundwater use and to require vapor barriers and passive venting systems in any building constructed within the area of the plume until the PRG is achieved for vapor intrusion. No ecological exposure to impacted groundwater was identified during the RI. This alternative is protective of human health and the environment.

<u>Compliance with ARARs</u>: Although the aquifer is designated as a Class G1 aquifer of drinking water quality, groundwater at the Site is not currently used as drinking water. In-situ abiotic dechlorination using ZVI would be targeted to reduce concentration of PCE and daughter products in groundwater to respective groundwater standards for Class G1 classification as per Title 21 DCMR. All actions planned under this alternative will be designed to comply with applicable ARARs.

Long-term Effectiveness and Permanence: The efficacy of ZVI for degradation of PCE and TCE is well demonstrated. A ZVI-to-soil dose of 0.25% is anticipated to be sufficient for treating potential COCs in the MW-09 Treatment Zone. Two rounds of ZVI injection are assumed to be sufficient to treat the potential COCs within this treatment zone. Similarly, a ZVI-to-soil dose of 0.63% is assumed to be sufficient to treat potential COCs in groundwater passing through the ZVI curtain. However, bench-scale studies would be needed to evaluate and optimize the ZVI dose for achieving the respective groundwater standards for potential COCs. Effectiveness would also depend upon the extent to which proper distribution of the ZVI slurry can be achieved in the sub-surface. Nano- and micro-scale ZVI (<300 um) is more reactive than granular or coarse ZVI (300 – 2400 um) but has a shorter lifespan (Labeeuw, 2013; Przepiora & Roberts, 2016). ZVI formulation, dosing, and spacing of injection points may be revised based on results from bench- and pilot-scale studies. Based on available data and experience with similar systems, the estimated timeframe for achieving the PRGs is 15 to 30 years for this alternative. Results from pilot testing can be used to further refine the timeframe for achieving the PRGs. ICs would not be required once the PRGs are achieved; therefore, monitoring and maintenance of ICs would be eliminated providing further long-term effectiveness.

Reduction of Toxicity, Mobility, or Volume Through Treatment: This alternative would result in a substantial reduction of the toxicity and volume of PCE and daughter products in groundwater via abiotic dechlorination treatment that would convert these contaminants to non-toxic byproducts.

Short-term Effectiveness: This alternative would require time for planning, permitting, mobilization, and implementation. A two to three year timeframe is anticipated for design of the remedy and construction. Dechlorination is expected to begin once appropriate conditions such as a strongly reducing environment with ORP < -400 mV are achieved in the sub-surface (Cook, 2009; Gavaskar et al., 2005). Implementation of ICs would provide short-term protection for human receptors until treatment is complete and RAOs are achieved. Short-term exposures to the workers to treatment chemicals are possible. Short-term risks to the community, workers, and the environment are possible during well installation via generation of dust. Short-term risks would be mitigated through implementation of dust suppression measures, site control measures, use of PPE by workers, implementation of soil erosion control measures, a soil management plan and air monitoring. Pepco will develop and implement an air monitoring plan and mitigation measures for any construction/excavation activities associated with remedy implementation. The air monitoring plan is prepared as part of the remedial design and will be compliant with OSHA requirements.

Implementability: Abiotic dechlorination using ZVI is a well-developed technology which has been applied successfully at several sites for treating PCE and TCE in groundwater. The materials and methods needed are readily available. The sub-surface geology in the UWZ consists of sand/gravel and intermixed clay, silt, and sand, which is expected to be generally favorable for injection of ZVI slurry. Implementation of this remedy may impact surrounding on-site activities. Degradation reactions for PCE and TCE in the presence of ZVI are faster at lower pH values than at higher pH values, and degradation is significantly retarded at pH of 8.1 and above (Cook, 2009). The site groundwater exhibits pH range 4.41 to 6.54 (AECOM, 2023) and thus should be suitable for treatment via ZVI. A strongly reducing environment with ORP levels below -400 mV is necessary for abiotic dechlorination to proceed via the reductive β elimination pathway which minimizes generation of toxic intermediates such as cis-1,2 DCE and VC (Gavaskar et al., 2005). Only one on-site well exhibited ORP close to -400 mV (TP-2B, ORP of -325 mV, AECOM 2023). Several wells within the groundwater plume exhibited positive ORPs. ZVI dose needed to achieve the necessary ORP levels would need to be evaluated as part of bench-scale studies. Furthermore, the presence of numerous utilities and transit infrastructure within or adjacent to the plume pose implementation challenges that could lead to delays and/or ineffective treatment. Implementation challenges could arise from sub-optimal location of injection points and possible preferential pathways created by utilities and transit infrastructure that could impact uniform distribution of reagents. Delivery of ZVI to parts of the plume, such as the plume underneath the DC Metro track, is not considered to be feasible. Therefore, this alternative is moderately implementable.

Cost: The capital cost for this alternative, consisting of costs for bench- and pilot-scale testing, professional/technical services, preparation of deed notice and groundwater monitoring plan are estimated to be $1,690,000. O&M costs over 30 years include reviews every 5 years and annual groundwater sampling events (one event per year for first 5 years and one event every 5 years thereafter). Net present value of O&M costs is estimated to be $193,000. The total present worth cost of this alternative is $1,880,000 (**Table 6-11**). Key assumptions used for developing cost estimates are provided in **Appendix E**.

