FINAL RECORD OF DECISION FOR SITE 2 WASTE DISPOSAL AREA B ST JULIENS CREEK ANNEX CHESAPEAKE VA

01/01/2011

CH2M HILL

Naval Facilities Engineering Command

Final

Record of Decision
Site 2: Waste Disposal Area B

St. Juliens Creek Annex
Chesapeake, Virginia

EPA ID: VA5170000181

(EPA Designation: OU-2 Landfill B)

January 2011

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Chesapeake, Virginia

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Record of Decision

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St. Juliens Creek Annex, Chesapeake, Virginia

January 2011

1. Declaration

1.1 Site Name and Location

This Record of Decision (ROD) presents the selected remedy for Site 2, Waste Disposal Area B, St. Juliens Creek Annex (SJCA), Chesapeake, Virginia. SJCA was placed on the United States Environmental Protection Agency (USEPA) National Priorities List (NPL) effective July 27, 2000 (USEPA ID: VA5170000181).

1.2 Statement of Basis and Purpose

This remedy was selected in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and, to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). This decision is based on information contained in the Administrative Record[a] file for the site. Information not specifically summarized in this ROD but contained in the Administrative Record has been considered and is relevant to the selection of the remedy at Site 2. Thus, the ROD is based upon and relies upon the entire Administrative Record file for the site for the remedy selection decision.

The Department of the Navy (Navy) is the lead agency and provides funding for site cleanups at SJCA. The Navy and USEPA Region III issue this ROD jointly. The Commonwealth of Virginia, Virginia Department of Environmental Quality (VDEQ) concurs with the decision.

Site 2 is one of several Environmental Restoration Program (ERP) sites at SJCA that are subject to the requirements of CERCLA. The status of all the ERP sites at SJCA can be found in the current version of the **Site Management Plan**[1] (SMP), which is located in the Administrative Record.

1.3 Assessment of the Site

Previous investigations have identified waste and the presence of chemicals of concern (COCs) at concentrations that pose a potential threat to human health and/or the environment, consisting of:

- chlorinated volatile organic compounds (VOCs) in shallow groundwater (Columbia aquifer), surface water, and sediment pore water
- semi-volatile organic compounds (SVOCs) in shallow groundwater, surface soil, and inlet sediment

[a]**Bold blue text** identifies detailed site information available in the Administrative Record and listed in numerical order in the References Table.

- pesticides in shallow groundwater, surface soil, and inlet sediment
- polychlorinated biphenyls (PCBs) in surface soil and inlet sediment
- inorganics in surface and subsurface soil, surface water, and inlet sediment.

A plume of chlorinated VOCs has been identified in shallow groundwater and concentrations indicate the potential presence of dense non-aqueous phase liquid (DNAPL). Additionally, concentrations of inorganics, pesticides, PCBs, and SVOCs in St. Juliens Creek sediment pose a threat to the environment. The response action selected in this ROD is necessary to protect the public health, welfare and/or the environment from actual or threatened releases of hazardous substances.

1.4 Description of the Selected Remedy

1.4.1 Primary Remedy

The primary selected remedy for Site 2 is comprised of the following components:

- Cover installation over the waste, soil, and inlet sediment
- St. Juliens Creek sediment excavation and offsite disposal
- Enhanced reductive dechlorination (ERD) within target areas of shallow groundwater
- Monitored natural attenuation (MNA) within target areas of shallow groundwater
- Land use controls (LUCs) to maintain the soil cover and prevent exposure to waste and contaminants in soil and inlet sediment
- LUCs to prevent direct exposure to and/or potable use of shallow groundwater.

The selected remedy will address the potential principal threat waste, DNAPL, through treatment of contaminant source mass within the high-concentration area of chlorinated VOCs utilizing ERD. Performance monitoring will be conducted throughout the active treatment period to ensure effective and optimal conditions are established for the breakdown of DNAPL and mitigation of the high-concentration chlorinated VOCs through ERD and to ensure the treatment process is performing effectively.

1.4.2 Contingency Remedy Component

A permeable reactive barrier (PRB) has been developed as a contingency measure for potential addition to the selected remedy. Placement of the cover may result in changes in the shallow groundwater flow over time, and in turn potential shallow groundwater COC migration may occur. The selected remedy is protective based on current conditions; however, there is uncertainty as to how conditions may change (e.g., groundwater flow trending more towards St. Juliens Creek) as the remedy is implemented. If substantial changes in COC migration trends are observed, and if the results of modeling lead to the recognition of the potential for offsite migration of shallow groundwater COCs at concentrations that may result in exceedances of the surface water criteria, a contingency PRB may be installed to prevent offsite COC migration and discharge to St. Juliens Creek. As part of the remedial design, criteria for implementing the PRB will be established and will rely on several factors including, but not limited to: dilution attenuation factors (DAFs), site-specific groundwater and surface water flow rates, and surface water quality criteria.

1.5 Statutory Determinations

The selected remedy and the contingency remedy, if implemented, are protective of human health and the environment, comply with Federal and State regulations that are applicable or relevant and appropriate to the remedial action, are cost effective, utilize permanent solutions and alternative treatment (or resource recovery) technologies to the maximum extent practicable, and satisfy the preference for treatment as a principal element of the remedy. Because the remedy will result in pollutants or contaminants remaining onsite above levels that allow for unlimited use and unrestricted exposure, the Navy will conduct statutory reviews every five years after initiation of remedial action to ensure that the remedy is protective of human health and the environment. In accordance with current policy, the Naval Facilities Engineering Command, Mid-Atlantic, will conduct the first statutory remedy review concurrent with the next Site 4 statutory review in 2015.

1.6 Data Certification Checklist

The following information is included in the Decision Summary section of this ROD. Additional information can be found in the Administrative Record file for SJCA, Site 2.

- COCs and their respective concentrations (Section 2.5)
- Current and reasonably anticipated future land use assumptions and current and potential future beneficial uses of groundwater (Section 2.6)
- Baseline risk represented by the COCs (Section 2.7)
- Cleanup levels established for COCs and the basis for these levels (Section 2.8)
- Estimated capital, annual operation and maintenance (O&M), and total present worth costs, discount rate, and the number of years over which the remedy cost estimates are projected (Section 2.9, Table 8)
- How source materials constituting principal threats will be addressed (Section 2.10)
- Key factor(s) that led to selecting the remedy (i.e., describe how the selected remedy provides the best balance of tradeoffs with respect to the balancing and modifying criteria, highlighting criteria key to the decision) (Section 2.11.1)
- Potential land and groundwater use that will be available at the site as a result of the selected remedy (Section 2.11.5, Table 10)

1.7 Authorizing Signatures

G. R. THOMAS
Captain, U.S. Navy
Commander, Norfolk Naval Shipyard
Portsmouth, Virginia

January 25, 2011
Date

Ronald J. Borsellino, Director
Hazardous Site Cleanup Division
USEPA (Region III)

February 22, 2011
Date

2 Decision Summary

2.1 Site Name, Location, and Description

Site 2 (Waste Disposal Area B; EPA Designation: OU2 Landfill B)
St. Juliens Creek Annex
Chesapeake, Virginia
USEPA ID: VA5170000181

SJCA covers approximately 490 acres and is located in the city of Chesapeake, Virginia (**Figure 1**). Most of the surrounding area is developed and includes residences, schools, recreational areas, and shipping facilities for several large industries. Site 2 is a former waste disposal area located in the southern portion of SJCA (**Figure 2**). The Site 2 boundary encompasses approximately 5.7 acres.

2.2 Site History and Enforcement Activities

SJCA began operations as a naval ammunitions facility in 1849. The facility was one of the largest ammunition depots in the United States and was involved in the wartime transfer of ammunitions to other naval facilities. After ordnance operations ceased at SJCA in 1977, decontamination was performed in, around, and under ordnance-handling facilities by flushing the areas with chemical solutions and water. SJCA has also been involved in non-ordnance services, including degreasing; operating various shops, such as paint, machine, vehicle and locomotive maintenance, pest control, battery, printing, and electrical; operating boiler plants, wash racks, and potable-water and saltwater fire-protection systems; providing firefighter training; and storing oil and chemicals.

Site 2 was initially identified as Dump B, which was used for the disposal of mixed municipal wastes, abrasive blast material (ABM), waste ordnance, organics (including solvents), and inorganics (Figure 2). Operations began in 1921 and continued until sometime after 1947. Initially, refuse was burned openly on site and was used to fill in the swampy area of the site (Site 2 inlet). An incinerator was installed in 1943 to replace open burning practices. Construction debris (concrete, brick, and wood), as well as ABM, are currently visible on the ground surface. Additionally, historic reports indicate that prior to the 1930s ordnance may have been disposed of in Dump B. The total volume of waste accumulated is estimated to be 50,000 cubic yards (yd^3). Due to its proximity, former **Site 17**[2], initially identified as AOC A (Satellite Storage at Building 279) was incorporated into the Site 2 boundary in 2004 (Figure 2). Site 17 was used for lead battery maintenance after 1954. Waste acid electrolyte was collected in containers and transported off base for disposal. **Site visits**[3] indicated a concrete storage pad was used to store two 55-gallon drums of PD-680, a commercial product used as a degreaser. Stains on the ground near the pad, as well as indications of poor management (overflowing catchbucket under drum spigot) were also noted.

An underground stormwater sewer system originates approximately 1,000 ft northeast of Site 2, within the ERP Site 21 boundary, and discharges to the north end of the Site 2 inlet (Figure 2). The storm sewer system has historically received discharges from vehicle and equipment wash racks and ordnance degreasing operations, located to the north. Four above ground storage tanks (ASTs) (removed between 1986 and 1990) were formerly located east of Site 2. The former tanks were possibly used for storage of fuel oil and diesel. One underground storage tank (UST), which serves as a potable water reservoir for the base, is currently located east of the site. Upgradient buildings were historically used as machine, vehicle, and locomotive maintenance shops; electrical shops; and munitions loading facilities.

FIGURE 1
Site Location

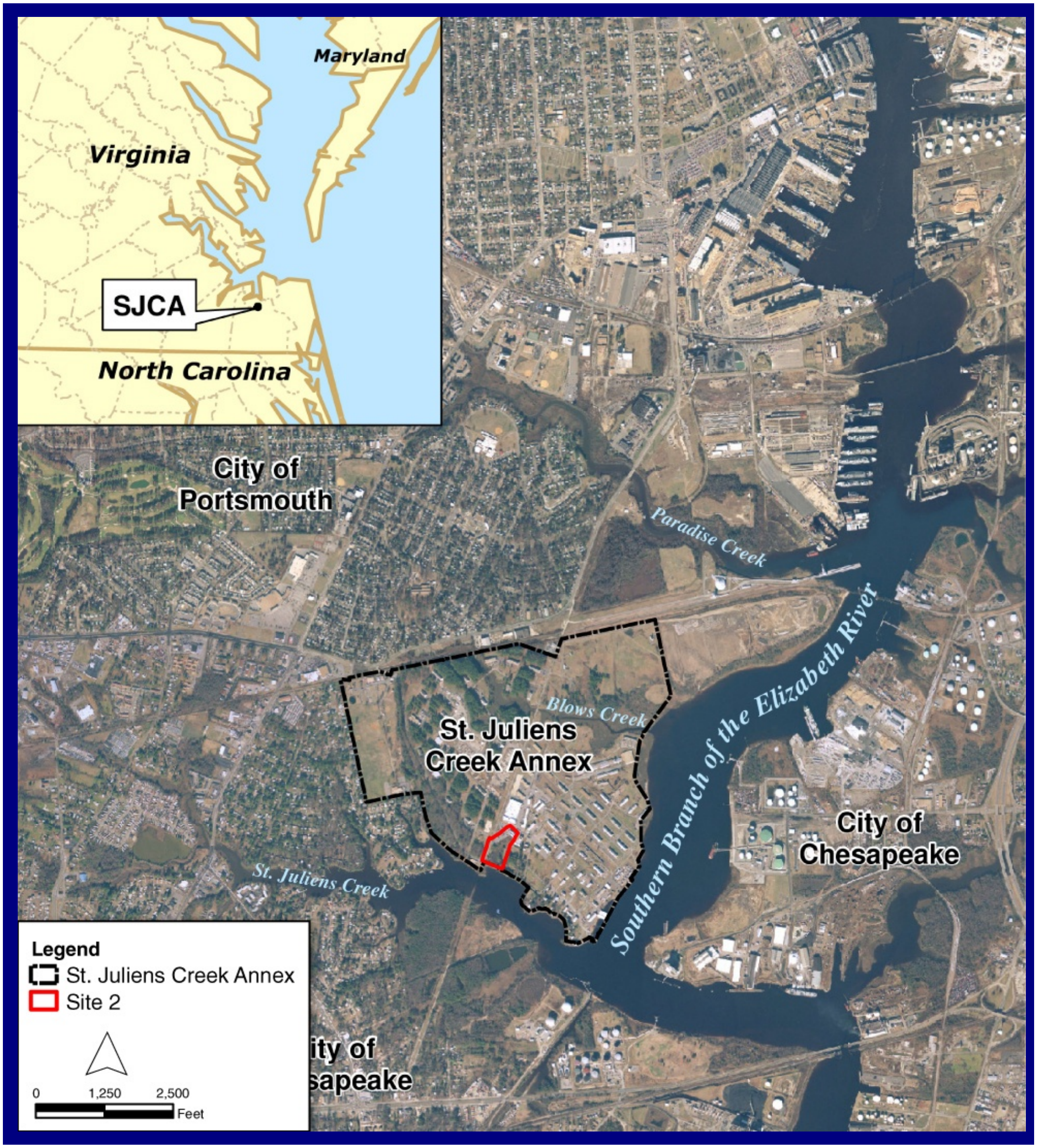


FIGURE 2
Site Map

Site 2 was characterized under numerous investigations and studies between 1981 and 2009. **Table 1** provides a chronological list and brief summary of previous investigations conducted at Site 2 and Site 17. The respective investigations are a part of the Administrative Record and can be referenced for further details for specific sampling strategies, media investigations, and when and where the sampling was performed.

TABLE 1
Previous Studies and Investigations Summary

Previous Study / Investigation* (Document and Document date)	Dates of Study/ Investi-gation	Investigation Activities
Initial Assessment Study (IAS) (Naval Engineering Environmental Support Activity, 1981)	1981	The IAS included collection and evaluation of archival records and an inspection of the site. The IAS noted the presence of broken glass, cinder, ash, deteriorated metal, and other residues of garbage burning operations within and surrounding the Site 2 boundary. Additionally, a drum of Pen-Strip-G (a chemical cleaner, penetone), reportedly used for vehicle and equipment cleaning, was identified in the wash rack at Building 249, just north of Site 2 (**Figure 2**). The IAS stated that lead-acid battery maintenance operations were conducted at Building 279 (Former Site 17); ordnance wastewaters and rinse waters were discharged into the wetland near Buildings 257 and 130, and wastewater effluent from operations in the adjacent industrial area (Site 21) was released into storm drains that emptied into the wetland (**Figure 2**).
Preliminary Assessment (PA) (NUS Corporation, 1983)	1983	The PA was conducted to identify sites that required further investigation based on potential threat to human health or the environment. Ambient air at Site 2 (termed Dump B and the Dump B Incinerator) was monitored for VOCs and radiation. No readings above background were encountered and no significant signs of contamination were observed.
Resource Conservation and Recovery Act (RCRA) Facility Assessment (RFA) (A.T. Kearney, 1989)	1989	A preliminary review of all available relevant documents and a visual site inspection were conducted to identify solid waste management units (SWMUs) and areas of concern (AOCs). The RFA recommended further action for three SWMUs and one AOC identified within the current Site 2 boundary: SWMU 2 (Dump B), SWMU 3 (Dump B Incinerator), SWMU 4 (Dump B Blast Grit), and AOC A (Satellite Storage at Building 279).
Relative Risk Ranking System (RRR) Data Collection Report (CH2M HILL, 1996)	1996	Groundwater and soil samples were collected to identify and prioritize sites requiring possible further investigation. SVOCs including polyaromatic hydrocarbons (PAHs), pesticides, PCBs, and inorganics were detected in soil; one VOC, explosives, and inorganics were detected in groundwater.
Site 17 Site Investigation (SI) (CH2M HILL, 2001)	2001	Soil samples were collected within the current Site 2 boundary at Site 17, former AOC A (Satellite Storage at Building 279) to verify the presence or absence of contamination and evaluate potential human health or ecological risks. Results indicated concentrations of PAHs, pesticides, PCBs, and inorganics pose potential risks to human health and the environment.
Site 2 Remedial Investigation (RI) (CH2M HILL, 2004)	1997 - 2001	Soil, groundwater, sediment, and surface water samples were collected to define the nature and extent of contamination and to evaluate potential human health and ecological risks. Results indicated there are concentrations of pesticides, PAHs, and inorganics in soil and sediment that pose potential risks to human health and the environment. VOCs were detected in surface water but the concentrations did not indicate an unacceptable risk. No risk from exposure to groundwater was identified; however, the source of the VOCs to surface water was unknown and a potential unidentified source within groundwater was suspected. The RI recommended additional investigation of all media to identify additional contamination sources and to delineate the nature and extent of contamination.

TABLE 1
Previous Studies and Investigations Summary

Previous Study / Investigation* (Document and Document date)	Dates of Study/ Investi-gation	Investigation Activities
Expanded Remedial Investigation (ERI) (CH2M HILL, 2008, Revised 2010)	2003 - 2007	Waste delineation was conducted using direct-push methods and shallow and deep groundwater, soil, inlet sediment, inlet sediment pore water, and surface water samples were collected to define the extent of waste, identify and delineate the source of VOCs to surface water, determine if VOCs have contaminated deep groundwater, characterize the toxicity of inlet sediment, evaluate the magnitude of VOCs in inlet sediment pore water, and evaluate the potential impacts from the Site 2 inlet to St. Juliens Creek. Potential risks to human health associated with exposure to waste, soil, shallow groundwater, and sediment as well as potential ecological risks associated with exposure to soil, sediment (including sediment pore water), and surface water were identified. COCs were identified for these media (Tables 2 - 6). Based on the elevated VOC concentrations detected in the shallow groundwater, it was assumed that **vapor intrusion**[4] from the shallow groundwater into indoor air would pose unacceptable risks to future residents and industrial workers. An FS was recommended to evaluate potential remedial alternatives to mitigate unacceptable human health and ecological risks from **COCs identified in shallow groundwater, soil, sediment, and surface water**[5]. No potential human health risks were identified from exposure to deep groundwater and **no further evaluation of deep groundwater**[6] was recommended.
Feasibility Study (FS) (CH2M HILL, 2009, Revised 2010)	2008 - 2009	Remedial action alternatives were developed and evaluated to mitigate unacceptable risk from exposure to shallow groundwater, soil, sediment, and surface water. Eight remedial alternatives were selected for detailed comparative analysis.

