RECORD OF DECISION

HIDDEN LANE LANDFILL SUPERFUND SITE
OPERABLE UNIT 3

STERLING
LOUDOUN COUNTY, VIRIGNIA

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION 3, PHILADELPHIA, PENNSYLVANIA
January 2022

TABLE OF CONTENTS

LIST OF ACRONYMS

1,1-DCE	1,1-dichloroethene
AR	Administrative Record
ARARs	Applicable or Relevant and Appropriate Requirements
bgs	Below Ground Surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
C.F.R.	Code of Federal Regulations
COC	Contaminant of Concern
CSM	Conceptual Site Model
DCE	*cis*-1,2 dichloroethene
DNAPL	Dense Non-aqueous Phase Liquid
EPA	Environmental Protection Agency
ERA	Ecological Risk Assessment
ERH	Electrical Resistivity Heating
ESD	Explanation of Significant Differences
ft.	Feet
FYR	Five-Year Review

FS	Feasibility Study
GAC	Granular Activated Carbon
HHRA	human health risk assessment
ISCO	In Situ Chemical Oxidation
LUCs	Land Use Controls
MCL	Maximum Contaminant Level
mg/kg	milligrams per kilogram
MSL	Mean Sea Level
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NHPA	National Historic Preservation Act
NPL	National Priorities List
O&M	Operation and Maintenance
OU	Operable Unit
POETS	Point-of-Entry Treatment System
RA	Remedial Action
RAO	Remedial Action Objective
RD	Remedial Design
RG	Remedial Goal
RI	Remedial Investigation
ROD	Record of Decision
SSL	Soil Screening Level
TBC	advisories, criteria, or guidance “to be considered”
TCE	Trichloroethylene
µg/L	micrograms per liter
U.S.C.	United States Code
VC	Vinyl Chloride
VDEQ	Virginia Department of Environmental Quality
VDH	Virginia Department of Health
VOCS	Volatile Organic Compounds
WMA	Waste Management Area

I. DECLARATION

HIDDEN LANE LANDFILL SUPERFUND SITE
OPERABLE UNIT 3

STERLING, LOUDOUN COUNTY, VIRGINIA

RECORD OF DECISION FOR REMEDIAL ACTION
HIDDEN LANE LANDFILL SUPERFUND SITE
OPERABLE UNIT 3
STERLING, LOUDOUN COUNTY, VIRGINIA

I. DECLARATION

Site Name and Location

The Hidden Lane Landfill Superfund Site (Site) was a privately owned and operated landfill situated north of Virginia Route 7 between the communities of Broad Run Farms, to the west, and Countryside, to the east, in Sterling, Loudoun County, Virginia. The landfill is approximately 40 acres in size and is adjacent to the flood plain of the Potomac River. Starting in 1971, the facility accepted a variety of solid wastes including construction and demolition wastes. The landfill was closed in 1986 by order of the Commonwealth of Virginia, pursuant to a 1983 Loudoun Circuit Court Order. As part of the close-out procedures, the landfill was covered with a two-foot clay cap. The Site is currently not in use and the landfill is covered in grass and trees. The National Superfund Database Identification Number is VAD980829030. A Site Location Map is included as Figure 1.

Statement of Basis and Purpose

For administrative purposes, the Site has been separated into three Operable Units (OUs). OU-1 addresses the Site-wide groundwater contamination, OU-2 addresses the exposure of the public to Site-related contaminants in groundwater in residential drinking water wells, and OU-3 addresses the landfill cap and the source of Site groundwater contamination.

This Record of Decision (ROD) presents the United States Environmental Protection Agency's (EPA's) selected remedy for OU-3 (Selected Remedy) to address the landfill cap and the source of Site groundwater contamination. The Selected Remedy was chosen in accordance with the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA), 42 United States Code (U.S.C.) § 9601 et seq., as amended, and to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 Code of Federal Regulations (C.F.R.) Part 300, as amended. This ROD is based on the Administrative Record (AR) for the Site, which was developed in accordance with Section 113 (k) of CERCLA, 42 U.S.C. § 9613(k). This AR file is available for review online at https://semspub.epa.gov/work/03/2309580.pdf, at the EPA Region III Records Center in Philadelphia, Pennsylvania, and at the Cascades Library in Potomac Falls, Virginia. The AR Index identifies each document contained in the AR upon which the selection of the remedy is based. The signed ROD will become part of the AR for the Site.

The Virginia Department of Environmental Quality (VDEQ) concurs with the Selected Remedy (Appendix A).

Assessment of the Site

The Selected Remedy in this ROD is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment.

Description of the Selected Remedy

The Selected Remedy described in this ROD will address the landfill cap and source of Site groundwater contamination (OU-3).

The Selected Remedy comprises the following components:

- Landfill Cap Repair and Maintenance with Land Use Controls (LUCs);
- Excavation and Offsite Disposal for Principal Threat Source Material; and
- *In Situ* Bioremediation and Chemical Reduction of Principal Threat Source Material in Bedrock.

The estimated cost to implement the OU-3 remedial action is $8,256,000.

Statutory Determinations

The Selected Remedy for OU-3 at the Site meets the mandates of CERCLA Section 121 and the regulatory requirements of the NCP. This Selected Remedy is protective of human health and the environment; is cost effective; complies with statutory requirements that are applicable or relevant and appropriate requirements (ARARs); and utilizes a permanent solution to the maximum extent practicable. This remedy also satisfies the statutory preference for treatment as a principal element of the remedy (i.e., reduction of the toxicity, mobility, or volume of hazardous substances). In accordance with CERCLA § 121(c), a remedy review will be conducted within 5 years after initiation of the Selected Remedy to ensure it continues to provide adequate protection of human health and the environment. Five-Year Reviews (FYRs) will be conducted at least every 5 years after the date of the initiation of the Selected Remedy and will continue until hazardous substances are no longer present above levels that allow for unlimited use and unrestricted exposure.

ROD Certification Checklist

The following information in the chart is included in the Decision Summary (Part II) of this ROD. Additional information can be found in the AR file for the Site.

ROD CERTIFICATION CHECKLIST	
Information	**Location/Page Number**
Chemicals of concern (COCs) and respective concentrations	Section 7.0, p. 14-16
Baseline risk represented by the COCs	Section 7.0, p. 14-16 Section 7.1, p. 17

	Section 7.3, p. 18
Performance Standards established for COCs and the basis for these levels	Section 8.0, p. 18-19
How source materials constituting principal threat are addressed	Section 11.0, p. 35-56 Section 12.2, p. 37-40
Current and reasonably anticipated future land use assumptions and potential future beneficial uses of groundwater	Section 6.0, p. 14
Potential future land and groundwater uses that will be available at the Site as a result of the Selected Remedy	Section 6.0, p. 14
Estimated capital, annual operation and maintenance, and total present worth costs, discount rate, and the number of years over which the remedial action cost estimates are projected	Section 10.7, p. 33-35
Key factors that led to selecting the remedy	Section 12.1, p. 36-37

Authorizing Signature

This ROD documents the Selected Remedy for OU-3 of the Site. EPA selected this Remedial Action with the concurrence of the VDEQ.

Approved by: Date:

PAUL LEONARD

Digitally signed by PAUL LEONARD
Date: 2022.02.08 16:09:34 -05'00'

Paul Leonard, Director
Superfund & Emergency Management Division
EPA Region III

II. DECISION SUMMARY

HIDDEN LANE LANDFILL SUPERFUND SITE
OPERABLE UNIT 3

STERLING, LOUDOUN COUNTY, VIRGINIA

II. DECISION SUMMARY

1.0 SITE NAME, LOCATION, AND DESCRIPTION

The Hidden Lane Landfill Superfund Site (Site) was a privately owned and operated landfill situated north of Virginia Route 7 between the communities of Broad Run Farms, to the west, and Countryside, to the east, in Sterling, Loudoun County, Virginia. The landfill is approximately 40 acres in size and is adjacent to the flood plain of the Potomac River. The Site is currently not in use and the landfill is covered in grass and trees. Access to the Site is unrestricted, except for a locked gate at the Site's road entrance. A Site Location Map is included as Figure 1.

Past landfill operations resulted in contamination of groundwater and nearby domestic use drinking water wells with trichloroethene (TCE). The Site has been subdivided into three Operable Units (OUs) and each OU is being addressed separately. OU-1 addresses Site-wide groundwater contamination, OU-2 addresses the exposure of the public to Site-related contaminants in groundwater in residential (or domestic) drinking water wells and OU-3 addresses the landfill cap and the source of Site groundwater contamination. OU-3 is the focus of this Record of Decision (ROD). In 2019, EPA signed a ROD and is currently conducting Remedial Action (RA) activities at OU-2 to address exposure to TCE and its breakdown products in residential drinking water wells at concentrations exceeding or potentially exceeding Maximum Contaminant Levels (MCLs) via installation of and connections to a waterline. The restoration of Site-wide contaminated groundwater will be addressed in a future ROD for OU-1, which EPA expects to be the final RA for the Site.

The National Superfund Database Identification Number for the Site is VAD980829030. The United States Environmental Protection Agency (EPA) is the lead agency for the Site and the Virginia Department of Environmental Quality (VDEQ) is the support agency.

2.0 SITE HISTORY AND ENFORCEMENT ACTIVITIES

Starting in 1971, the facility accepted a variety of solid wastes including construction and demolition wastes. The landfill was closed in 1986 by order of the Commonwealth of Virginia, pursuant to a 1983 Loudoun Circuit Court Order. As part of the close-out procedures, the landfill was covered with a two-foot clay cap. In the mid-1990s additional material, consisting primarily of soil, stone, and concrete rubble, was deposited on portions of the landfill in an effort by the landowner to fill sink holes and conduct post-closure maintenance.

2.1 Previous Environmental Investigations and Response Actions

VDEQ and EPA had led numerous environmental investigations at the Site since the mid-1980s. In the mid to late 1980s it was determined that methane gas was being generated by the landfill and was migrating toward the homes in the Countryside subdivision. In November 1988, the former operator of the landfill installed a series of ventilation wells on the east side of the landfill property.

EPA conducted a Preliminary Assessment of the landfill from 1988 to 1989. TCE contamination was detected in two drinking water wells in the Broad Run Farms community, west of the landfill. No TCE was detected in the three landfill monitoring wells located downgradient of the landfill, landfill seeps, soils or surface water. Based on the information available at the time and the limited scientific understanding of bedrock aquifers, the TCE in drinking water wells was not attributed to the landfill at that time. No further action under the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA), as amended, was recommended.

Over the next 16 years, TCE was found in five new drinking water wells installed in the Broad Run Farms community. In March 2005, 67 drinking water wells in the Broad Run Farms community were sampled for TCE by the Loudoun County Health Department. Based on the sampling results, VDEQ installed Point-of-Entry Treatment Systems (POETS) in 22 affected residences to remove the TCE before the well water was distributed in the home plumbing. Three additional residences were provided POETS during the VDEQ period of system maintenance.

EPA reopened its evaluation of the Site in October 2005. A Site Assessment was completed in 2007, which resulted in the Site being proposed to EPA's National Priorities List of contaminated sites (NPL) on September 19, 2007. The Site was listed on the NPL on March 19, 2008. Maintenance of the 25 residential POETS was transferred from VDEQ to EPA in June 2008. EPA installed additional POETS at residences where Site contaminants were found to pose a risk or potential risk to human health during the Remedial Investigation (RI). Currently, EPA monitors and maintains 37 residential POETS as called for in the 2019 OU-2 ROD until waterline connections are completed.

RI activities began in early 2009. The investigation included sampling and analysis of groundwater, soil, surface water, and sediments, as well as landfill gases including methane associated with the landfill. An evaluation of the potential for the migration of Site-related vapors into private homes was also conducted. This investigation also included a Human Health Risk Assessment (HHRA) and an Ecological Risk Assessment (ERA). The RI concluded that only human exposure to contaminated groundwater posed any unacceptable risk.

In 2016, EPA began work on a Feasibility Study (FS) at the Site to identify alternatives for a RA to address the drinking water well contamination and groundwater contamination. Due to uncertainties concerning the potential source of groundwater contamination and the need for further investigation, EPA and VDEQ in the summer of 2017 decided to propose a permanent remedy for the domestic drinking water wells affected by TCE in groundwater as a separate interim RA. In 2019, EPA developed a ROD for OU-2 which addresses exposure to TCE in residential drinking water wells at concentrations exceeding or potentially exceeding the Federal Safe Drinking Water Act MCL of 5 micrograms per liter (µg/L). The OU-2 remedy consists of extending an existing public waterline into the area of the Broad Run Farms development affected or potentially affected by the Site. See Figure 2 for a map of the Site which shows TCE concentrations in groundwater at the Site.

A treatability study was conducted in 2015-2016 to determine whether in-situ anaerobic biotic/abiotic treatment with bioaugmentation is a viable remedial alternative for remediating the TCE groundwater plume. The treatability study consisted of enhancing a combination of biotic and abiotic process to degrade chlorinated ethenes, primarily TCE, to nontoxic end products. It was concluded that an upgradient source within the landfill was introducing additional dissolved TCE mass into the treatability study area. Based on this finding, it was recommended that a Supplemental RI be completed, consisting of source area investigation to locate potential TCE source area(s) upgradient of the landfill.

In 2019, EPA conducted a Supplemental RI with the objectives of locating the TCE source area within the landfill footprint, characterizing the magnitude and extent of the source area contamination, and generating data to identify transport mechanisms associated with the migration of TCE from the source area into the bedrock aquifer. Several assessments were conducted to narrow the potential investigation area, including an extensive evaluation of geophysical and hydro-stratigraphic data as well as a thorough review of historical photographs to identify past operational areas of the landfill. Subsequent tree core sampling, direct sensing by membrane interface probe and hydraulic profiling tool, and direct push soil sampling were used to identify, characterize and delineate a source of TCE in soil within the landfill footprint. The TCE source area was found at the southern end of the landfill footprint within the soil overburden and saprolite, and also includes impact to shallow bedrock.

In 2020, EPA conducted additional studies to support the development of appropriate remedial alternatives for the source area. These activities involved a dye tracer study, a discrete fracture network evaluation, bedrock coring and sampling, advanced borehole geophysical logging, and installation and sampling of additional groundwater bedrock monitoring wells. Also, in 2020, EPA developed a FS for OU-3 to identify and evaluate potential actions to address the landfill cap and the source of Site groundwater contamination.

3.0 COMMUNITY PARTICIPATION

On April 12, 2021, pursuant to Section l13(k)(2)(B) of CERCLA, 42 U.S.C. § 9613(k)(2)(B), EPA released the Proposed Plan for OU-3 for a 30-day public comment period. The Proposed Plan was based on documents contained in the AR for the Site and set forth EPA's preferred remedial alternatives. EPA recorded a video presentation that was published in place of a public meeting to inform local officials, interested citizens, and other stakeholders about EPA's proposed cleanup plan and the Superfund process and to receive comments on the Proposed Plan. During the public comment period, EPA accepted written comments and oral comments submitted by voicemail and responded to the comments in the Responsiveness Summary section, which is included as Part III of this ROD. These community participation activities meet the public participation requirements in CERCLA Section 117, 42 U.S.C. § 9617 and 40 C.F.R. § 300.430(f)(3) of the NCP.

The notice of the availability of these documents was published in the *Loudoun Times-Mirror* on April 16, 2021. An extension of the public comment period was requested. As a result, the public comment period was extended to June 11, 2021. In addition, a virtual public meeting was held on April 21, 2021 to present the Proposed Plan to a broader community audience and answer any questions.

The AR can be viewed online at https://semspub.epa.gov/work/03/2309580.pdf, or at the EPA Region III Records Center in Philadelphia, Pennsylvania and at the Cascades Library in Potomac Falls, Virginia.

3.1 Cultural Investigation and National Historic Preservation Act Consultation

In 2020, EPA began consultation under the National Historic Preservation Act of 1966 (NHPA), 54 U.S.C. § 300101 *et seq*., with a number of interested parties, including several Federally Recognized Tribes. In addition, also in 2020, EPA undertook government-to-government consultation with the Federally Recognized Tribes, consistent with EPA policy. [1] Currently, EPA is performing investigations at the Site to determine the archeological significance, if any, of the activities associated with the OU-2 RA. EPA will initiate consultation under NHPA at the Site to determine the archeological significance, if any, of the activities associated with the OU-3 Selected Remedy described in this ROD prior to implementation of the RA.

4.0 SCOPE AND ROLE OF RESPONSE ACTION

OU-3, the focus of this ROD, is the second of three planned OUs for the Site and addresses the landfill cap and source of Site groundwater contamination. In 2019, EPA signed a ROD selecting the RA for OU-2 and is currently conducting OU-2 RA activities to address exposure to TCE and its breakdown products in residential drinking water wells at concentrations exceeding or potentially exceeding MCLs. EPA is doing this via installation of, and connections to, a waterline. EPA expects the future ROD for OU-1 will select the final RA for the Site and will focus on Site-wide groundwater contamination.

For the purposes of this ROD, the landfill at the Site is designated as a Waste Management Area (WMA). The preamble to the NCP states EPA's policy that "remediation levels generally should be attained throughout the contaminated plume or at beyond the edge of the waste management area when waste is left in place." [2] Thus, EPA uses the edge of the WMA to determine the point of compliance to assess whether groundwater cleanup standards have been achieved. The contaminated source material located in overburden soils, bedrock and groundwater at the southern entrance of the landfill and under the WMA has been designated by EPA as a principal threat because the source material would pose a significant risk to human health or the environment should exposure occur.

EPA characterizes waste onsite as either principal threat or low-level threat. The concepts of principal threat waste or low-level threat waste, as developed by EPA in the NCP, is applied on a site-specific basis when characterizing source material. "Source material" is defined by EPA policy as material that includes or contains hazardous substances, pollutants, or contaminants that act as a reservoir for migration of contamination to groundwater, to surface water, to air, or

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[1] Government-to-government consultation provides the opportunity for Federally Recognized Tribes associated with the Site to provide meaningful input in the selection of a remedy. This consultation is described in "EPA Policy on Consultation and Coordination with Indian Tribes" (May 4, 2011) (https://www.epa.gov/sites/production/files/2013-08/documents/cons-and-coord-with-indian-tribes-policy.pdf).

[2] See 55 Fed. Reg. 8439, 8753 (March 8, 1990).

that act as a source for direct exposure. Principal threat wastes are those source materials considered to be highly toxic or highly mobile, which would present a significant risk to human health or the environment should exposure occur.

The landfill cap has not been maintained since 1997. There are currently no maintenance plans in place to protect the cap or limit exposure to potential contaminants in the landfill. The Selected Remedy presented in this ROD would provide long-term stewardship of the landfill cap and would address the source of groundwater contamination found at the Site. The Selected Remedy would address the principal threat source material in the overburden and bedrock by removal and treatment. It is expected the actions will result in a substantial decrease in TCE concentrations in groundwater under and downgradient of the WMA.

5.0 SITE CHARACTERISTICS

This section of the ROD provides an overview of the Site's geology and hydrogeology, the sampling strategy used during Site investigations, and the nature and extent of contamination. Additional information regarding the nature and extent of contamination can be found in the AR.

5.1 Surface Features

The Site is located in a residential area of Sterling, Loudoun County, Virginia. Residential developments are present to the immediate east, west, and south of the Site. The Site occupies approximately 40 acres of 150 acres of undeveloped property. The property extends from the Potomac River south approximately 5,000 feet (ft.) to Persimmon Road and separates the Broad Run Farms development from the Countryside development. The landfill is approximately 50 ft. high, 400 ft. wide, and 2,000 ft. long. The area north of the landfill is undeveloped woodland bounded by the Potomac River.

Topographically, the Site lies within the Triassic Lowlands, a subdivision of the Piedmont Physiographic Province. Apart from the landfill itself, the topography of the Site consists of a series of fluvial terraces and the 100-year floodplain of the Potomac River. The floodplain of the Potomac River extends from the river southward approximately 2,000 ft. to near the northern extent of the landfill. Most of this area is designated wooded wetland. The elevation of the Site changes from approximately 240 ft. above mean sea level (MSL) in the southern portion of the Site to approximately 200 ft. above MSL near the Potomac River. The top of the landfill itself is approximately 276 ft. above MSL.