6.6.4 Alternative LGW-GR-5: Treatment via Biowalls and ZVI Injection, with MNA and ICs

This alternative would treat PCE and daughter products in groundwater using a combination of bioremediation and ZVI. Bioremediation involves application of substrates, nutrients, and/or microbes via injection wells, in conjunction with injectable reactive media, to enhance biodegradation of PCE and daughter products in groundwater via reductive dechlorination process. Native or injected microbial population of halorespirers use substrates as electron donors and in the process, sequentially dechlorinate PCE to ethene, via formation of TCE, cis-1,2-DCE, and vinyl chloride as intermediate reaction products. Injectable reactive media such as ZVI can be used to further enhance the reductive dechlorination process. Mechanism for dechlorination via ZVI was discussed under Alternative LGW-GR-3 above. This alternative thus combines biotic and abiotic dechlorination processes to degrade PCE and daughter products in the groundwater.

Existing conditions in several on-site wells, such as dissolved oxygen levels < 1 mg/L and low values of oxidation-reduction potential (ORP), are somewhat favorable for biotic reductive dechlorination as evidenced by presence of daughter products TCE and cis-1,2-DCE in some of the on-site wells (AECOM, 2023). This alternative would enhance the dechlorination process to enable degradation of PCE and daughter products to ethene. Typical substrates include sodium lactate, methanol, ethanol, molasses, high fructose corn syrup, etc. which are fast-release substrates. Slow-release substrates include vegetable oils, vegetable oil emulsions, and whey (USEPA, 2013). Bioaugmentation may be necessary if the on-site soils do not have sufficient or sufficiently active population of halorespirers. Furthermore, the groundwater pH ranges from 4.41 to 6.54 at the site, which is not conducive for survival and growth of microbial populations.

To account for the above conditions, bioremediation under this alternative would be implemented using underground trenches filled with a mixture of limestone and mulch, typically referred to "permeable mulch biowalls (Parsons, 2008)". The limestone would increase the pH of the groundwater as it passes through the biowalls. Within each biowall, mulch would serve as a slow-release substrate to stimulate growth of native dechlorinating bacteria. EVO, an additional substrate, would be injected into the biowall using PVC pipes installed along the length of the biowall. Some bioaugmentation may be necessary at the beginning of the treatment. Overall, three biowalls would be constructed along the length of the plume.

Each biowall would be 2 ft. wide and extend to 30 ft. bgs. Saturated thickness of the aquifer averages ~ 20 ft and thus, the bottom 20 ft. of each biowall would be filled with a mix of mulch and limestone (60% mulch and 40% limestone by volume). The top 10 ft. of each biowall would be backfilled with soil excavated during construction of the trenches.

Overall, three biowalls would be constructed along the length of the plume. These are designated as "Biowall A" (close to the eastern edge of the plume), "Biowall B" (downstream of Biowall A), and "Biowall C" (close to the western edge of the plume).

Due to the presence of underground utilities within the plume footprint, Biowall B and Biowall C cannot be constructed across the entire width of the plume. At these two locations, biowalls would be constructed up to a safe offset distance from the underground utility lines running east to west. The plume areas between the edge of the plume and biowalls containing the utility lines would be treated by injecting ZVI at a dose of 0.25% (ZVI-to-soil) to create ZVI "curtains." These curtains would treat PCE and daughter products in the groundwater passing through them.

Downgradient of the biowalls, ZVI would be injected into the sub-surface via direct push methods (at a ZVI-to-soil dose of 0.63%) along a transect to create a ZVI “curtain”. The ZVI curtain would be created just beyond the western edge of the plume to treat any remaining PCE and daughter products in the groundwater flowing through the curtain.

A conceptual approach for implementation of this alternative is shown in **Figure 5-7**.

Groundwater would be monitored for PCE, degradation products, and performance parameters. Anaerobic reductive dechlorination of PCE (within the biowalls) results in formation of toxic intermediates such as TCE, DCE and its isomers, or vinyl chloride. Thus, ensuring that conditions suitable for complete dechlorination continue to exist in the sub-surface is necessary and monitoring of PCE and degradation by-products is critical. Post-remedy monitoring for rebounding of PCE would be implemented. As described in Section 6.2, some natural attenuation appears to be taking place at the Site. This alternative includes periodic groundwater monitoring to assess the effectiveness of both active remediation and natural attenuation. This alternative also would include ICs as described in Section 5.1.

<u>Overall Protection of Human Health and the Environment</u>: Under LGW-GR-5, in-situ enhanced bioremediation, involving addition of substrates, micro-organisms, and injectable reactive media such as ZVI, would be implemented to achieve groundwater standards for PCE and daughter by degrading these potential COCs via a combination of biotic and abiotic dechlorination processes. ICs are implemented to prevent groundwater use and to require vapor barriers and passive venting systems in any building constructed within the area of the plume until the PRG is achieved for vapor intrusion. No ecological exposure to impacted groundwater was identified during the RI. This alternative is protective of human health and the environment.

<u>Compliance with ARARs:</u> Although the aquifer is designated as a Class G1 aquifer of drinking water quality, groundwater at the Site is not currently used as drinking water. Remedial actions under this alternative would be targeted to reduce concentration of PCE and daughter in groundwater to respective groundwater standards for Class G1 classification as per Title 21 DCMR. All actions planned under this alternative will be designed to comply with applicable ARARs.