Notes:

*The documents listed are available in the Administrative Record and provide detailed information used to support remedy selection at Site 2.

2.3 Community Participation

The Navy and USEPA provide information regarding the cleanup of SJCA to the public through the community relations program, which includes a Restoration Advisory Board (RAB) that was formed in 1999, public meetings, the Administrative Record file for Site 2, the information repository, and announcements published in the local newspapers. During the course of investigations at Site 2, the RAB has been apprised of all environmental activities related to the site.

In accordance with Sections 113 and 117(a) of CERCLA, the Navy provided a public comment period between May 18, 2010 and July 2, 2010, for the Site 2 Proposed Plan. A public meeting to present the Proposed Plan was held on May 18, 2010 at the Major Hillard Public Library. Public notice of the meeting and availability of documents was placed in *The Virginian-Pilot* newspaper on May 14, 2010.

The Proposed Plan was available during the public comment period at the Major Hillard Public Library. The final Proposed Plan and previous investigation reports for Site 2 are available to the public in the Administrative Record. Appointments to review the Administrative Record can be made by contacting:

Public Affairs Office, NNSY
NNSY, Building 1500-2
Portsmouth, Virginia 23709-5000
Phone: (757) 396-9550

Or a copy of the Administrative Record is available online at:
https://portal.navfac.navy.mil/portal/page/portal/navfac/navfac_ww_pp/navfac_hq_pp/navfac_env_pp/env_restoration_installations/lant/midlant/sjca

2.4 Scope and Role of Response Action

Site 2 is one of several ERP sites at SJCA that are part of the comprehensive environmental investigation and cleanup currently being performed at SJCA under the CERCLA program. The status of all the ERP sites at SJCA can be found in the current version of the SMP, which is located in the Administrative Record. This ROD documents the final remedy for Site 2 and does not include the other sites at the facility. An Interim ROD for Site 21, which is immediately upgradient of Site 2, was finalized in May 2010. A chlorinated VOC shallow groundwater plume posing potential risk to human health through potable use of groundwater is present at Site 21 and has been identified as a source of chlorinated VOCs to Site 2 through stormwater sewer system discharge. The Site 21 chlorinated shallow groundwater plume does not extend to the Site 2 border; therefore, the chlorinated VOC plumes at Sites 2 and 21 are not co-mingled. The interim remedy for Site 21 is in situ chemical reduction and ERD, and will be initiated prior to the Site 2 remedy.

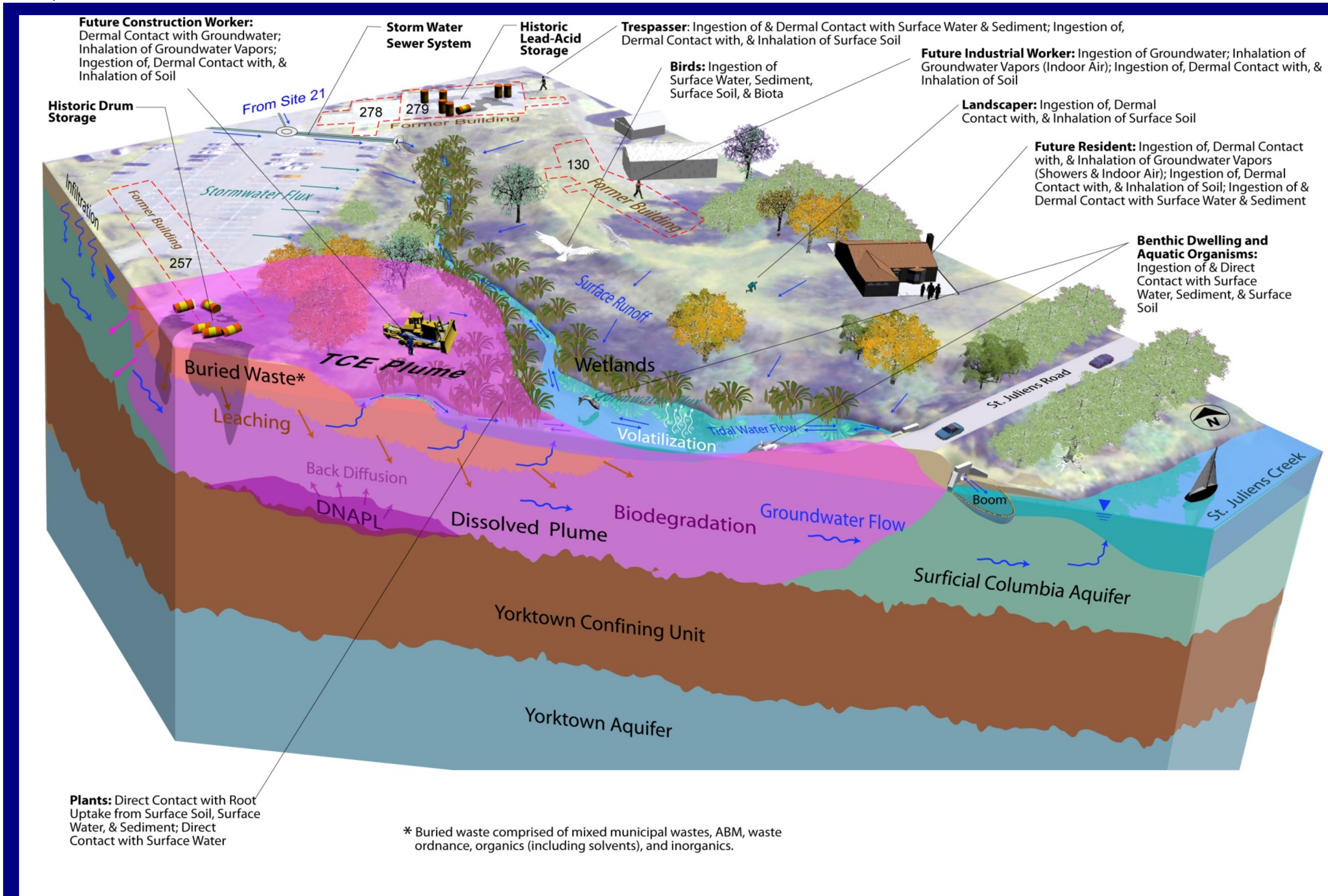
2.5 Site Characteristics

A conceptual site model (CSM) (**Figure 3**) has been developed to summarize the site conditions, contaminant distribution, transport pathways, potential receptors and exposure pathways, and land use data collected during site investigations. Site 2 consists of a water body (inlet) in the center of the site surrounded by wetland, brush, trees, and grass. The inlet is tidally-influenced, directly connected to St. Juliens Creek through a culvert that drains surface water from adjoining land into the creek during low tide and receives water from St. Juliens Creek during high tide. With the exception of the inlet, the topography of the site is relatively flat. Grassed drainage ditches originate northwest of Site 2 and discharge stormwater runoff to the inlet. An underground stormwater sewer system originates approximately 1,000 feet northeast of Site 2, within Site 21, and discharges to the north end of the inlet. Most of the stormwater sewer system is below the water table within Site 21, where a chlorinated VOC plume is present in shallow groundwater. Groundwater underlying Site 21 infiltrates into the stormwater sewer system through cracks and joints and is transported to Site 2.

Shallow groundwater at Site 2 is encountered from 3 to 7 ft below ground surface (bgs) and flows from the east, west, and north towards the tidal inlet and then to the south towards St. Juliens Creek, mimicking the topography. Shallow groundwater temporally discharges to the tidal inlet at a rate of 0.010 cubic feet per second or 6,300 gallons per day during low tide. During high tide conditions, tidal inflow from St. Juliens Creek may potentially recharge shallow groundwater at Site 2.

The subsurface geology at Site 2 consists of the fine to coarse silty and clayey sands of the Columbia aquifer, underlain by the high plasticity clay of the Yorktown confining unit. The Columbia aquifer extends to a depth of between 15 and 25 feet bgs. Shallow groundwater flow velocity has been calculated to be approximately 55 feet per year. The Yorktown confining unit, consisting of relatively impermeable silt and clay layers, is approximately 30 ft thick at Site 2 and lies above the fine to coarse shelly sands of the Yorktown aquifer.

FIGURE 3
Conceptual Site Model



2.5.1 Nature and Extent of Contamination

Several sources of contamination have been identified at Site 2, including buried waste, waste-incinerator residue, former chemical and fuel storage, lead-acid maintenance activities, degreasing activities, runoff from an upgradient industrial area, and discharge of upgradient Site 21 groundwater from the stormwater sewer system. Numerous investigations have been conducted to characterize potential impacts. Sample locations are depicted on **Figure 4** and the nature and extent of contamination in Site 2 media is discussed below. Maximum concentrations of constituents identified as site COCs detected in each medium are presented on **Table 2**.

TABLE 2
Maximum Detected Concentrations of COCs

COCs	Maximum Detected Concentrations						
	Surface Soil	Subsurface Soil	Sediment		Shallow Groundwater	Surface Water	Sediment Pore Water
			Inlet	Creek			
Volatile Organic Compounds	µg/kg				µg/L		
1,1,2-Trichloroethane	--	--	--	--	1,400 J	--	--
1,1-Dichloroethene	--	--	34.0 J	--	1,500 L	0.70 J	730 J
Chloroform	--	--	3.00 J	--	130 L	12	--
Methylene chloride	2.8 J	--	--	--	26 L	--	--
Tetrachloroethene	--	--	--	--	39 L	--	--
Trichloroethene	--	14,000,000	9.8 J	10 J	530,000	140	5,100
Vinyl chloride	--	28,000	9,800 J	--	32,000	21.9	4,400
cis-1,2-Dichloroethene	--	320,000	2,300	NS	130,000	84	87,000
trans-1,2-Dichloroethene	--	870 J	38.0 J	NS	1,200 J	0.50 J	710 J
Semivolatile Organic Compounds	µg/kg				µg/L		
2-Methylnaphthalene	310 J	--	250 J	--	75	--	NS
Acenaphthene	370	--	490 J	--	85	--	NS
Acenaphthylene	820 J	150 J	--	220 J	--	--	NS
Anthracene	790	62 J	1,200	410 J	11	--	NS
Benzo(a)anthracene	2,300	410 J	3,500	1,100	--	--	NS
Benzo(a)pyrene	2,100	290 J	3,900	1,600	--	--	NS
Benzo(b)fluoranthene	2,000	1,100 J	3,800	2,800	--	--	NS
Benzo(g,h,i)perylene	1,600	580 J	2,700 J	760	--	--	NS
Benzo(k)fluoranthene	1,600	290 J	1,000	970	--	--	NS
Chrysene	2,700	470 J	3,300	1,800	--	--	NS
Dibenz(a,h)anthracene	440	130 J	500 J	290 J	--	--	NS
Diethylphthalate	--	--	250 L	100 L	--	--	NS
Fluoranthene	5,000	640	4,300	2,300	5.9 J	--	NS
Fluorene	380 L	--	550 J	--	62	--	NS
Indeno(1,2,3-cd)pyrene	1,500	440 J	1,800 J	750	--	--	NS
Naphthalene	250	--	280 J	--	1300	--	NS
Phenanthrene	4,400	410	5,300	190 J	56	--	NS
Pyrene	7,200	760 J	9,400 J	1,800	4.1 J	--	NS

TABLE 2
Maximum Detected Concentrations of COCs

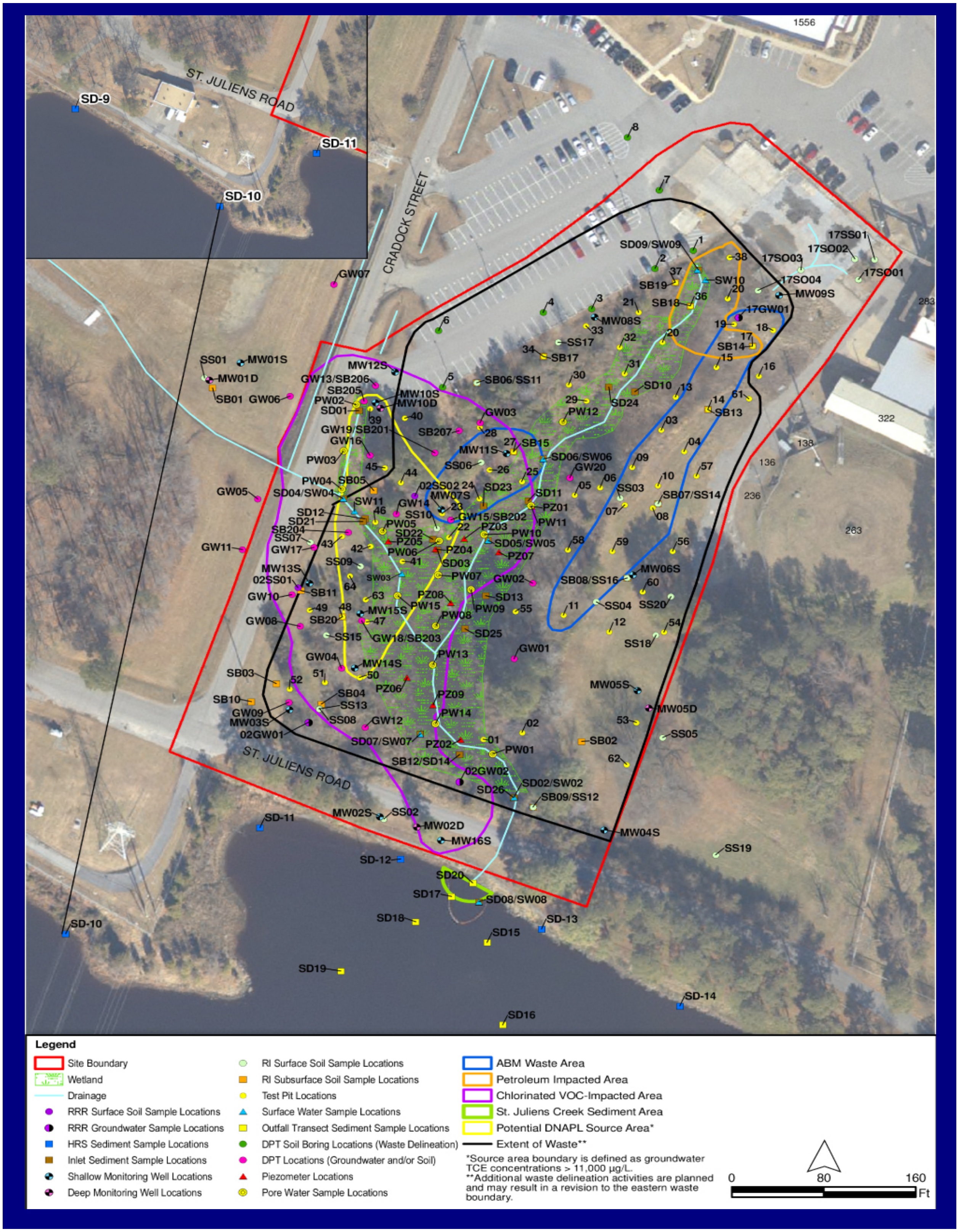
COCs	Maximum Detected Concentrations						
	Surface Soil	Subsurface Soil	Sediment		Shallow Groundwater	Surface Water	Sediment Pore Water
			Inlet	Creek			
Pesticides/Polychlorinated Biphenyls	µg/kg				µg/L		
4,4'-DDD	4200	2,100 J	980 J	93	--	0.20	NS
4,4'-DDE	7200 J	4,600 J	130 J	200 J	0.0051 J	--	NS
4,4'-DDT	12000 J	290,000 J	3,200 J	11 J	--	--	NS
Aroclor-1254	--	--	110 J	--	--	--	NS
Aroclor-1260	2700 C	21 J	69 J	--	--	--	NS
Alpha-Chlordane	50 J	--	79 J	6.7 J	--	--	NS
Gamma-Chlordane	29 J	38 J	96 J	19 J	--	--	NS
Dieldrin	3.8 J	0.84 J	36	--	--	--	NS
Heptachlor epoxide	--	--	--	--	1.11	--	NS
Inorganics*	mg/kg				µg/L		
Aluminum	18,600	21,700	33,000	19,600	35,000 J	9,390	NS
Antimony	7 J	77.7	27.6 L	--	--	3.30 J	NS
Barium	469	459	131	68.5 J	726	70.7 J	NS
Cadmium	9.3 K	11.2	12.3	4.5	--	2.50 J	NS
Chromium	246	335	2,630	443	56.3 J	166	NS
Copper	5,030 J	3,100	2,620	461 K	35.9	203	NS
Cyanide	0.85 J	0.36	0.584	3	13.2 L	18.9 L	NS
Iron	106,000	210,000	38,200	33,500	337,000 J	18,800	NS
Lead	3,130 K	8,850	545	219	36.7 L	77.9 L	NS
Manganese	688	1,260	242	223	2,550	2,490	NS
Nickel	246	243	45.8	20	29.8 J	81.4	NS
Vanadium	1,410	73	147	37.3	79.6	32.8 J	NS
Zinc	7,560	9,070	1,470 J	609 K	638	1,310	NS

NS – Not sampled
-- Not detected
mg/kg – milligram per kilogram
µg/L – microgram per liter
µg/kg – microgram per kilogram
C – presence confirmed by gas chromatography/mass spectrometry
J – reported value is estimated
K – reported value may be biased high
L – reported value may be biased low
*Total inorganic concentrations in shallow groundwater were used when evaluating risk; therefore maximum total inorganic concentrations detected are reported.

Waste and Soil

The extent of waste at Site 2 was conservatively estimated to be approximately 3.9 acres and consists mainly of ABM, burnt/stained soil, concrete, asphalt, brick, metal, glass, wood, solvents, munitions and explosives of concern (MEC)-related scrap, and potentially MEC; however, the area may be refined through additional waste delineation activities (Figure 4). An area of petroleum-impacted soils was identified southwest of former Buildings 278/279. The thickness of waste varies from surficial to 11 ft bgs and is present within the unsaturated zone and the saturated zone.