5.2 Geology and Hydrogeology

The Site lies within the Culpeper Basin, the largest of the Mesozoic age rift basins in Virginia. These early Mesozoic basins were formed during downfaulting associated with the continental breakup of Pangaea and are filled with mostly sedimentary rocks. The Culpeper Basin is bound to the west by east-dipping normal faults. The basin shallows to the east, unconformably overlying rocks of the Potomac Terrane, and is bounded locally by an antithetic west-dipping normal fault.

Two major geologic units are found at the Site: unconsolidated alluvium and terrace deposits, and bedrock. Based on the Geologic Map of Loudoun County, Virginia, overburden on the southern portion of the Site consists of terrace deposits while overburden in the northern portion consists of alluvium. Observations made during the RI field activities determined that the alluvium and terrace deposits near the Site are approximately 7 to 37 ft. thick. Weathered bedrock (saprolite), ranging from 3 to 5 ft. in thickness, separate the alluvium deposits from the underlying bedrock. The bedrock encountered beneath the Site consists of the ancient river (fluvial) and lake (lacustrine) deposits of the Balls Bluff Siltstone. Depth to bedrock ranges from approximately 16 ft. to 37 ft. below ground surface (bgs). The Balls Bluff Siltstone is estimated to be approximately 4,000 ft. thick near the Site. The fluvial member is a red-brown silty sandstone interbedded with clay and sandy siltstone layers. In contrast, the lacustrine member consists of thin-bedded silty and sandy shale interbedded with clay and sandy siltstone. Siltstone is the predominant rock type encountered near the Site.

5.3 Landfill

The landfill at the Site is mounded (50 ft. in height) relative to surrounding grades, is steeply sloping, and has a relatively flat, but irregular topographic top surface. The landfill boundaries were surveyed as part of the 2020 FS. The landfill is designated as a WMA. A WMA is defined in the NCP preamble for the purpose of identifying the point of compliance for purposes of groundwater remediation.

In 1986, the landfill was closed by the Commonwealth of Virginia pursuant to a 1983 Loudoun Circuit Court Order. As part of the close-out procedures, the landfill was covered with a two-foot clay cap. Virginia Department of Health (VDH) Bureau of Solid Waste provided oversight of the implementation of the order utilizing the Commonwealth of Virginia's regulations that were applicable at the time. The VDH Site Inspection report noted that the landfill cap appeared to be well constructed with no erosion or leachate problems. During the RI, the landfill cap was inspected, and it was found the cap consisted primarily of clay and/or silt.

The landfill cap limits infiltration of rainwater into the landfill and isolates any unknown contaminant sources in the landfill, preventing additional groundwater contamination. The cap has not been maintained since 1997. There are currently no maintenance plans or Land Use Controls (LUCs) in place to protect the landfill cap or limit exposure to potential contaminants in the landfill.

5.4 Groundwater

Groundwater elevation data collected from overburden and bedrock monitoring wells at the Site indicate the presence of a multi-aquifer system. The two aquifer units are the overburden and bedrock aquifers. The overburden aquifer consists of the soil and saprolite overlying the bedrock. Near the landfill, shallow groundwater is present in the overburden and appears to be temporary during times of precipitation. Closer to the Potomac River, groundwater in the overburden is more widespread and persistent. This is evidenced by the presence of a wooded wetland north of the landfill. The direction of groundwater flow within the overburden aquifer is from areas of higher upland elevation north toward lowland elevation near the Potomac River.

The bedrock aquifer is separated from the overburden aquifer by a clay layer at the base of the overburden. The upper 20 ft. of bedrock near the landfill is not saturated with groundwater. The thickness of unsaturated bedrock decreases north toward the Potomac River. Groundwater flow within the bedrock is restricted to secondary openings, known as joints and fractures. Like the overburden aquifer, the preferred direction of groundwater flow in the bedrock aquifer is north toward the river. However, the specific pathway is controlled by the orientation and degree of connection of bedrock fractures. This results in a north/northwest direction of groundwater flow in the bedrock aquifer. Residences in the Broad Run Farms development obtain their drinking water from the bedrock aquifer. Residences in the Countryside development are serviced by public water.

5.5 Source Area Overburden

The 2019 Supplemental RI located a TCE source area on the southern end of the landfill where source material is present in the unsaturated and saturated overburden (approximately 8 to 35 ft. bgs) and bedrock aquifer matrix. See Figure 3 for detailed view of the TCE plume and approximate source area extent. The sampling results from the 2019 Supplemental RI suggest overburden soil beneath the landfill and at the landfill-bedrock interface are impacted with TCE and TCE degradation products, 1,1-dichloroethene (1,1-DCE), *cis*-1,2-dichloroethene (DCE) and vinyl chloride (VC).

The dimensions of the overburden source area are approximately 100 ft. by 50 ft. TCE concentrations exceeding EPA's Soil Screening Levels (SSL) of 0.0012 milligrams per kilogram (mg/kg) were detected in the source area soils in the following overburden layers:

- 8 – 20 ft. bgs - layer of wood debris,
- 20 – 30 ft. bgs – layer of saturated clay, and
- 30 – 35 ft. bgs – saprolite to bedrock interface.

Waste characterization results from analysis of soil samples from the overburden source area indicate that TCE and its breakdown products are present at concentrations greater than EPA's SSL. Overall, most of the contaminant mass in the overburden is located within the clay layer and TCE concentrations generally increase with depth down to the bedrock surface. The highest TCE concentration detected in soil was reported at approximately 25,000 mg/kg in the clay layer near the bedrock interface.

The source area material located within the footprint of the landfill WMA is considered a principal threat. Principal threat material includes saturated and unsaturated overburden and bedrock material because TCE is being released from the overburden source material into groundwater, where it creates a dissolved-phase plume that flows through the bedrock fractures. The high concentrations present within the overburden clay represent a long-term source of groundwater contamination. This source of contamination is expected to persist in groundwater until the source material is addressed.

5.6 Source Area Bedrock

Sampling from the 2019 Supplemental RI detected TCE in bedrock groundwater at concentrations up to 120,000 µg/L, which exceeds EPA's MCL of 5 µg/L. The highest concentrations detected were at depths between 25 and 71 ft. bgs. TCE contamination appears to extend vertically to the depth of bedrock and may spread out laterally on the bedrock surface. Findings also indicate that a preferential pathway exists in this region for groundwater impacts between the saprolite and fractured bedrock. See Figure 4 and Figure 4A for a cross-section depiction of the TCE plume in groundwater at the Site.

It can be inferred that pure TCE product may have originally been present as a dense non-aqueous phase liquid (DNAPL) in the source area. This DNAPL would have been present both near and below the overburden-bedrock interface, where TCE concentrations exceed 100,000 µg/L. Given the time since the landfill operations have occurred, it is likely that released TCE has dissolved and diffused into the low permeability, high porosity clays and into the bedrock matrix through the process of matrix diffusion. No pure TCE product has been detected during the investigations.

Dissolved-phase groundwater contaminant migration from the source area is controlled by a network of secondary geologic features such as fractures and bedding planes. Dissolved-phase TCE has migrated from the source area downward into the fractures of the Balls Bluff Siltstone to depths of approximately 460 ft. bgs. The dissolved-phase TCE plume extends approximately 4,000 ft. downgradient of the landfill (to the Potomac River). Based on the monitoring well and residential well data, the TCE plume appears to be in a steady-state condition. Vertical flow paths with downward gradients along fractures intersect the zone of highest concentrations detected at the Site, while upward gradients are more prevalent in wells located nearer to the Potomac River. The data collected indicates no evidence that contaminated groundwater is adversely impacting surface water or sediment quality in nearby water bodies.

5.7 Nature and Extent of Contamination and Conceptual Site Model

An initial Conceptual Site Model (CSM) was developed as part of the RI. Since then, EPA generated additional data relevant to the CSM as part of a treatability study, supplemental RI and additional investigations conducted between 2019 and 2020. The CSM was updated to present findings from the recent investigation activities and provide a consolidated resource to support future remedial activities associated with the Site. The CSM synthesizes the known geologic context, Site groundwater flow characteristics and other investigation data to provide an integrated framework for understanding and predicting environmental processes at the Site. A TCE source area exists on the southern end of the landfill with impacts to the overburden soils, saprolite, bedrock and groundwater in both perched overburden and bedrock aquifers. TCE appears to have migrated vertically downward from the initial release area through the soil and spread out as bedrock was reached. Groundwater within the bedrock aquifer migrates predominantly through secondary porosity (fracture-flow) along a network of low-angle bedding plane partings and high-angle joint and fault-related tensional fractures. The CSM is included in the AR file for the Site and can be referenced for additional details.

6.0 CURRENT AND POTENTIAL FUTURE LAND USE AND RESOURCE USE

The Site is located in a residential area of Sterling, Loudoun County, Virginia. Residential development is present to the immediate east, south, and west. The area north of the landfill is undeveloped woodland bounded by the Potomac River. The Countryside subdivision is a high-density residential community located to the east and south of the Site. Countryside is serviced by public water and sewer connections. The Broad Run Farms community is an older residential community located to the west and northwest of the Site. These homes are connected to public sewer; however, they receive their potable water from individual domestic water wells.

The former landfill is no longer in use and has unrestricted access. The entrance to the Site is an unvegetated area and has been referred to as the "laydown yard" when used for staging of equipment during previous investigations.

Between 2018 and 2019, EPA conducted a reuse assessment for the Site to identify potential future use options. This assessment included engagement with key stakeholders, gathering input from community members and residents, analyzing Site conditions, developing a future use suitability map and summarizing the information in a Vision for Future Use report. In 2021, EPA became aware of a potential sale for the parcel of the land including the Site for redevelopment purposes. EPA conducted an evaluation of the redevelopment plans and concluded the plans do not interfere with any component of EPA's cleanup plans and follows the recommendations identified in the Vision for Future Use Report. EPA will work with any future development plans to ensure protectiveness of the remedy. Disturbance of the landfill cap is prohibited and would continue to be prohibited in the future by implementation of LUCs.

7.0 SUMMARY OF SITE RISK

The environmental data collected from the RI and the Supplemental RI indicate that TCE and TCE degradation products, 1,1-DCE, DCE and VC, are the primary contaminants of concern (COCs) that pose the greatest potential unacceptable risk to human health at the Site.

The RI included a Site-wide HHRA that evaluated risk posed by resident ingestion of and dermal contact with groundwater, surface water, seep water, and sediment, and inhalation of Volatile Organic Compounds (VOCs) while showering.

WHAT ARE THE PRIMARY "CONTAMINANTS OF CONCERN"?

In the OU-2 ROD, EPA identified trichloroethene (TCE) and its potential breakdown products, 1,1-dichloroethene (1,1-DCE), *cis*-1,2 dichloroethene (DCE) and vinyl chloride (VC), as the primary COCs at the Site. These contaminants pose the greatest potential risk to human health at the Site.

Trichloroethene (TCE): TCE has been detected in source area groundwater at concentrations up to 120,000 µg/L. TCE has been detected in source area soils at concentrations up to 25,000 milligrams per kilogram (mg/kg). TCE is a halogenated organic compound historically used as an industrial solvent and a degreaser. Exposure to this compound has been associated with deleterious health effects in humans, including anemia, skin rashes, diabetes, liver conditions and urinary tract disorders. Other health effects for TCE include specific cancers, mutagenicity, immunotoxicity and probable fetal heart malformations. TCE is carcinogenic to humans by all routes of exposure.

1,1-Dichloroethene (1,1-DCE): 1,1-DCE has been detected in source area groundwater at concentrations up to 36 µg/L. 1,1-DCE has been detected in source area soils at concentrations up to 580 mg/kg.

***cis*-1,2-Dichloroethene (*cis*-1,2-DCE):** *cis*-1,2-DCE has been detected in source area groundwaters at concentrations up to 180 µg/L. *cis*-1,2-DCE has been detected in source area soils at concentrations up to 61 mg/kg.

Vinyl chloride (VC): VC has been detected in source area groundwaters at concentrations up to 8.2 µg/L. VC has been detected in source area soils at concentrations up to 1.6 mg/kg.

WHAT IS HUMAN HEALTH RISK AND HOW IS IT CALCULATED?

A Superfund human health **risk assessment** estimates the "baseline risk." This is an estimate of the likelihood of developing cancer or non-cancer health effects if no cleanup action were taken at a site. To estimate baseline risk at a Superfund site, EPA undertakes a four-step process:

1. Analyze Contamination
2. Estimate Exposure
3. Assess Potential Health Dangers
4. Characterize Site Risk

In Step 1, EPA looks at the concentrations of contaminants found at a site as well as past scientific studies on the effects these contaminants have had on people (or animals, when human studies are unavailable). A comparison between site-specific concentrations and concentrations reported in past studies helps EPA to determine which concentrations are most likely to pose the greatest threat to human health.

In Step 2, EPA considers the different ways that people might be exposed to the contaminants identified in Step 1, the concentrations that people might be exposed to, and the potential frequency and duration of exposure. Using this information, EPA calculates a "reasonable maximum exposure" (RME) scenario, which portrays the highest level of exposure that could reasonably be expected to occur.

In Step 3, EPA uses the information from Step 2 combined with information on the toxicity of each chemical to assess potential health risks. EPA considers two types of risk: cancer and non-cancer risk. The likelihood of any kind of cancer resulting from a Superfund site is generally expressed as an upper bound probability; for example, a "1 in 10,000 chance." In other words, for every 10,000 people that could be exposed, one extra cancer may occur as a result of exposure to site contaminants. An extra cancer case means that one more person could get cancer than would normally be expected to from all other causes. For non-cancer health effects, EPA calculates a "hazard index." The key concept here is that a "threshold level" (measured usually as a hazard index (HI)) of less than 1 usually indicates that non-cancer health effects are not expected.

In Step 4, EPA determines whether site risks are great enough to cause health problems for people at or near the Superfund site. The results of the three previous steps are combined, evaluated and summarized. EPA adds up the potential risks from the individual contaminants and exposure pathways and calculates a total site risk.

7.1 Summary of Human Health Risk Assessment

Data used in the HHRA were divided into two exposure areas for evaluation—The Landfill and Adjacent Wells Exposure Area and The Potomac River Exposure Area. Potential concerns for human health exposure to groundwater near the Site in the short-term is being addressed as part of OU-2.

- The Landfill and Adjacent Wells Exposure Area – The HHRA evaluated groundwater data from wells located immediately to the west of the landfill, data from surface water and sediment samples collected adjacent to the landfill, and data from seep water samples. The cumulative carcinogenic risk posed by exposure to groundwater for the resident adult and child was $2x10^{-4}$, which is above the EPA's target risk range of $1x10^{-4}$ to $1x10^{-6}$.

  The resident adult had a non-carcinogenic HI of 21 and the resident child had a non-carcinogenic HI of 43. The non-carcinogenic HI for both the resident adult and child exceed the non-carcinogenic threshold of 1.0. Exceedance of the non-carcinogenic threshold was due to risk posed by TCE, cobalt, and manganese. The HHRA reached a final conclusion that potential concerns for human health from exposure to groundwater near the Site is primarily due to TCE.

- The Potomac River Exposure Area – The HHRA evaluated groundwater data from wells northwest of the landfill near the Potomac River and data from surface water and sediment samples collected from the Potomac River and a pond east of the landfill. The cumulative carcinogenic risks for the resident adult and child was $1x10^{-4}$ which is equal to the upper end of the EPA's target risk range of $1x10^{-4}$ to $1x10^{-6}$.

  The resident adult had a non-carcinogenic HI of 4 and the resident child had a non-carcinogenic HI of 6. The non-carcinogenic HI for both the resident adult and child exceed the non-carcinogenic threshold of 1.0. Exceedance of non-carcinogenic thresholds was due to TCE only.

The results of the HHRA indicated that there are no human health concerns for exposure to surface water, sediment, and seep water, regardless of exposure area evaluated. Groundwater was identified as the only medium of concern for human health. Concerns for human health exposure to groundwater near the Site in the short-term is currently being addressed as part of OU-2.

The Supplemental RI included an HHRA that evaluated the risk and hazard to potential construction workers from exposure to subsurface soil and groundwater in the TCE source area in the event that the source area was excavated. The cumulative carcinogenic risk posed to the construction worker receptor was calculated to be $1x10^{-3}$ which is above the EPA's target risk range of $1x10^{-4}$ to $1x10^{-6}$. This risk was primarily due to volatilization of TCE into the air from groundwater. The total non-carcinogenic HI for the construction worker is 11,278, which is above the acceptable threshold of 1.0. This HI is primarily due to the volatilization of TCE into the air.

7.2 Summary of Ecological Risk Assessment

The ERA conducted as part of the RI evaluated data generated from surface water and sediment samples collected from ponds and drainages in the vicinity of the landfill, and from the Potomac River. The ERA concluded that COCs in sediment and surface water are unlikely to pose risks to ecological receptors. In addition, the landfill cap evaluation completed in 2013 included visual examinations of the landfill cap and the advancement of shallow soil borings to observe the depth of the cap. The landfill cap was determined to be intact and to not allow for potential landfill contents/contaminants to affect ecological receptors. Furthermore, the TCE source area is in subsurface soil to which ecological receptors are not exposed.

7.3 Basis for Remedial Action

In summary, the HHRA for the Site demonstrates the presence of unacceptable risk to human health and the environment, and that remedial actions are necessary to reduce the risks to within or below EPA's acceptable risk range. EPA has identified TCE and TCE degradation products, 1,1-DCE, DCE and VC, as the COCs that pose the greatest potential unacceptable risk to human health and the environment at the Site. Therefore, EPA has determined that the Selected Remedy identified in this ROD is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment.

8.0 REMEDIAL ACTION OBJECTIVES

Remedial Action Objectives (RAOs) are specific goals to protect human health and the environment. These objectives are based on available information and standards, such as applicable or relevant and appropriate requirements (ARARs), to-be-considered (TBC) guidance, and site-specific risk-based levels. In order to develop remedial alternatives to protect the long-term integrity of the WMA cap and to address principal threat source material in overburden and bedrock, RAOs are first developed to guide remediation.

The following RAOs are established for OU-3:

- Prevent direct contact with landfill waste and minimize infiltration of precipitation into the landfill.
- Reduce mass and concentration of the source area contaminants sufficiently to allow groundwater plume concentrations beyond the WMA to achieve MCLs in the future.

For purposes of creating a substantial decrease in TCE concentrations downgradient of the WMA and facilitating future reduction of concentrations below the MCLs on the downgradient/western side of the landfill, Remedial Goals (RGs) are established for source area soils and groundwater.

The RG developed for removing/treating TCE contamination in soil in the overburden source area is 25 mg/kg. TCE concentrations in soil in the overburden source area are up to 25,000 mg/kg. This RG was selected to guide treatment alternatives to address source area overburden remediation and reduce downgradient contamination. The concentration was selected based on analysis using the EPA Region 3 Soil Screening & Remediation Goals Tool (Version 2.2, August 2011), which incorporates site-specific parameters including chemical concentrations in soil and groundwater as well as soil type and properties of underlying geologic layers. Treatment of TCE between 25 mg/kg and 25,000 mg/kg in soil within the source area is expected to substantially decrease the total contaminant mass at the Site and result in a substantial decrease in downgradient groundwater concentrations.

The RG for removing/treating TCE contamination in source area bedrock/groundwater is 1,000 µg/L. The investigations conducted during the Remedial Design (RD) will further evaluate the extent of contaminated bedrock/groundwater to determine the greatest area practicable for achieving the RG. TCE concentrations in bedrock/groundwater in the source area are up to 120,000 µg/L. Treatment of TCE principal threat material at concentrations between 1,000 µg/L and 120,000 µg/L in groundwater is expected to substantially decrease the total contaminant mass at the Site and result in a substantial decrease in downgradient groundwater concentrations.