<u>Long-term Effectiveness and Permanence:</u> The efficacy of enhanced bioremediation for PCE and daughter products via anaerobic dechlorination has been well demonstrated. Common factors that impact the efficacy of the process are lack of appropriate substrate and lack of sufficient bacterial population capable of anaerobic dechlorination. Bench-scale studies would be needed to evaluate and optimize the substrates, bacterial culture, and their dosages for achieving the respective groundwater standards for potential COCs. Effectiveness would also depend upon the extent to which proper distribution of the reagents can be achieved in the sub-surface. Substrates, micro-organisms, and/or reactive media and their dosages may be

revised based on results from bench- and pilot-scale tests. The efficacy of ZVI for degradation of PCE and TCE is also well demonstrated. Bench- and pilot-scale studies would be needed to evaluate and optimize the ZVI dose for achieving the respective groundwater standards for potential COCs. Effectiveness would also depend upon the extent to which proper distribution of the ZVI slurry can be achieved in the sub-surface. Based on available data and experience with similar systems, estimated timeframe for achieving the PRGs is 15 to 30 years for this alternative. Results from pilot testing can be used to further refine the timeframe for achieving the PRGs. ICs would not be required once the PRGs have been achieved; therefore, monitoring and maintenance of ICs would be eliminated providing further long-term effectiveness.

<u>Reduction of Toxicity, Mobility, or Volume Through Treatment</u>: This alternative would result in a substantial reduction of the toxicity and volume of PCE and daughter products in groundwater via enhanced bioremediation and ZVI treatment that would convert these contaminants to non-toxic byproducts.

<u>Short-term Effectiveness</u>: This alternative would require time for planning, permitting, mobilization, and implementation. A two to three year timeframe is anticipated for design of the remedy and construction. Dechlorination is expected to begin once appropriate conditions such as a strongly reducing environment with ORP < -200 mV (for bioremediation) and < -400 mV (for ZVI) are achieved in the sub-surface. Anaerobic dechlorination of PCE via biotic processes could increase the toxicity in the short-term through formation and accumulation of intermediates such as TCE, cis-1,2-DCE, and VC, which are more toxic than PCE. However, with sufficient application of substrates and halorespirers, the remedy can fully degrade PCE and intermediates to ethene. Implementation of ICs would provide short-term protection for human receptors until treatment is complete and RAOs are achieved. Short-term exposures to the workers to treatment chemicals are possible. Short-term risks to the community, workers, and the environment are possible during well installation via generation of dust. Short-term risks could be mitigated through implementation of dust suppression measures, site control measures, use of PPE by workers, implementation of soil erosion control measures, a soil management plan and air monitoring. Pepco will develop and implement an air monitoring plan and mitigation measures for any construction/excavation activities associated with remedy implementation. The air monitoring plan is prepared as part of the remedial design and will be compliant with OSHA requirements.

<u>Implementability:</u> Enhanced bioremediation and ZVI are both well-developed technologies which have been applied successfully at several sites for treating PCE and TCE in groundwater. The materials and methods needed are readily available. The sub-surface geology in the UWZ consists of sand/gravel and intermixed clay, silt, and sand, which is expected to be generally favorable for injection of substrates, nutrients, microbial augmentation, and ZVI. Implementation of this remedy may impact surrounding on-

site activities. Existing conditions in several on-site wells, such as dissolved oxygen levels < 1 mg/L and low values of ORP observed at a few monitoring wells, are somewhat favorable for reductive dechlorination as evidenced by presence of daughter products TCE and cis-1,2-DCE in some of the on-site wells (AECOM, 2023). However, conditions are not favorable for complete dechlorination of PCE and TCE to ethene and ethane but may be enhanced by injection of sufficient quantities of appropriate substrate. Sufficiently reducing conditions (ORP < -200 mV) are typically required to for complete dechlorination of PCE and daughter products. The groundwater pH ranges from 4.41 to 6.54 at the site, which is not conducive for survival and growth of microbial populations, thus requiring use of limestone within the biowalls to raise the pH of the groundwater passing through the biowalls. However, degradation rate of potential COCs via ZVI is significantly retarded at pH > 8.1 (Cook, 2009). Controlling the pH within a narrow range that enables both bioremediation and ZVI degradation processes to perform effectively is anticipated to be challenging. Furthermore, the presence of numerous utilities and transit infrastructure within or adjacent to the plume pose implementation challenges that could lead to delays and/or ineffective treatment. Construction of underground trenches for biowalls within the plume footprint is likely to be challenging. Implementation challenges could arise from sub-optimal location of injection points and possible preferential pathways created by utilities and transit infrastructure that could impact uniform distribution of reagents. Direct delivery of substrate and microbial augments to parts of the plume, such as the plume underneath the DC Metro track, is not considered to be feasible. Therefore, this alternative is regarded as being difficult to implement.

<u>Cost</u>: The capital cost for this alternative, consisting of costs for bench- and pilot-scale testing, professional/technical services, preparation of deed notice and groundwater monitoring plan are estimated to be $2,400,000. O&M costs over 30 years include reviews every 5 years, annual groundwater sampling events (one event per year for first 5 years and one event every 5 years thereafter), and one EVO dosing per year in one of the three biowalls. Net present value of O&M costs is estimated to be $387,000. The total present worth cost of this alternative is $2,790,000 (**Table 6-12**). Key assumptions used for developing cost estimates are provided in **Appendix E**.

6.6.5 Alternative LGW-GR-6: Groundwater Extraction and Treatment using GAC, with MNA and ICs

This alternative would extract the groundwater to remove PCE and daughter products by adsorption on GAC. This system is typically referred to as a “pump and treat” system.