FIGURE 4
Nature and Extent of Contamination



VOCs, SVOCs, pesticides, one PCB (Aroclor-1260), and inorganics were detected in surface and subsurface soil above background values (where available). VOCs were detected sporadically in surface soil and subsurface soil collected above the water table at generally low concentrations (< 210 micrograms per kilogram [µg/kg]). Chlorinated VOCs were detected in subsurface soil collected at or below the water table with a maximum total chlorinated VOC concentration of greater than 14,000,000 µg/kg (sample location SB205). The highest concentrations of chlorinated VOCs were detected at sample locations SB201 through SB207 collected adjacent to and south (downgradient) of former Building 257. SVOCs, mainly PAHs, were detected in surface and subsurface soil across the site. The highest concentrations in surface soil were detected east of the tidal inlet (sample location SS03) and adjacent to former Buildings 278/279 (sample locations 17SO03 and 17SO04). The highest concentrations in subsurface soil were detected in the southwestern portion of the site near the intersection of Cradock Street and St. Juliens Road (sample location SB03). In surface soil, pesticides were found at elevated concentrations across the site; however, they were detected with no definitive pattern, suggesting they may have been applied historically across the site. In subsurface soil, the pesticide 4,4′-dichlorodiphenyltrichloroethane (4,4-DDT) was significantly elevated at one location (sample location SB08) near the southwest corner of former Building 130. The PCB Aroclor-1260 was detected in surface soil across the site with elevated concentrations detected in the northern portion of the site (sample location 17SO03), within a drainage ditch passing under the foundation of former Buildings 278/279. Aroclor-1260 was also detected in one subsurface soil sample (sample location SB03) collected in the southwest corner of the site. Nineteen inorganics (including antimony, cadmium, copper, cyanide, lead, and zinc) were detected in surface and subsurface soil above background concentrations across the site with the highest concentrations generally limited to the ABM waste areas.

Shallow Groundwater

VOCs, SVOCs, pesticides, and inorganics were detected in shallow groundwater (Columbia aquifer) above background concentrations and/or maximum contaminant levels (MCLs) (where available). Three explosives, which have no background concentration or MCL for comparison, were detected in shallow groundwater at isolated locations (MW04S and MW10S). A chlorinated VOC plume, consisting primarily of TCE and its breakdown products, was identified in shallow groundwater and extends from a suspected release area near former Building 257 to near St. Juliens Creek, covering an area of approximately 1.6 acres. Vertically, the chlorinated VOC plume extends to the bottom of the Columbia aquifer and the highest concentrations are generally located at the base of the aquifer/top of the Yorktown confining unit. Although **DNAPL**[7] was not physically observed during site investigations, concentrations of TCE were detected greater than 1 percent of its pure phase solubility (11,000 µg/L), one "rule of thumb" indicator that DNAPL may be present. SVOCs and pesticides were detected above background concentrations or MCLs at isolated locations in shallow groundwater (MW07S, MW08S, and MW10S) within the limits of waste and chlorinated VOC plume. Elevated concentrations of inorganics were detected in shallow groundwater across the site.

Deep Groundwater

Chlorinated VOCs (TCE and vinyl chloride) were detected at concentrations (maximum concentrations are 2,200 µg/L and 6.5 µg/L, respectively) exceeding the MCL in deep groundwater (Yorktown aquifer) collected from one monitoring well (MW10D) immediately following well installation. Additional activities, including subsequent rounds of groundwater sampling and aquifer pump testing, were conducted to further investigate the presence of chlorinated VOCs in deep groundwater and the potential for transport from the shallow aquifer to deep groundwater. During these subsequent sampling events, chlorinated VOC concentrations significantly decreased to below the drinking water standards or were not detected. In addition, pump test results indicated the Yorktown confining unit is an effective barrier to vertical contaminant migration. Therefore, it is likely the chlorinated VOCs were carried down during well installation and naturally degraded. Four SVOCs and two pesticides were detected in deep groundwater; however, concentrations did not exceed the MCLs. Inorganics were detected in deep groundwater; however, concentrations were similar across the site and no exceedances of MCLs were detected.

Sediment

VOCs were detected in sediment and sediment pore water collected within the Site 2 inlet. The highest concentrations of VOCs in sediment and sediment pore water were detected in the western drainage ditch (sample locations SD21 and PW03 through PW05) just south of the area where the highest concentrations of VOCs were detected in shallow groundwater. SVOCs, pesticides, and inorganics were detected in sediment above background concentrations. The highest SVOC concentrations were detected in sediment collected near the center of the tidal inlet (sample locations SD05 and SD25). Pesticides in sediment were at the highest concentrations to the west and southwest of former Building 130 (sample locations SD02, SD05, SD06, SD25, and SD26) and within the western drainage ditch (sample location SD03). Elevated inorganics were detected in sediment across the tidal inlet, with the highest concentrations occurring within the central portion of the Site 2 inlet (sample locations SD03, SD05, SD06, and SD25). Two PCBs were detected at isolated locations upstream of the inlet outfall (sample location SD02) and in the central portion of the inlet (sample location SD03). Dioxins and furans, ranging in total concentration from 0.75 J to 6.4 J µg/kg, were detected in each sample collected within the Site 2 inlet.

Two VOCs (carbon disulfide and TCE) were detected in one sediment sample (sample location SD08) collected within St. Juliens Creek. SVOCs, pesticides, and inorganics were detected in St. Juliens Creek above background concentrations near the outfall of the culvert that connects Site 2 to St. Juliens Creek. Although Site 2 is potentially contributing, or has historically contributed, chemicals to St. Juliens Creek via tidal influx through the low-flow culvert, notable site-related effects are only indicated in a localized area directly at the outfall location. Because multi-depth sediment samples were not collected, additional investigation will be performed during the Remedial Design or Remedial Action to define the vertical extent of the sediment exceeding the cleanup levels.

Surface Water

Several VOCs, including chlorinated VOCs, were detected in inlet surface water; however, concentrations were below Virginia Water Quality Standards (VWQS) for human health and aquatic life. The highest concentrations were detected in surface water collected in the upstream portion of the Site 2 inlet adjacent to the storm sewer outfall. One SVOC [bis(2-ethylhexyl)phthalate], one pesticide (4,4′-DDD), and several inorganics were detected in inlet surface water above VWQS. One explosive, for which no water quality standard is established, was detected at three isolated locations (sample locations SW04, SW05, and SW07) within the inlet. Bis(2-ethylhexyl)phthalate was detected above the VWQS in the downgradient portion of the inlet at one sample location (sample location SW07). 4,4′-DDD was detected in surface water above the VWQS in several samples collected across the Site 2 inlet. Although inorganics were detected in surface water across the inlet, the highest concentrations were detected in the most downstream sample locations (sample location SW02).

2.5.2 Fate and Transport

As depicted on the CSM, the current primary contaminant migration pathways for COCs at Site 2 consist of:

- Back diffusion or dissolution of DNAPL sorbed or trapped in the residual pore space at the top of the Yorktown confining unit into shallow groundwater
- Natural biodegradation of VOCs in groundwater
- Leaching of inorganics from buried wastes into groundwater
- Dissolved VOC migration downgradient with groundwater flow (advection), additionally resulting in migration through residual pore space to surface water
- Surface water runoff erosion of inorganics, SVOCs, pesticides, and PCBs in surface soil and deposition as sediment
- Surface water flow/tidal flux transport of SVOCs and inorganics in sediment from Site 2 to St. Juliens Creek and from St. Juliens Creek to Site 2.
- Leaching of inorganics from surface soil and inlet sediment into surface water

2.6 Current and Potential Future Land and Water Uses

Site 2 currently consists of a stormwater drainage inlet surrounded by a wetland, open field of mowed grass, and asphalt parking lot. Construction and excavation activities at the site are prohibited and controlled through site signs and notation in the Navy geographic information system data base maintained by Naval Facilities Engineering Command Mid-Atlantic. Current land use is expected to continue at Site 2, and there is no other planned future land use. However, future land use such as industrial, recreational, and operational activities may be implemented provided the activities are consistent with protection of human health and the environment. Groundwater is not currently used as a potable water supply at or in the vicinity of SJCA because of its general poor quality (naturally-present iron and manganese above secondary drinking water standards) and low yield (generally less than 3 to 5 gallons per minute). Potable water is supplied to the base by the City of Portsmouth. However, the Navy acknowledges the Commonwealth of Virginia's and USEPA's expectation to return usable groundwaters to their **beneficial uses**[8] wherever practicable.

Land use within St. Juliens Creek, downgradient of Site 2, includes industrial and recreational boating and recreational fishing and crabbing. Fish and blue crab consumption advisories are in place for the Southern Branch of the Elizabeth River and St. Juliens Creek. Current land use is expected to continue and there is no other planned future land use.

2.7 Summary of Site Risks

Potential human health and ecological risks at Site 2 were evaluated and documented in the Expanded Remedial Investigation (ERI) report. The following subsections and Tables 3, 4, and 5 briefly summarize the findings of the risk assessments.

2.7.1 Human Health Risk Summary

A Human Health Risk Assessment (HHRA) was conducted to evaluate the **potential human health risks**[9] from **current receptor**[10] and **hypothetical future receptor**[11] exposure to soil, groundwater, sediment, and surface water at Site 2 using reasonable maximum exposure (RME) and central tendency exposure (CTE) point concentrations. The RME assumes the highest level (maximum concentrations) of human exposure that could reasonably be expected to occur, whereas the CTE scenario reflects human exposure to average concentrations across the site.

The potential for non-cancer hazards, the hazard quotient (HQ), is evaluated by determining the ratio of exposure to toxicity. An HQ greater than 1 indicates that a receptor's exposure to a particular constituent may present an unacceptable non-cancer hazard. In addition, a hazard index (HI) is generated by adding the HQs for all constituents that affect the same target organ or cause adverse health effects within a medium or across all media to which an individual may reasonably be exposed. HI values greater than 1 indicate the potential for unacceptable non-cancer hazards due to site exposure.

For known or suspected carcinogens, acceptable exposure levels generally are concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} (a 1 in 10,000 chance of developing cancer) and 10^{-6} (a 1 in 1,000,000 chance of developing cancer), using information on the relationship between dose and response. The 10^{-6} risk level is used as the point of departure for determining performance standards for alternatives when Applicable or Relevant and Appropriate Requirements (ARARs) are not available or are not sufficiently protective because of the presence of multiple contaminants at a site or multiple pathways of exposure.

Current **exposure scenarios**[12] evaluated consist of adult/adolescent trespassers and adult landscaper exposure to soil, sediment, and surface water. Hypothetical future exposure scenarios were evaluated for the construction worker and industrial worker exposure to soil and shallow groundwater; adult/adolescent trespasser and adult/child resident exposure to soil, shallow and deep groundwater, sediment, and surface water. The exposure pathways evaluated were dermal contact, inhalation, and ingestion of surface soil, subsurface soil, shallow and deep groundwater, sediment, and surface water. A summary of non-cancer hazards and cancer risks exceeding USEPA threshold levels is provided in **Table 3**.

Waste and Soil

Current and potential future unacceptable risks are associated with exposure to waste remaining in place. The results of the HHRA indicated there are no unacceptable RME cancer risks associated with exposure to site soil for current and future receptors and no RME non-cancer hazards above USEPA's acceptable levels for adult trespassers and landscapers. Potential unacceptable RME non-cancer hazards associated with current/future adolescent trespasser, future child resident, and future industrial worker exposure to antimony, iron, and vanadium in soil were identified. There are no unacceptable CTE non-cancer hazards above USEPA's acceptable levels. The unacceptable risks and hazards are summarized in Table 3.

Exposure to lead is regulated by the USEPA based on the concentration of lead in blood. Blood lead concentrations were estimated through the use of a model and indicated a potential risk associated with exposure to lead in soil. Therefore, in addition to waste remaining in place and antimony, iron, and vanadium in soil, the HHRA identified potential risks associated with exposure to lead in soil.

Shallow Groundwater

Risk estimates were calculated for future residents and industrial workers based on potable use of groundwater and for future construction worker exposure to groundwater in an open excavation. These exposure scenarios would result in cancer risks and non-cancer hazards primarily associated with chlorinated VOCs, naphthalene, and heptachlor epoxide above USEPA's acceptable levels. The unacceptable risks and hazards are summarized on Table 3.

Arsenic, iron, manganese, and 2,6-dinitrotoluene were among the contaminants identified as potentially causing unacceptable human health risks. Concentrations of these contaminants in groundwater resulted in cancer risks or non-cancer hazards above USEPA's acceptable levels based on RME calculations. However, the potential risks or hazards are considered acceptable based on the following:

- Arsenic
  - There is no risk based on CTE.
  - During the most recent round of sampling, arsenic was detected below the federal MCL and background in all but one monitoring well (SJS02-MW09S).
  - There is no discernable arsenic plume. Elevated arsenic in the area of SJS02-MW09S, adjacent to the petroleum impacted area, has likely resulted from reducing conditions created during degradation of petroleum compounds, as supported by field observations and measurements collected in the vicinity of this monitoring point.

- Iron
  - Concentrations are statistically similar to background levels.

- Manganese
  - Concentrations are below background levels.

- 2,6-dinitrotoluene
  - There is no risk based on CTE.
  - The explosive was only detected in one well, which, based on its high mobility, indicates that it is most likely naturally degrading and not migrating across the site.

Because the Commonwealth of Virginia considers all groundwater a potential drinking water source, two VOCs (chloroform and methylene chloride) and two inorganics (lead and thallium) detected in shallow groundwater that did not pose unacceptable cancer risks or non-cancer hazards, but were detected above their respective MCLs, were retained as chemicals of potential concern. Although detected above their MCLs, lead and thallium were not retained as COCs based on the following:

- Lead
  - No risk based on RME.
  - Concentrations were detected above the MCL at only two monitoring wells and the average lead concentration in groundwater is below the MCL.
  - Concentrations were detected above background at only two monitoring wells.

- Thallium
  - No risk based on RME.
  - Concentrations were detected above the MCL at only two monitoring wells and were detected below the MCL during subsequent sampling events.
  - Concentrations were detected above background at only one monitoring well.

The shallow groundwater COCs are summarized in **Table 6**.

Deep Groundwater

Risk estimates were calculated during the Remedial Investigation (RI) for current/future adult and child resident exposure based on potable use of deep groundwater (Yorktown aquifer). The results of the HHRA indicated no unacceptable cancer risks based on RME exposure. Potential unacceptable RME non-cancer hazards associated with current and future adult and child resident exposure were identified due to ingestion of deep groundwater. Based on RME calculations, no target organ effects were above USEPA's acceptable level of 1. No unacceptable haards were identified based on CTE calculations. The RI concluded no unacceptable risks or hazards are associated with exposure to deep groundwater at Site 2.

TABLE 3
Summary of Unacceptable Human Health Risks

Receptor	Media*	Exposure Route	COPC	RME EPC**	RME		CTE		Cancer Toxicity Factor (CSF) mg/kg-day-1	Non-Cancer Toxicity Factor (RfD) mg/kg-day
					Cancer Risk	Non-Cancer Hazard	Cancer Risk	Non-Cancer Hazard		
Current/ Future Trespasser - Adolescent	Soil	Dermal	Vanadium	690	NA	**1.2**	NA	0.0025	NA	0.000026
Future Resident Adult	Shallow groundwater	Ingestion	1,1,2-TCA	170	NA	**1.2**	NA	0.54	NA	0.004
			VC	10,000	NA	**91**	NA	**7.3**	NA	0.003
			cis-1,2-DCE	46,000	NA	**130**	NA	**13**	NA	0.01
			Naphthalene	1,200	NA	**1.6**	NA	0.078	NA	0.02
			Heptachlor epoxide	1.0	NA	**2.1**	NA	0.12	NA	0.000013
			Iron	69,000	NA	**2.7**	NA	0.41	NA	0.7
			Manganese	1,100	NA	**1.2**	NA	0.45	NA	0.024
		Dermal	VC	10,000	NA	**4.8**	NA	0.35	NA	0.003
			cis-1,2-DCE	46,000	NA	**11**	NA	**1.1**	NA	0.01
			Naphthalene	1,200	NA	**1.1**	NA	0.049	NA	0.02
		Inhalation***	TCE	74,000	**3.8E-03**	NA	**1.6E-04**	NA	7.0E-03	NA
			VC	10,000	**1.6E-03**	**11**	1.8E-05	0.34	1.5E-02	0.028
			trans-1,2-DCE	720	NA	**1.1**	NA	0.19	NA	0.017
			naphthalene	1,200	**1.0E-03**	**29**	7.4E-06	0.54	1.2E-01	0.0009
	Sediment	Dermal	Chromium	1,500	NA	**1.5**	NA	0.18	NA	0.000075
Future Child Resident	Soil	Ingestion	Antimony	34	NA	**1.1**	NA	0.056	NA	0.0004
			Iron	91,000	NA	**1.7**	NA	0.14	NA	0.7
			Vanadium	450	NA	**1.2**	NA	0.059	NA	0.005
		Dermal	Vanadium	450	NA	**6.2**	NA	0.13	NA	0.000026
	Shallow groundwater	Ingestion	1,1,2-TCA	170	NA	**2.7**	NA	**1.8**	NA	0.004
			1,1-DCE	1,500	NA	**1.9**	NA	0.63	NA	0.05
			VC	10,000	NA	**210**	NA	**24**	NA	0.003
			cis-1,2-DCE	46,000	NA	**300**	NA	**45**	NA	0.01
			trans-1,2-DCE	720	NA	**2.3**	NA	**1.5**	NA	0.02
			Naphthalene	1,200	NA	**3.8**	NA	0.26	NA	0.02
			Heptachlor epoxide	1.0	NA	**5.0**	NA	0.39	NA	0.000013
			2,6-dinitrotoluene	20	NA	**1.3**	NA	0.12	NA	0.001
			Arsenic	11	NA	**2.3**	NA	0.84	NA	0.0003
			Iron	69,000	NA	**6.3**	NA	**1.4**	NA	0.7

TABLE 3
Summary of Unacceptable Human Health Risks

Receptor	Media*	Exposure Route	COPC	RME EPC**	RME Cancer Risk	RME Non-Cancer Hazard	CTE Cancer Risk	CTE Non-Cancer Hazard	Cancer Toxicity Factor (CSF) mg/kg-day-1	Non-Cancer Toxicity Factor (RfD) mg/kg-day
			Manganese	1,100	NA	**2.9**	NA	**1.5**	NA	0.024
		Dermal	VC	10,000	NA	**12**	NA	0.7	NA	0.003
			cis-1,2-DCE	46,000	NA	**26**	NA	**2.2**	NA	0.01
			Naphthalene	1,200	NA	**2.4**	NA	0.096	NA	0.02
			Heptachlor epoxide	1.0	NA	**2.3**	NA	0.1	NA	0.000013
	Sediment	Dermal	Chromium	1,500	NA	**7.7**	NA	**3.0**	NA	0.000075
Future Resident Lifetime	Shallow groundwater	Ingestion	1,1,2-TCA	170	**1.4E-04**	NA	5.1E-05	NA	5.7E-02	NA
			PCE	39	**3.1E-04**	NA	**1.1E-04**	NA	5.4E-01	NA
			TCE	74,000	**1.4E-02**	NA	**3.1E-03**	NA	1.3E-02	NA
			VC	10,000	**1.9E-01**	NA	**1.3E-02**	NA	1.4E+00	NA
			Heptachlor epoxide	1.0	**1.4E-04**	NA	5.8E-06	NA	9.1E+00	NA
			Arsenic	11	**2.4E-04**	NA	4.7E-05	NA	1.5E+00	NA
		Dermal	PCE	39	**1.8E-04**	NA	4.5E-05	NA	5.4E-01	NA
			TCE	74,000	**2.4E-03**	NA	**3.6E-04**	NA	1.3E-02	NA
			VC	10,000	**1.1E-02**	NA	**4.4E-04**	NA	1.4E+00	NA
Future Construction Worker	Shallow groundwater	Dermal	VC	10,000	**1.6E-04**	**5**	1.2E-05	0.4	7.2E-01	0.003
		Inhalation***	Naphthalene	1,200	3.3E-06	**2.2**	8.5E-08	0.055	1.2E-01	0.0009
Future Industrial Worker	Soil	Dermal	Vanadium	450	NA	**1.1**	NA	0.015	NA	0.000026
	Shallow groundwater	Ingestion	TCE	74,000	**3.4E-03**	NA	**6.4E-04**	NA	1.3E-02	NA
			VC	10,000	**2.5E-02**	**33**	**1.3E-03**	**4.9**	7.2E-01	0.003
			cis-1,2-DCE	46,000	NA	**45**	NA	**8.9**	NA	0.01

Notes:
EPC – exposure point concentration
CSF – cancer slope factor
RfD – reference dose
COPCs in italics not identified as COCs based upon risk management considerations presented in Section 2.7.1.
* Current and potential future unacceptable risks are associated with exposure to waste remaining in place.
**The RME EPC for site media were calculated as the 95% UCL of the arithmetic mean. In cases where there were less than five samples in the data set, or the recommended UCL exceeded the maximum detected concentration, the maximum concentration was used as the RME EPC. The arithmetic mean concentration was used as the CTE EPC.
***Inhalation exposure pathway evaluated for adult exposure while showering and volatile emission inhalation during construction activities. There is not current pathway for indoor air. Due to the uncertainties associated with quantifying the risks associated with the inhalation [indoor air vapor] future pathway; risks associated with this pathway were not quantitatively evaluated. Based on the elevated VOC concentrations detected in the shallow groundwater, it is assumed that vapor intrusion from the shallow groundwater into indoor air would pose unacceptable risks to future residents and industrial workers.