The RGs may be modified during RD or RA in order to meet the RAOs, such that compliance with groundwater restoration standards are achieved in downgradient groundwater beyond the waste management unit in the future. Following implementation of the OU-3 RA, the need for further groundwater treatment will be evaluated and considered under OU-1, restoration of Site-wide contaminated groundwater, which EPA expects to be the final remedial decision for the Site.

9.0 DESCRIPTION OF REMEDIAL ALTERNATIVES

CERCLA Section 121, 42 U.S.C § 9621, requires that any RA to address contamination at a Superfund site be protective of human health and the environment, cost effective, in compliance with regulatory and statutory provisions that are ARARs, and compliant with the NCP to the extent practicable. Permanent solutions to contamination, which reduce the volume, toxicity, or mobility of the contaminants should be developed whenever possible. Emphasis is also placed on treating the wastes at a site whenever possible, and on applying innovative technologies to clean up the contaminants. Detailed descriptions of the remedial alternatives evaluated for addressing the contamination associated with OU-3 at the Site can be found in the OU-3 FS report. The remedial alternatives are summarized below.

9.1 Remedial Alternatives

The remedial alternatives evaluated were designed to meet RAOs and are identified in Table 1 below.

Table 1. Remedial Alternatives

Alternative	Description
1	No Action
2	Landfill Cap Repair, and Maintenance with LUCs
3A	Principal Threat Source Area Overburden Excavation and Offsite Disposal
3B	Principal Threat Source Area Overburden Excavation and Soil Treatment with Onsite Disposal
4	Principal Threat Source Area Bedrock Groundwater Extraction and Treatment with Cosolvent/Surfactant Flushing and Recirculation
5A	In Situ Bioremediation and Chemical Reduction of Principal Threat Source Material in Overburden and Bedrock
5B	In Situ Bioremediation and Chemical Reduction of Principal Threat Source Material in Bedrock
6A	In Situ Chemical Oxidation of Principal Threat Source Material in Overburden and Bedrock
6B	In Situ Chemical Oxidation of Principal Threat Source Material in Bedrock
7	In Situ Thermal Treatment/Ex Situ Treatment of Extracted Vapor for Principal Threat in Overburden and Bedrock

Common Elements

Alternative 2 is the only alternative developed to address the WMA. Alterative 2 needs to be coupled with an alternative or alternative(s) to address the principal threat source material in overburden and bedrock. Alternatives 5 and 6 are divided into two separate alternatives listed as "A" and "B". Alternatives 5A and 6A contain a remedial technology that addresses principal threat source material in both overburden and bedrock while alternatives 5B and 6B contain a remedial technology that addresses principal threat source material only in bedrock.

All alternatives were developed to achieve the RAOs for the cap and the principal threat source material at OU-3 of the Site.

ALTERNATIVE 1: NO ACTION

Estimated Capital Cost: $0
Estimated Periodic and O&M Cost: $0
Estimated Present Worth Cost: $0
Estimated Construction Timeframe: N/A

The NCP, 40 C.F.R. § 300.430(e)(6), which governs Superfund response actions, requires that EPA evaluate a "No-Action" alternative for every NPL site to establish a baseline for the comparison of alternatives. The No-Action alternative serves as a basis against which each of the other proposed remedial alternatives can be compared. Alternative 1 requires no additional RA to be taken at the Site. Under this alternative, the Site would remain in its present condition, groundwater contamination would be subject to natural processes only and the landfill cap would not be maintained.

ALTERNATIVE 2: LANDFILL CAP REPAIR AND MAINTENANCE WITH LAND USE CONTROLS

Estimated Capital Cost: $52,000
Estimated Periodic and O&M Cost: $227,000
Estimated Present Worth Cost: $280,000
Estimated Construction Timeframe: 0 years

The landfill cap was installed in 1986 and not been maintained since 1997. During the first year of implementation of Alternative 2, it is anticipated that significant time and effort would be required to complete repair and maintenance. Annual inspection and maintenance thereafter would require a reduced effort.

Repair and maintenance may include filling holes, including those made by wildlife or trespassers, with topsoil; if the clay cap has been penetrated, clay would be used first to repair the cap. Maintenance may also include replacing fallen trees on the landfill to help stabilize landfill slopes and help limit infiltration. Native tree species would be selected for tree replacement. Disturbance of the cap is prohibited and would continue to be prohibited in the future by implementation of LUCs.

An implementation plan for LUCs would be prepared to clarify maintenance activities, defining the land use, land use restrictions, and identifying responsibility for implementation of LUCs. Land use restrictions will ensure that no action may be taken at the landfill property which obstructs, interferes with, or alters the landfill cap and remedy. LUCs will include restricting the use of groundwater for any purpose other than environmental remediation, testing, or monitoring until performance standards for the COCs are achieved. In addition, the Commonwealth of Virginia has applicable regulations that limit certain uses and activities on the landfill property.

ALTERNATIVE 3A: PRINCIPAL THREAT SOURCE AREA OVERBURDEN EXCAVATION AND OFFSITE DISPOSAL

Estimated Capital Cost: $2,040,000
Estimated Periodic and O&M Cost: $0
Estimated Present Worth Cost: $2,040,000
Estimated Construction Timeframe: 2 years (design, field activities, and report)

Alternative 3A includes excavation of principal threat source material in the overburden followed by offsite disposal.

Contaminated soil would be removed via excavation from an area delineated by soil data with concentrations that exceed the principal threat RG for overburden soil of 25 mg/kg. Based on the data collected from the RI and Supplemental RI, the soil excavation area was established and is approximately 100 ft. in length by 50 ft. in width. The excavation depth would be to the top of bedrock, approximately 30 – 35 ft. bgs. It is anticipated that the top 8 ft. of soil would be set aside and stockpiled onsite to be used as backfill after offsite disposal.

Excavation could require installation of shoring, such as sheet piling, to ensure the integrity of the side slopes during excavation activities. If perched groundwater is present in the overburden, dewatering would be necessary, and a temporary groundwater treatment system could be required onsite to treat the collected water.

Alternative 3A also includes the offsite disposal of the contaminated material at an approved facility, licensed to accept the waste. A detailed contaminant analysis would be required before an offsite disposal facility would accept materials. Following excavation, the area would be backfilled with clean material and regraded. A layer of clay or other low permeability material would be placed above the bedrock interface during backfilling to avoid creating a zone of high permeability between the ground surface and the groundwater in the excavation area. An infiltration gallery may be installed between the clay layer and top of bedrock to facilitate the bedrock groundwater RA. Following grading and backfilling, the area would be planted with seed for vegetation at the surface. See Figure 5 for details of this remedial alternative.

ALTERNATIVE 3B: PRINCIPAL THREAT SOURCE AREA OVERBUREN EXCAVATION AND SOIL TREATMENT WITH ONSITE DISPOSAL

Estimated Capital Cost: $2,232,000
Estimated Periodic and O&M Cost: $0
Estimated Present Worth Cost: $2,232,000
Estimated Construction Timeframe: 2.5 years (design, field activities, and report)

Alternative 3B includes excavation of principal threat source material in the overburden, followed by *ex situ* treatment low temperature thermal desorption (LTTD) and onsite disposal. The principal threat material excavation is as described above in Alternative 3A, however this alternative includes onsite disposal instead of offsite disposal.

This alternative would include clearing trees to stage the excavated material for onsite treatment via LTTD and to create space for equipment. A mobile treatment system would be required onsite to implement LTTD and an extension of the power supply would be required to power the equipment. Excavated soils would be placed in the mobile treatment system and heated to a temperature appropriate to remove VOCs. Off-gas from the soil treatment containing VOCs would be collected and treated. It is expected that treated soils would be available to backfill the excavation. See Figure 6 for details of this remedial alternative.

ALTERNATIVE 4: PRINCIPAL THREAT SOURCE AREA BEDROCK GROUNDWATER EXTRACTION AND TREATMENT WITH COSOLVENT/SURFACTANT FLUSHING AND RECIRULATION

Estimated Capital Cost: $3,573,000
Estimated Periodic and O&M Cost: $9,673,000
Estimated Present Worth Cost: $13,246,000
Estimated Construction Timeframe: 2-3 years (design, pilot study, construction, and report)

Alternative 4 includes extraction of principal threat groundwater from the bedrock in the source area. The extracted groundwater would be treated with a cosolvent/surfactant and reinjected upgradient of or within the source area.

Groundwater extraction wells would be installed in the downgradient (western) portion of the source area. It is anticipated that two extraction wells would be installed in the shallow bedrock (top of bedrock down to 100 ft. bgs) and two extraction wells would be installed approximately 20 ft. farther downgradient in the deeper bedrock (100 - 200 ft. bgs) to capture groundwater from the source area.

The effectiveness of groundwater capture by the groundwater extraction system would be assessed by monitoring drawdown in the extraction wells and nearby monitoring wells. The groundwater extracted by the system would be transported through a piping network to an aboveground treatment facility onsite where the groundwater would be treated and then amended with cosolvents/surfactants. The groundwater treatment facility would utilize an air stripper and granular activated carbon (GAC) for treatment of the groundwater; vapor-phase GAC would also be required for treatment of the vapor removed by the air stripper.

The treated groundwater containing cosolvents/surfactants would then be reinjected in the upgradient (eastern) portion of the source area, to promote mobilization of COC mass and removal by the extraction wells. The groundwater pump and treat system would remain in operation until TCE concentrations in groundwater in the source area meet the RAO. Any treated water that is not reinjected could be discharged to a local surface water body under a site-specific Virginia Pollutant Discharge Elimination System permit, or to a public sewer system to be treated further at a public wastewater treatment facility. See Figure 7 for details of this remedial alternative.

ALTERNATIVE 5A: IN SITU BIOREMEDIATION AND CHEMICAL REDUCTION OF PRINCIPAL THREAT SOURCE MATERIAL IN OVERBURDEN AND BEDROCK

Estimated Capital Cost: $7,672,000
Estimated Periodic and O&M Cost: $1,311,000
Estimated Present Worth Cost: $8,983,000
Estimated Construction Timeframe: 5 years (design, pilot study, 3 injections, and report)

Alternative 5A includes *in situ* bioremediation and chemical reduction of principal threat source material in overburden and bedrock. Amendments to promote chemical reduction and promote biological activity would be injected into the source area overburden and bedrock.

A treatability study was conducted in 2017 to determine whether *in situ* anaerobic biotic/abiotic treatment with bioaugmentation is a viable remedial alternative for remediating the TCE groundwater plume at the Site. Results indicated that injections established appropriate conditions for bioremediation and chemical reduction. The enhanced bioremediation and chemical reduction program developed under this alternative would be based on the injections performed as part of the treatability study.

Amendments could include multiple components, such as zero-valent iron to promote chemical reduction, activated carbon to decrease contaminant mobility, and a carbon substrate and a bioaugmentation culture to promote biological activity. Addition of activated carbon to the amendment could enhance back diffusion rates and sequester COCs within the treatment zone, facilitating treatment and further decreasing downgradient migration of COCs from the source area. For amendments intended to promote bioremediation, addition of a bioaugmentation culture would be helpful to facilitate complete TCE dechlorination since that culture may not naturally be present in groundwater at high enough concentrations. The amendments to promote bioremediation and chemical reduction would be injected into the bedrock and could also be injected into the overburden. It is anticipated that this alternative would include two rows of injection wells with five wells in each row to inject the amendments into the bedrock.

One row of injection wells would be placed in the overburden source area, where TCE concentrations exceed RGs at depths of approximately 10 – 35 ft. bgs. These wells would inject a less mobile, longer lasting amendment to promote TCE degradation in the bedrock beneath the overburden source area. This technique would reduce the frequency of reinjections, and the amendment would remain within the bedding planes/fractures, treating any upgradient groundwater that comes in contact with it.

Potential amendments for the first line of wells, closest to the overburden source area, would include BOS 100® and EHC®-Plus. BOS 100® is an *in situ* chemical reduction technology specifically designed to degrade chlorinated solvents. It is manufactured from food-grade carbon impregnated with metallic iron. EHC®-Plus is composed of controlled-release organic carbon to stimulate biological activity, zero-valent iron for chemical reduction, and activated carbon to reduce mobility of the contaminants.

The second row of injection wells would be placed at the beginning of the landfill to the south, where TCE concentrations exceed RGs at depths of approximately 200 ft. bgs. These wells would be injected with a more mobile amendment to transport downgradient to address elevated TCE concentrations in groundwater extending below the landfill.

Potential amendments for the second line of wells, at the beginning edge of the landfill would include PlumeStop®, which consists of a very fine suspension of activated carbon, along with a microscale zero-valent iron to promote chemical reduction. The suspension has a water-like viscosity and is therefore mobile in the subsurface.

The injection volumes would be based on overburden porosity and total (matrix and fracture) bedrock porosity. Water for injection could be obtained from the injection wells and pumped into water conditioning frac tanks, where it would be treated with sodium lactate to establish anaerobic conditions prior to injection. The amendment would likely be delivered to the target intervals following a top-down injection procedure, with monitoring of injection flow rates and pressures. See Figure 8 for details of this remedial alternative.

ALTERNATIVE 5B: IN SITU BIOREMEDIATION AND CHEMICAL REDUCTION OF PRINCIPAL THREAT SOURCE MATERIAL IN BEDROCK

Estimated Capital Cost: $4,625,000
Estimated Periodic and O&M Cost: $1,311,000
Estimated Present Worth Cost: $5,936,000
Estimated Construction Timeframe: 5 years (design, pilot study, 3 injections, and report)

Alternative 5B includes *in situ* bioremediation and chemical reduction of principal threat source material in bedrock. Amendments to promote chemical reduction and promote biological activity would be injected into the bedrock.

The description of *in situ* bioremediation and chemical reduction of principal threat source material is as described above in Alternative 5A, however this alternative does not include injection in the overburden. The exact number and location of bedrock injection wells will be determined following additional vertical and horizontal delineation of bedrock requiring injection to meet the RAOs, and after any overburden alternative is implemented. This alternative is specific to treating principal threat source material in bedrock and would have to be paired with an alternative for treating principal threat source material in overburden. See Figure 9 for details of this remedial alternative.

ALTERNATIVE 6A: IN SITU CHEMCIAL OXIDATION OF PRINCIPAL THREAT SOURCE MATERIAL IN OVERBURDEN AND BEDROCK

Estimated Capital Cost: $19,248,000
Estimated Periodic and O&M Cost: $1,311,000
Estimated Present Worth Cost: $20,559,000
Estimated Construction Timeframe: 4.5 years (design, pilot study, 5 injections, and report)

Alternative 6A include *in situ* chemical oxidation (ISCO) of principal threat source material in overburden and bedrock. Chemical oxidants would be injected in the source area overburden and bedrock to degrade COCs.

Oxidant injection in the overburden would be conducted within the source area, where TCE concentrations exceed RGs, at depths of approximately 10-35 ft. bgs. Oxidant would be injected at regular depth intervals, and groundwater would be monitored to assess the continued effectiveness of the chemical oxidation program for decreasing COC concentrations in groundwater.

Potential chemical oxidants for this alternative could include sodium permanganate or caustic persulfate. Caustic persulfate has a lower persistence when compared to sodium permanganate and would require an additional injection to provide sufficient mass reduction.

Post-injection monitoring events would be conducted in the injection wells and the surrounding monitoring network to monitor changes in the groundwater quality in and around the treatment area following injection of the oxidant. See Figure 10 for details of this remedial alternative.

ALTERNATIVE 6B: IN SITU CHEMICAL OXIDATION OF PRINCIPAL THREAT SOURCE MATERIAL IN BEDROCK

Estimated Capital Cost: $9,831,000
Estimated Periodic and O&M Cost: $1,311,000
Estimated Present Worth Cost: $11,142,000
Estimated Construction Timeframe: 4.5 years (design, pilot study, 5 injections, and report)

Alternative 6B includes ISCO of principal threat source material in bedrock. The description of ISCO of principal threat source material is as described above in Alternative 6A, however this alternative does not include injection in the overburden. Oxidant injection in the bedrock would be conducted within the source area, where TCE concentrations exceed RGs, at depths of approximately 200 ft. bgs. This alternative is specific to treating principal threat source material in bedrock and would have to be paired with an alternative for treating principal threat source material in the overburden. See Figure 11 below for details of this remedial alternative.

ALTERNATIVE 7: IN SITU THERMAL TREATMENT/EX SITU TREATMENT OF EXTRACTED VAPOR FOR PRINCIPAL THREAT IN OVERBURDEN AND BEDROCK

Estimated Capital Cost: $25,729,000
Estimated Periodic and O&M Cost: $1,311,000
Estimated Present Worth Cost: $27,040,000
Estimated Construction Timeframe: 3 years (design, pilot study, drilling, construction, operation and report)

Alternative 7 includes *in situ* thermal treatment of principal threat source material in overburden and bedrock. The *in situ* thermal treatment technology would be Electrical Resistivity Heating (ERH). ERH would eliminate the human health risks associated with principal threat source material in the area where it is applied.

For this alternative, electrodes would be installed into the overburden and bedrock. The electrodes would be heated to temperatures above the boiling points of the contaminants, enhancing volatilization of adsorbed VOCs. Volatilized compounds are removed by applying a vacuum to the treatment area. The extracted vapor would be treated using a vapor-phase GAC system, and condensate would then be treated using liquid-phase GAC. Vapor and liquid treatment system monitoring would be conducted to monitor for mass removal and discharge compliance. See Figure 12 for details of this remedial alternative.

To be effective, ERH would be subject to performance standards consisting of the following elements:

- Heat the overburden and bedrock to establish and maintain subsurface temperatures of 85° C in the vadose zone and 100° C in the saturated zone through the treatment area to boil principal threat source material soil and groundwater;
- Extract vapor and steam using vapor recovery wells;
- Establish and maintain control of vapor, steam, and principal threat source material within the treatment area.
- Cool and treat extracted vapor and steam.
- Monitor and report the following parameters throughout treatment:
  - Temperature in the vadose and saturated zones;
  - Vapor and steam extraction rates; and,
  - Groundwater contaminant concentrations;
  - Air emissions from the thermal treatment system, if any.
- Conduct groundwater and soil sampling and analysis prior to, during, and following the conclusion of thermal treatment. Post-treatment sampling would be conducted a minimum of fourteen (14) days following shutdown of the thermal treatment system. Continue treatment until EPA determines that the following parameters indicate the maximum treatment of principal threat waste within the treatment area has been achieved:
  - Temperature in the vadose and saturated zones;
  - Vapor and steam extraction rates;
  - Groundwater and vapor contaminant concentrations; and,
  - Soil concentrations.
- Monitor and report groundwater contaminant concentrations following treatment until temperatures within vadose and saturated zones return to ambient levels;
- Conduct additional treatment within the treatment area or portions thereof, based on the results of post-treatment sampling prescribed above, until EPA determines the maximum treatment of principal threat waste has been achieved.

10.0 SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

In this section, the remedial alternatives summarized above are compared to each other using the nine criteria set forth in 40 C.F.R § 300.430(e)(9)(iii). In the remedial decision process, EPA analyzes the relative performance of each alternative against the evaluation criteria, noting how each alternative compares to the other options under consideration. Additional information supporting this analysis of remedy alternatives can be found in the AR file for the Site.

These evaluation criteria relate directly to requirements of Section 121 of CERCLA, 42 U.S.C. § 9621, for determining the overall feasibility and acceptability of a remedial action. The nine criteria fall into three groups described as follows:

Threshold criteria must be satisfied for a remedy to be eligible for selection.
Primary balancing criteria are used to weigh major tradeoffs between remedies.
Modifying criteria are considered after public comment is received on the Proposed Plan.