Under this alternative, four groundwater extraction wells would be installed within the plume footprint. For the purposes of this feasibility evaluation, an extraction rate of 7.2 gallons per minute (gpm) from each well is assumed. This extraction rate is based on a pump and treat system that was installed at the site in July

1996 for remediation of BTEX in groundwater resulting from a leak in an underground storage tank. This system extracted and treated 2.1 million gallons of groundwater over 202 days of operation at an average rate of 7.2 gpm (Pepco, 1997). Aquifer tests would be conducted to establish a long-term extraction rate that can be supported by the low-yield UWZ.

Potential locations of the extraction wells are shown in **Figure 5-8**. Two extraction wells would be installed in the middle of the plume area while the remaining two would be installed downgradient close to the edge of the total VOC plume. Extraction wells would be connected via underground pipelines and the extracted groundwater would be pumped to a treatment building. Potential location of the treatment building is shown in **Figure 5-8**. Conceptually, the treatment train within this building would consist of injection of groundwater with chemical amendments to minimize any potential lime scaling on the treatment equipment, followed by in-line bag filters for removal of silt, grit, and any iron and manganese precipitates that can result in fouling of the treatment equipment, and finally, two 1000-lb (each) GAC vessels in series wherein PCE and daughter products in the groundwater would be removed via adsorption. The locations of the extraction wells as well as the conceptual treatment train would be optimized during the remedial design stage based on data from aquifer tests, and bench- and pilot-scale studies.

The treated water from the GAC units would be discharged to a POTW or to MS4 under appropriate permits. Groundwater would be monitored for PCE, daughter products, and performance parameters. This alternative also would include ICs as described in Section 5.1.

<u>Overall Protection of Human Health and the Environment</u>: Under LGW-GR-6, the pump and treat system would be implemented to achieve groundwater standards for PCE and daughter by adsorption of these potential COCs on GAC. ICs are implemented to prevent groundwater use and to require vapor barriers and passive venting systems in any building constructed within the area of the plume until the PRG is achieved for vapor intrusion. No ecological exposure to impacted groundwater was identified during the RI. This alternative is protective of human health and the environment.

<u>Compliance with ARARs:</u> Although the aquifer is designated as a Class G1 aquifer of drinking water quality, groundwater at the Site is not currently used as drinking water. Remedial actions under this alternative would be targeted to reduce concentration of PCE and daughter in groundwater to respective groundwater standards for Class G1 classification as per Title 21 DCMR. All actions planned under this alternative will be designed to comply with applicable ARARs.

<u>Long-term Effectiveness and Permanence:</u> The efficacy of GAC for removal of PCE and daughter products via adsorption has been well demonstrated. GAC is anticipated to be effective for treatment of the relatively low concentrations of potential COCs in groundwater. Effectiveness of the system may be limited by the

extraction rates that can be feasibly supported by the UWZ at the site. Additionally, extraction may also draw unknown off-site contaminants onto the site and into the treatment train, which can impact the effectiveness of the treatment. Bench- and pilot-scale studies can be performed for optimizing the GAC treatment set-up and for selection of the most effective GAC product. Based on available data and experience with similar systems, it is estimated that 3 to 30 years may be required for achieving the PRGs. Results from pilot testing can be used to further refine the timeframe for achieving the PRGs. ICs would not be required once the PRGs have been achieved; therefore, monitoring and maintenance of ICs would be eliminated providing further long-term effectiveness.

Reduction of Toxicity, Mobility, or Volume Through Treatment: This alternative would result in a substantial reduction of the toxicity and volume of PCE and daughter products in groundwater by removal of these potential COCs via adsorption on GAC.

Short-term Effectiveness: This alternative would require time for planning, permitting, mobilization, and implementation. A two to three year timeframe is anticipated for design of the remedy and construction. Treatment timeframe is dependent upon the extraction rates that can be supported by the aquifer. However, pump and treat systems generally need to be operated for several years to achieve the PRGs. Implementation of ICs would provide short-term protection for human receptors until treatment is complete and RAOs are achieved. Short-term exposures to the workers to treatment chemicals are possible during construction. Short-term risks to the community, workers, and the environment are possible during well installation via generation of dust. Short-term risks could be mitigated through implementation of dust suppression measures, site control measures, use of personal protective PPE by workers, implementation of soil erosion control measures, a soil management plan and air monitoring. Pepco will develop and implement an air monitoring plan and mitigation measures for any construction/excavation activities associated with remedy implementation. The air monitoring plan is prepared as part of the remedial design and will be compliant with OSHA requirements.

Implementability: Pump and treatment using GAC is a well-developed technology for which materials and methods needed are readily available. Groundwater yields from the UWZ beneath the site are anticipated to be low and in certain areas the UWZ may not produce sufficient water to allow sustained operation of the system. Extraction may also draw unknown off-site contaminants onto the site and into the treatment train, which can impact the effectiveness of the treatment. Some construction challenges are anticipated due to the presence of several underground utilities within the plume area. Implementation challenges could arise from sub-optimal location of extraction wells and possible preferential pathways created by utilities and transit infrastructure that could impact complete capture of the impacted groundwater. Therefore, this alternative is regarded as being moderately difficult to implement.

Cost: The capital cost for this alternative, which include of costs for bench- and pilot-scale testing, professional/technical services, installation of extraction and treatment systems, installation of additional groundwater monitoring wells, and preparation of deed notice and groundwater monitoring plan are estimated to be $1,000,000. O&M costs over 30 years include reviews every 5 years, annual groundwater sampling events (one event per year for first 5 years and one event every 5 years thereafter), and costs for the treatment system including annual replacement of GAC beds, system operator, annual reporting, and project management. Net present value of O&M costs is estimated to be $1,951,000. The total present worth cost of this alternative is $2,950,000 (**Table 6-13**). Key assumptions used for developing cost estimates are provided in **Appendix E**.