Bold, highlighted values indicate a cancer risk outside of USEPA's acceptable range of 1x10-4 to 1x10-6 or a non-cancer hazard greater than 1.

Although VOCs were detected above the MCLs in deep groundwater during the initial phases of the ERI, VOC concentrations detected during the most recent investigation phases are below the MCLs. The more recent ERI activities confirmed that the earlier MCL exceedances were not an indication of deep groundwater contamination, but instead indicated that contaminants were likely carried down from the shallow groundwater during monitoring well installation and had naturally degraded to below MCLs. Therefore, the RI conclusion was considered appropriate and this medium was not evaluated further during the HHRA conducted as part of the ERI.

Sediment

Risk estimates were calculated for current/future trespassers and future resident exposure to sediment. The results of the HHRA indicated there are no unacceptable cancer risks and non-cancer hazards associated with current and future trespasser exposure based on RME calculations. There are no cancer risks to the future lifetime resident from exposure to sediment. Future adult and child resident exposure scenarios result in RME non-cancer hazards above USEPA's acceptable threshold of 1 due to chromium. There is no risk to the future adult resident based on CTE calculations. The unacceptable risks and hazards are summarized on **Table 3**.

Surface Water

RME cancer risks and non-cancer hazards were below or within USEPA's acceptable risk levels; therefore, no unacceptable human health risks are associated with exposure to surface water at Site 2.

Indoor Air Vapor

There is no current exposure pathway associated with indoor air. Due to the uncertainties associated with quantifying the risks associated with the inhalation [indoor air vapor] future pathway; such as uncertainties with future building size, air exchange systems, and foundations; risks associated with this pathway were not quantitatively evaluated in the HHRA. Based on the elevated VOC concentrations detected in the shallow groundwater, it is assumed that vapor intrusion from the shallow groundwater into indoor air would pose unacceptable risks to future residents and industrial workers.

2.7.2 Ecological Risk Summary

An ERA (Steps 1 through 7 of the ERA process) was completed to evaluate **potential risks**[13] to **ecological receptors**[14] through direct exposure to surface soil, sediment (including sediment pore water), and surface water; and exposure via the food web. There is no complete pathway for ecological receptor exposure to groundwater. Potential risks to terrestrial, aquatic, and wildlife receptors were evaluated. Although maximum exposure scenarios were first evaluated (Step 2), the potential for unacceptable risk was subsequently refined using average media concentrations (Step 3). The average concentration estimates provide a representative estimate of exposures and risks to receptor populations rather than individual organisms; populations were the focus of the assessment endpoints evaluated in the ERA. Base-wide soil background as well as site-specific sediment reference samples were also considered. Additionally, bioavailability, or the degree to which a chemical in an environmental medium can be assimilated by an organism, was considered.

Potential unacceptable ecological risks are identified as HQs greater than or equal to 1. HQs are calculated by dividing the estimated exposure concentration by the corresponding media specific screening toxicity value (direct exposure) or by dividing the exposure dose by the corresponding ingestion screening toxicity values (food web exposure). Based on the ERA, potential risks were calculated for terrestrial, aquatic, and wildlife receptors exposed to soil, sediment, and/or surface water at Site 2.

Direct Exposure Assessment

Terrestrial Receptors

Terrestrial plants and soil invertebrates could be exposed to constituents in Site 2 surface soil. Potential risks to terrestrial plants and soil invertebrates were identified due the presence of several PAHs, pesticides, inorganics, and one PCB (Aroclor-1260) in surface soil. The unacceptable risks are summarized on **Table 4**.

Aquatic Receptors

Several pathways were identified by which aquatic life could be exposed to contaminants in the Site 2 inlet. Benthic invertebrates can be exposed to constituents directly associated with sediment particles, or to constituents in groundwater (primarily chlorinated VOCs) as it discharges through sediment into the surface water body (sediment pore water). Potential risks to benthic invertebrates from direct exposure to sediment in the Site 2 inlet were identified due to the presence of PAHs, pesticides, PCBs, and inorganics in inlet sediment. Additionally, sediment bioassay results indicate the potential for adverse effects to benthic invertebrates, likely resulting from PAHs and bioavailable inorganics.

Limited potential for chlorinated VOCs to adversely affect benthic invertebrates was identified. Chlorinated VOCs were detected in sediment pore water along the western branch of the inlet; however, the highest concentrations were detected in the portion of the branch serving as a drainage ditch that only periodically contains water, making it a poor habitat for benthic invertebrates. Potential risks to benthic invertebrates in St. Juliens Creek were identified at a localized area at the outfall of the culvert from Site 2 due to the presence of PAHs and inorganics.

Water-column-dwelling aquatic life could be exposed to constituents in surface water from surface runoff and following discharge of groundwater. Limited potential risks to water-column-dwelling aquatic life were identified due to inorganics and VOCs in Site 2 surface water. The unacceptable risks are summarized on **Table 4**.

Carbon disulfide, arsenic, mercury, and vanadium were among the contaminants identified as potentially causing unacceptable risks to ecological receptors. Concentrations of these contaminants in sediment and/or surface water resulted in HQs greater than 1 based upon direct exposure evaluations; however, the potential risks are considered acceptable based on the following:

- Carbon Disulfide
  - 40 to 80 percent of carbon disulfide released to the environment is a result of natural or biological activity. Production of carbon disulfide from soil and plants occurs naturally from the metabolism of soil bacteria and plants during the growing season. Soil, marshes, and coastal regions tend to be some of the most biologically active habitats. Carbon disulfide released is rapidly metabolized by organisms and, therefore, does not build up in organism tissues or get carried or increase through the food chain.
- Arsenic
  - The mean HQ for the site (1.19) was only slightly above the acceptable HQ value of 1
  - Concentrations are below background levels
- Mercury
  - Concentrations are below background levels and consistent with levels detected in **urbanized soil and sediment**[15]
- Vanadium
  - The mean HQ (1.01) is approximately equal to the target HQ of 1, and, therefore, does not pose risk

TABLE 4
Summary of Unacceptable Ecological Risks – Lower Trophic Level Receptors

Receptor	Media	COPC	EPC[1]	Screening Toxicity Value[2]	HQ	Assessment Endpoint
Terrestrial Receptors						
Terrestrial Plants/ Soil Invertebrates	Surface Soil	**PAHs**				Protection of terrestrial plant and soil invertebrate communities from the toxic effects (on survival and growth) of site-related constituents present in surface soil.
		Acenaphthene	317	100	3.17	
		Acenaphthylene	334	100	3.34	
		Anthracene	352	100	3.52	
		Benzo(a)anthracene	568	100	5.68	
		Benzo(a)pyrene	541	100	5.41	
		Benzo(b)fluoranthene	611	100	6.11	
		Benzo(g,h,i)perylene	476	100	4.76	
		Benzo(k)fluoranthene	415	100	4.15	
		Chrysene	629	100	6.29	
		Dibenz(a,h)anthracene	372	100	3.72	
		Fluoranthene	987	100	9.87	
		Fluorene	326	100	3.26	
		Indeno(1,2,3-cd)pyrene	407	100	4.07	
		Naphthalene	250*	100	2.50	
		Phenanthrene	714	100	7.14	
		Pyrene	1,067	100	10.7	
		Pesticides				
		4,4'-DDD	248	100	2.48	
		4,4'-DDE	659	100	6.59	
		4,4'-DDT	961	100	9.61	
		Inorganics				
		Aluminum	5,578	1.00	5,578	
		Copper	493	70	7.04	
		Iron	18,136	12	1,511	
		Lead	442	120	3.68	
		Vanadium	94	0.50	188	
		Zinc	780	10	78.0	
		PCBs				
		Aroclor-1260	167	100	1.67	
Aquatic Receptors						
Benthic Invertebrates	Sediment	**PAHs**				Protection of aquatic receptor (invertebrates) communities from the toxic effects (on survival and growth) of site-related constituents present in the sediment.
		2-methylnaphthalene	695	70	3.57	
		Acenaphthene	711	16	30.6	
		Anthracene	691	85.3	8.10	
		Benzo(a)anthracene	810	261	3.10	
		Benzo(a)pyrene	832	430	1.93	
		Benzo(g,h,i)perylene	739	670	1.10	
		Benzo(k)fluoranthene	596	240	2.48	
		Chrysene	866	384	2.26	
		Dibenz(a,h)anthracene	712	63.4	7.89	
		Diethylphthalate	641	200	1.25	
		Fluoranthene	763	600	1.27	
		Fluorene	698	19	28.9	
		Indeno(1,2,3-cd)pyrene	649	600	1.08	
		Naphthalene	697	160	1.75	
		Phenanthrene	954	240	3.97	
		Pyrene	1,186	665	1.78	

TABLE 4
Summary of Unacceptable Ecological Risks – Lower Trophic Level Receptors

Receptor	Media	COPC	EPC[1]	Screening Toxicity Value[2]	HQ	Assessment Endpoint
		Pesticides				
		Dieldrin	4.77	0.72	6.67	
		alpha-Chlordane	17.4	0.50	34.8	
		gamma-Chlordane	23.8	0.50	47.6	
		PCBs				
		Aroclor-1254	47.2	22.7	2.08	
		Aroclor-1260	43.8	22.7	1.93	
		Inorganics				
		Arsenic	9.78	8.20	1.19	
		Barium	68.6	48	1.43	
		Cadmium	5.21	1.20	4.34	
		Chromium	683	5.00	137	
		Copper	742	34	21.8	
		Cyanide	0.46	0.10	4.56	
		Lead	252	46.7	5.40	
		Mercury	0.52	0.15	3.47	
		Nickel	22.7	20.9	1.08	
		Vanadium	57.6	57.0	1.01	
		Zinc	671	150	4.47	
		VOCs				
		Carbon Disulfide	15.5	0.85	18.3	
Water-Column-Dwelling Aquatic Life	Surface Water	**Inorganics**				Protection of aquatic receptor (fish) communities from the toxic effects (on survival and growth) of site-related constituents present in the surface water.
		Aluminum	2,038	25	81.5	
		Chromium	14.7	2.00	7.36	
		Copper	28.7	2.85	10.1	
		Cyanide	7.06	1.00	7.06	
		Iron	4,281	320	13.4	
		Lead	11.3	3.20	3.54	
		Manganese	433	10	43.3	
		Nickel	14.5	8.30	1.75	
		Zinc	232	19	12.2	
		VOCs				
		*Carbon Disulfide***	2	2	1.14	
		Chloroform**	6.13	1.80	3.40	
		TCE**	76	21	3.62	

EPC - exposure point concentration

HQ - hazard quotient

[1] Mean concentrations used.

[2] Source:
Soil - USEPA 1995. *Revised Region III BTAG Screening Levels.* Memorandum from R.S. Davis to Users.
Sediment - Long and Morgan 1990; Ontario Ministry of the Environment 1993; USEPA 1995; Buchman 1999
Surface Water - USEPA 1995; The Canadian Council of Ministers of the Environment 2008

* Calculated mean concentration greater than maximum detection. Maximum detected concentration used.

** VOC HQ values for surface water re-calculated as part of ERI to include additional data collected.

COPCs in italics not identified as COCs based upon risk management considerations presented in Section 2.7.2.

Food Web Exposure

Wildlife Receptors

Food web modeling was conducted to evaluate potential risk to wildlife. Modeled food web exposure estimates were compared to the No Observed Adverse Effects Level (NOAEL), Maximum Acceptable Threshold Concentration (MATC), and Lowest Observed Adverse Effects Level (LOAEL). The dose that is protective to wildlife is expected to fall between the NOAEL and the LOAEL. The MATC is the geometric mean of the NOAEL and LOAEL and provides realistic risk estimates as the MATC represents a standard estimation of the threshold concentration (i.e., the concentration above which a toxic effect on the test endpoint is produced). Potential risks to avian vermivores (American Woodcock) and reptiles due to lead, zinc, and 4,4′-DDE in soil as well as potential risks to avian piscivores (Belted Kingfisher) and reptiles due to mercury in sediment were identified. The unacceptable risks are summarized on **Table 5**.

TABLE 5
Summary of Unacceptable Ecological Risks – Upper Trophic Level Receptors

Receptor*	Exposure Parameter	COPC[1]	NOAEL HQ[2]	LOAEL HQ[2]	MATC HQ[2]	Assessment Endpoint
Wildlife Receptors						
American Woodcock	Soil Invertebrates	Lead	**5.4**	**1.1**	**2.4**	Protection of insectivorous birds to ensure that ingestion of contaminants in soil and prey does not have a negative impact on growth, survival, and reproduction.
		Zinc	**16.2**	**1.8**	**5.4**	
		4,4′-DDE	**1.5**	0.2	0.5	
Belted Kingfisher	Aquatic Invertebrates/ Fish/Amphibians	*Mercury*	**7.1**	**2.4**	**4.1**	Protection of piscivorous, sometimes omnivorous, birds to ensure that ingestion of contaminants in sediment and prey does not have a negative impact on growth, survival, and reproduction.

HQ – hazard quotient

*Risk to reptiles was evaluated using birds as surrogates due to limitations and relevant toxicity data; therefore potential risks indicated for birds are also interpreted as indicating a potential risk to reptiles.

[1] Dietary intake values calculated for COPCs using mean detected concentrations.

[2] Source: McLane and Hall 1972; Coulston and Kolbye 1994; Sample et al. 1996; Beyer et al. 1996

Bold, highlighted values indicate an HQ greater than 1.

COPCs in italics not identified as COCs based upon risk management considerations presented in Section 2.7.2.

2.7.3 Basis for Response Action

It is the current judgment of the Navy and USEPA, with the concurrence of VDEQ, that the selected remedy identified in this ROD is necessary to protect public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment.

Based on the HHRA and ERA, exposure to waste and VOCs, SVOCs, pesticides, PCBs, and/or inorganics in soil, shallow groundwater, sediment, and surface water at Site 2 poses an unacceptable risk to human health and/or the environment (Tables 3 - 5). In addition, the Navy acknowledges the Commonwealth of Virginia's and USEPA's expectation to return groundwaters to their beneficial uses wherever practicable. Therefore, as discussed in Section 2.7.1, chloroform and methylene chloride, which did not pose unacceptable risks but which exceeded their respective MCLs, were also included as COCs in shallow groundwater. The selected remedy identified in this ROD is also necessary to address the potential continuing source of chlorinated VOCs (DNAPL) to groundwater. The COCs requiring a response action are summarized on **Table 6**.

TABLE 6
COCs Requiring a Response Action

COCs	Surface Soil	Combined Surface and Subsurface Soil	Shallow Groundwater	Surface Water	Sediment	Sediment Pore Water
Volatile Organic Compounds						
1,1,2-Trichloroethane			X			
1,1-Dichloroethene			X			X
Chloroform			X	X		
Methylene chloride			X			
Tetrachloroethene			X			
Trichloroethene			X	X		X
Vinyl chloride			X			X
cis-1,2-Dichloroethene			X			X
trans-1,2-Dichloroethene			X			
Semivolatile Organic Compounds						
2-Methylnaphthalene					X	
Acenaphthene	X				X	
Acenaphthylene	X					
Anthracene	X				X	
Benzo(a)anthracene	X				X	
Benzo(a)pyrene	X				X	
Benzo(b)fluoranthene	X					
Benzo(g,h,i)perylene	X				X	
Benzo(k)fluoranthene	X				X	
Chrysene	X				X	
Dibenz(a,h)anthracene	X				X	
Diethylphthalate					X	
Fluoranthene	X				X	
Fluorene	X				X	
Indeno(1,2,3-cd)pyrene	X				X	
Naphthalene	X		X		X	
Phenanthrene	X				X	
Pyrene	X				X	
Pesticides/Polychlorinated Biphenyls						
4,4'-DDD	X					
4,4'-DDE	X					
4,4'-DDT	X					
Aroclor-1254					X	
Aroclor-1260	X				X	
Alpha-Chlordane					X	
Gamma-Chlordane					X	
Dieldrin					X	
Heptachlor epoxide			X			

TABLE 6
COCs Requiring a Response Action

COCs	Surface Soil	Combined Surface and Subsurface Soil	Shallow Groundwater	Surface Water	Sediment	Sediment Pore Water
Inorganics						
Aluminum	X			X		
Antimony		X				
Barium				X	X	
Cadmium					X	
Chromium				X	X	
Copper	X			X	X	
Cyanide				X	X	
Iron	X	X		X		
Lead	X	X		X	X	
Manganese				X		
Nickel				X	X	
Vanadium	X	X				
Zinc	X			X	X	

Human health risk drivers
Ecological risk drivers
Human health and ecological risk drivers

2.8 Remedial Action Objectives

The site-specific remedial action objectives (RAOs) for Site 2 are as follow:

Waste, soil, and sediment (including sediment pore water):

- Prevent direct media contact by human and ecological receptors with contaminants at concentrations that pose unacceptable risks
- Prevent migration of contaminants through surface water runoff and erosion pathways
- Prevent or minimize transport of COCs from waste to site media, including groundwater

Shallow groundwater:

- Reduce contaminant source mass to the maximum extent practicable
- Prevent activities that might cause migration of COCs in the Columbia aquifer to the underlying Yorktown aquifer
- Prevent COCs migration from the shallow groundwater to surface water and sediment
- Reduce COC concentrations in shallow groundwater to the maximum extent practicable
- Prevent human exposure to COCs present in groundwater at concentrations that pose unacceptable risks

Surface Water:

- Minimize degradation of surface water through source control in shallow groundwater, waste, surface soil, and sediment

Cleanup levels have been established for constituents with concentrations contributing to unacceptable human health and ecological risks in soil, sediment, and shallow groundwater. No cleanup levels were established for surface water and sediment pore water because remediation of the soil, sediment, and shallow groundwater is expected to address these media. The cleanup levels were developed from the human health risk-based and ecological risk-based **preliminary remediation goals**[16] (PRGs) developed in the Feasibility Study (FS). In instances where both a human health and ecological PRG were developed, the cleanup level was established as the more conservative value. Cleanup levels are identified in **Table 7**.