Evaluation Criteria for Superfund Remedial Alternatives	
Threshold Criteria	**1. Overall Protection of Human Health and the Environment** determines whether an alternative can adequately protect human health and the environment by eliminating, reducing, or controlling exposures to hazardous substances, pollutants or contaminants to levels that do not pose an unacceptable risk.
	2. Compliance with ARARs evaluates whether an alternative meets Federal and more stringent State environmental laws or facility siting laws, or whether a waiver is justified.
Primary Balancing Criteria	**3. Long-term Effectiveness and Permanence** considers the ability of an alternative to maintain protection of human health and the environment over time.
	4. Reduction of Toxicity, Mobility, or Volume of Contaminants through Treatment evaluates an alternative's use of treatment to reduce the harmful effects of principal contaminants, their ability to move in the environment, and the amount of contamination present.
	5. Short-term Effectiveness considers the length of time needed to implement an alternative and the risks the alternative poses to workers, residents, and the environment during implementation.
	6. Implementability considers the technical and administrative feasibility of implementing an alternative, including factors such as the relative availability of goods and services.
	7. Cost includes the estimated capital and annual operation and maintenance costs, as well as present worth cost of an alternative. Present-worth cost is the total cost of an alternative over time in today's dollar value. Cost estimates are expected to be accurate within a range of +50 to -30 percent.

Modifying Criteria	**8. State/ Support Agency Acceptance** considers whether the State agrees with EPA's analyses and recommendations, as described in the Feasibility Study and Proposed Plan.
	9. Community Acceptance considers whether the local community agrees with EPA's analyses and preferred alternative. Comments received on the Proposed Plan are an important indicator of community acceptance.

The following subsections summarize the comparative analysis evaluation of the remedial alternatives developed for the Site against the nine evaluation criteria. To facilitate the comparative analysis evaluation, Alternative 2 will be discussed under WMA and Alternatives 3 through 7 will be discussed under Principal Threat Source Material.

10.1 Overall Protection of Human Health and Environment

The results of the HHRA indicated that current and future exposure to groundwater was identified as the only medium of concern for human health. Concerns for human health exposure to groundwater near the Site in the short-term is currently being addressed as part of OU-2 (waterline). The ERA did not identify risks to ecological receptors, therefore, environmental protection is already achieved. Overall protection of human health and the environment is addressed to varying degrees by the evaluated alternatives.

Alternative 1, No Action, would not effectively protect human health and the environment. This alternative would include no additional action or monitoring. Because Alternative 1 would not include any monitoring, there would be no way to confirm any presence, increase in volume or toxicity of the current contamination. Alternative 1 would not satisfy the Threshold Criteria, and therefore is not eligible for selection and is eliminated from further discussion.

<u>WMA Alternative Evaluation</u>

Alternative 2 is protective of human health and the environment because maintenance of the landfill cap minimizes risks to ecological and human receptors by maintaining the physical barrier of the cap to prevent contact with material under the cap and by minimizing infiltration of precipitation into the landfill, thereby preventing further groundwater contamination from migration of contaminants in the landfill. The environmental protection and prevention of human exposure provided by the cap would continue to be achieved through maintenance and LUCs.

<u>Principal Threat Source Material Alternatives Evaluation</u>

Alternatives 3 through 7 are all protective of human health and the environment but to varying degrees. Alternatives 3A and 3B would contribute to protecting human health in the long-term by removing the principal threat source mass that contributes contamination to downgradient groundwater.

Alternatives 5A, 5B, 6A and 6B, would protect human health in the long-term by degrading COC mass and decreasing potential COC migration downgradient.

Alternatives 4 and 7 would protect human health in the long-term by removing COC mass and decreasing potential COC migration downgradient.

10.2 Compliance with ARARS

Section 121(d) of CERCLA, 42 U.S.C. § 9621(d), and the NCP at 40 C.F.R. § 300.430(f)(1)(ii)(B), require that remedial actions at CERCLA sites at least attain legally applicable or relevant and appropriate Federal and state requirements, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or state law, which are collectively referred to as "ARARs," unless such ARARs are waived under Section 121(d)(4) of CERCLA, 42 U.S.C. § 9621(d)(4), and the NCP at 40 C.F.R. § 300.430(f)(1)(ii)(C).

"Applicable" requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or state environmental or facility-siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site. Only those state standards that are identified by a state in a timely manner and that are more stringent than Federal requirements may be applicable.

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

Based on a detailed evaluation, Alternatives 2 through 7 will comply with ARARs, a threshold criterion. A complete list of all identified ARARs is included in Appendix B. Major ARARs include, but are not limited to:

- National Primary Drinking Water Standards: 40 C.F.R. § 141. 11, 141.13,141.22-23.
- Virginia Groundwater Standards: 9VAC25-280, -30-, -40, -50, and -70. Because all groundwater in Virginia is viewed as a potential source of drinking water, remedial action should be implemented with a target goal of achieving groundwater standards.
- Transportation and Disposal standards for soil excavation: 40 C.F.R. § 261.10 - 11.
- Underground Injection: 40 C.F.R. 144.12 and 144.82 Regulates the subsurface emplacement of liquids through the Underground Injection Control program,

which governs the design and operation of five classes of injection wells to prevent contamination of underground sources of drinking water. The Underground Injection Control program regulates well construction, well operation, and monitoring. Groundwater treatment alternatives include substrate injections. Permits and administrative reviews are not required for on-site CERCLA injection wells; however, the remedial action will comply with the substantive requirements of the regulations.

10.3 Long-Term Effectiveness

<u>WMA Alternative Evaluation</u>

Alternative 2 would be the most effective alternative in the long term for the landfill because the landfill cap would be maintained and LUCs would be implemented.

<u>Principal Threat Source Material Alternatives Evaluation</u>

Alternative 3A or 3B would be the most effective alternatives in the long term for the overburden source area because the contaminated soil in the overburden would be removed and either disposed of offsite or treated onsite.

Alternatives 5B and 7 would be the most effective alternatives in the long term and also the most permanent for treatment of COC mass in the bedrock. Thermal treatment as part of Alternative 7 would be expected to efficiently remove the majority of source mass from both the overburden and the bedrock.

In situ treatment under Alternatives 5A and 5B would degrade COCs in groundwater within bedrock fractures in the treatment area. Multiple regular injections would be necessary to achieve the groundwater RGs for the source area groundwater by enhanced bioremediation and chemical reduction. The effects of the amendments on groundwater chemistry and the resulting increase in degradation rates would persist after the last injection.

Alternatives 4, 6A, and 6B would also address the area of the highest TCE concentrations in groundwater; however, the effectiveness of these alternative would likely be limited by difficulty in achieving complete hydraulic control, due to bedrock fractures limiting groundwater flow. This impediment would result in a longer remedial time frame under Alternative 4, and difficulty achieving and maintaining sufficient oxidant concentrations under Alternatives 6A and 6B.

10.4 Reduction of Toxicity, Mobilization, or Volume Through Treatment

<u>WMA Alternative Evaluation</u>

Alternative 2 does not include treatment and therefore does not reduce the toxicity, mobility, or volume of the COCs through treatment.

Principal Threat Source Material Alternatives Evaluation

Alternative 3A does not include treatment and therefore does not reduce the toxicity, mobility, or volume of the COCs through treatment. Alternative 3B includes treatment of excavated soil using LTTD which would decrease the volume and toxicity of the removed soil.

Alternative 4 would use groundwater extraction, treatment and recirculation to decrease the toxicity and volume of impacted groundwater and could also decrease the mobility of groundwater impacts, to the degree that hydraulic control can be achieved.

Alternatives 5A and 5B would decrease the toxicity of the COCs and reduce the volume of COCs in groundwater by a mix of biotic and abiotic degradation.

Alternatives 6A and 6B would use chemical oxidation to decrease the toxicity of COCs and reduce the volume of COCs in groundwater and soil.

Alternative 7 would use thermal treatment to decrease the toxicity and volume of the COCs in groundwater and soil.

Alternatives 5A, 5B, 6A, 6B, and 7 would achieve the greatest overall decrease in toxicity, mobility, and volume of COCs through *in situ* destruction of TCE and other VOCs in the source area.

10.5 Short-Term Effectiveness

Alternatives 3 through 7 all pose some short-term impacts to the surrounding community due to application of the technologies and required drilling at the Site. Implementation of Alternatives 2 through 7 all pose some risk to workers. These risk concerns include construction-related disturbances and hazards; contact with impacted groundwater during well installation, groundwater sampling, and system maintenance; and contact with injected amendments. Under any of these alternatives, such concerns and hazards would be addressed in the site-specific Health and Safety Plan, using personal protective equipment and other precautions, as necessary.

WMA Alternative Evaluation

Landfill cap repair and maintenance along with LUCs do not pose potential hazards from the contaminants in the landfill because a cap is already in place and field personnel would not be encountering contaminated soil or groundwater to implement maintenance or repairs.

Principal Threat Source Material Alternatives Evaluation

Alternatives 3A and 3B would pose the most potential impacts to workers and to the community, due to the challenges of excavation to 35 ft. bgs and the need to transport and/or handle contaminated material onsite or offsite for disposal. Alterative 3A would impact the surrounding community due to increased truck traffic associated with contaminated soil transport offsite.

Alternatives 5A and 5B also would have the potential to cause a temporary increase in dissolved phase contaminant concentrations, which could potentially lead to additional impacts to residential wells.

The timeframe for achieving RGs in overburden is expected to be shortest under Alternatives 3A and 3B, followed by Alternative 7. The timeframe for achieving RGs in bedrock groundwater is expected to be shortest under Alternative 7. RGs in overburden are also expected to be met at relatively the same time under Alternatives 5A, 5B, 6A and 6B. Alternative 4 would take the longest to implement and optimize due to the time required for maximization of hydraulic control and matrix diffusion.

10.6 Implementability

WMA Alternative Evaluation

The landfill cap is already in place. Alternative 2 includes maintenance and repair of the cap, along with implementation of LUCs, which is common and highly implementable.

Principal Threat Source Material Alternatives Evaluation

Alternatives 3A and 5B would be the most implementable at the Site and are all technically feasible to implement.

The excavation required under Alternatives 3A and 3B is highly implementable using standard construction equipment. Alternatives 4, 5A, 6A, 6B, and 7 are also expected to be readily implementable.

For Alternative 3B, a large area would be needed, requiring tree clearing and potentially regrading, to provide space for the treatment equipment as well as untreated and treated soil piles. Alternative 7 would require tree clearing for the network of thermal wells, power distribution, and thermal oxidizer. Alternatives 4, 5A, 5B, 6A and 6B would require less tree clearing and installation of shallow and deep wells.

Alternatives 5A and 6A are somewhat less implementable because they require injection into the clay overburden in order to ensure effectiveness. Long-term operation and maintenance, up to 30 years, would be required for Alternative 4, whereas multiple injections would likely be required for Alternatives 5A, 5B, 6A, and 6B.

10.7 Cost

Present worth cost information for Alternatives 2 through 7 including a discount rate of 3 percent over a presumed 30-year period is presented below. These preliminary cost estimates are anticipated to be within -30 percent to +50 percent of the actual costs for implementing each alternative. The combined cost for Alternatives 2, 3A and 5B is less than the cost of Alternatives 4, 5A, 6A, 6B or 7, individually. A summary of the capital costs, operation and maintenance (O&M) costs, and total costs are presenting in the Table 2 below.

Table 2: Costs Associated with Remedial Alternatives

Alternative	Depth Range(s) Addressed			Capital Cost	Periodic and O&M	Total Cost
	Landfill Cap	Overburden	Bedrock			
Alternative 1 – No Action	X	X	X	$0	$0	$0
Alternative 2 – Landfill Cap Repair and Maintenance with Land Use Controls	X			$52,000	$227,000	$280,000
Alternative 3A – Principal Threat Source Area Overburden Excavation with Offsite Disposal		X		$2,040,000	$0	$2,040,000
Alternative 3B – Principal Threat Source Area Overburden Excavation with Onsite Treatment		X		$2,232,000	$0	$2,232,000
Alternative 4 – Principal Threat Source Area Bedrock Groundwater Extraction and Treatment with Cosolvent/Surfactant Flushing and Recirculation			X	$3,573,000	$9,673,000	$13,246,000
Alternative 5A – *In Situ* Bioremediation and Chemical Reduction of Principal Threat Source Material in Overburden and Bedrock		X	X	$7,672,000	$1,311,000	$8,983,000
Alternative 5B – *In Situ* Bioremediation and Chemical Reduction of Principal Threat Source Material in Bedrock			X	$4,625,000	$1,311,000	$5,936,000

Alternative 6A – *In Situ* Chemical Oxidation of Principal Threat Source Material in Overburden and Bedrock		X	X	$19,248,000	$1,311,000	$20,559,000
Alternative 6B – *In Situ* Chemical Oxidation of Principal Threat Source Material in Bedrock			X	$9,831,000	$1,311,000	$11,142,000
Alternative *7 – In Situ* Thermal Treatment/*Ex situ* Treatment of Extracted Vapor of Principal Threat Material in Overburden and Bedrock		X	X	$25,729,000	$1,311,000	$27,040,000

10.8 State Acceptance

EPA has coordinated closely with VDEQ in the preparation and evaluation of this ROD. VDEQ concurred with the Selected Remedy in a letter dated December 30, 2021 (Appendix A).

10.9 Community Acceptance

During the public comment period, EPA received comments via email and voicemail from residents of the local community as well as Loudoun County officials. A majority of the comments received from the local community expressed support for EPA's Preferred Alternatives. Some of the comments from the local community identified a preference for only one alternative for this remedy. Loudoun County expressed its support for Alternative 2 and Alternative 3A but does not support EPA's preference of Alternative 5B. Loudoun County recommends that Alternatives 6B and 7 should be revisited as Preferred Alternatives for the Principal Threat Source Material in Bedrock. These comments are addressed in the Responsiveness Summary included in as part III of this ROD.

11.0 PRINCIPAL THREAT WASTE

The NCP, 40 C.F.R. § 300.430(a)(l)(iii)(A), establishes an expectation that EPA will use treatment to address the principal threats posed by a site wherever practicable. The principal threat concept is applied to the characterization of source materials at a Superfund site. A source material is material that includes or contains hazardous substances, pollutants, or contaminants that act as a reservoir for migration of contamination, for example, to groundwater. Principal threat wastes are those source materials considered to be highly toxic or highly mobile, which would present a significant risk to human health or the environment should exposure occur.

The high concentrations of TCE indicative of DNAPL, are considered to be principal threat waste at the Site. In this case, the DNAPL is considered a principal threat waste that is a source of contamination to groundwater. DNAPL present in the overburden and bedrock groundwater is considered principal threat waste because it acts as a reservoir for continued groundwater contamination. Treatment of principal threat waste to the maximum extent practical is therefore a component of the OU-3 ROD. By addressing the DNAPL, a major source to groundwater contamination will be eliminated. A final remedy for groundwater will be designated as OU-1 and addressed in a future ROD.

12.0 SELECTED REMEDY

Following review and consideration of the information provided in the AR file, the requirements of CERCLA and the NCP, state acceptance and public comments, EPA has selected the following alternatives as the Selected Remedy for OU-3 at the Site:

WMA:

- **Alternative 2 –** Landfill Cap Repair and Maintenance with LUCs

Principal Threat Source Material:

- Overburden:
  - **Alternative 3A –** Principal Threat Source Area Overburden Excavation and Offsite Disposal
- Bedrock:
  - **Alternative 5B –** *In Situ* Bioremediation and Chemical Reduction of Principal Threat Source Material in Bedrock

12.1 Summary of the Rationale for Selected Remedy

EPA's Selected Remedy meets the threshold criteria for protection of human health and the environment and compliance with ARARs. Based on the information currently available, EPA has determined that the Selected Remedy provides the best balance of advantages and disadvantages among the alternatives when evaluating them using the balancing criteria. EPA's Selected Remedy for OU-3 satisfies the following requirements of CERCLA Section 121, 42 U.S.C § 9621:

1) be protective of human health and the environment;
2) comply with ARARs;
3) be cost-effective;
4) provide short- and long-term reduction of risk;
5) utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable; and
6) satisfy the preference for treatment as a principal element.

WMA

The Selected Remedy for the WMA will meet the following RAO:

- Prevent direct contact with landfill waste and minimize infiltration of precipitation into the landfill.

Principal Threat Source Material

The Selected Remedy for the Principal Threat Source Material will meet the following RAO:

- Reduce mass and concentration of the source area contaminants to allow groundwater plume concentrations beyond the WMA area to achieve MCLs in the future.

12.2 Description of the Selected Remedy

WMA

Based on the comparison of the nine criteria, EPA's Selected Remedy for the WMA is ***Alternative 2 - Landfill Cap Repair and Maintenance with LUCs.*** EPA has determined that the Selected Remedy for the WMA will be most effective in maintenance of the landfill cap.

Remedy Components of WMA Remedy

During the first year of implementation, it is anticipated that significant time and effort will be required to complete repair and maintenance of the landfill cap. A topographical survey will be conducted to identify depressions in the existing landfill cap that require repair and maintenance.

Repair and maintenance may include filling holes, including those made by wildlife or trespassers, with topsoil; if the clay cap has been penetrated, clay would be used to repair the cap, before covering with topsoil. Maintenance may also include replacing fallen trees on the landfill to help stabilize landfill slopes and help limit infiltration. Native tree species will be selected for tree replacement. Disturbance of the cap is prohibited and will continue to be prohibited in the future by implementation of LUCs. EPA will work with any future development plans to ensure protectiveness of the landfill cap.

O&M Components of WMA Remedy

Annual inspection and maintenance of the landfill cap will be conducted. An implementation plan for LUCs will be prepared to clarify maintenance activities, defining the land use, land use restrictions, and identifying responsibility for implementation of LUCs. Land use restrictions will ensure that no action may be taken at the landfill property which obstructs, interferes with, or alters the landfill cap and remedy. LUCs will include restricting the use of groundwater under the WMA for any purpose other than environmental remediation, testing, or monitoring until performance standards for the COCs are achieved. In addition, the Commonwealth of Virginia has applicable regulations that limit certain uses and activities on the landfill property.

Design Considerations of WMA Remedy

An implementation plan for LUCs will be prepared to clarify maintenance activities, defining the land use, land use restrictions, and identifying responsibility for implementation of LUCs.

Principal Threat Source Material

Based on the comparison of the nine criteria, EPA's Selected Remedy for the Principal Threat Source Material is:

Alternative 3A - Principal Threat Source Area Overburden Excavation and Offsite Disposal; and

Alternative 5B - In Situ Bioremediation and Chemical Reduction of Principal Threat Source Material in Bedrock

Remedy Components of Principal Threat Source Material – **Overburden Remedy**

Contaminated soil will be removed via excavation from an area delineated by soil sampling data with concentrations that exceed the principal threat RG for overburden soil of 25 mg/kg. Based on the data collected from the RI and Supplemental RI, the soil excavation area was established and is approximately 100 ft. in length by 50 ft. in width. The excavation depth will be to the top of bedrock, approximately 30 – 35 ft. bgs. It is anticipated that the top 8 ft. of soil will be set aside and stockpiled onsite to be used as backfill after offsite disposal of the deeper soils.

The remedy for the overburden also includes the offsite disposal of the contaminated material at an approved facility, licensed to accept the waste. A detailed contaminant analysis will be undertaken as a requirement for an offsite disposal facility to accept excavated materials for disposal. Following excavation, the area will be backfilled with clean material and regraded. A layer of clay or other low permeability material will be placed above the bedrock interface during backfilling to avoid creating a zone of high permeability between the ground surface and the groundwater in the excavation area. Following grading and backfilling, the area will be planted with seed for vegetation at the surface.

O&M Components of Principal Threat Source Material – **Overburden Remedy**

This component of the Selected Remedy will not require O&M since the overburden source material would be excavated to the depth of the top of bedrock, approximately 30 – 35 ft. bgs. Following excavation, the area would be backfilled with clean material and regraded.

Design Considerations of Principal Threat Source Material – **Overburden Remedy**

Excavation could require installation of shoring, such as sheet piling, to ensure the integrity of the side slopes during excavation activities. If perched groundwater is present in the overburden, dewatering will be necessary, and a temporary groundwater treatment system could be required onsite to treat the collected water. An infiltration gallery may be installed between the clay layer and top of bedrock to facilitate the bedrock groundwater RA.