6.6.6 Summary

A summary of the detailed analysis performed for the three alternatives for groundwater restoration is presented in **Table 6-14**. A comparative analysis of these alternatives is discussed in Section 7.0.

7 Comparative Analysis of Remedial Alternatives

This section provides a comparative evaluation of the remedial alternatives described in Section 6 to assess the relative performance of each alternative with respect to the remedy selection criteria and to identify key tradeoffs. A scoring matrix for each criterion was developed to compare the overall rankings of the alternatives. Each alternative must meet the two threshold criteria (overall protection of human health and the environment and compliance with ARARs) to be eligible for selection. The balancing criteria (long-term effectiveness and permanence; reduction of toxicity, mobility, and volume through treatment; short-term effectiveness; implementability; and cost) generally present tradeoffs among the alternatives and were scored on a scale of 1 to 5 where:1 = low, 2 = low to moderate, 3 = moderate, 4 = moderate-high, and 5 = high). The rating scale is a linear relationship, with minimum performance given a rating of 1 and maximum performance given a rating of 5.

7.1 Comparative Evaluation of Alternatives for PCB-Impacted Soil

Four alternatives were evaluated for PCBs in soil. These are:

- **LSS-PCB-1:** No Action
- **LSS-PCB-2:** PTSM Excavation with Off-Site Treatment and Disposal, and ICs
- **LSS-PCB-4:** PTSM Excavation with Off-Site Treatment and Disposal, Excavation of Surface Soils (with PCBs > 7 mg/kg) and Sub-Surface Soils (1-2 ft. at SUSDPGD21-G1 and at SUSDP21), and ICs
- **LSS-PCB-5:** PTSM Excavation with Off-Site Treatment and Disposal, Complete Excavation of 0-2 ft. Interval Soils with PCBs > 7 mg/kg, with Off-Site Disposal, and ICs

7.1.1 Threshold Criteria

Overall Protection of Human Health and the Environment

Alternative LSS-PCB-1 does not include any remedial activities or ICs and would not achieve RAOs in a reasonable timeframe. Therefore, LSS-PCB-1 would not be protective of human health and the environment. LSS-PCB-2, LSS-PCB-4, and LSS-PCB-5 are protective of human health as all three alternatives involve removal and treatment of PTSM and implementation of ICs to manage any residual impacts as well as protect the integrity of the caps. No ecological risks were identified for the LIA.

Compliance with ARARs

As no actions are taken under LSS-PCB-1 it would not comply with the ARARs. LSS-PCB-2, LSS-PCB-4, and LSS-PCB-5 would be implemented pursuant to the risk-based approach under TSCA and would meet ARARs by addressing regulatory and permitting requirements through the remedial design and regulatory review process.

7.1.2 Balancing Criteria

Long-Term Effectiveness and Permanence

ICs, implemented under LSS-PCB-2, LSS-PCB-4, and LSS-PCB-5 have been demonstrated to be reliable and effective in protecting human receptors in the long-term. Alternatives LSS-PCB-2, LSS-PCB-4, and LSS-PCB-5 all involve permanent removal and treatment of PTSM. LSS-PCB-2 removes 1.8 CY of PTSM, LSS-PCB-4 and LSS-PCB-5 would permanently remove 73 CY and 126 CY of soil with PCBs > 7 mg/kg from the site, respectively, in addition to 1.8 CY of PTSM. Thus, LSS-PCB-2 was rated low, LSS-PCB-4 was rated moderate, while LSS-PCB-5 was rated high.

Reduction of Toxicity, Mobility and Volume

LSS-PCB-2 would result in substantial reduction in toxicity, but only minor reductions in mobility or volume through treatment and was rated moderate. Both LSS-PCB-4 and LSS-PCB-5 would result in substantial reduction in toxicity and a moderate reduction in volume through a combination of treatment of PTSM and removal of soils 73 CY and 126 CY of soil, respectively, with PCBs > 7 mg/kg. Thus, LSS-PCB-2 was rated low, LSS-PCB-4 was rated moderate, while LSS-PCB-5 was rated high.

Short-term Effectiveness and Potential Impacts During Remediation

LSS-PCB-2 may present minor risks to workers and community during asphalt removal and replacement, and excavation of PTSM. Both LSS-PCB-4 and LSS-PCB-5 present slightly higher risks to the community and workers due to activities associated with excavation of substantially greater quantities of soil with PCBs > 7 mg/kg. LSS-PCB-2 can be implemented in a shorter timeframe than LSS-PCB-4 and LSS-PCB-5 due to lower volume of soil to be excavated. Therefore, LSS-PCB-2 was rated moderate-to-high, LSS-PCB-4 was rated moderate, while LSS-PCB-5 was rated low-to-moderate.

Implementability

All action alternatives require excavation in tight spaces (such as between the retaining wall along Kenilworth Avenue and Building 57) and in locations with underground utilities, and would need excavation permits. However, LSS-PCB-2 involves excavation of only the PTSM while both LSS-PCB-4 and LSS-PCB-5 involve excavation of substantially greater volume of soils in the narrow space between Building 57 and the retaining wall. Both LSS-PCB-4 and LSS-PCB-5 also involve subsurface excavations along the retaining wall, which is expected to present implementation challenges. However, LSS-PCB-5 would need subsurface excavation along a much longer portion of the retaining wall than would LSS-PCB-4. Based on the above considerations, LSS-PCB-2 was ranked moderate-to-high on implementability, LSS-PCB-4 was ranked low-to-moderate, while LSS-PCB-5 was ranked low.