2.9 Description and Comparative Analysis of Remedial Alternatives

For the development of remedial alternatives, the site-specific media have been divided into six areas (**Figure 5**) to address the COCs in shallow groundwater, soil (surface and subsurface), sediment (including sediment pore water), and surface water. The six areas are:

- Waste, soil, and inlet sediment area – The waste area is estimated at approximately 3.9 acres; however, additional waste delineation to refine the boundary will be performed prior to remedial design. The soil and inlet sediment remediation areas were defined as the portions of the site with concentrations of COCs exceeding established cleanup levels.
- St. Juliens Creek sediment area – The St. Juliens Creek sediment area is defined as the portion of St. Juliens Creek adjacent to the culvert connecting the creek to the Site 2 inlet with concentrations of COCs exceeding established cleanup levels. Additional sediment sampling will be performed prior to remedial design to delineate the vertical remediation area boundary.
- High-concentration target area – The high-concentration target area is defined as the portion of the shallow groundwater plume where the potential presence of DNAPL (potential principal threat waste, Section 2.10) has been identified and where concentrations of chlorinated VOCs are detected above the aquifer's calculated **natural attenuation capacity**[17] (NAC). This is the aquifer's ability to degrade constituents to below cleanup levels by natural physical, chemical, or biological processes prior to offsite migration and discharge into St. Juliens Creek. The presence of potential DNAPL was defined by groundwater monitoring results and a membrane interface probe electron capture device (ECD) study. Based on current site conditions, trichloroethene (TCE) is the only chlorinated VOC detected above its respective calculated NAC of the aquifer (7,800 micrograms per liter [µg/L]). Therefore, the high-concentration target area is currently defined as the portions of the shallow groundwater plume with concentrations of TCE exceeding 7,800 µg/L and where ECD response was greater than 5,000,000 uV. The limits of the high-concentration area are anticipated to change throughout the remedial action, with areas transitioning into the low-concentration target area as TCE concentrations decrease.
- Low-concentration target area - The low-concentration target area is defined as the portion of the shallow groundwater plume where, excluding the high-concentration target area, chlorinated VOC concentrations exceed the established cleanup levels. The extent of the low-concentration target area will be adjusted to encompass areas of the former high-concentration target area where COC concentrations are greater than the cleanup levels but where TCE concentrations no longer meet the high-concentration target area criterion.
- Heptachlor epoxide target area – The heptachlor epoxide target area is an isolated portion of shallow groundwater with heptachlor epoxide concentrations exceeding the established cleanup level. The limits of this target area will be refined during implementation of the selected remedy.
- Naphthalene target area - The naphthalene target area is an isolated portion of shallow groundwater with naphthalene concentrations exceeding the established cleanup level. The limits of this target area will be refined during implementation of the selected remedy.

TABLE 7
Cleanup Levels

COC	Ecological Risk-Based PRG	Human Health Risk-Based PRG	Cleanup Level**	COC	Ecological Risk-Based PRG	Human Health Risk-Based PRG	Cleanup Level**	COC	Ecological Risk-Based PRG	Human Health Risk-Based PRG	Cleanup Level**
Surface Soil				**Inlet Sediment**				**St. Juliens Creek Sediment**			
Inorganics (mg/kg)				**Inorganics (mg/kg)**				**Inorganics (mg/kg)**			
Aluminum	7,669	NA	7,669	Barium	121	NA	121	Barium	121	NA	121
Copper	70	NA	70	Cadmium	10.9	NA	10.9	Cadmium	10.9	NA	10.9
Iron	3,669	NA	3,669	Chromium	260	53	53	Chromium	260	53	53
Lead	120	400*	120	Copper	421	NA	421	Copper	421	NA	421
Vanadium	26.6	72	26.6	Cyanide	0.1	NA	0.1	Cyanide	0.67	NA	0.67
Zinc	38	NA	38	Lead	351	NA	351	Lead	351	NA	351
Pesticides/PCB (µg/kg)				Nickel	44	NA	44	Nickel	44	NA	44
4,4-DDD	100	NA	100	Zinc	758	NA	758	Zinc	758	NA	758
4,4-DDE	532	NA	532	**Pesticides/PCBs (µg/kg)**				**Pesticides/PCB (µg/kg)**			
4,4-DDT	237	NA	237	Aroclor-1254	22.7	NA	22.7	Aroclor-1254	22.7	NA	22.7
Aroclor-1260	100	NA	100	Aroclor-1260	22.7	NA	22.7	Aroclor-1260	22.7	NA	22.7
SVOCs (µg/kg)				Alpha-Chlordane	9.1	NA	9.1	Alpha-Chlordane	9.1	NA	9.1
Acenaphthene	29,000	NA	29,000	Gamma-Chlordane	9.7	NA	9.7	Gamma-Chlordane	9.7	NA	9.7
Acenaphthylene	29,000	NA	29,000	Dieldrin	2.9	NA	2.9	Dieldrin	2.9	NA	2.9
Anthracene	29,000	NA	29,000	**SVOCs (µg/kg)**				**SVOCs (µg/kg)**			
Benzo(a)anthracene	1,100	NA	1,100	2-Methylnaphthalene	70	NA	70	2-Methylnaphthalene	70	NA	70
Benzo(a)pryene	1,100	NA	1,100	Acenaphthene	292	NA	292	Acenaphthene	292	NA	292
Benzo(b)fluoranthene	1,100	NA	1,100	Anthracene	332	NA	332	Anthracene	492	NA	492
Benzo(g,h,i)perylene	1,100	NA	1,100	Benzo(a)anthracene	749	NA	749	Benzo(a)anthracene	1,300	NA	1,300
Benzo(k)fluoranthene	1,100	NA	1,100	Benzo(a)pryene	732	NA	732	Benzo(a)pryene	1,000	NA	1,000
Chrysene	1,100	NA	1,100	Benzo(g,h,i)perylene	670	NA	670	Benzo(g,h,i)perylene	672	NA	672
Dibenz(a,h)anthracene	1,100	NA	1,100	Benzo(k)fluoranthene	467	NA	467	Benzo(k)fluoranthene	1,400	NA	1,400
Fluoranthene	1,100	NA	1,100	Chrysene	986	NA	986	Chrysene	1,500	NA	1,500
Flourene	29,000	NA	29,000	Dibenz(a,h)anthracene	292	NA	292	Dibenz(a,h)anthracene	410	NA	410
Indeno(1,2,3-cd)pyrene	1,100	NA	1,100	Diethylphehalate	200	NA	200	Diethylphehalate	608	NA	608
Naphthalene	29,000	NA	29,000	Fluoranthene	2,500	NA	2,500	Fluoranthene	2,600	NA	2,600
Phenanthrene	29,000	NA	29,000	Flourene	292	NA	292	Flourene	292	NA	292
Pyrene	1,100	NA	1,100	Indeno(1,2,3-cd)pyrene	600	NA	600	Indeno(1,2,3-cd)pyrene	624	NA	624

TABLE 7
Cleanup Levels

COC	Ecological Risk-Based PRG	Human Health Risk-Based PRG	Cleanup Level**
Combined Surface and Subsurface Soil			
Inorganics (mg/kg)			
Antimony	NA	26.4	26.4
Iron	NA	53,529	53,529
Lead	NA	400*	400
Vanadium	NA	72	72
Groundwater* **			
VOCs (µg/L)			
1,1,2-Trichloroethane	NA	5	5
1,1-Dichloroethene	NA	7	7
Tetrachloroethene	NA	5	5
Trichloroethene	NA	5	5
cis-1,2-Dichloroethene	NA	70	70
Chloroform	NA	80	80
Methylene chloride	NA	5	5
trans-1,2-Dichloroethene	NA	100	100
Vinyl chloride	NA	2	2
SVOC (µg/L)			
Naphthalene	NA	170	170
Pesticide (µg/L)			
Heptachlor Epoxide	NA	0.2	0.2

COC	Ecological Risk-Based PRG	Human Health Risk-Based PRG	Cleanup Level**
Inlet Sediment (continued)			
Naphthalene	292	NA	292
Phenanthrene	376	NA	376
Pyrene	1,905	NA	1,905

COC	Ecological Risk-Based PRG	Human Health Risk-Based PRG	Cleanup Level**
St. Juliens Creek Sediment (continued)			
Naphthalene	292	NA	292
Phenanthrene	920	NA	920
Pyrene	1,905	NA	1,905

Notes:

Cleanup levels were not established for surface water and sediment pore water because remediation of the soil, inlet sediment, and shallow groundwater will eliminate these media from the site.

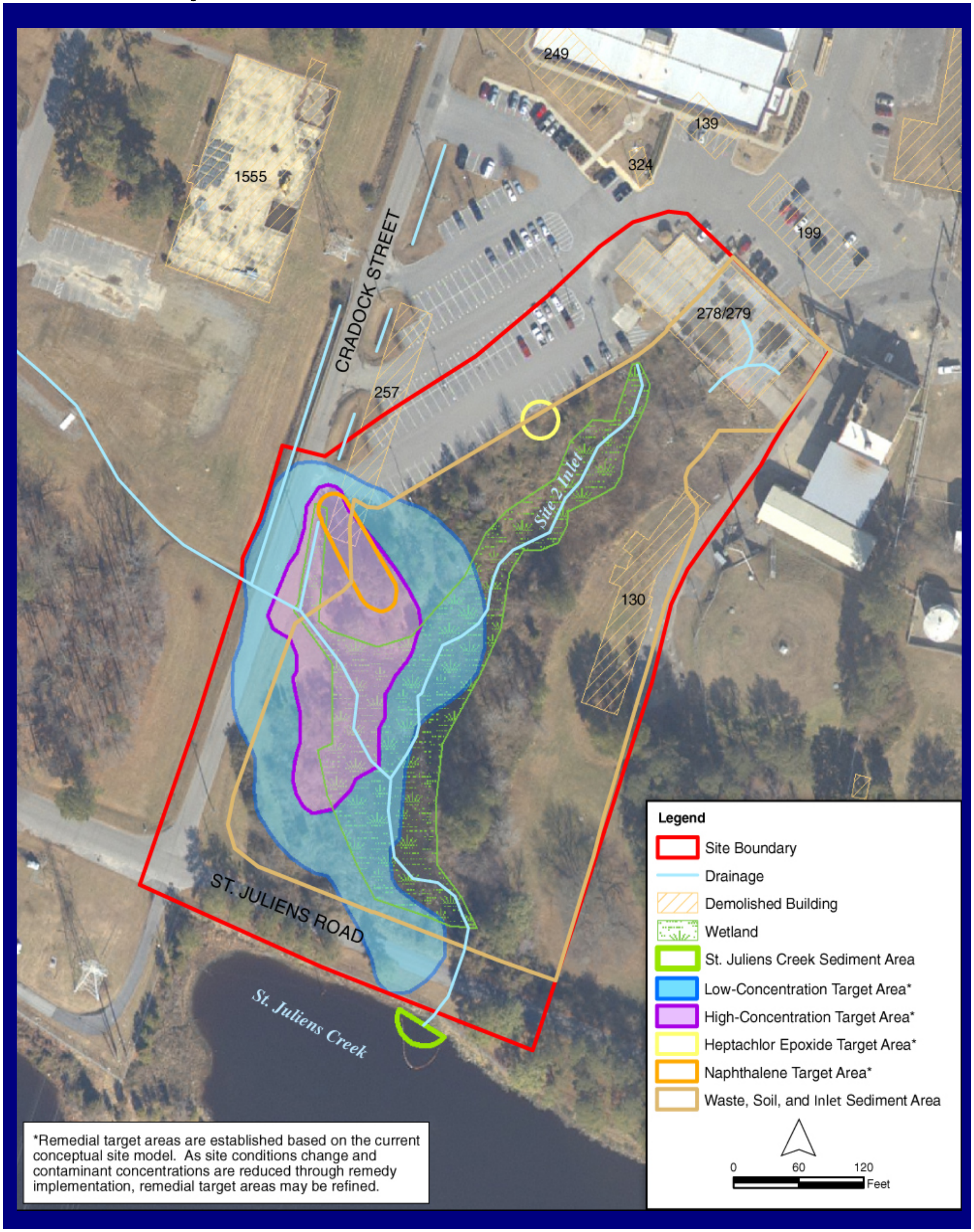
*Site-wide average concentration

**Cleanup level was established as more conservative PRG calculated.

***Groundwater human health risk-based PRG based upon Federal Maximum Contaminant Levels for potable use of groundwater.

NA - No associated risk, PRG not established

FIGURE 5
Remedial Alternative Target Areas



2.9.1 Description of Remedial Alternatives

Primary Remedial Alternatives

Following the establishment of cleanup levels, areas requiring remedial action were defined. As outlined above in Section 2.9, six remediation areas were established to address the waste and COCs in shallow groundwater, soil, inlet sediment (including sediment pore water), and surface water (**Figure 5**). Remedial alternatives to address each area were developed by mixing and matching options for the six remediation areas and are detailed in the FS (CH2M HILL, 2009, Revised 2010). Based on initial **screening of technologies**[18], eight remedial alternatives were retained for detailed comparative analysis as follows:

- Alternative 1 – No Action
- Alternative 2 – Cover and Land Use Controls (Waste and Soil), Excavation and Offsite Disposal (St. Juliens Creek Sediment), and Monitored Natural Attenuation and Land Use Controls (High- and Low-Concentration, Naphthalene, and Heptachlor Epoxide Target Areas)
- Alternative 3 – Cover and Land Use Controls (Waste and Soil), Excavation and Offsite Disposal (St. Juliens Creek Sediment), Sheet Pile and Land Use Controls (High-Concentration Target Area), and Monitored Natural Attenuation and Land Use Controls (Low-Concentration, Naphthalene, and Heptachlor Epoxide Target Areas)
- Alternative 4 – Cover and Land Use Controls (Waste and Soil), Excavation and Offsite Disposal (St. Juliens Creek Sediment), Enhanced Reductive Dechlorination and Land Use Controls (High-Concentration Target Area), and Monitored Natural Attenuation and Land Use Controls (Low-Concentration, Naphthalene, and Heptachlor Epoxide Target Areas)
- Alternative 5 – Cover and Land Use Controls (Waste and Soil), Excavation and Offsite Disposal (St. Juliens Creek Sediment), Enhanced Reductive Dechlorination and Land Use Controls (High- and Low-Concentration Target Areas), and Monitored Natural Attenuation and Land Use Controls (Naphthalene and Heptachlor Epoxide Target Areas)
- Alternative 6 – Cover and Land Use Controls (Waste and Soil), Excavation and Offsite Disposal (St. Juliens Creek Sediment), Funnel and Gate and Land Use Controls (High- Concentration Target Areas), and Monitored Natural Attenuation and Land Use Controls (Low-Concentration, Naphthalene, and Heptachlor Epoxide Target Areas)
- Alternative 7 – Cover and Land Use Controls (Waste and Soil), Excavation and Offsite Disposal (St. Juliens Creek Sediment and High-Concentration Target Area), and Monitored Natural Attenuation and Land Use Controls (Low-Concentration, Naphthalene, and Heptachlor Epoxide Target Area)
- Alternative 8 – Cover and Land Use Controls (Waste and Soil), Excavation and Offsite Disposal (St. Juliens Creek Sediment and High-Concentration Target Area), Enhanced Reductive Dechlorination and Land Use Controls (Low-Concentration Target Area), and Monitored Natural Attenuation and Land Use Controls (Naphthalene and Heptachlor Epoxide Target Areas)

Each alternative employs the same technologies for addressing the St. Juliens Creek sediment area (excavation and offsite disposal) and naphthalene and heptachlor epoxide target areas (MNA and LUCs). Alternatives 2 through 6 (soil cover and LUCs) and Alternatives 7 and 8 (excavation and offsite disposal) also employ the same technology for the waste, soil, and inlet sediment area. The primary difference between the alternatives is in their technologies for addressing the high-concentration and low-concentrations target areas; therefore, the comparative analysis presented below focuses on these technologies. The components of each alternative are described briefly in **Table 8**. The No Action alternative does not protect human health and the environment, but is presented as a baseline for comparison purposes. Because implementation of the cover under each alternative will result in a permanent loss of the existing wetland, the loss will be offset through a compensatory wetland mitigation.

Contingency Remedy Component

A PRB has been developed as a contingency measure for potential addition to the selected remedy. Each of the remedial alternatives includes placement of a soil cover, which will likely result in changes in the shallow groundwater flow over time, and in turn potential shallow groundwater COC migration may occur. The PRB is an underground vertical "wall", through which groundwater passes, that is constructed of material that facilitates the breakdown of site contaminants. To enhance the PRB's effectiveness, it is assumed that a reactive material [e.g. emulsified oil substrate (EOS) or zero valent iron] will be injected into the "wall" throughout the remediation timeframe. The primary remedial alternatives are protective based on current conditions, but there is uncertainty as to how conditions may change (e.g., groundwater flow trending more towards St. Juliens Creek) as the remedy is implemented. If substantial changes in COC migration trends are observed, and if the results of modeling lead to the recognition of the potential for offsite migration of shallow groundwater COCs at concentrations that may result in exceedances of the surface water criteria , a contingency PRB may be installed downgradient of the shallow groundwater plume to prevent offsite COC migration and discharge to St. Juliens Creek. As part of the remedial design, criteria for implementing the PRB will be established and will rely on several factors including, but not limited to: DAFs, site-specific groundwater and surface water flow rates, and surface water quality criteria.