Remedy Components of Principal Threat Source Material – **Bedrock Remedy**

The *in-situ* bioremediation and chemical reduction of principal threat source material in bedrock will be based on the injections performed as part of the treatability study. Amendments to promote chemical reduction and promote biological activity will be injected into the bedrock. Amendments could include multiple components, such as zero-valent iron to promote chemical reduction, activated carbon to decrease contaminant mobility, and a carbon substrate and a bioaugmentation culture to promote biological activity.

The exact number and location of bedrock injection wells will be determined following additional vertical and horizontal delineation of bedrock requiring injection to meet the RAOs, and after the overburden remedy has been implemented. It is assumed that a total of three injections into the bedrock would be enough to meet the groundwater RG in the source area and also promote biodegradation downgradient beneath the landfill. Concentrations of COCs and amendments will be monitored following the first full-scale injection and the volume and time interval between injections will likely need to be adjusted based on the monitoring results.

O&M Components of Principal Threat Source Material – **Bedrock Remedy**

Post-injection monitoring events will be conducted in the surrounding monitoring network to monitor changes in the groundwater quality in and around the treatment area following injection of the substrate. Multiple performance monitoring events are anticipated after the injections. After the data from the last performance monitoring event is evaluated, a decision will be made whether a follow-up injection will be required.

Five years of quarterly sampling followed by five years of semi-annual sampling will be undertaken post injections. If additional monitoring wells are needed, they will be added after the injection of any activated carbon amendments, in order to avoid affecting the monitoring well sand pack.

Design Considerations of Principal Threat Source Material – **Bedrock Remedy**

Investigations conducted during the RD will further evaluate the horizontal and vertical extent of contaminated groundwater in bedrock and determine potential treatment locations. This investigation will include installation of monitoring wells and additional boreholes that will be converted to nested screened monitoring wells. Standard geophysical logs will be collected along with nuclear magnetic resonance hydrogeologic analyses.

Design for injection volume will be based on total (matrix and fracture) bedrock porosity. Pilot testing will be conducted to confirm the radius of influence, injection rates and contaminant response.

12.3 Cost Estimate of the Selected Remedy

The estimated present worth for the Selected Remedy is listed in Table 3 below. The information in this cost estimate is based upon the best available information regarding the anticipated scope of the RA.

Table 3: Estimated Present Worth for Selected Remedy

Remedial Component	Estimated Present Worth
Landfill Cap Repair and Maintenance with LUCs	$280,000
Principal Threat Source Area Overburden Excavation and Offsite Disposal	$2,040,000
In Situ Bioremediation and Chemical Reduction of Principal Threat Source Material in Bedrock	$5,936,000
Total costs for OU-3 Selected Remedy	**$8,256,000**

Changes to the cost estimates may occur during implementation as a result of new information and data collected during the engineering design of the Selected Remedy. Changes to the Selected Remedy may be documented in the form of a memorandum to the AR file, an Explanation of Significant Differences (ESD), or a ROD amendment, as appropriate.

12.4 Expected Outcomes of the Selected Remedy

WMA

Implementation of the Selected Remedy in the WMA is expected to protect human health and the environment because maintenance of the landfill cap minimizes risks to ecological and human receptors by maintaining the physical barrier of the cap to prevent contact with material under the cap and by minimizing infiltration of precipitation into the landfill, thereby preventing further groundwater contamination. The environmental protection and prevention of human exposure provided by the cap will continue to be achieved through maintenance and LUCs.

Principal Threat Source Material

Implementation of the Selected Remedy to address the Principal Threat Source Material is expected to be protective of human health and the environment because excavation will remove the principal threat source mass in the overburden that contributes contamination to downgradient groundwater and *in situ* bioremediation and chemical reduction of DNAPL in the bedrock will degrade COC mass and decrease potential COC migration downgradient.

Based on the information available at this time, EPA believes the Selected Remedy meets the threshold criteria and provides the best balance of tradeoffs among the other alternatives with respect to the balancing criteria. EPA expects the Selected Remedy to satisfy the following statutory requirements of CERCLA Section 121(b), 42 U.S.C § 9621(b): 1) to be protective of human health and the environment; 2) to comply with ARARs; 3) to be cost-effective; and 4) to utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. The Selected Remedy satisfies the preference for treatment as a principal element and eliminates principal threat source material in the overburden and bedrock at the Site.

13.0 STATUTORY DETERMINATIONS

Under Section 121 of CERCLA, 42 U.S.C § 9621, and 40 C.F.R. § 300.430(f)(5)(ii) of the NCP, EPA must select remedies that are protective of human health and the environment, comply with ARARs, are cost effective, and utilize permanent solutions and alternative treatment technologies or resource recovery to the maximum extent possible. There is also a preference for remedies that use treatment that permanently and significantly reduce the volume, toxicity, or mobility of hazardous wastes as a principal element. The following sections discuss how the remedy meets these statutory requirements.

13.1 Protection of Human Health and the Environment

WMA

Based on the information currently available, EPA has determined that the Selected Remedy for the WMA is protective of human health and the environment as it would achieve RAOs in a relatively quick timeframe.

Principal Threat Source Material

Based on the information currently available, EPA has determined that the Selected Remedy for the Principal Threat Source Material is protective of human health and the environment, as it would remove overburden source material and it would degrade COC mass in bedrock groundwater, thereby decreasing the potential for COC migration downgradient.

13.2 Compliance with Applicable or Relevant and Appropriate Requirements

The NCP, at 40 C.F.R. §§ 300.430(f)(5)(ii)(B) and (C), requires that a ROD describe federal and state ARARs that the remedy will attain or, if not, provide a justification for any waivers. Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, or contaminant; remedial action; location; or other circumstance at a CERCLA site. Relevant and appropriate requirements, while not legally applicable to a hazardous substance, pollutant, or contaminant; remedial action; location; or other circumstances at a particular CERCLA site, address problems or situations sufficiently similar to those encountered at the site such that their use is considered well-suited to the particular site. Each of the components of the Selected Remedy will comply with ARARs (Appendix B).

13.3 Cost Effectiveness

Under Section 300.430(f)(1)(ii)(d) of the NCP, once a remedy satisfies the threshold criteria of overall protection of human health and the environment and compliance with ARARs, the remedy's cost-effectiveness is determined by evaluating its long-term effectiveness and permanence; reduction in toxicity, mobility, or volume through treatment; and short-term effect. If the overall cost of the remedy is proportional to its overall effectiveness, then it is cost-effective.

The estimated present worth cost of the Selected Remedy is $8,256,000. The Selected Remedy is cost-effective because it satisfies the criteria listed above and will achieve the RAOs identified in this ROD.

13.4 Utilization of Permanent Solutions to the Maximum Extent

The Selected Remedy represents the maximum extent to which permanent solutions and treatment are practicable at the Site through the treatment of contaminants in soils, sediments, and surface water. EPA has determined that the Selected Remedy provides the best balance of tradeoffs in terms of long-term effectiveness and permanence, reduction in toxicity, mobility, or volume through treatment, short-term effectiveness, implementability, and costs while also considering the statutory preference for the treatment as a principal element and state and community acceptance.

The Selected Remedy will meet the statutory preference for treatment as a principal element by addressing principal threat waste (i.e., DNAPL) via *in situ* bioremediation and chemical reduction to degrade TCE in bedrock.

13.5 Five-Year Review Requirements

Because the Selected Remedy will result in hazardous substances remaining on-Site above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted no less often than every five years to ensure that the Selected Remedy is, or will be, protective of human health and the environment pursuant to Section 121(c) of CERCLA, 42 U.S.C. § 9621(c), and 40 C.F.R § 300.430(f)(4)(ii) of the NCP. The first Five-Year Review (FYR) will be completed five years after the start of on-Site construction for OU-3, and subsequent FYRs will be conducted every five years thereafter. FYRs will continue until hazardous substances are no longer present above levels that allow for unlimited use and unrestricted exposure.

14.0 DOCUMENTATION OF SIGNIFICANT CHANGES

The Proposed Plan was released for public comment on April 12, 2021. EPA has reviewed all comments submitted during the public comment period. EPA has determined that no significant changes to the Selected Remedy, as originally identified in the Proposed Plan, were necessary or appropriate.

III. RESPONSIVENESS SUMMARY

HIDDEN LANE LANDFILL SUPERFUND SITE
OPERABLE UNIT 3
RECORD OF DECISION

STERLING, LOUDOUN COUNTY, VIRGINIA

III. RESPONSIVENESS SUMMARY

This section summarizes the questions and comments received during the public comment period for the Hidden Lane Landfill Superfund Site, OU-3 Proposed Remedial Action Plan (PRAP). The PRAP was released for public comment on April 12, 2021. EPA recorded a video presentation that was published in place of a public meeting to inform local officials, interested citizens, and other stakeholders about EPA's proposed cleanup plan and the Superfund process and to receive comments on the PRAP. During the public comment period, EPA accepted written comments and oral comments submitted by voicemail. The notice of the availability of these documents was published in The Loudoun Times-Mirror on April 16, 2021. An extension to the public comment period was requested. As a result, it was extended to June 11, 2021. In addition, a virtual public meeting was held on April 21, 2021 to present the Proposed Plan to a broader community audience and answer questions.

Comments Received during Public Comment Period

EPA received 10 comments via email and 2 comments via voicemail from a total of 12 residents of the local community. Loudoun County and Loudoun County's consultant, Dr. Mark Widdowson, also provided comments on the PRAP. Below are the comments EPA received and EPA's responses to them.

Comment #1

Comment: A majority of the comments received from the residents of the local community expressed concerns with the redevelopment proposal for the landfill and the future use of the property.

Response: Between 2018 and 2019, EPA conducted a reuse assessment for the Site to identify potential future use options. This assessment included engagement with key stakeholders, gathering input from community members and residents, analyzing Site conditions, developing a future use suitability map and summarizing the information in a Vision for Future Use report. In 2021, EPA became aware of a potential sale of the parcel of land that includes the Site for redevelopment purposes. EPA conducted an evaluation of the redevelopment plans and concluded the plans do not interfere with any component of EPA's cleanup plans and follow the recommendations identified in the Vision for Future Use report. EPA will work with any future developer to ensure the protectiveness of remedy. LUCs will be instituted to ensure that any future development will be implemented in a manner that is protective of human health and the environment.

Comment #2

Comment: There were multiple comments from the residents of the local community in which the commenter identified a preference for only one alternative for this remedy.

Response: The Selected Remedy for OU-3 will include the selection of multiple alternatives identified in this Record of Decision (ROD) to address the landfill cap and source of Site groundwater contamination (OU-3). EPA has selected all of the following alternatives for the OU-3 Selected Remedy:

Alternative 2 – Landfill Cap Repair and Maintenance with Land Use Controls (LUCs);
Alternative 3A – Principal Threat Source Area Overburden Excavation and Offsite Disposal; and
Alternative 5B – *In Situ* Bioremediation and Chemical Reduction of Principal Threat Source Material in Bedrock.

Comments #3 - #6 are comments received from Loudoun County:

Comment #3

Comment: The County supports the EPA's preference of Alternative 2 – Landfill Cap Repair and Maintenance with Land Use Controls**.**

Response: EPA thanks the County for its support for the proposed remedy.

Comment #4

Comment: The County supports the EPA's preference of Alternative 3A – Principal Threat Source Area Overburden Excavation and Offsite Disposal.

Response: EPA thanks the County for its support for the proposed remedy.

Comment #5

Comment: County staff does not support EPA's preference of Alternative 5B – *In Situ* Bioremediation and Chemical Reduction of Principal Threat Source Material in Bedrock and Groundwater.

Response: This comment did not have an explanation why the County staff does not support EPA's preference of Alternative 5B- *In Situ* Bioremediation and Chemical Reduction of Principal Threat Source Material in Bedrock and Groundwater.

Comment #6

Comment: The County recommends that Alternatives 6B and 7 should be revisited as Preferred Alternatives for the Principal Threat Source Material in Bedrock. The technical merit for revisiting these alternatives is that the likelihood of success for these alternatives is greater than Alternative 5B and is further explained in Dr. Widdowson's review.

Response: A treatability study was conducted at the Site in 2015-2016 to determine whether *in-situ* anaerobic biotic/abiotic treatment with bioaugmentation is a viable remedial alternative for remediating the dissolved-phase (groundwater) portion of the TCE plume. During this study, biostimulation (electron donor) and bioaugmentation (enriched microbial cultures) injections established appropriate conditions for complete reductive dechlorination to occur within groundwater; thereby reducing dissolved-phase TCE to *cis*-1,2-dichlorethene, and with some exceptions, further reducing the dissolved phase contamination to ethene. Overall, the results of the treatability study (and numerous applications at sites across the United States) have shown that a biostimulation/bioaugmentation application for treatment of groundwater is not only appropriate but viable for fractured bedrock sites that have been impacted with a TCE (and other chlorinated VOCs) source. Alternative 5B ranks higher than Alternatives 6B and 7 when considering the alternatives pursuant to the evaluation criteria set forth in Section 121 of CERCLA, 42 U.S.C. § 9621, and the NCP, 40 CFR 300.430(e)(9), for determining the overall feasibility and acceptability of a remedial action. In the remedial decision process, EPA analyzes the relative performance of each alternative against these evaluation criteria. Alternative 6B – *in situ* chemical oxidation's (ISCO) effectiveness requires good subsurface delivery, distribution, and residence time of oxidant which would be a challenge given the constraints of the landfill slopes, etc. Effectiveness may also be decreased by mass transfer limitations of sorbed contaminants from the bedrock matrix into the high-flow fracture zones in the source area. If injections were stopped prior to depletion of the TCE source, a rebound in groundwater impacts would be expected to occur once the oxidant was exhausted. Moreover, sites with TCE DNAPL have been observed to have an increase in Contaminant of Concern (COC) concentrations following individual ISCO injections. Alternative 7 is the most expensive alternative due to the requirement of a network of thermal wells, power distribution and thermal oxidizer. Extension of a 480 volt/3-phase power lines and a pole drop to the site would be required to power the treatment system and would require approval to install it within existing easements. Though *in situ* thermal treatment (with SVE for extracted vapor) is designed to aggressively target TCE mass removal, because to constraints related to the landfill slopes, etc. the likelihood of sufficient mass removal to mitigate groundwater without polishing treatment (which is another treatment to complete this remediation) is low, thereby decreasing the benefit of an expensive treatment option. Alternative 5B is the most cost effective when compared to Alternatives 6B and 7. Alternative 6B would double the cost due to the need for multiple injections to support ISCO of COCs in the groundwater.

Comments #7 - #14 are comments received from Loudoun County's consultant, Dr. Mark Widdowson. Dr. Widdowson's comments were broken into 2 sections: 1) Overall Approach and 2) Preferred Alternatives

Dr. Mark Widdowson's Review – Comments and Significant Concerns: Overall Approach

Comment #7

Comment: Separation of the Site into three Operable Units (OUs) is appropriate.

Response: EPA thanks Dr. Widdowson for this comment.

Comment #8

Comment: The conceptual approach of addressing source area remediation through treatment as a means to reduce Site-wide groundwater contamination is sound and reasonable.

Response: EPA thanks Dr. Widdowson for this comment.

Comment #9

Comment: The Principal Threat Remedial Goal (RG) for TCE in groundwater (10,000 µg/L) stated in the Feasibility Study will not achieve the Remedial Action Objectives (RAOs) and overall goals of reducing contaminant concentrations to MCLs or below at the downgradient/western side of the landfill.

Response: EPA agrees and also came to a similar conclusion while preparing the Proposed Plan. After the Feasibility Study was finalized and during the development of the Proposed Plan, EPA had internal discussions with EPA technical support, VDEQ and EPA management regarding the RG for bedrock/groundwater for OU-3. After the internal discussions, the RG was changed from 10,000 µg/L to 1,000 µg/L. The investigations conducted during the Remedial Design (RD) will further evaluate the extent of contaminated bedrock/groundwater to determine the greatest area practicable for achieving the RG. This updated RG has been established in the ROD.

Comment #10

Comment: A specific Point of Compliance (s) for evaluating the remedy success is not identified in the Proposed Plan.

Response: The remedy for OU-3 for the Site is an interim action to address the source of groundwater contamination and landfill cap. The restoration of Site-wide contaminated groundwater will be addressed in a future ROD for OU-1, which EPA expects to be the final Remedial Action for the Site. The evaluation of success for the OU-3 remedy is achieving the RAOs established. The RAOS are:

- Prevent direct contact with landfill waste and minimize infiltration of precipitation into the landfill
- Reduce mass and concentrations of the source area contaminants sufficiently to allow groundwater plume concentrations beyond the Waste Management Area (WMA) to achieve MCLs in the future.

RGs are established for purposes of creating a substantial decrease in TCE concentrations downgradient of the WMA and facilitating future achievement of concentrations below the MCLs on the downgradient/western side of the landfill. RGs are selected to guide remediation within interim remedial actions.

Dr. Mark Widdowson's Review – Comments and Significant Concerns: Preferred Alternatives

Comment #11

Comment: The Preferred Alternative for the Waste Management Area (Alternative 2) is sound and reasonable.

Response: EPA thanks Dr. Widdowson for the support for the proposed remedy.

Comment #12

Comment: The Preferred Alternative for the Principle Threat source material in Overburden Soil Waste Management Area (Alternative 3A) is superior to other alternatives.

Response: EPA thanks Dr. Widdowson for the support for the proposed remedy.

Comment #13 is split into three parts (13A, 13B, 13C)

Comment: The Preferred Alternative for the Principal Threat Source Material in Bedrock Waste (Alternative 5B) has a low likelihood of success relative to other alternatives.

Comment #13A

Comment: The use of a bioremediation/chemical reduction-based remedy to reduce source material at such large TCE concentrations is highly questionable. It is not scientifically defensible to expect significant TCE mass reduction in bedrock can be achieved by relying on source zone microorganisms and/or chemical reductants. The use of In Situ Bioremediation and Chemical Reduction in bedrock aquifers does not have a strong track record of success at other Superfund sites.

Response: A treatability study was conducted at the Site in 2015-2016 to determine whether *in-situ* anaerobic biotic/abiotic treatment with bioaugmentation is a viable remedial alternative for remediating the dissolved-phase (groundwater) portion of the TCE plume. During this study, biostimulation (electron donor) and bioaugmentation (enriched microbial cultures) injections established appropriate conditions for complete reductive dechlorination to occur within groundwater; thereby reducing dissolved-phase TCE to *cis*-1,2-dichlorethene, and with some exceptions, further reducing the dissolved phase contamination to ethene. Overall, the results of the treatability study (and numerous applications at sites across the United States) have shown that a biostimulation/bioaugmentation application for treatment of groundwater is not only appropriate but viable for fractured bedrock sites that have been impacted with a TCE (and other chlorinated VOCs) source. This type of application includes periodic injections to sustain long-term, optimal conditions for reductive dechlorination in, and stabilization of, groundwater until TCE source mass has been depleted. Similar treatment applications have shown that mass transfer from a TCE source is enhanced by 3 to 5 times the effectiveness under biostimulation/bioaugmentation conditions, linearly decreasing cleanup timeframes to achieve TCE source depletion.

Biological parameters were assessed within the treatment area and samples demonstrated that all groundwater samples collected from bedrock wells had detectable concentrations of *Dehalococcoides* (DHC), indicating the potential for complete reduction of TCE. DHC is the key bacterium for complete degradation of TCE; however, the presence of other bacteria can also indicate the potential for TCE degradation. Concentrations of cis-1,2-DCE and VC have been increasing over time in source area monitoring wells, indicating that bioremediation processes are also naturally occurring.

Comment #13B

Comment: The use of a bioremediation remedy to reduce source material present as a chemical liquid in bedrock pore spaces (i.e., NAPL mass) is highly questionable. Results of the SRI source investigation revealed TCE concentrations in two SRI monitoring wells (OB-3 and RI-27S at high levels that strongly suggest the presence of a TCE NAPL. The occurrence of TCE in the form of a dense non-aqueous phase liquid (DNAPL) has been raised with the USEPA in the RI Review (2016) and in the SRI Review (2020). In contrast, the Proposed Plan states that pure TCE product has not been detected in the source area (page 14). However, the USEPA is ignoring its own technical guidance where the presence of a TCE DNAPL is inferred from high levels of TCE groundwater concentrations.