Cost

LSS-PCB-2 was ranked high, LSS-PCB-4 was ranked moderate, and LSS-PCB-5 was ranked low, based on their respective costs.

7.1.3 Summary of Comparative Evaluation and Recommendation

A summary of comparative evaluation for PCB-impacted LIA soils is presented below. While the overall score for all alternatives was equal, alternative LSS-PCB-5 would: (a) remove more PCB mass as compared to LSS-PCB-2 and LSS-PCB-3; (b) result in a 94% reduction in the EPC to the construction worker compared to current EPC; and (c) result in a post-implementation EPC (7.1 mg/kg) that is very close to the combined soil PRG (7 mg/kg).

Evaluation Criteria	LSS-PCB-1	LSS-PCB-2	LSS-PCB-4	LSS-PCB-5
	No Action	Removal with Off-Site Treatment and Disposal of PTSM, and ICs	Removal with Off-Site Treatment/Disposal of PTSM, Surface Soils with PCBs > 7 mg/kg, and Select Sub-Surface Soils (1-2 ft.), and ICs	Removal with Off-Site Treatment/Disposal of PTSM and Soils (0-2 ft.) with PCBs > 7 mg/kg, and ICs
Threshold Criteria				
Overall Protectiveness of Human Health and the Environment	X	✓	✓	✓
Compliance with ARARs	X	✓	✓	✓
Balancing Criteria				
Reduction in Toxicity, Mobility and Volume	NA	1	3	5
Long-term Effectiveness and Permanence	NA	1	3	5
Short-term Effectiveness and Potential Impacts During Remediation	NA	4	3	2
Implementability	NA	4	3	2
Cost Effectiveness	NA	5	3	1
Total Score	**NA**	**15**	**15**	**15**
Total Cost	$0	**$253,000**	**$502,000**	**$976,000**

7.2 Comparative Evaluation of Alternatives for Vanadium-Impacted Soil

Three alternatives were evaluated for vanadium in soil. These are:

- **LSS-V-1:** No Action
- **LSS-V-2:** Institutional Controls
- **LSS-V-3:** Excavation with Off-Site Disposal, and ICs

7.2.1 Threshold Criteria

Overall Protection of Human Health and the Environment

Alternative LSS-V-1 does not include any remedial activities or ICs and would not achieve RAOs in a reasonable timeframe. Therefore, LSS-V-1 would not be protective of human health and the environment. LSS-V-2 is protective of human health as this alternative implements ICs to eliminate exposure to human receptors, and to manage any residual impacts. LSS-V-3 involves removal of 1530 CY of soil from the Warehouse and Laydown area, in addition to implementing ICs. No ecological risks were identified for the LIA.

Compliance with ARARs

As no actions are taken under LSS-V-1, it would not comply with the ARARs. Both LSS-V-2 and LSS-V-3 would meet ARARs by addressing regulatory and permitting requirements through the remedial design and regulatory review process.

7.2.2 Balancing Criteria

Long-term Effectiveness and Permanence

ICs to be implemented under LSS-V-2 have been demonstrated to be reliable and effective in protecting construction worker receptors in the long-term. In addition to implementing ICs, LSS-V-3 would also permanently remove 1530 CY of surface soils from the site with vanadium concentrations above PRGs. Therefore, thus LSS-V-3 was rated high, while LSS-V-2 was rated moderate.

Reduction of Toxicity, Mobility and Volume

LSS-V-2 would not result in any substantial reduction in toxicity, mobility, or volume and was rated low. LSS-V-3 would result in substantial reduction in both toxicity and volume of vanadium-impacted soil. Therefore, LSS-V-3 was ranked high on this criterion.

Short-term Effectiveness and Potential Impacts During Remediation

Implementation of ICs under LSS-V-2 is unlikely to present any risks to workers and can be implemented in a much shorter timeframe. As a result, LSS-V-2 was ranked high. LSS-V-3 presents higher risks to the community and workers due to activities associated with excavation, transportation, and disposal of 1530 CY of soil. LSS-V-3 would also need longer time to implement as compared to LSS-V-2. Therefore, LSS-V-3 was ranked low-to-moderate.

Implementability

LSS-V-2 relies on ICs to reduce human exposure to impacted soils and would be easy to implement. In addition to ICs, LSS-V-3 entails excavation of 1530 CY of soil from the Warehouse and Laydown area, some of which may be challenging to excavate due to presence of aboveground structures and underground utilities. As a result, LSS-V-2 was ranked high while LSS-V-3 was ranked moderate.

Cost

LSS-V-2 was ranked high while LSS-V-3 was ranked low.

7.2.3 Summary of Comparative Evaluation and Recommendation

A summary of comparative evaluation for vanadium-impacted LIA soils is presented below. LSS-V-2 scored highest and is therefore recommended for implementation.

Evaluation Criteria	LSS-V-1	LSS-V-2	LSS-V-3
	No Action	Institutional Controls	Excavation with Off-Site Disposal, and ICs
Threshold Criteria			
Overall Protectiveness of Human Health and the Environment	X	✓	✓
Compliance with ARARs	X	✓	✓
Balancing Criteria			
Reduction in Toxicity, Mobility and Volume	NA	1	5
Long-term Effectiveness and Permanence	NA	3	5
Short-term Effectiveness and Potential Impacts During Remediation	NA	5	2
Implementability	NA	5	3
Cost Effectiveness	NA	5	1
Total Score	**NA**	**19**	**16**
Total Cost	**$0**	**$80,000**	**$670,000**

7.3 Comparative Evaluation of Alternatives for Addressing Vapor Intrusion Risks from LIA Groundwater

LGW-VB-3 (Thermoplastic Membrane Vapor Barriers with Passive Venting System) was the only retained alternative for addressing vapor intrusion risks from groundwater in UWZ contingent on the hypothetical construction of a building within the CVOC plume before groundwater concentrations are reduced to below the PRGs. LGW-VB-3 was rated high on all criteria as compared to the LGW-VB-1 – No Action alternative. Comparative evaluation of LGW-VB-1 and LGW-VB-3 is presented in the table below.