2.9.2 Comparative Analysis of Remedial Alternatives

A comparative analysis of the eight alternatives and the contingency remedy component with respect to the **nine evaluation criteria**[19] was completed and is summarized below. **Table 9** depicts a comparison of the alternatives to the criteria to support ranking of the alternatives. Alternative 1 (No Action) does not achieve RAOs designed to protect human health and the environment; therefore, it fails the first threshold criterion and is not considered further in this ROD.

Threshold Criteria

Overall Protection of Human Health and the Environment

Overall protection of human health and the environment addresses whether each alternative provides adequate protection of human health and the environment and describes how risks posed through each exposure pathway are eliminated, reduced, or controlled through treatment, engineering controls, and/or institutional controls.

With the exception of Alternative 1 (no action), each alternative is protective of human health and the environment based on the current and reasonably anticipated future site conditions. Each alternative results in contamination remaining in place; however, performance monitoring will be conducted to confirm that the remedies are functioning and protective, and LUCs will be implemented and maintained to provide adequate protection of human health and the environment by controlling exposure to contaminated site media until RAOs are met and while waste remains in place.

TABLE 8
Remedial Alternatives Summary

Alternative	Waste, Soil, and Inlet Sediment Area	St. Juliens Creek Sediment Area	High-Concentration Target Area	Low-Concentration Target Area	Naphthalene Target Area	Heptachlor Epoxide Target Area
1	No Action	No Action	No Action	No Action	No Action	No Action
No cost Cost estimate timeframe: 0 yrs						
2	Cover and LUCs	Excavation and Offsite Disposal	MNA	MNA	MNA	MNA
Capital cost: $1.3M O&M PV Cost: $1.1M Total PV: $2.4M -30%/+50%: $1.7M/$3.6M Cost estimate timeframe: 30 years	• Install soil cover over waste and contaminated soil and inlet sediment to prevent direct exposure to contaminated media. • Implement and maintain LUCs to maintain the cover and prevent exposure to waste and contaminants in soil and inlet sediment. • Implement and maintain LUCs to prevent unrestricted exposure to shallow groundwater and/or shallow groundwater vapors until conditions allow for unlimited use and unrestricted exposure.	Remove contaminated sediment from St. Juliens Creek to prevent direct exposure to contaminated sediment.	Allow chlorinated VOCs in the target area to break down naturally over time and implement a monitoring plan to confirm the continued breakdown.	Allow chlorinated VOCs in the target area to break down naturally over time and implement a monitoring plan to confirm the continued breakdown.	Allow naphthalene to break down naturally over time and implement a monitoring plan to confirm the continued breakdown.	Allow heptachlor epoxide to break down naturally over time and implement a monitoring plan to confirm the continued breakdown.
3	Cover and LUCs	Excavation and Offsite Disposal	Sheet Pile	MNA	MNA	MNA
Capital cost: $3.0M O&M PV Cost: $1.0M Total PV: $4.0M -30%/+50%: $2.8M/$6.0M Cost estimate timeframe: 30 years	See Alternative 2.	See Alternative 2.	Install impermeable sheet pile barrier surrounding the target area to create a hydraulic barrier, preventing migration of chlorinated VOCs outside of the high-concentration target area.	See Alternative 2.	See Alternative 2.	See Alternative 2.
4	Cover and LUCs	Excavation and Offsite Disposal	ERD	MNA	MNA	MNA
Capital cost: $2.2M O&M PV Cost: $3.6M Total PV: $5.8M -30%/+50%: $4.0M/$8.6M Cost estimate timeframe: 30 years	See Alternative 2.	See Alternative 2.	Inject a substrate to create reducing conditions and produce electron donors to directly treat the target area through ERD of chlorinated VOCs.	See Alternative 2.	See Alternative 2.	See Alternative 2.
5	Cover and LUCs	Excavation and Offsite Disposal	ERD	ERD	MNA	MNA
Capital cost: $3.73M O&M PV Cost: $7.5M Total PV: $11.2M -30%/+50%: $7.9M/$16.9M Cost estimate timeframe: 30 years	See Alternative 2.	See Alternative 2.	See Alternative 4.	Inject a substrate to create reducing conditions and produce electron donors to directly treat the target area through ERD of chlorinated VOCs.	See Alternative 2.	See Alternative 2.
6	Cover and LUCs	Excavation and Offsite Disposal	Funnel and Gate	MNA	MNA	MNA
Capital cost: $3.3M O&M PV Cost: $1.8M Total PV: $5.1M -30%/+50%: $3.6M/$7.6M Cost estimate timeframe: 30 years	See Alternative 2.	See Alternative 2.	Install impermeable sheet pile barriers sidegradient of the high-concentration target area to act as a funnel and direct chlorinated VOC-contaminated groundwater through a treatment (ERD) zone.	See Alternative 2.	See Alternative 2.	See Alternative 2.
7	Cover and LUCs	Excavation and Offsite Disposal	Excavation and Offsite Disposal	MNA	MNA	MNA
Capital cost: $22.9M O&M PV Cost: $1.0M Total PV: $23.9M -30%/+50%: $16.7M/$35.8M Cost estimate timeframe: 30 years	See Alternative 2.	See Alternative 2.	Remove waste, contaminated soil and sediment, and all of the saturated soil (potentially containing DNAPL) from within the target area to prevent direct exposure to select areas of contaminated soil and inlet sediment and reduce contaminant source mass.	See Alternative 2.	See Alternative 2.	See Alternative 2.
8	Cover and LUCs	Excavation and Offsite Disposal	Excavation and Offsite Disposal	ERD	MNA	MNA
Capital cost: $24.4M O&M PV Cost: $5.0M Total PV: $29.4M -30%/+50%: $20.1M/$43.2M Cost estimate timeframe: 30 years	See Alternative 2.	See Alternative 2.	See Alternative 7.	See Alternative 5.	See Alternative 2.	See Alternative 2.

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Because each alternative includes placement of a soil cover, which will likely alter the shallow groundwater flow conditions and may resultantly impact the shallow groundwater contaminant pathways, the contingency remedial component has been developed for addition to any of Alternatives 2 through 8. The contingency remedy, in combination with the primary remedy, is protective of human health and the environment because it will reduce contaminant concentrations in groundwater prior to offsite migration. Performance monitoring will be conducted to confirm that the contingency remedy component, if implemented, is functioning and protective.

TABLE 9
Relative Ranking of Alternatives

	Primary Alternatives								Contingency Remedy Component
CERCLA Criteria	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 6**	**Alternative 7**	**Alternative 8**	**PRB**
Threshold Criteria									
Protection of Human Health and the Environment	❍	●	●	●	●	●	●	●	●
Compliance with ARARs	❍	●	●	●	●	●	●	●	●
Primary Balancing Criteria									
Long-term Effectiveness and Permanence	1.0	8.5	8.0	8.5	8.5	8.0	9.0	9.0	●
Reduction in Toxicity, Mobility, and Volume Through Treatment	1.0	1.0	1.0	8.0	9.0	5.0	1.0	4.0	●
Short-term Effectiveness	7.8	7.5	6.5	7.5	7.8	6.5	4.8	5.0	●
Implementability	6.6	8.8	7.9	9.1	9.3	8.2	8.3	8.4	●
Present-worth Cost (estimated total present value in millions)	$0	$2.4M	$4.0M	$5.8M	$11.2M	$5.1M	$23.9M	$29.4M	$0.8M

Relative Ranking: 10 high to 1 low, ● meets and ❍ does not meet

Note: The FS report provides the details for the **qualitative comparative analysis ratings**[20].

Compliance with Applicable or Relevant and Appropriate Requirements

Compliance with ARARs addresses whether a remedy will meet all of the applicable or relevant and appropriate requirements of Federal and State environmental laws, or whether there is a basis for invoking a waiver.

The ARARs for the selected remedy at Site 2 are listed in Appendix A. Each alternative is expected to comply with the Federal and State **ARARs**[21]. The applicability of most ARARs is the same for Alternatives 2 through 8, with the following exceptions. Each alternative requires compliance with regulations established to prevent discharge to surface water due to construction of the cover; however, the high-concentration area excavation components of Alternatives 7 and 8 require additional measures to be taken to prevent discharge of groundwater encountered during the excavation. Alternatives 4, 5, 6, 8, and the contingency remedy component require compliance with underground injection regulations due to the ERD component of these alternatives. Although each alternative requires compliance with control measures established for the use and/or presence of chlorofluorocarbons used as aerosol propellants, hexavalent chromium, and PCBs, the ARAR (40 CFR 761.50 and .61) is applicable for Alternatives 6, 7, and 8 because these alternatives require excavation of soil and sediment in which PCBs have been detected as waste in which the exact contents are unknown.

Primary Balancing Criteria

Long-term Effectiveness and Permanence

Long-term effectiveness and permanence refers to the magnitude and characteristics of the residual risk at the conclusion of remedial activities, and the ability of a remedy to maintain reliable protection of human health and the environment over time.

Each alternative is expected to achieve long-term effectiveness and permanence at the conclusion of remedial activities; however, when compared against one another the alternative rankings from highest to lowest are 8, 7, 5, 4, 2, 6, and 3. Although residual risks for Alternatives 2, 4, 5, 7, and 8 are anticipated at the same magnitude; because of the excavation and offsite disposal of the area with the highest contaminant concentrations, Alternatives 7 and 8 may result in slightly lower residual risk. Similarly, because of the active treatment of the high- and low-concentration target areas under Alternatives 4 and 5, they are expected to result in slightly lower residual risk than Alternative 2, which relies on natural attenuation. Alternatives 3 and 6 have lower levels of long-term reliability because of their dependence on groundwater COC containment, the potential for failure over time, and the need for replacement or maintenance. With proper engineering, planning, and implementation, controls can be put in place to monitor all of the alternatives effectively and to verify continued compliance with RAOs. If monitoring results in the determination that a substantial change in site conditions has resulted in the potential for off-site migration of shallow groundwater, the contingency remedial component can be added to any of Alternatives 2 through 8 to improve the long-term effectiveness and permanence of the overall site remedy. Each alternative will require LUCs be continually enforced until RAOs are achieved and while waste remains in place.

Reduction in Toxicity, Mobility, or Volume through Treatment

Reduction of toxicity, mobility, or volume through treatment refers to the anticipated performance of the treatment technologies that may be included as part of a remedy.

Alternatives 4, 5, 6, and 8 each reduce toxicity, mobility, and volume through active treatment, which is the statutory preference. Alternatives 4 and 5 include active treatment of the high-concentration target area, which encompasses the estimated extent of the potential principal threat waste (Section 2.10), through ERD. Implementation of ERD within the high-concentration target area will accelerate COC reduction, resulting in the greatest short-term reduction in toxicity, mobility, and volume at the site. Alternative 4 is rated slightly lower than Alternative 5 in this evaluation criterion because it limits active treatment to the high-concentration target area. Alternative 8 only provides treatment in the comparatively small low-concentration area with ERD. Alternative 6 provides treatment in the gate but relies on the migration of the contamination to the treatment area and will, therefore, not result in a short-term significant reduction in toxicity or volume of COCs. Treatment is not a component of Alternatives 2, 3, or 7; therefore, the alternatives do not satisfy this criterion. While MNA is not considered an active treatment, the natural reduction of contaminant concentrations through a variety of physical, chemical, or biological activities is expected over time with implementation of these alternatives. Therefore, when the alternatives employing treatment as a component of the remedy are compared against one another, the alternative rankings from highest to lowest are 5, 4, 6, and 8. If implemented, the contingency remedy component would reduce toxicity, mobility, and volume of contaminants through treatment by reducing shallow groundwater COCs that migrate to the downgradient perimeter of the site to harmless by-products as they pass through reactive material.

Short-term Effectiveness

Short-term effectiveness addresses the period of time needed to implement the remedy and any adverse impacts that may be posed to workers, the community, and the environment during construction and operation of the remedy until cleanup levels are achieved. Due to the potential presence of DNAPL at the site and the associated significant uncertainty of calculating timeframe for reducing DNAPL concentrations to the site cleanup levels, specific timeframes for achieving the RAOs are not provided. However, the variation in timeframe between the alternatives is discussed qualitatively below.

Alternatives 2, 4, and 5 have the highest and similar levels of short-term effectiveness. Alternative 2 poses the lowest risk during implementation whereas Alternatives 4 and 5 pose slightly higher risks to workers due to the additional handling of groundwater treatment materials. Alternatives 4 and 5 have higher short-term effectiveness than Alternative 2 as a result of the shortest timeframe for achieving RAOs through active shallow groundwater treatment, which as discussed in detail in the FS is assumed will decrease the overall timeframe of remediation by accelerating chlorinated VOC degradation. Alternative 5 has the shortest anticipated timeframe to meet the cleanup levels as a result of treatment of the largest area. Because Alternative 2 relies on natural degradation of COCs, the timeframe for achieving the RAOs is estimated to be longer than Alternatives 4 and 5. Alternatives 3 and 6 have similar impacts on the community and risks to workers during implementation as Alternatives 4 and 5; however, they are rated slightly lower because they will require a longer timeframe to achieve the RAOs due to their reliance on natural degradation or groundwater flow to carry the contamination to a treatment area. Under each of these alternatives (2, 3, 4, 5, and 6), protection of the community and workers is possible through proper engineering and implementation. Alternatives 7 and 8 have the lowest level of short-term effectiveness because of the significant intrusiveness involved with their implementation in order to excavate the waste, inlet sediment, and saturated soil within the high-concentration target area and associated potential risk of exposure to site contaminants. Therefore, when compared against one another the alternative rankings from highest to lowest are 5, 4, 2, 3, 6, 8, and 7.

The short-term effectiveness of the contingency remedial component, if implemented, would be equal when added to any of the primary alternatives. The timeframe for achieving the cleanup levels would not change from the primary remedy. The adverse affects to the workers would be slightly increased from the primary remedies due to the additional intrusive activities to install the PRB, potential utility relocation, and chemical handling. However, these adverse effects could be managed through engineering controls. The impacts to the community would be similar to those imposed by primary remedies.

Implementability

Implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation.

The levels of implementability of Alternatives 2, 4, and 5 are the highest because their technologies are readily available, able to be monitored for effectiveness, and can be followed by other remedial actions if necessary. Alternatives 4 and 5 are considered to have a slightly higher level of implementability than Alternative 2 because the performance of ERD is considered to be more reliable than MNA based on current site conditions, specifically the high concentrations of COCs and complex hydrogeology. Between Alternatives 4 and 5, the implementability of Alternative 5 is higher because it involves using a common, dependable technology (ERD) over the largest area, making it a more reliable alternative than Alternative 4, which has a smaller treatment area. MNA under Alternative 2 has a lower level of implementability than ERD under Alternatives 4 and 5 because it is a less reliable technology. Alternatives 3, 6, 7, and 8 have similarly lower levels of implementability. Alternatives 3 and 6 use technology in a newer, less frequently used application that lacks proven effectiveness, while Alternatives 7 and 8 require significant deep excavation, most of which would be conducted below the water table, and require significant engineering controls. Therefore, when compared against one another the alternative rankings from highest to lowest are 5, 4, 2, 8, 7, 6, and 3. If the contingency remedy component is required, it is implementable because the technology is readily available, reliable, and able to be monitored.

Cost

The **estimated capital costs**[22], O&M present values, and **total present values**[23] associated with each of the alternatives are presented in **Table 8**. The cost for each alternative was calculated based on the assumption of a 30-year implementation period. The actual timeframe to achieve RAOs may vary by alternative, as discussed above; however, significant uncertainty is associated with the timeframes, and costs beyond 30 years have minimal impact to the overall evaluation as a result of the present worth adjustment. The least expensive alternative is Alternative 2, with an estimated total present value of $2.4 million. The total present value increases sequentially with Alternatives 3, 6, 4, 5, 7, and 8, with the highest present value of $28.8 million. Alternative 2 also has the lowest total capital cost, estimated a $1.3 million. The capital cost increases sequentially with Alternatives 4, 3, 6, 5, 7, and 8, with the highest total capital cost of $24.4 million. The cost varies significantly with the intrusiveness of the remedy. The alternatives relying on natural attenuation have the lowest associated costs, while alternatives that require significant excavation and offsite disposal have significantly higher costs. If the contingency remedy component is necessary, its capital cost is estimated at $0.8 million and total present value is estimated at $1.5 million, each to be added to the primary remedy cost.

Modifying Criteria

State Acceptance

State involvement has been solicited throughout the CERCLA and remedy selection process. VDEQ, as the designated State support agency in Virginia, has reviewed this ROD and has given concurrence on the selected remedy. The selected remedy, Alternative 4 (Cover, Excavation and Offsite Disposal of Creek Sediment, LUCs, and ERD in the High-concentration Target Area), is consistent with the VDEQ's preference for active treatment of the high-concentration target area, which includes the potential principal threat waste (Section 2.10).

Community Acceptance

The public meeting was held on May 18, 2010 to present the Proposed Plan and answer community questions regarding the proposed remedial action at Site 2. The questions and concerns raised at the meeting were general inquiries for informational purposes only; no comments were received from the public.

2.10 Principal Threat Wastes

Principal threat wastes are source materials considered to be highly toxic or highly mobile that generally cannot be reliably contained or would present a significant risk to human health or the environment should an exposure occur. Although no "threshold level" of risk has been established to identify principal threat waste, a general guideline is to consider a principal threat those source materials with toxicity and mobility characteristics that combine to pose a potential risk several orders of magnitude greater than the risk level that is acceptable for the current or reasonably anticipated future land use, given realistic exposure scenarios. The waste at Site 2 consists of mixed municipal waste, which is not considered a principal threat waste. Contaminated groundwater at Site 2 is also not considered to be a source material; however, any potentially existing non-aqueous phase liquids (NAPLs) in groundwater may be viewed as a source material. Investigations have not confirmed that DNAPL exists at the site, though the chlorinated VOC concentrations, as discussed in Section 2.5, indicate it is likely present. Therefore, DNAPL, if present at the top of the Yorktown confining unit, could represent a principal threat waste because it cannot be easily contained and, for the VOCs identified at Site 2, is highly toxic. The selected remedy includes a treatment technology that will be used to permanently reduce the toxicity, mobility, and volume of the DNAPL, if present, to the maximum extent practicable.