Response: EPA agrees that TCE DNAPL is likely present; however, even though bedrock at the Site has been characterized by numerous high-resolution and state-of-the-art methods, a target location of treatment for potential DNAPL remains highly uncertain. Besides excavation, the likelihood of implementing a technology that is effective at physically removing TCE DNAPL from fractured bedrock pores is low and excavation is not feasible in bedrock. Therefore, a method of risk reduction by mitigating groundwater contaminants, while passively enhancing contaminant mass transfer from the DNAPL bedrock source, is highly preferred.

Comment #13C

Comment: Alternative 5B will result in the generation of dissolved cis-1,2-DCE and VC in groundwater. Vinyl Chloride (VC) is more toxic than TCE with a lower MCL (2 µg /L). Both cis-1,2-DCE and VC were generated and persisted in groundwater in monitoring well nets following the introduction of biostimulation materials to the bedrock aquifer during the treatability study.

Response: In-Situ Bioremediation/Chemical Reduction under Alternative 5B is an *in-situ* treatment option that combines two processes to promote both biotic and abiotic treatment of chlorinated VOCs in anoxic groundwater. The injected amendment would include both 1) carbon substrate to promote the creation of anaerobic conditions through microbial activity and then to support reductive dechlorination and 2) chemical reductant such as zero-valent iron to further promote reducing conditions and directly reduce COCs. Reductive dechlorination of TCE via biological reactions typically follow a path from TCE to DCE (primarily *cis*-DCE), VC, and finally ethene and ethane. Abiotic degradation via β-elimination will convert TCE directly to ethene and ethane, without the formation of reductive dechlorination daughter products. The process of β-elimination is a chemical reaction in which atoms are lost from adjacent atoms, resulting in new bond. The final remedy at the site will include robust design to ensure complete reductive dechlorination (through biostimulation and bioaugmentation) through enhanced bioremediation as wells as to ensure β-elimination through abiotic reaction is occurring as designed. Effects of the amendments on groundwater chemistry and the resulting increase in degradation rates would be expected to persist for up to 5 years per injection. Given these time frames, enhanced bioremediation is expected to be more permanent, more controllable, and more sustainable than groundwater extraction or *in situ* chemical oxidation.

Comment #14

Comment: Alternatives 6B and 7 should be revisited as Preferred Alternatives for the Principal Threat Source Material in Bedrock.

Response: See response to comment #6 above.

FIGURES

Figure 1: Site Location Map

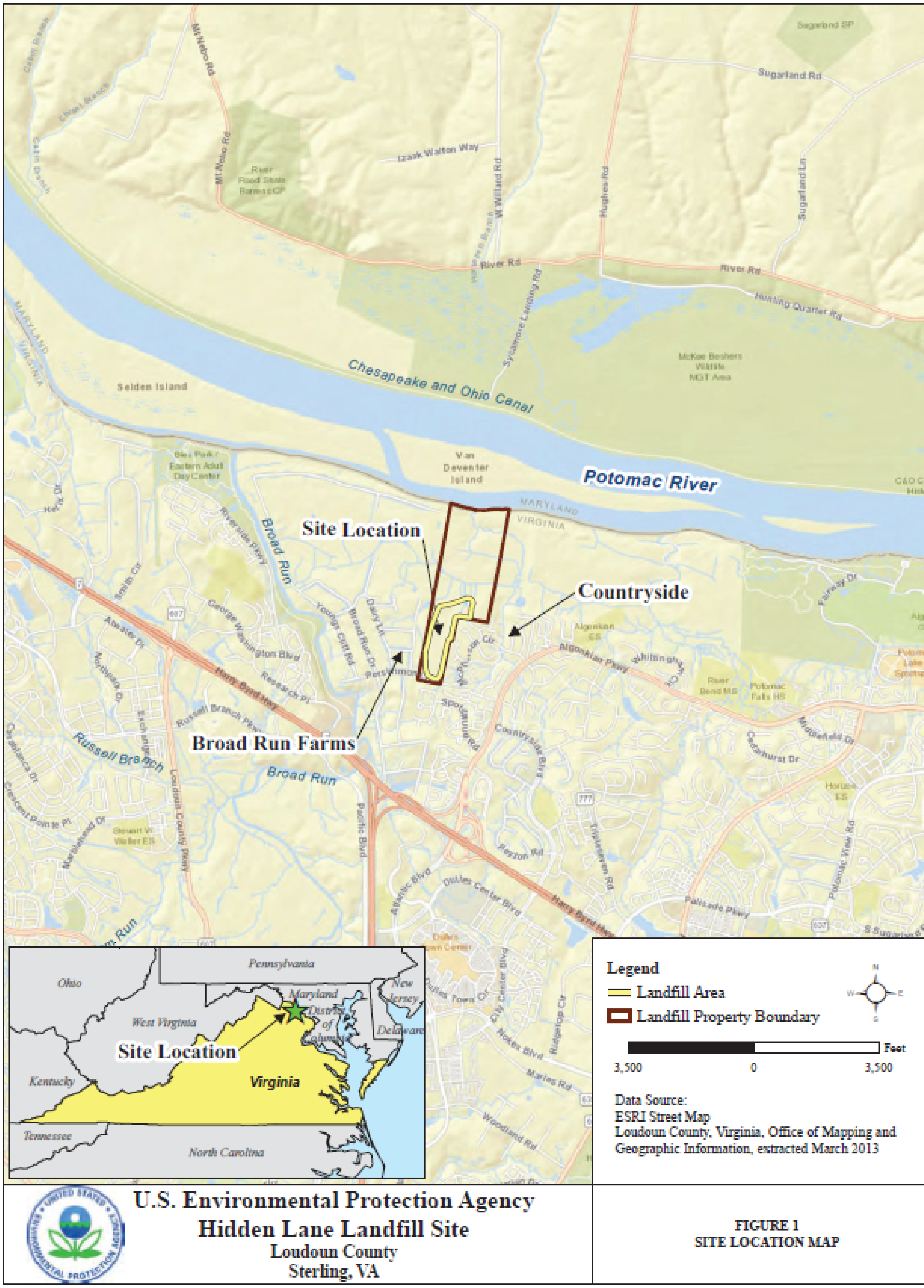
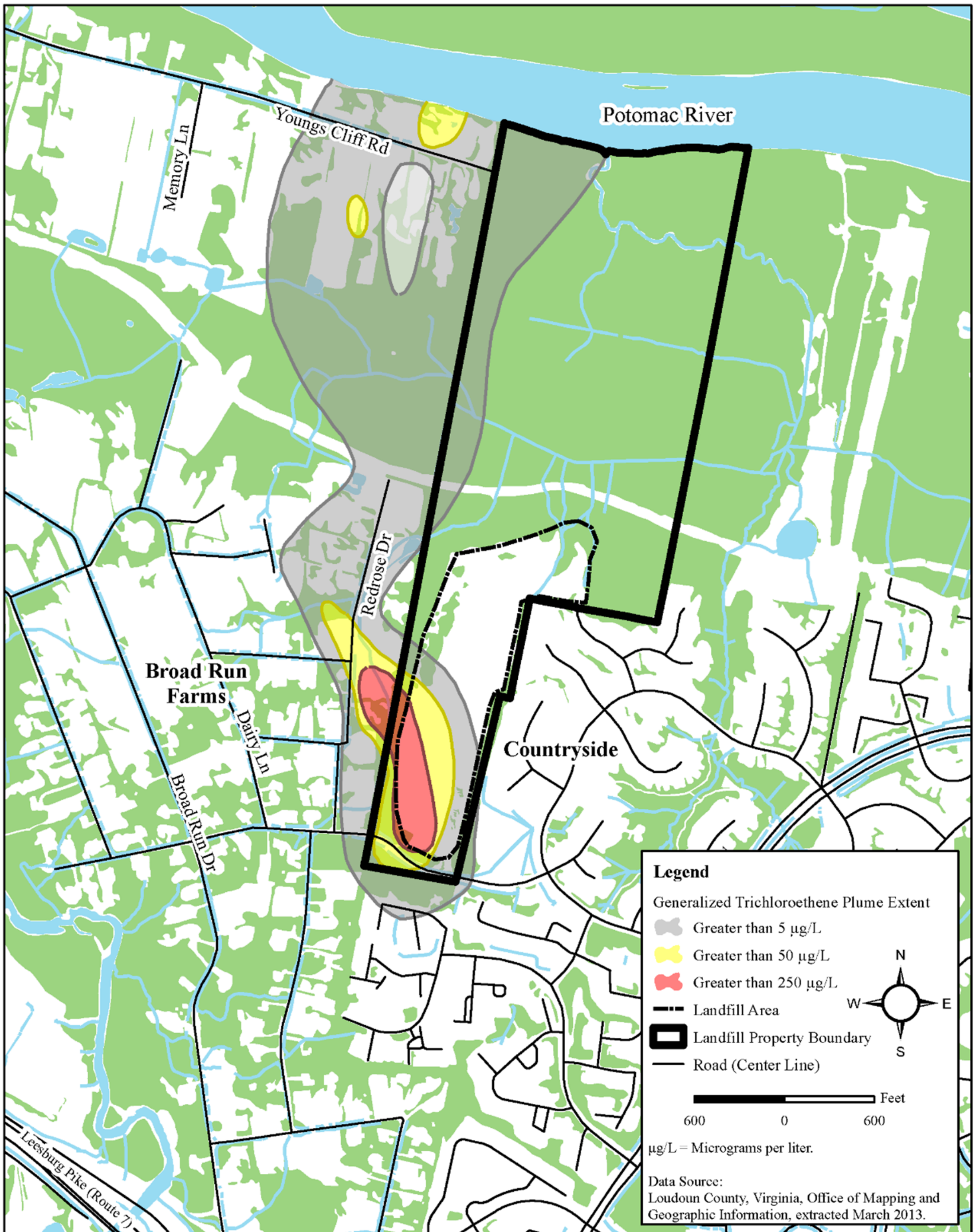


Figure 2: Trichloroethene Plume Extent



U.S. Environmental Protection Agency
Hidden Lane Landfill Site
Loudoun County
Sterling, VA