Evaluation Criteria	LGW-VB-1	LGW-VB-3
	No Action	Thermoplastic Membrane Vapor Barriers with Passive Venting System
Threshold Criteria		
Overall Protectiveness of Human Health and the Environment	X	✓
Compliance with ARARs	X	✓
Balancing Criteria		
Reduction in Toxicity, Mobility and Volume	NA	5
Long-term Effectiveness and Permanence	NA	5
Short-term Effectiveness and Potential Impacts During Remediation	NA	5
Implementability	NA	5
Cost Effectiveness	NA	5
Total Score	**NA**	**20**
Total Cost	**$0**	**$680,000**

7.4 Comparative Evaluation of LIA Groundwater Restoration Alternatives

Five groundwater alternatives were evaluated. These are:

- **LGW-GR-1:** No Action
- **LGW-GR-2:** MNA, Groundwater Monitoring, and ICs
- **LGW-GR-4:** Treatment via ZVI Injection, with MNA and ICs
- **LGW-GR-5:** Treatment with Biowalls and ZVI, with MNA and ICs

- **LGW-GR-6:** Groundwater Extraction and Treatment using GAC, with MNA and ICs

7.4.1 Threshold Criteria

Overall Protection of Human Health and the Environment

Alternative LGW-GR-1 does not include any remedial activities or ICs and would not achieve RAOs in a reasonable timeframe. Therefore, LGW-GR-1 would not be protective of human health and the environment. Alternative LGW-GR-2 includes long-term groundwater monitoring, evaluation of MNA, and ICs, and is protective of human health and the environment as the on-site plume currently does not pose human health and ecological risks and is unlikely to do so in the future. Alternatives LGW-GR-4 to LGW-GR-6 include treatment to reduce concentrations of potential COCs in groundwater to meet respective standards. No ecological risks were identified for the LIA. Thus, LGW-GR-2, LGW-GR-4, LGW-GR-5, and LGW-GR-6 are all protective of human health and environment.

Compliance with ARARs

As no actions are taken under LGW-GR-1 it would not comply with the ARARs. Alternative LGW-GR-2 would implement a long-term groundwater monitoring program and ICs to ensure that current site conditions, whereby no human or ecological receptors are exposed to potential COCs in groundwater, are maintained, while relying on MNA to reduce groundwater concentrations over time. Alternatives LGW-GR-4, LGW-GR-5, and LGW-GR-6 would be targeted to reduce concentrations of potential COCs in groundwater to meet respective standards as per Title 21 of DCMR, which serve as the ARARs. All remedial actions would be designed to comply with regulatory and permitting requirements through the remedial design and regulatory review process.

7.4.2 Balancing Criteria

Long-term Effectiveness and Permanence

Alternative LGW-GR-2 includes implementation of ICs which will prevent use of on-site groundwater. Groundwater in the UWZ at the Site (and in DC generally) is not currently used as drinking water. Furthermore, no ecological risks were identified for potential COCs in groundwater. These conditions are unlikely to change for the foreseeable future and implementation of ICs and long-term monitoring program would ensure long-term effectiveness, while MNA processes would reduce contaminant concentrations over time given the absence of an ongoing source of PCE at the Site. Alternatives LGW-GR-4, LGW-GR-5, and LGW-GR-6 all include treatment processes that would be targeted to reduce potential COC concentrations to meet respective groundwater standards. Long-term effectiveness would be evaluated during bench-scale and pilot-scale studies. The treatment processes under these alternatives all have been demonstrated to be reliable and effective in reducing contaminant concentrations and protecting human receptors in the long-term. For LGW-GR-5, maintaining the field, biological, and geochemical conditions necessary for effective dechlorination in the long-term is likely to be difficult and may impact the long-term effectiveness of this alternative. Effectiveness of the extraction and treatment system under LGW-GR-6 may be limited by the extraction rates that can be feasibly supported by the UWZ at the site. Additionally, extraction may also draw unknown off-site contaminants onto the site and into the treatment train, which can impact the effectiveness of the treatment. No such effectiveness consideration were identified for LGW-GR-4 but bench- and pilot-scale studies would still be required for this alternative. Based on the above discussion, LGW-GR-2 was ranked moderate, LGW-GR-4 and LGW-GR-5 were both ranked moderate-to-high, while LGW-GR-6 was ranked moderate.

Reduction of Toxicity, Mobility and Volume Through Treatment

Alternative LGW-GR-2 does not include any treatment. However, natural process (such as physical and biological degradation) are anticipated to reduce the groundwater concentrations over time. Alternatives LGW-GR-4, LGW-GR-5, and LGW-GR-5 all include treatment processes that would be targeted to reduce potential COC concentrations to meet respective groundwater standards, thereby resulting in reduction in toxicity, mobility, and volume of impacted groundwater through treatment. Groundwater extraction and treatment under LGW-GR-6 may draw off-site contaminants on to the site. Based on the above discussion, LGW-GR-2 was ranked low, LGW-GR-4 was ranked moderate-to-high, and both LGW-GR-5 and LGW-GR-6 were ranked moderate.