2.11 Selected Remedy

Based on the comparative analysis, the selected remedy to address risk associated with waste, soil, shallow groundwater, sediment, and surface water is Alternative 4, consisting of Cover (waste, soil, and inlet sediment), Excavation and Offsite Disposal (St. Juliens Creek sediment), ERD (high-concentration target area), MNA (low-concentration, naphthalene, and heptachlor epoxide target areas), and LUCs to prevent exposure to waste, soil, and shallow groundwater.

2.11.1 Rationale for the Selected Remedy

Based on the evaluation of the data and information currently available, the Navy, in partnership with EPA, has determined the selected remedy meets the threshold criteria and provides the best balance of tradeoffs among the other alternatives with respect to the balancing and modifying criteria.

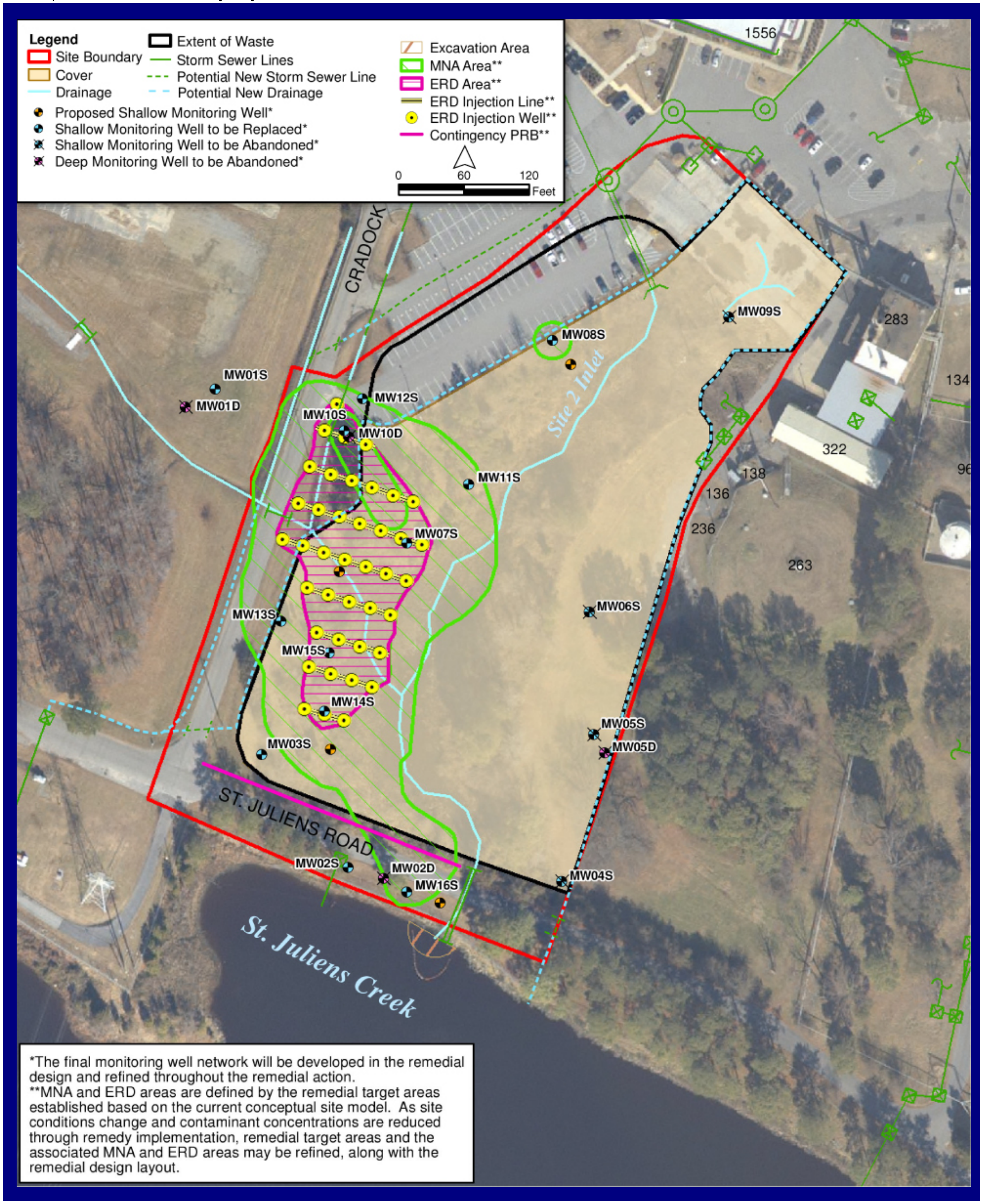
Alternative 4 was chosen over Alternatives 2, 3, 5, 6, 7, and 8 based on the following. Each alternative except for Alternative 1 will achieve RAOs and comply with ARARs. However, Alternatives 2, 3, and 7 do not meet the statutory preference for active treatment, result in a less immediate reduction in toxicity, mobility, and volume of COCs, and take longer to achieve the RAOs than Alternatives 4, 5, 6, and 8. Alternatives 6 and 8 are less effective than Alternatives 4 and 5 at reducing the toxicity, mobility, and volume of COCs, more difficult to implement, and pose a higher risk to construction workers during implementation. Alternatives 4 and 5 achieve similar short-term and long-term effectiveness, reduce toxicity, mobility, and volume through active treatment, and are highly implementable. Alternative 5 rates slightly higher than Alternative 4 because it employs active treatment over a larger area and will result in a shorter timeframe to achieve RAOs; however, the benefit is marginal and Alternative 5 is significantly more expensive than Alternative 4.

2.11.2 Description of the Selected Remedy

The Navy will implement the selected remedy in phases to optimize treatment in the various impacted media. The remedy implementation approach will be finalized during remedial design. The selected remedy for the various impacted media at Site 2, presented in **Figure 6**, is as follows:

- Cover installation over waste, soil, and inlet sediment
- Excavation and offsite disposal of St. Juliens Creek sediment
- ERD within high-concentration target area of shallow groundwater
- MNA within low-concentration, naphthalene, and heptachlor epoxide target areas of shallow groundwater
- LUCs

FIGURE 6
Conceptual Selected Remedy Layout



Although the effectiveness of mitigation of COCs in groundwater will be measured by comparison to cleanup levels, the remedial technologies (ERD and MNA) are not guaranteed to reduce COC concentrations to levels at or below cleanup levels across Site 2 in any particular timeframe due to the potential presence of DNAPL, which is a principal threat waste (Section 2.10). Following is a description of the selected remedy components.

Cover Over Waste, Soil, and Inlet Sediment

As part of the final remedy, a cover will be installed over the waste, soil, and inlet sediment area with the exception of the northwestern portion that is currently covered by the existing asphalt parking lot. As a part of remedial design, additional test pits will be excavated to delineate the eastern waste boundary in support of cover design. The cover and asphalt parking lot will prevent direct contact by human and ecological receptors with site media (waste, soil, and inlet sediment), prevent migration of contaminants through surface water runoff and erosion pathways, and will minimize infiltration of precipitation and subsequent transport of COCs through leaching. Prior to installation of the soil cover, the stormwater sewer and overland flow drainage systems will be re-routed, piped either below the ground surface or in an aboveground drainage ditch, discharging to St. Juliens Creek. Once the drainage has been re-routed, a soil cover will be placed over the waste, soil, and inlet sediment and the site topography will be modified to ensure drainage and prevent pooling. The cover will be a minimum of 2 feet thick consisting of an 18-inch vegetative support layer overlain by a 6-inch topsoil layer, and will be stabilized with native grasses and other vegetation. Installation of the soil cover will result in the permanent loss of the existing wetland; therefore, as part of the final remedy, a compensatory mitigation wetland will be constructed offsite.

Excavation and Offsite Disposal of St. Juliens Creek Sediment

The sediment within the remediation area in St. Juliens Creek will be excavated and disposed of offsite. Prior to remedial design, additional sediment samples will be collected and analyzed for St. Juliens Creek sediment COCs. Analytical results will be compared to established cleanup levels to delineate the vertical extent of excavation. Disposal facility selection will be based on the results of waste characterization sampling.

ERD Within High-Concentration Target Area of Shallow Groundwater

Biological reductive dechlorination is a naturally-occurring, microbially-mediated, anaerobic process in which chlorine atoms on a parent VOC molecule are sequentially replaced with hydrogen. In the reductive dechlorination process, electrons are transferred from an electron donor to the VOC compound, which functions as the electron acceptor. Therefore, an external electron donor source is required for the reaction to occur. Potential electron donor sources include biodegradable organic co-contaminants, native organic matter, or substrates intentionally added to the aquifer. Deeply anaerobic (reducing) conditions are required for reductive dechlorination of many compounds, and competing electron acceptors such as dissolved oxygen, nitrate, nitrite, manganese (IV), ferric iron, and sulfate must be depleted. The predominant parent COC at Site 2 is TCE, and its principal anaerobic biodegradation pathway is as follows:

$$\text{TCE} \rightarrow \text{cis-1,2-DCE} \rightarrow \text{VC} \rightarrow \text{ethene} \rightarrow \text{ethane}$$

The transformation rate for each step varies but tends to become slower with progress along the breakdown sequence, and may result in accumulation of cis-1,2-DCE and vinyl chloride if an adequate quantity of electron donor and/or the appropriate biological community are not present.

ERD will be implemented in the high-concentration target area, encompassing the estimated extent of the potential principal threat waste, through direct injection of a suitable carbon substrate (e.g., emulsified vegetable oil) and, if necessary, a microbial culture into shallow groundwater. The microbial culture may be necessary if it is determined through groundwater performance monitoring that an appropriate population of reductive dechlorinators is not present at the site to prevent the accumulation of cis-1,2-DCE and vinyl chloride. The introduced substrate will serve multiple purposes: depleting competing electron acceptors, creating strongly reducing conditions, and producing an electron donor source for reductive dechlorination. Following im plementation of ERD, groundwater performance monitoring will be conducted to evaluate the effectiveness of ERD and confirm that favorable geochemical conditions are established and maintained for dechlorinating microorganisms to facilitate degradation of chlorinated VOCs. If the evaluation of groundwater monitoring data, which will be conducted annually, determines that favorable geochemical conditions are no longer present for reductive dechlorination, subsequent rounds of ERD may be injected. If necessary, as treatment progresses and the concentrations of COCs and their daughter products change, the type and quantity of substrate, frequency of injection, and the location of injection may be revised to address current site conditions. In addition to the annual evaluation, the need for additional action to achieve the cleanup levels will be evaluated and documented during CERCLA Five-Year Reviews.

MNA of Low-Concentration, Naphthalene, and Heptachlor Epoxide Target Areas of Shallow Groundwater

Because the shallow groundwater conditions are conducive to **natural degradation of contamination**[24], MNA will be implemented to address the low-concentration, naphthalene, and heptachlor epoxide target areas. MNA is a passive treatment that relies on physical (dilution, volatilization, and adsorption), biological (aerobic and anaerobic biodegradation), and chemical processes (abiotic transformation) to naturally reduce the toxicity, mobility, volume, and mass, or concentration of contaminants.

Natural attenuation of chlorinated VOCs includes biological reductive dechlorination. Based upon the presence of degradation products at Site 2 (cis-1,2-DCE, vinyl chloride, ethene, and ethane) complete dechlorination of TCE has been occurring and is expected to continue. Naphthalene can be used as an electron donor source under aerobic and anaerobic conditions and is ultimately mineralized to carbon dioxide. The rate of naphthalene biodegradation is impacted by the extent of sorption and available electron acceptors. Heptachlor epoxide attenuation is reliant upon a combination of physical, chemical, and biological processes. It strongly sorbs to soil; therefore, it is highly retarded in groundwater and is not expected to migrate. Therefore, even though anaerobic biodegradation and abiotic photolysis rates are generally very low in the environment, contaminant mobility is reduced, allowing these processes to reduce contaminant mass without plume migration.

Land Use Controls

Throughout implementation of the remedy, the Navy will implement LUCs to prevent unacceptable risks to human receptors from exposure to waste and COCs in soil and inlet sediment, as well as exposure to COCs in shallow groundwater. Waste, soil, and inlet sediment LUCs will be implemented within the waste boundary (**Figure 7**) as long as waste remains in place and/or soil and inlet sediment COC concentrations remain above cleanup levels. Shallow groundwater LUCs will be implemented within the shallow groundwater LUC boundary (**Figure 7**) until site conditions allow for unlimited use and unrestricted exposure. The waste, soil, and inlet sediment LUCs will meet the following objectives:

- Prohibit digging into or disturbing the soil cover, disposal area contents, and/or contaminated soil and inlet sediment.

The shallow groundwater LUCs will meet the following objectives:

- Prohibit activities that would result in contact with shallow groundwater except for environmental monitoring;
- Prohibit the withdrawal of shallow groundwater except for environmental monitoring;
- Prohibit construction of new buildings at the site without evaluation of potential vapor intrusion and/or ensuring vapor intrusion mitigation measures are included in building design;
- Prohibit intrusive activities that would compromise the integrity of the Yorktown confining unit; and
- Maintain the integrity of any current or future remedial or monitoring system.

The Navy will develop and submit to USEPA and VDEQ, in accordance with the Federal Facility Agreement (FFA), a Remedial Design, and an LUC Remedial Design. The LUC Remedial Design will provide for implementation and maintenance actions, including periodic inspections and reporting. The Navy will implement, maintain, monitor, report on, and enforce the LUCs according to the LUC RD.

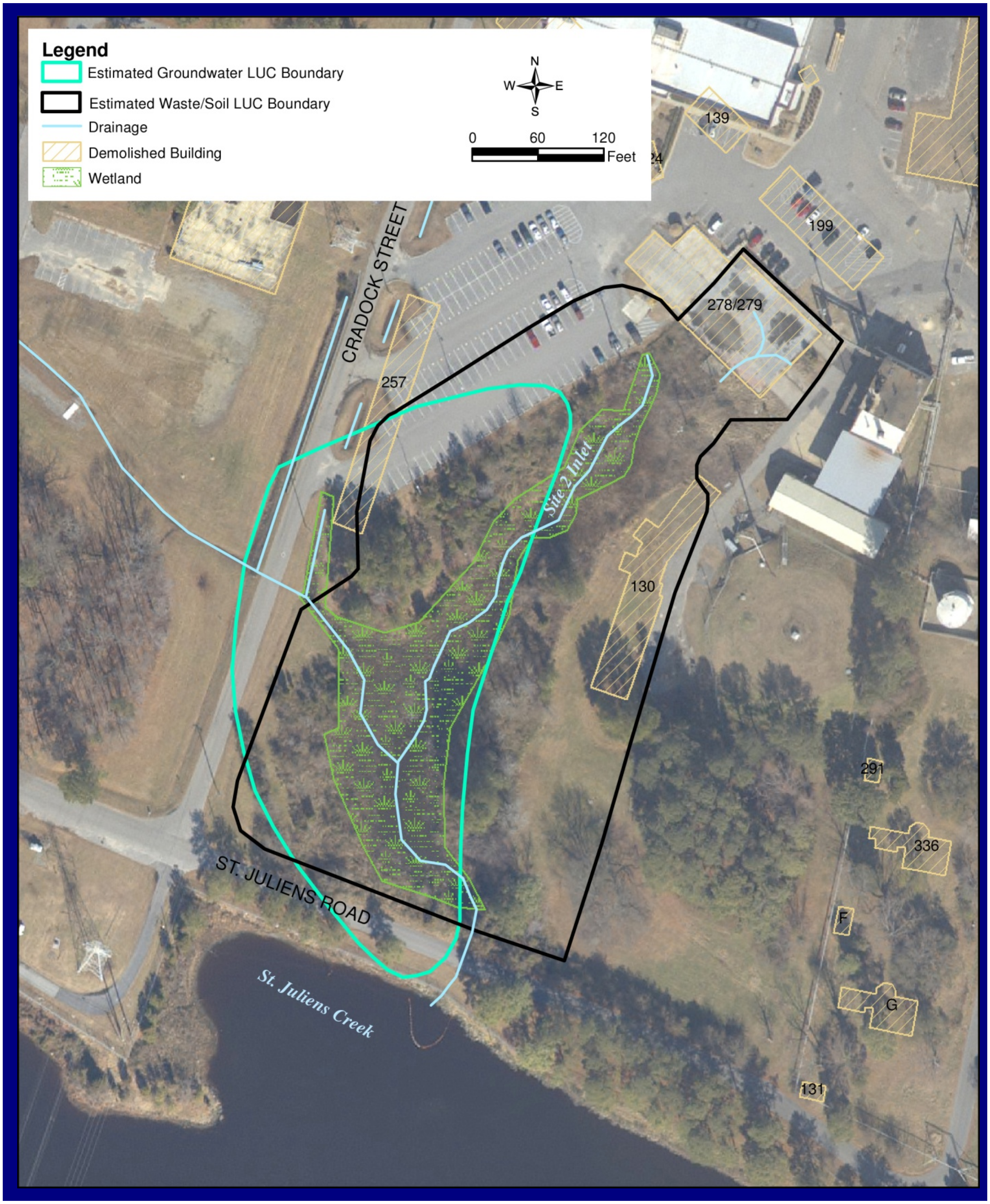
Although the Navy may transfer these responsibilities to another party by contract, property transfer agreement, or through other means, the Navy shall remain ultimately responsible for remedy integrity and shall: i) perform CERCLA Section 121(c) five-year reviews; ii) notify the appropriate regulators and/or local government representatives of any known LUC deficiencies or violations; iii) provide access to the property to conduct any necessary response; iv) retain the ability to change, modify, or terminate LUCs and any related deed or lease provisions; and, v) ensure that the LUC objectives are met to maintain remedy protectiveness.

2.11.3 Contingency Remedy

A PRB has been developed as a contingency measure for potential addition to the selected remedy. Placement of the soil cover will likely result in changes in the shallow groundwater flow over time, and in turn potential COC migration may occur. The selected remedy is protective based on current conditions, but there is uncertainty as to how conditions may change (e.g., groundwater flow trending more towards St. Juliens Creek) as the remedy is implemented. If substantial changes in COC migration trends are observed, and if the results of modeling lead to recognition of the potential for offsite migration of shallow groundwater COCs at concentrations that may result in exceedances of the surface water criteria, a contingency PRB may be installed to prevent offsite COC migration and discharge to St. Juliens Creek. As part of the remedial design, criteria for implementing the PRB will be established and will rely on several factors including, but not limited to: DAFs, site-specific groundwater and surface water flow rates, and surface water quality criteria.