FIGURE 2
GENERALIZED TRICHLOROETHENE PLUME EXTENT

Figure 3: Approximate Source Area Map

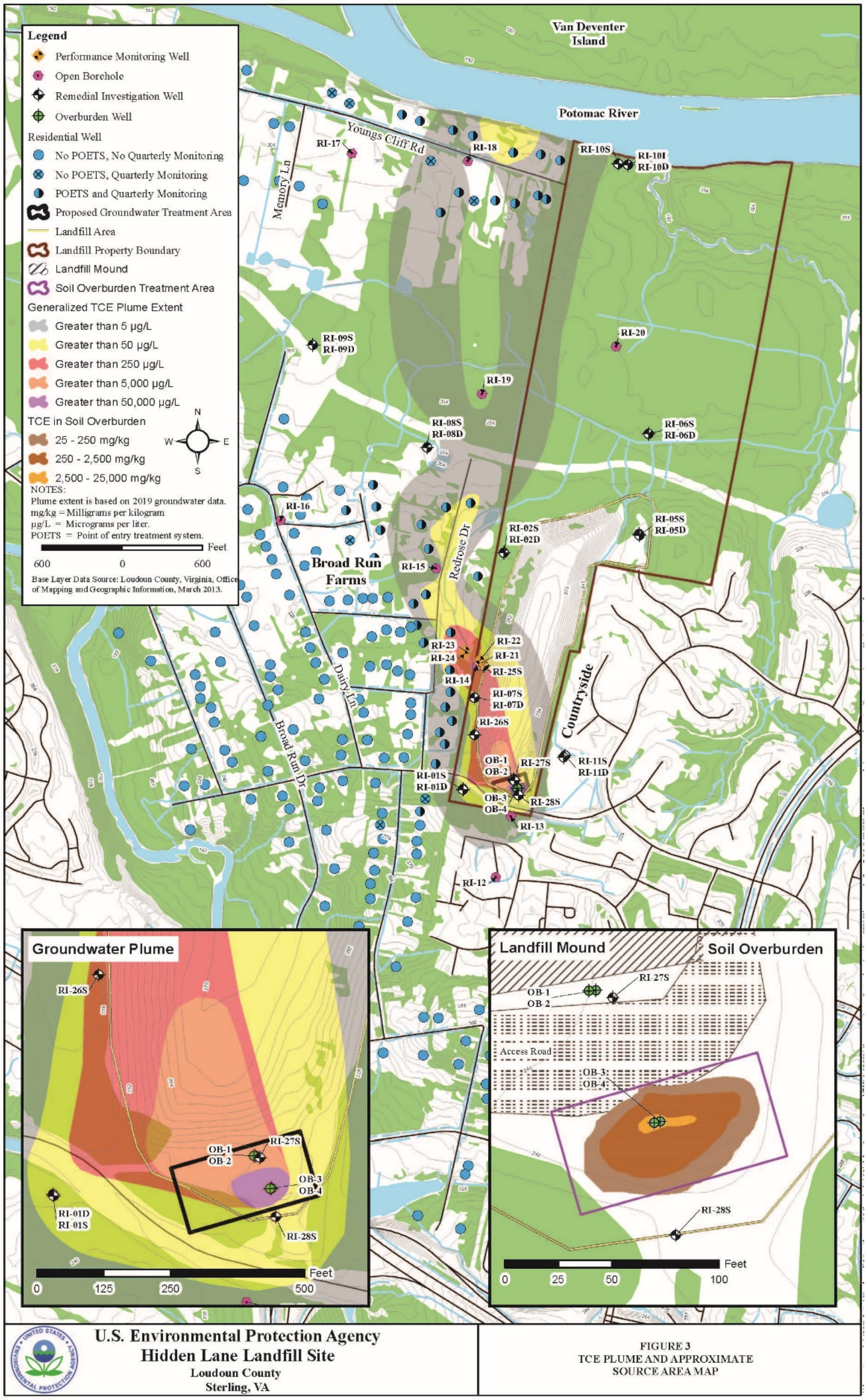


Figure 4: Cross-Section of TCE Concentrations in Groundwater

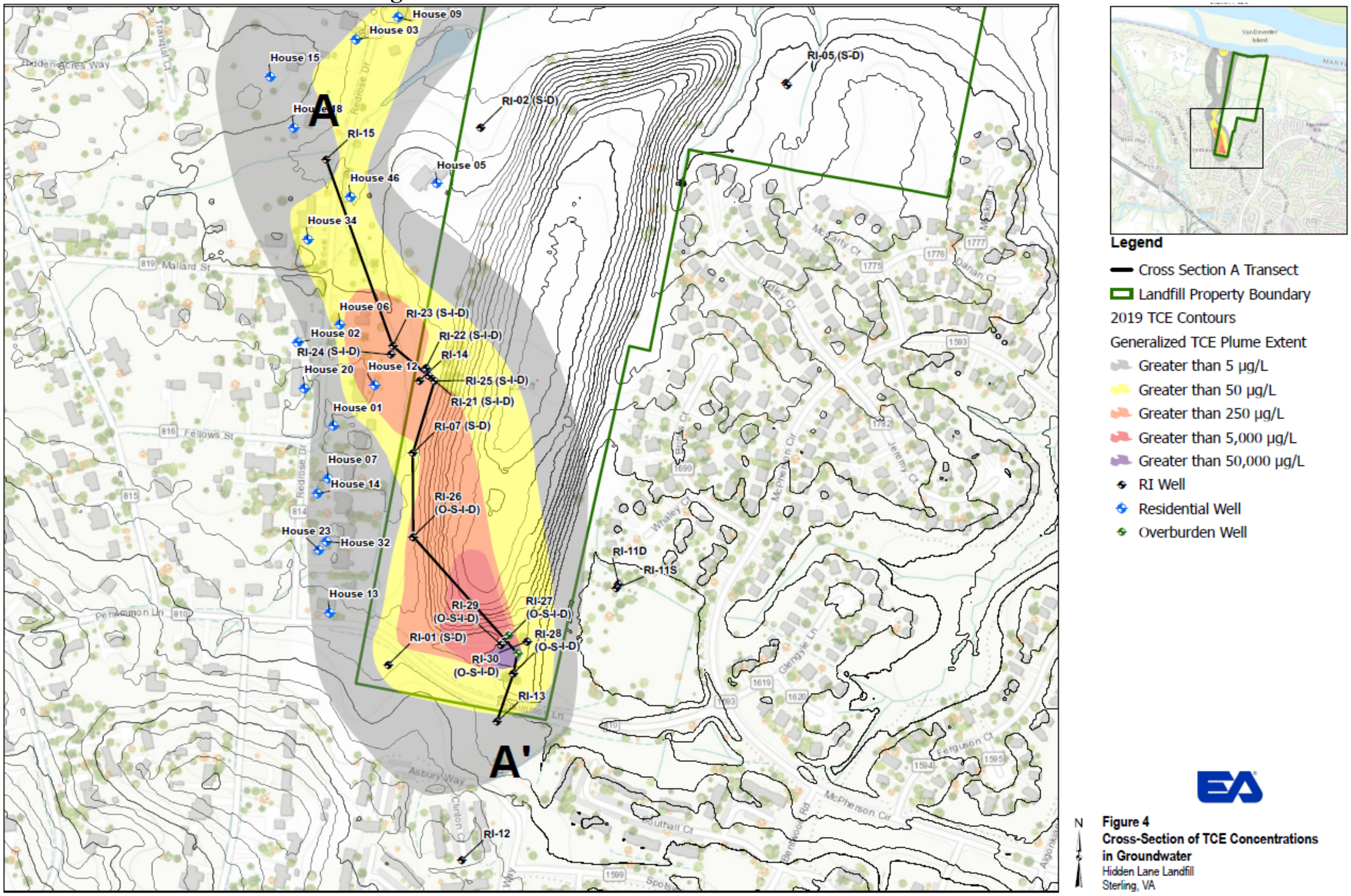


Figure 4A: Cross-Section of TCE Concentrations in Groundwater

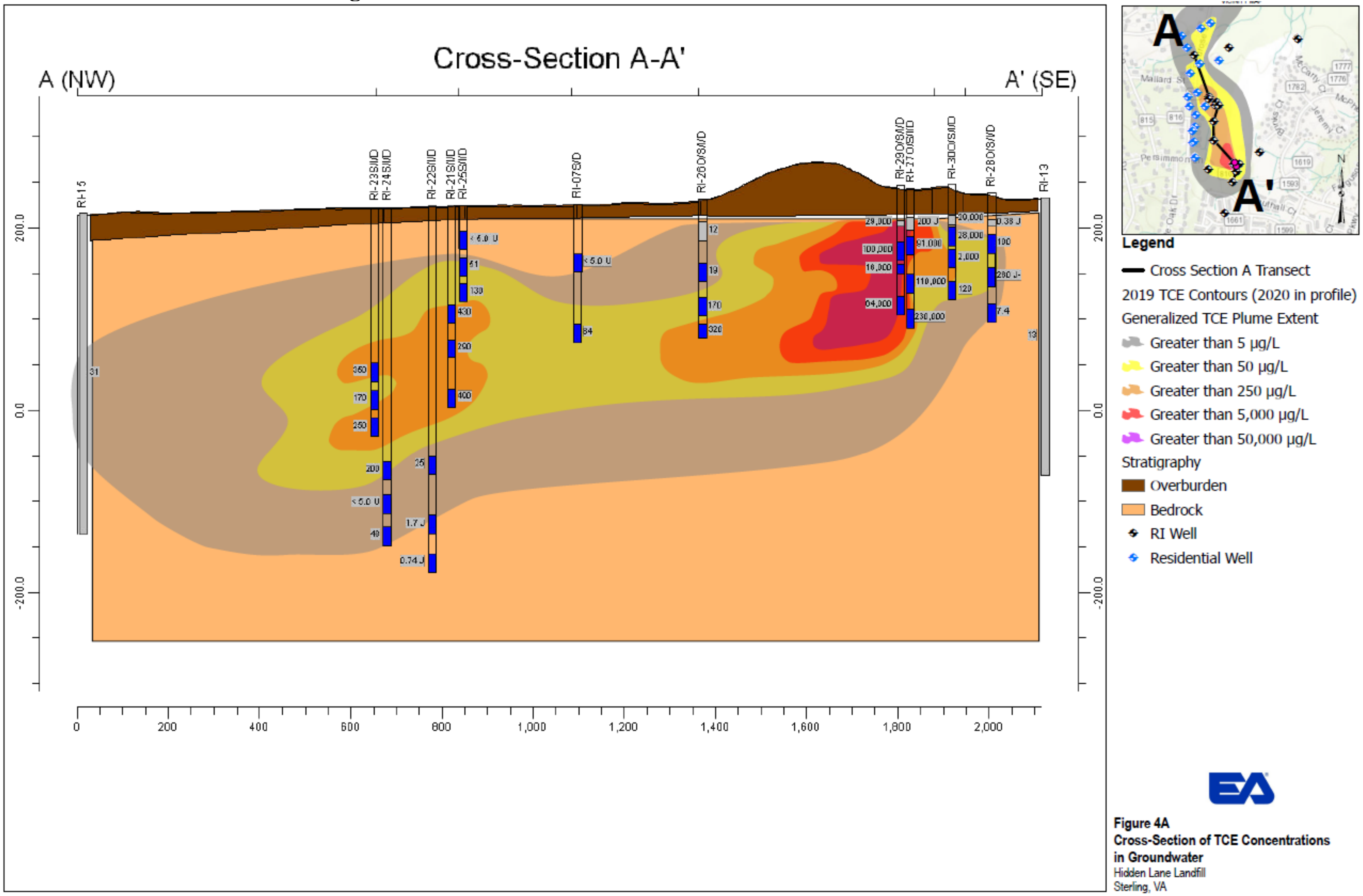


Figure 5: Alternative 3A Remedial Components

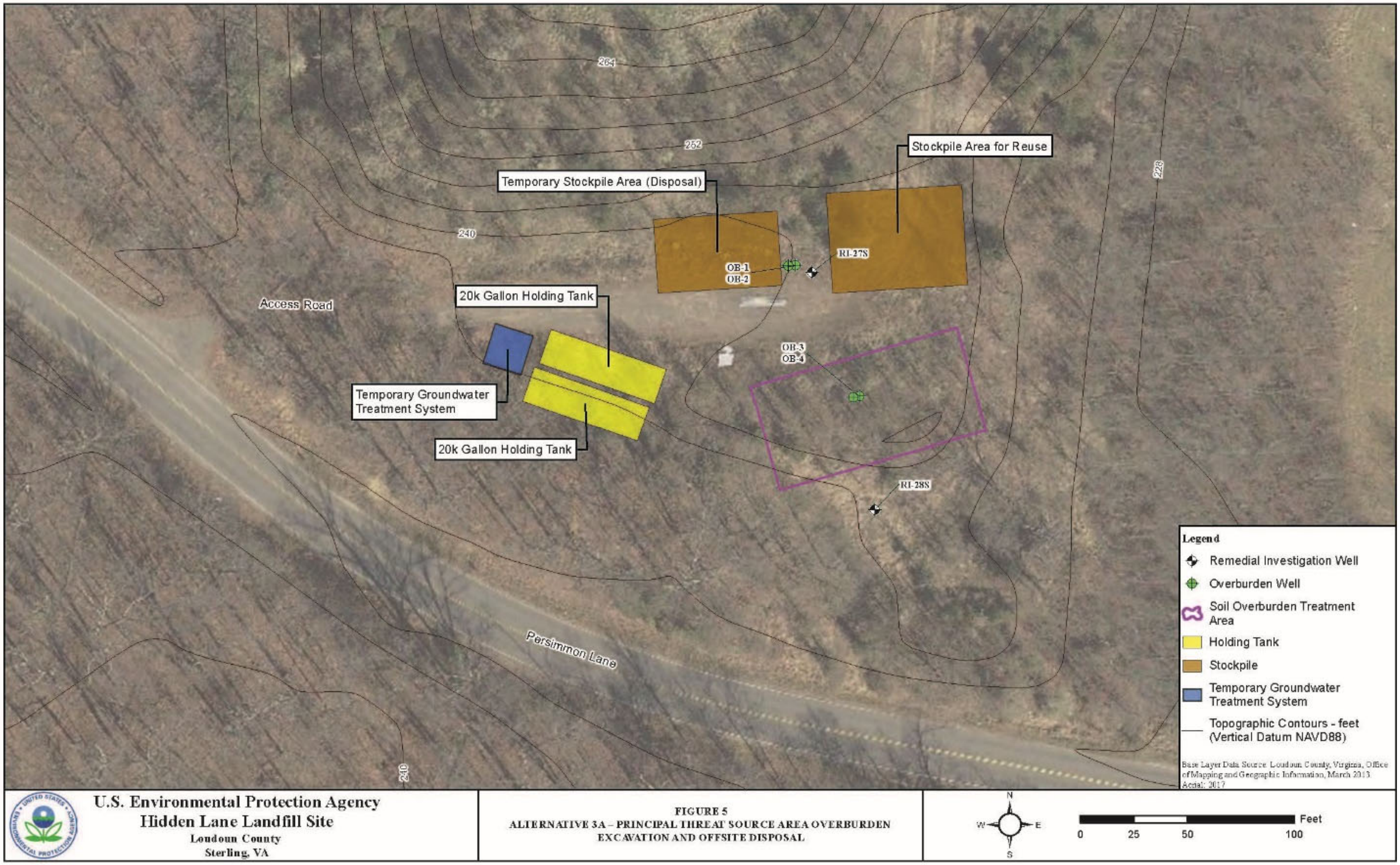


Figure 6: Alternative 3B Remedial Components

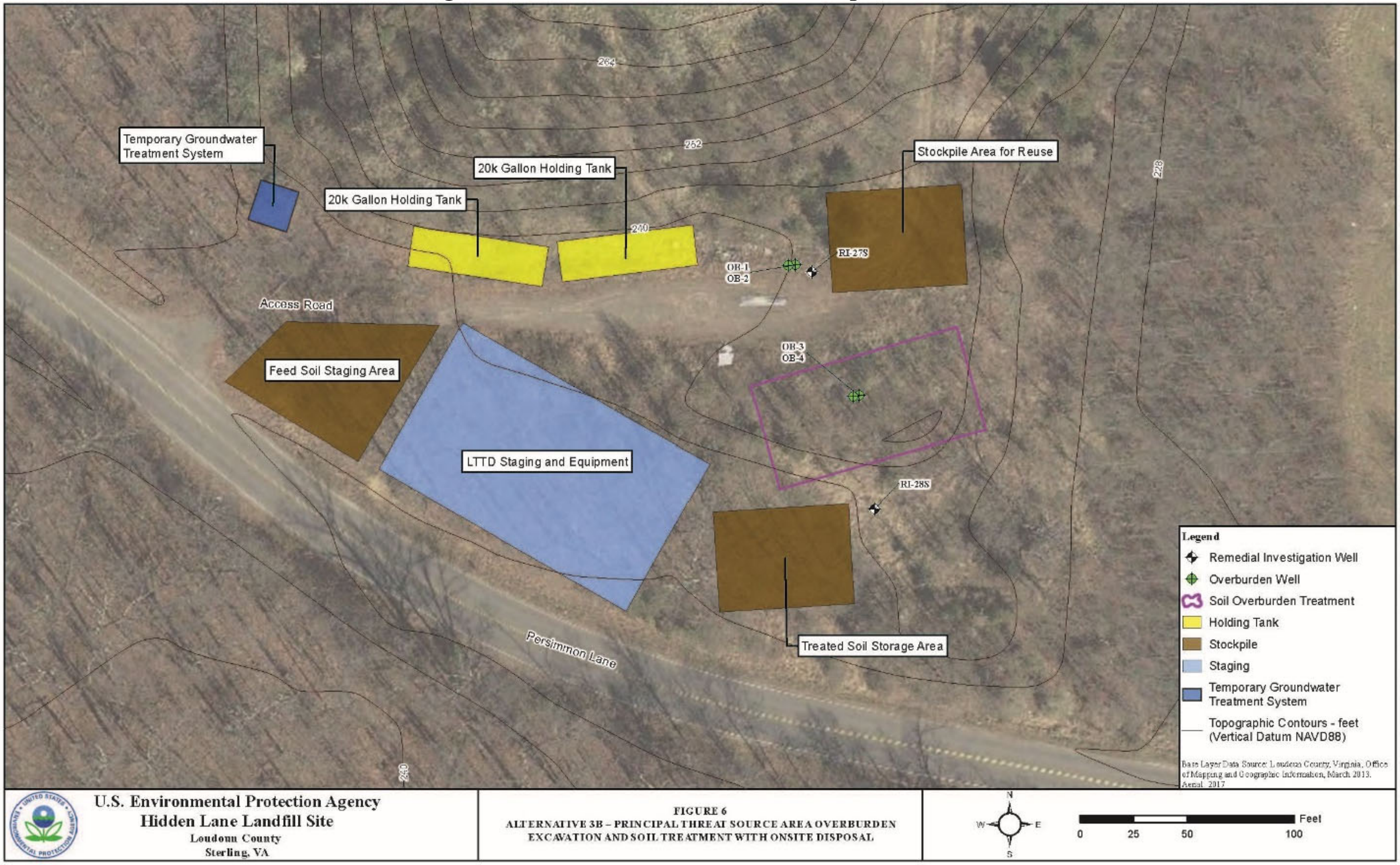


Figure 7: Alternative 4 Remedial Components

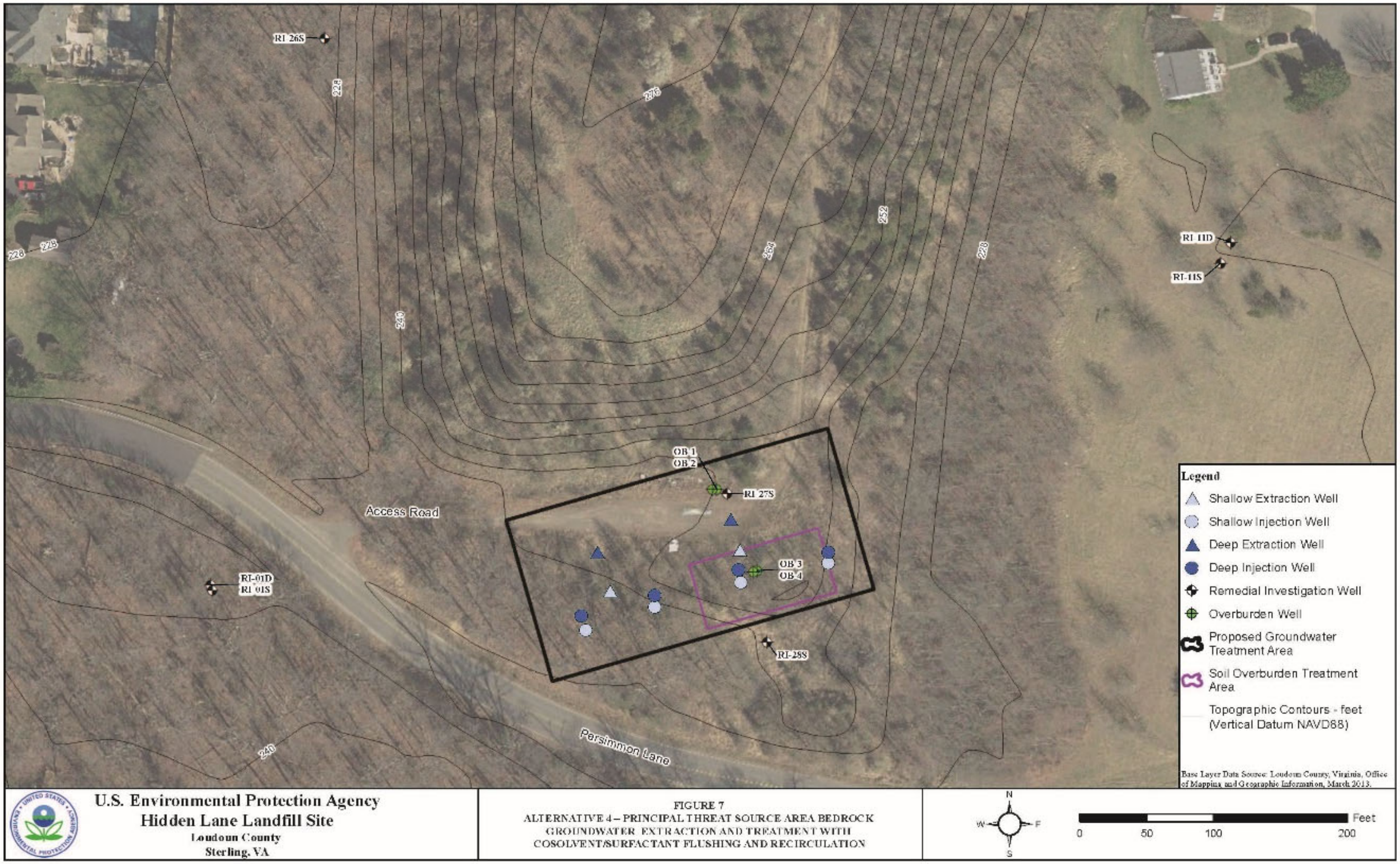


Figure 8: Alternative 5A Remedial Components

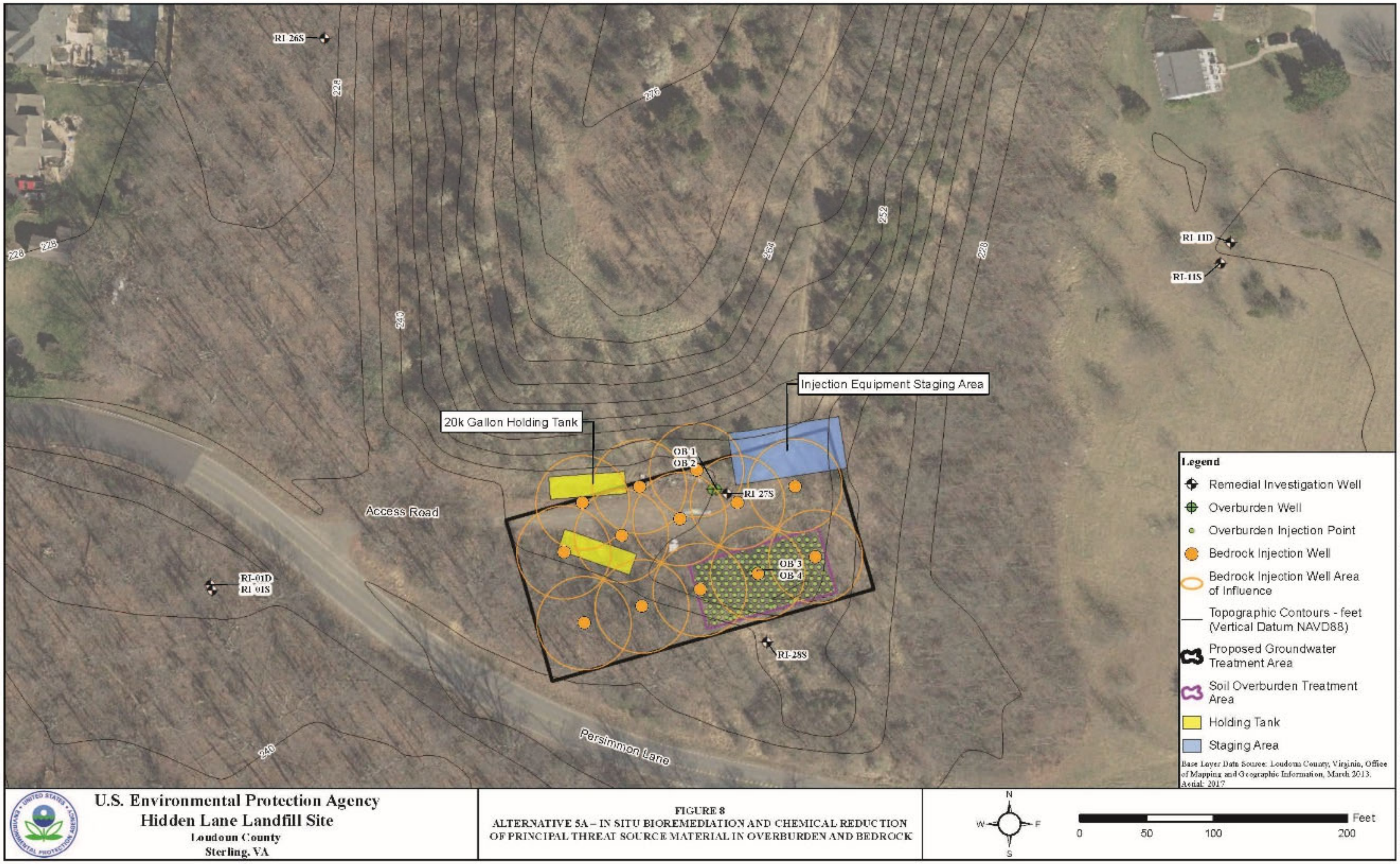


Figure 9: Alternative 5B Remedial Components

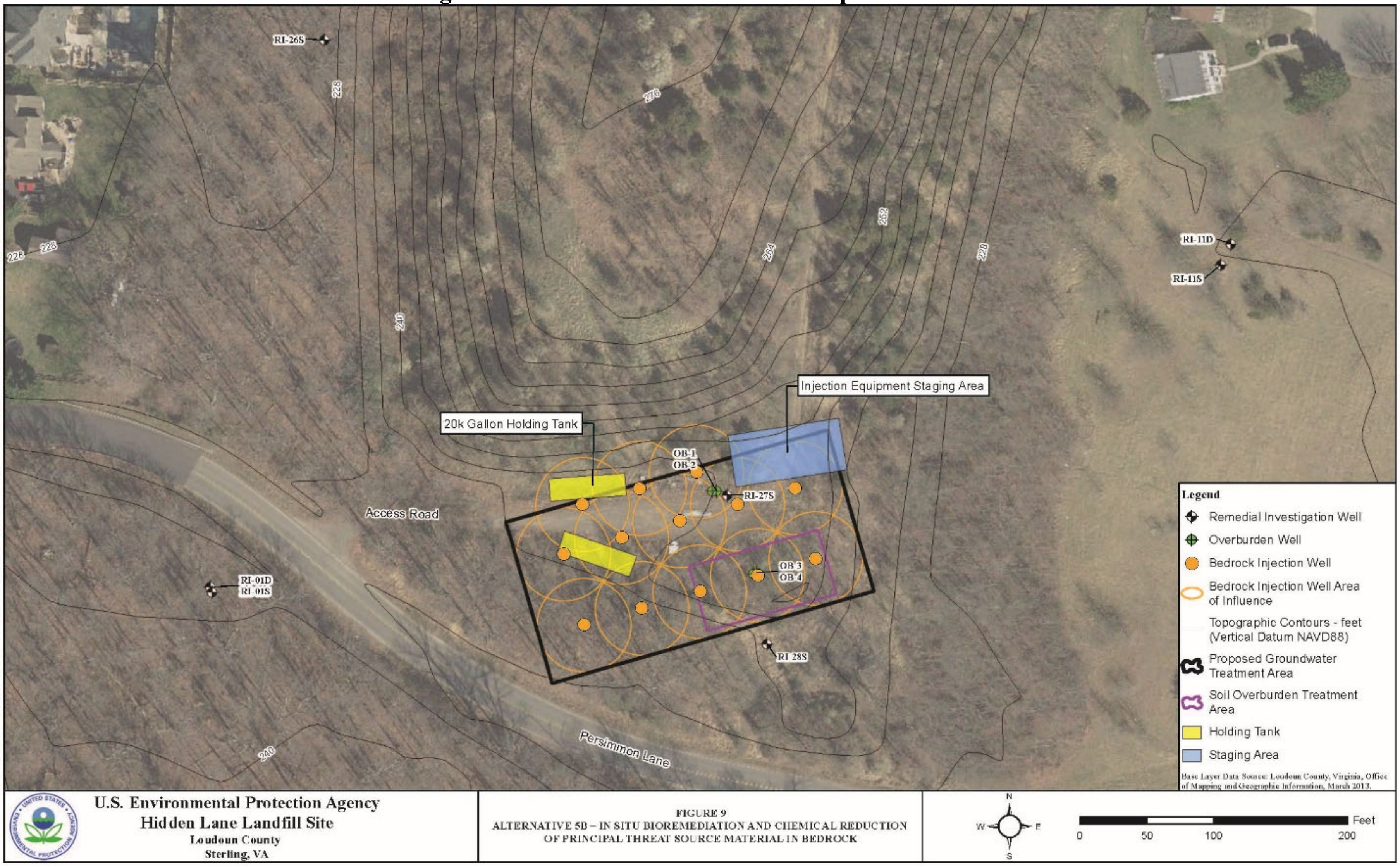


Figure 10: Alternative 6A Remedial Components

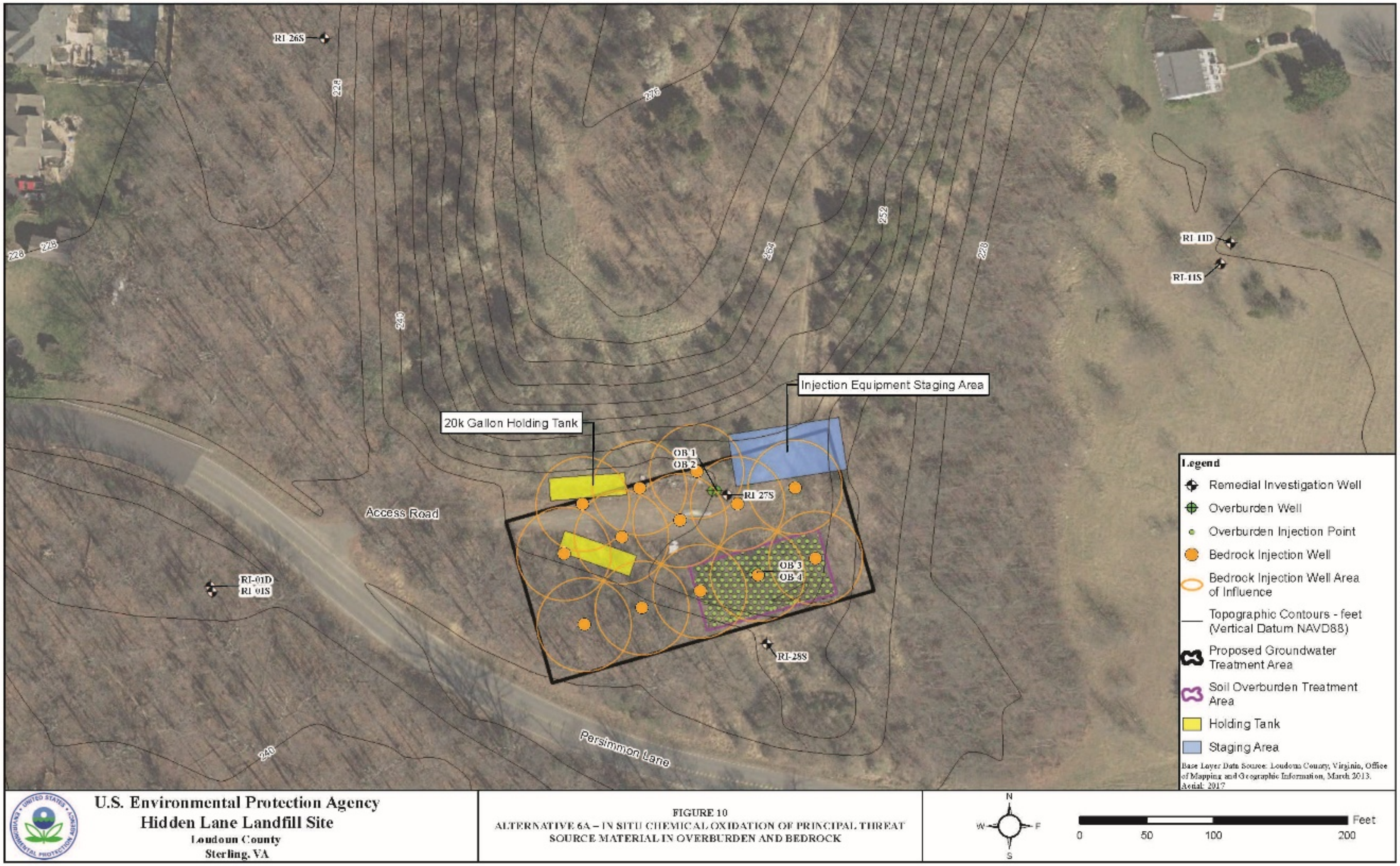


Figure 11: Alternative 6B Remedial Components

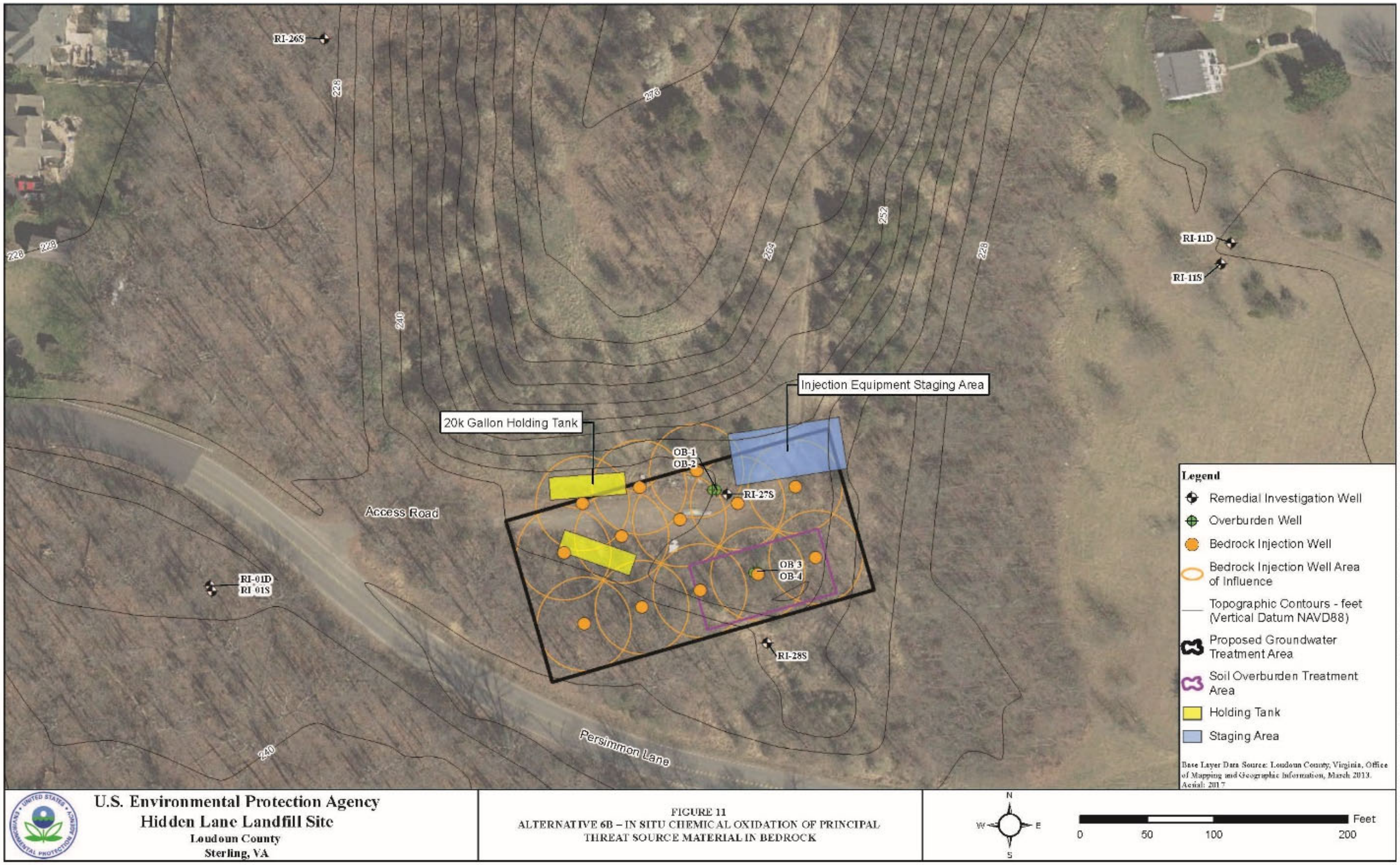
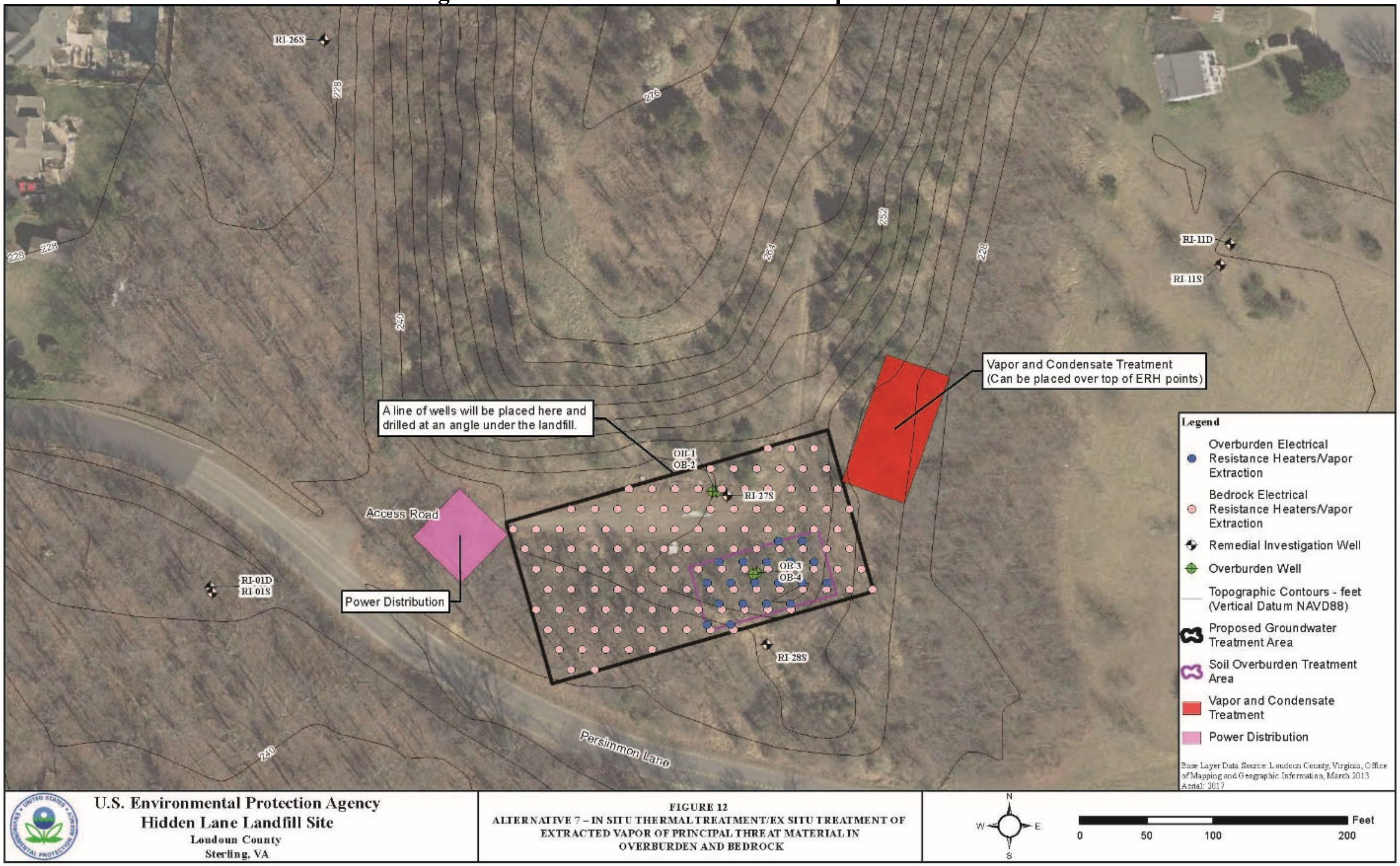


Figure 12: Alternative 7 Remedial Components



APPENDIX A

Virginia Department of Environmental Quality (VDEQ) Letter of Concurrence

Commonwealth of Virginia

VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

1111 E. Main Street, Suite 1400, Richmond, Virginia 23219
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Ann F. Jennings
Secretary of Natural and Historic Resources

David K. Paylor
Director
(804) 698-4000

December 30, 2021

Paul Leonard, Director
Superfund & Emergency Management Division
U.S. Environmental Protection Agency, Region III
1650 Arch Street
Philadelphia, PA 19103

Re: Hidden Lane Landfill – Record of Decision –Operable Unit 3 (OU3)

Dear Mr. Leonard,

The Virginia Department of Environmental Quality, Office of Remediation Programs, has reviewed the Record of Decision for the Hidden Land Landfill Operable Unit 3 (OU3). We concur with the selected remedial alternatives as outlined in the Record of Decision dated December 2021.

Should you have any questions regarding this letter, please feel free to contact Aaron Siegel at (804) 718-8770, or aaron.siegel@deq.virginia.gov.

Sincerely,

Chris M. Evans, Director
Office of Remediation Programs

Cc: Chris Vallone, EPA Region III

APPENDIX B
Applicable or Relevant and Appropriate Requirements

Appendix B - Applicable or Relevant and Appropriate Requirements

ARAR	Legal Citations	Status	Requirement	Relationship to the Final Remedial Action
Chemical Specific ARARs				
A. Water				
Safe Drinking Water Act (SDWA) National Primary Drinking Water Regulations	40 C.F.R. § 141.11 40 C.F.R. § 141.13 40 C.F.R. § 141.22 40 C.F.R. § 141.23 40 C.F.R. § 141.61 40 C.F.R. § 141.62	Relevant & Appropriate	MCLs under the SDWA are federal standards that protect public water systems. An MCL is the highest level of a contaminant allowed in drinking water.	Relevant and appropriate for contaminants which impact groundwater.
Virginia Water Quality Standards	9VAC25-280-30 9VAC25-280-40 9VAC25-280-70	Applicable	Provides that waters of the Commonwealth, including wetlands, shall be free from substances attributable to industrial or other waste in concentrations, amounts, or combinations that contravene established standards or interfere with designated uses of such water or which are inimical or harmful to human, animal, plant, or aquatic life.	The remedial action should be implemented with a target goal of achieving groundwater standards.

Location-Specific ARARs				
ARAR	**Legal Citation**	**Status**	**Requirement**	**Relationship to the Final Remedial Action**
National Historic Preservation Act (NHPA)	54 U.S.C. § 306108 36 C.F.R. Part 800	Applicable	Requires any federal undertaking to evaluate the effect it may have on any historic property and to afford the Federal Advisory Council on Historic Preservation (FACHP) a reasonable opportunity to comment on such undertakings. The procedures set forth in 36 C.F.R. Part 800 define how federal agencies meet their statutory responsibilities by consulting with the Preservation Officer for Commonwealth of Virginia and the FACHP to determine if the Remedial Action will affect cultural or historic sites on or eligible for the National Register of Historic Places.	Excavation of soils during the remedial action may affect a cultural or historic site subject to the NHPA.
Migratory Bird Treaty Act	16 U.S.C. § 703 50 C.F.R. Parts 10 and 21	Applicable	Protects most species of native birds in the United States from unregulated taking.	If migratory birds or their nests or eggs are identified at the Site, EPA will ensure that these birds, nests, or eggs are not destroyed during implementation of the Remedial Action.