Short-term Effectiveness and Potential Impacts During Remediation

LGW-GR-2 does not involve any design or construction as there are no active remedial actions proposed under this alternative. LGW-GR-4 relies on direct injection of ZVI into the sub-surface. LGW-GR-5 would need excavation up to 30 ft. bgs at three locations across the width of the plume wherein several underground utilities are present, while LGW-GR-6 would need excavation, installation of extraction wells, and construction of underground pipelines to connect the extraction wells to the treatment building. Thus, the design and construction timeframes for LGW-GR-4 are anticipated to be shorter than those for LGW-GR-5 and LGW-GR-6. All of LGW-GR-4, LGW-GR-5, and LGW-GR-6 may present short-term exposure of workers to dust from installation of injection points and to chemicals used for treatment, but any associated risks can be mitigated through suitable PPE, dust control measures, SMPs, and air monitoring. Short-term risks to the environment and surrounding community from dust generation and increased traffic are possible. Impacts from LGW-GR-5 on workers, environment, and surrounding community are anticipated to be higher due to larger scope of excavation and construction. LGW-GR-5 may also result in accumulation of toxic intermediates such as DCE and VC in the groundwater in the short-term until treatment is complete. No such potential impacts on groundwater quality were identified for LGW-GR-4. Short-term effectiveness of LGW-GR-6 may be limited by low groundwater yields. Based on the above factors as well as the anticipated extent of impacts during remedy implementation, LGW-GR-2 was ranked high, LGW-GR-4 was ranked moderate, LGW-GR-5 was ranked low, while LGW-GR-6 was ranked moderate-to-high.

Implementability

ICs and long-term groundwater monitoring program under LGW-GR-2 would be easy to implement. All treatment alternatives, LGW-GR-4 to LGW-GR-6, would include handling and injection of chemicals, may require more involved underground injection permits. For LGW-GR-4 to LGW-GR-6, the presence of numerous utilities and transit infrastructure within or adjacent to the plume pose implementation challenges that could lead to delays, construction challenges, and/or ineffective treatment. The pH range of groundwater in the UWZ is suitable for LGW-GR-4. The groundwater pH range is currently not suitable for the bioremediation aspect of LGW-GR-5 and would need incorporation of limestone to raise the pH to levels suitable for survival and growth of dechlorinating bacteria. However, degradation of potential COCs via ZVI is substantially less effective at pH greater than 8. Controlling groundwater pH within a narrow range wherein both bioremediation and ZVI are effective is anticipated to be challenging. Groundwater yields from the UWZ beneath the site are anticipated to be low and in certain areas the UWZ may not produce sufficient water to allow sustained operation of pump and treat system under LGW-GR-6. Extraction may also draw unknown off-site contaminants on to the site and into the treatment train, which can impact the effectiveness of the treatment. Therefore, LGW-GR-2 was ranked high, LGW-GR-4 and LGW-GR-6 were ranked moderate, while LGW-GR-5 was ranked low for this criterion.

Cost Effectiveness

LGW-GR-2 was ranked high, LGW-GR-4 was ranked low-to-moderate, while both LGW-GR-5 and LGW-GR-6 were ranked low.

7.4.3 Summary of Comparative Evaluation and Recommendation

A summary of the comparative evaluation for LIA Groundwater alternatives is presented below. LGW-GR-2 scored highest and is therefore recommended for implementation. Based on groundwater monitoring data collected under LGW-GR-2, the performance of LGW-GR-2 will be evaluated as part of the periodic reviews. If deemed necessary to accelerate the achievement of RAOs, additional alternatives (such as LGW-GR-4, LGW-GR-5, LGW-GR-6, or components thereof) would be evaluated to enhance natural attenuation under LGW-GR-2. In the meantime, the groundwater use restrictions to be implemented as part of the ICs for LGW-GR-2 would be fully protective of human health.

Evaluation Criteria	**LGW-GR-1**	**LGW-GR-2**	**LGW-GR-4**	**LGW-GR-5**	**LGW-GR-6**
	No Action	MNA, Groundwater Monitoring, and ICs	Treatment via ZVI Injection, with MNA and ICs	Treatment with Biowalls and ZVI, with MNA and ICs	Groundwater Extraction and Treatment using GAC, with MNA and ICs
Threshold Criteria					
Overall Protectiveness of Human Health and the Environment	X	✓	✓	✓	✓
Compliance with ARARs	X	✓	✓	✓	✓
Balancing Criteria					
Reduction in Toxicity, Mobility and Volume	NA	1	4	3	3
Long-term Effectiveness and Permanence	NA	3	5	4	3
Short-term Effectiveness and Potential Impacts During Remediation	NA	5	3	1	4
Implementability	NA	5	3	1	3
Cost Effectiveness	NA	5	2	1	1
Total Score	**NA**	**19**	**17**	**10**	**14**
Total Cost	**$0**	**$586,000**	**$1,880,000**	**$2,790,000**	**$2,950,000**

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Figures

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Tables

Appendix A

Post-RI Tech Memo #1 – PCE Data Gap Investigation

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Appendix B

PCB Minimization Plan – Tables and Figures

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Appendix C

Derivation of Risk-Based Target Concentrations for Potential COCs in Landside Soil and Groundwater Tables

Appendix D

Post-Excavation Risk Assessment for Impacted Soil

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Appendix E

Key Assumptions for Cost Estimates