Action-Specific ARARs				
A. Water				
ARAR	**Legal Citation**	**Status**	**Requirement**	**Relationship to the Final Remedial Action**
Underground Injection Control (UIC) Regulations	40 C.F.R. § 144.12 40 C.F.R. § 144.80 (e) 40 C.F.R. § 144.82 40 C.F.R. §146.8(a)-(e) 40 C.F.R. §146.10(c)	Applicable	Establishes classes of injection wells and requirements for those wells pursuant to the UIC Program.	The remedial action includes Bioremediation and Chemical Reduction, which will involve substrate injections.
Virginia Monitoring Well Installation and Abandonment Act	12VAC5-630-410 12VAC5-630-420 12VAC5-630-450	Applicable	Ensures that all wells will be located, constructed, and maintained in a manner that does not adversely affect groundwater resources, or the public welfare, safety and health.	The remedial action will include construction of several monitoring and remediation wells.
Virginia Stormwater Management Act Code of Virginia, Stormwater Management Program (VSMP) Regulations	9VAC25-870-46 9VAC25-870-54 9VAC25-870-55 9VAC25-870-56	Applicable	Sets out the procedures, requirements, and best management practices to be followed during construction activities.	A Site-specific stormwater management plan will be implemented for excavation and other construction activities conducted during the Remedial Action.

B. Soil				
ARAR	**Legal Citation**	**Status**	**Requirement**	**Relationship to the Final Remedial Action**
Virginia Erosion and Stormwater Management Law Code of Virginia, Erosion and Sediment Control Regulations	9VAC25-840-40.1-11, 17-19 9VAC25-840-60	Applicable	Provides for control of soil erosion, sediment deposition, and nonagricultural runoff to prevent degradation of properties, stream channels, waters, and other natural resources.	An erosion and sediment control plan will be implemented as part of the Remedial Action to monitor and prevent erosion and runoff during excavation and construction activities at the Site.
C. Solid/Hazardous Waste				
Virginia Waste Management Act Code of Virginia, Solid Waste Management Regulations	9VAC20-81-40 9VAC20-81-170	Applicable	Establishes standards and procedures pertaining to the management of solid wastes.	The remedial action will generate investigation-derived waste that may include non-hazardous waste.
Standards for Waste Generators and Transporters	40 C.F.R. § 261.10-.35 40 C.F.R. § 262.10-.44 40 C.F.R § 263.10-.25	Applicable	Establishes standards and procedures pertaining to the exports of hazardous waste.	The remedial action will include transportation and disposal of hazardous wastes during the excavation.
Land Disposal Restrictions	40 C.F.R. § 268	Applicable	Establishes standards involving land disposal of hazardous wastes and requires treatment to diminish a waste’s toxicity and/or minimize contaminant migration	All hazardous wastes generated from the remedial action will be disposed at appropriately licensed and permitted facilities.

D. Air				
Clean Air Act Code of Virginia, Regulations for New and Modified Stationary Sources	9VAC5-50-90 to 110 9 VAC5-50-260	Relevant & Appropriate	Requires reasonable precautions to be taken to prevent particulate matter from becoming airborne. Also establishes the requirements for the use of best available control technology for new air pollutant emissions sources.	Fugitive dust caused by construction activities during the remedial action will be managed according to these requirements.
Code of Virginia National Ambient Air Quality Standards – Particulates	9VAC5-30-60 to 67	Applicable	Establishes the fugitive dust regulation for particulate matter	Any construction and/or excavation activities will comply with the substantive requirements of these regulations
National Emission Standards for Hazardous Air Pollutants for Source Categories	40 CFR Part 63, Subpart G	Relevant & Appropriate	Establishes national emissions limitations and work practice standards for hazardous air pollutants emitted from site remediation activities.	Construction, excavation, or treatment activities that would result in the emission of COCs to the air are subject to these regulations.

Notes:
ARAR = Applicable or Relevant and Appropriate Requirement
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
CFR = Code of Federal Regulations
EPA = U.S. Environmental Protection Agency
TBC = To Be Considered
MCL = Maximum Contaminant Level