If required, the PRB will be constructed along or as close as possible to the downgradient edge of the shallow groundwater plume, underground, to intercept groundwater flow and provide a preferential path through reactive materials (e.g. EOS or zero valent iron). As groundwater passes through the reactive materials contaminants are treated and transformed into harmless by-products. Throughout implementation of the PRB, groundwater performance monitoring will be conducted to evaluate the effectiveness of the PRB and confirm the degradation of chlorinated VOCs prior to offsite migration. Effectiveness will be evaluated annually and documented in groundwater monitoring reports. As treatment progresses and the concentrations of COCs and their daughter products change, the type and quantity of reactive materials and the proposed location of the PRB may be revised to address current site conditions. The need for additional action to achieve the established criteria prior to offsite migration of shallow groundwater will be evaluated and documented during the CERCLA Five-Year Reviews.

FIGURE 7
Estimated Land Use Control Boundaries



2.11.4 Summary of the Estimated Remedy Costs

Table 8 presents a cost estimate summary for implementation of the selected remedy and contingency remedy, if necessary. Detailed cost estimates are provided in the FS. The information used to develop the cost estimates is based on the best available information regarding the anticipated scope of the remedial alternative. Changes in the cost elements are likely to occur as a result of new information and data collected during the engineering design of the remedial alternative.

2.11.5 Expected Outcomes of the Selected Remedy

Current land uses are expected to continue at Site 2 and there are no other planned land uses in the foreseeable future. Cleanup levels for the selected remedy are based on unlimited use and unrestricted exposure. Exposure will be controlled through LUCs until COCs in shallow groundwater are reduced to the cleanup levels and as long as waste remains in place. Remedial activities at Site 2 will consist of the installation of a cover over waste, soil and inlet sediment, excavation and offsite disposal of contaminated sediment from St. Juliens Creek, ERD in the High-concentration Target Area, and MNA in the remaining areas. **Table 10** identifies the unacceptable human health and ecological risks for each medium, the RAO established to address the unacceptable risks, the remedy component that will be implemented to achieve the RAO, what metrics will be used to confirm the RAOs are met, and the expected outcome from implementation of the remedy components.

2.11.6 Statutory Determinations

In accordance with the NCP, the selected remedy, including the contingency remedy, if implemented, meets the following statutory requirements:

Protection of Human Health and the Environment—The selected remedy will prevent potential human health and ecological risks posed by direct contact with waste and contaminated soil and inlet sediment by means of a durable physical barrier provided by the soil cover. LUCs will ensure the soil cover is not altered or disturbed, and site use does not change. Additionally, the selected remedy will protect human health and the environment from known site risks to future receptors through groundwater treatment and performance monitoring, MNA, and LUCs to reduce COC concentrations and restrict the use of shallow groundwater until concentrations are reduced to levels that allow for unrestricted use and unlimited exposure.

Compliance with ARARs—The selected remedy will meet all identified ARARs. Federal and state ARARs for Site 2, summarized by classification, are presented in Appendix A. The classification of ARARs identified includes chemical-specific, location-specific, and action-specific requirements.

Cost-Effectiveness—The selected remedy provides the most reasonable value relative to the cost through the use of active treatment in the high-concentration target area, encompassing the estimated extent of the potential principal threat waste area, while allowing for MNA in the low-concentration, heptachlor epoxide, and naphthalene target areas.

Utilization of Permanent Solutions and Alternative Treatment Technologies or Resource Recovery Technologies to the Maximum Extent Practicable—The selected remedy represents the maximum extent to which permanent solutions and treatment technologies can be used in a practicable manner at Site 2. The selected remedy provides treatment through substrate injection that enhances dechlorination through natural microbial degradation processes to reduce contaminant mass. Because the long-term effectiveness and permanence, as well as reduction of toxicity and volume, are achieved through the selected remedy, the Navy, USEPA, and VDEQ concur that the selected remedy provides the best balance of tradeoffs in terms of the balancing criteria, while also considering the statutory preference for treatment as a principal element and considering State and community acceptance.

Preference for Treatment as a Principal Element—The selected remedy uses treatment of the high-concentration target area, which includes the estimated potential principal threat waste area, as a principal element, and, therefore, satisfies the statutory preference for treatment. The contingency remedy, if implemented, also includes treatment as a principal element.

Five-Year Review Requirements—This remedy will result in hazardous substances, pollutants, or contaminants remaining onsite above levels that allow for unlimited use and unrestricted exposure. The Navy will maintain LUCs and conduct a statutory remedy review every 5 years after initiating remedial action to ensure that the remedy continues to provide adequate protection of human health and the environment. If the remedy is determined not to be protective of human health and the environment because, for example, LUCs have failed or treatment is unsuccessful, then additional remedial actions would be evaluated by the FFA parties and the Navy may be required to undertake additional remedial action.

2.12 Documentation of Significant Changes

The Proposed Plan for Site 2 was released for public comment on May 18, 2010. General inquiries were received during the public meeting on May 18, 2010, but no comments were received requiring amendment to the Proposed Plan and no additional written comments, concerns, or questions were received from community members during the public comment period. It was determined that no significant changes to the remedy as originally identified in the Proposed Plan were necessary or appropriate.

TABLE 10
Expected Outcomes

<table>
<tr><th colspan="2">Risk</th><th rowspan="2">RAO</th><th rowspan="2">Remedy Component</th><th rowspan="2">Metric</th><th rowspan="2" colspan="2">Expected Outcomes</th></tr>
<tr><th>Human Health</th><th>Ecological</th></tr>
<tr><td colspan="7">Waste/Soil/Inlet Sediment</td></tr>
<tr><td>Ingestion of and dermal contact with waste, soil, and inlet sediment</td><td>Terrestrial plant and soil invertebrate direct exposure to surface soil; avian vermivore food web exposure to surface soil; avian piscivore food web exposure to inlet sediment</td><td>Prevent direct media contact with human and ecological receptors at concentrations that pose unacceptable risks</td><td>Soil Cover and LUCs</td><td>Periodic inspection of the integrity of the cover and confirmation of LUC adherence</td><td colspan="2">Allow for restricted industrial use</td></tr>
<tr><td>Ingestion of and dermal contact with inlet sediment</td><td>Benthic invertebrate direct exposure to inlet sediment; water column-dwelling aquatic life direct exposure to surface water; avian piscivore food web exposure to sediment</td><td>Prevent migration of contaminants through surface water runoff and erosion pathways</td><td>Soil Cover and LUCs</td><td>Periodic inspection of the integrity of the cover and confirmation of LUC adherence</td><td colspan="2">Allow for restricted industrial use</td></tr>
<tr><td colspan="2">Not applicable – RAO established to prevent future degradation of site media</td><td>Prevent or minimize transport of COCs from waste to site media</td><td>Soil Cover and LUCs</td><td>Periodic inspection of the integrity of the cover and confirmation of LUC adherence</td><td colspan="2">Allow for restricted industrial use</td></tr>
<tr><td colspan="7">St. Juliens Creek Sediment</td></tr>
<tr><td>Dermal contact with sediment</td><td>Benthic invertebrate direct exposure to sediment</td><td>Prevent direct media contact with human and ecological receptors at concentrations that pose unacceptable risks</td><td>Excavation and Offsite Disposal</td><td>Confirmation sampling to ensure the excavation of all sediment exceeding established cleanup levels</td><td colspan="2">Achieve unlimited use and unrestricted exposure</td></tr>
<tr><td colspan="7">Shallow Groundwater</td></tr>
<tr><td>Ingestion of, dermal contact with, and inhalation of chlorinated VOCs, naphthalene, and heptachlor epoxide in groundwater under future potable use scenario; dermal contact with vinyl chloride and inhalation of naphthalene in shallow groundwater in an open excavation</td><td>No exposure pathway</td><td>Reduce contaminant source mass to the maximum extent practicable</td><td>ERD</td><td>Monitor shallow groundwater COC concentrations to confirm reduction to below the calculated NAC of the aquifer</td><td colspan="2">Elimination of high-concentration target area</td></tr>
<tr><td rowspan="7">Ingestion of, dermal contact with, and inhalation of chlorinated VOCs, naphthalene, and heptachlor epoxide in groundwater under future potable use scenario; dermal contact with vinyl chloride and inhalation of naphthalene in shallow groundwater in an open excavation</td><td rowspan="7">Benthic invertebrate direct exposure to sediment pore water; water-column-dwelling aquatic life direct exposure to surface water</td><td rowspan="3">Reduce COC concentrations in shallow groundwater to the maximum extent practicable and maintain LUCs until concentrations allow for unlimited use and unrestricted exposure</td><td>ERD</td><td rowspan="2">Monitor shallow groundwater COC concentrations to confirm the natural degradation process until concentrations are below the cleanup levels</td><td rowspan="3" colspan="2">Removal of groundwater LUCs</td></tr>
<tr><td>MNA</td></tr>
<tr><td>LUCs</td><td>Periodic inspection of the site to confirm adherence to LUCs until shallow groundwater COCs are at or below their respective cleanup levels</td></tr>
<tr><td rowspan="4">Prevent COC migration from the shallow groundwater to surface water and sediment</td><td>Soil Cover and LUCs</td><td>Periodic inspection of the integrity of the cover and confirmation of LUC adherence</td><td>Elimination of the Site 2 inlet sediment, sediment pore water, and surface water exposure pathway</td><td rowspan="4">Removal of groundwater LUCs</td></tr>
<tr><td>ERD</td><td>Monitor shallow groundwater COC concentrations to confirm reduction to below the calculated NAC of the aquifer</td><td>Elimination of high-concentration target area</td></tr>
<tr><td>MNA</td><td>Monitor shallow groundwater COC concentrations to confirm the natural degradation process until concentrations are below the cleanup levels</td><td>Identify the potential for chlorinated VOC concentrations above established cleanup levels to migrate to St. Juliens Creek. Trigger implementation of potential contingency remedy component</td></tr>
<tr><td>PRB*</td><td>Monitor downgradient shallow groundwater COC concentrations to confirm concentrations are below established cleanup prior to offsite migration</td><td>Reduction of chlorinated VOC concentrations to below established clean-up levels prior to migration to St. Juliens Creek</td></tr>
<tr><td>Ingestion of, dermal contact with, and inhalation of chlorinated VOCs, naphthalene, and heptachlor epoxide in groundwater under future potable use scenario</td><td>No exposure pathway.</td><td>Prevent activities that might cause migration of COCs in the Columbia aquifer to the underlying Yorktown Aquifer</td><td>LUCs</td><td>Periodic inspection of the site to confirm adherence to LUCs until shallow groundwater COCs are at or below their respective cleanup levels</td><td colspan="2">Removal of groundwater LUCs</td></tr>
</table>

TABLE 10
Expected Outcomes

Risk: Human Health	Risk: Ecological	RAO	Remedy Component	Metric	Expected Outcomes	
Surface Water						
No unacceptable risks or hazards identified	Water-column-dwelling aquatic life direct exposure to surface water	Minimize degradation of surface water through source control in shallow groundwater, waste, surface soil, and sediment	Soil Cover and LUCs	Periodic inspection of the integrity of the cover and confirmation of LUC adherence	Elimination of the Site 2 inlet sediment, sediment pore water, and surface water exposure pathway	Removal of groundwater LUCs
			ERD	Monitor shallow groundwater COC concentrations to confirm reduction to below the calculated NAC of the aquifer	Elimination of high-concentration target area	
			MNA	Monitor shallow groundwater COC concentrations to confirm the natural degradation process until concentrations are below the cleanup levels	Identify the potential for chlorinated VOC concentrations above established cleanup levels to migrate to St. Juliens Creek. Trigger implementation of potential contingency remedy component	
			PRB*	Monitor downgradient shallow groundwater COC concentrations to confirm concentrations are below established criteria prior to offsite migration	Reduction of chlorinated VOC concentrations to below established criteria prior to migration to St. Juliens Creek	

* The PRB is a contingency remedy component that will be implemented if site conditions and the results of modeling indicate chlorinated VOCs could migrate offsite at concentrations that may exceed surface water criteria.

3 Responsiveness Summary

The participants in the public meeting held on May 18, 2010 included representatives of the Navy, USEPA, and VDEQ. Two community members attended the meeting. Questions received during the public meeting were general inquiries and are described in the public meeting minutes in the Administrative Record. There were no comments received at the public meeting requiring amendment to the Proposed Plan and no additional written comments, concerns, or questions were received from community members during the public comment period.

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Appendix A
ARARs

TABLE A-1
Federal Chemical-Specific ARARs
Site 2 ROD
St. Juliens Creek Annex
Chesapeake, Virginia

Media	Requirement	Prerequisite	Citation*	ARAR Determination	Comment
Safe Drinking Water Act					
Groundwater	SDWA standards serve to protect public water systems. Primary drinking water standards consist of federally enforceable MCLs. MCLs are the highest level of a contaminant that is allowed in drinking water.	Groundwater contamination exceeds MCLs and background levels. Cleanup to MCLs for the contaminants presenting Human Health Risk is driven by EPA's and the state's expectations to clean up groundwater for beneficial use.	40 CFR 141.61(a)(1), (5), (7) and (9)	Relevant and Appropriate	These remedial actions are being implemented with the goal of achieving MCLs. However, the aquifer is not currently, nor reasonably anticipated in the future to be, used as a potable water supply.

*Federal Chemical-Specific ARARs are the substantive requirements found within the referenced citations.

TABLE A-2
Virginia Chemical-Specific ARARs
Site 2 ROD
St. Juliens Creek Annex
Chesapeake, Virginia

Media	Requirement	Prerequisite	Citation*	ARAR Determination	Comment
State Water Control Law [VA Code Ann. §§ 62.1-44.2 to 62.1-44.34:28 (2003)]					
Groundwater	Establishes antidegradation policy to support groundwater quality standards to protect the public health or welfare and enhance the quality of water.	Groundwater is addressed in the remedy	*Groundwater Quality Standards*, 9 VAC 25-280-30	Applicable	These remedial actions are being implemented with the goal of achieving MCLs. A baseline HHRA has been performed to calculate site specific risks and was used in the development of PRGs in the event that MCLs were not available for a constituent of concern. The aquifer is not currently, or reasonably anticipated to be, used as a potable water supply.

*Virginia Chemical-Specific ARARs are the substantive requirements found within the referenced citations.

TABLE A-3
Federal Location-Specific ARARs
Site 2 ROD
St. Juliens Creek Annex
Chesapeake, Virginia

Location	Requirement	Prerequisite	Citation*	ARAR Determination	Comment
Clean Water Act					
Wetlands	Avoid adverse effects, minimize potential harm, and preserve and enhance wetlands, to the extent possible. Mitigate and/or compensate for lost wetland when avoidance of adverse effects is not feasible.	Action involving construction of facilities or management of property in wetlands. Wetland as defined by Executive Order 11990 Section 7 (protection of Wetlands).	40 CFR 230.75(d); *Clean Water Act,* §404 (b)(1) Guidelines	Applicable	Construction of a cover will require fill material to be placed over existing wetland areas and will therefore require compensatory mitigation of wetlands. Activities undertaken entirely on a CERCLA site by authority of CERCLA as approved or required by USEPA, are not required to obtain permits under Section 404 of the Clean Water Act or Section 10 of the Rivers and Harbors Act. They are, however, required to meet the intent of the permit.
Coastal Zone Management Act					
Coastal zone or area that will affect the coastal zone	Federal activities must be consistent, to the maximum extent practicable, with State coastal zone management programs.	Wetland, flood plain, estuary, beach, dune, barrier island, coral reef, and fish and wildlife and their habitat, within the coastal zone.	*Coastal Zone Management Act*, 16USC1456(c)(1)(A), 15 CFR 930.30 to .33, .36(a)	Relevant and Appropriate	Site 2 is excluded from the coastal zone as lands held in trust by the Federal Government are exempt. A consistency determination is not required where a remedial action is carried out in compliance with CERCLA.
Migratory Bird Treaty Act					
Migratory bird area	Protects almost all species of native birds in the United States from unregulated taking.	Presence of migratory birds.	*Migratory Bird Treaty Act*, 16 USC 703	Applicable	Site 2 is located in the Atlantic Migratory Flyway. If migratory birds, or their nests or eggs, are identified at Site 2, operations will not destroy the birds, nests or eggs.

*Federal Location-Specific ARARs are the substantive requirements found within the referenced citations.

TABLE A-4
Virginia Location-Specific ARARs
Site 2 ROD
St. Juliens Creek Annex
Chesapeake, Virginia

Location	Requirement	Prerequisite	Citation*	ARAR Determination	Comment
General Provisions Relating to Marine Resources Commission [VA Code Ann. §§ 28.2-1300 to 1320 (1998)]					
Wetlands	Mitigate or minimize the loss of wetlands and the adverse ecological effects of all permitted activities. To preserve the wetlands as much as possible in their natural state and to consider appropriate requirements for compensation only after it has been proven that the loss of the natural resource is unavoidable and that the project will have the highest public and private benefit. The determination as to whether compensation is warranted and permissible is conducted on a case-by-case basis. Commitments to preserve other existing wetlands shall not ordinarily be an acceptable form of compensation.	If a wetlands zoning ordinance has been adopted by local government, in accordance with the *General Provisions Relating to Marine Resources Commission*, and the response action is not exempt from its provisions, the project must comply with the requirements of the ordinance. In the case of absence of an ordinance, or of an exemption to it, VMRC can exercise jurisdiction over tidal wetlands.	*Wetlands Mitigation Compensation Policy*, 4 VAC 20-390-30 to 50	Applicable	Wetlands are present at Site 2, and construction of a cover will require fill material to be placed over existing wetland areas. Compensation or mitigation will be determined based on this regulation.

*Virginia Location-Specific ARARs are the substantive requirements found within the referenced citations.

TABLE A-5
Federal Action-Specific ARARs
Site 2 ROD
St. Juliens Creek Annex
Chesapeake, Virginia

Action	Requirement	Prerequisite	Citation*	ARAR Determination	Comment
Clean Water Act					
Discharge of dredge-and-fill	No discharge of dredged or fill material will be allowed unless appropriate and practicable steps are taken that minimize potential adverse impacts of the discharge on the aquatic ecosystem.	Discharges of dredged or fill material to surface waters, including wetlands.	40 CFR 230.2(b), .10, .20, .25, .31, .32, .41-.42, .53, .60. .61, .70(f), .72, .74(a),(b), and (e), .75(b) and (d); 33 CFR 320.4(a)-(d), (h), (m), (p), and (r)	Applicable	Construction of a cover will require fill material to be placed over existing wetland areas.
Safe Drinking Water Act					
Underground injection	Regulates the subsurface emplacement of liquids through the Underground Injection Control program, which governs the design and operation of five classes of injection wells in order to prevent contamination of underground sources of drinking water. The Underground Injection Control program regulates well construction, well operation, and monitoring.	Any dug hole or well that is deeper than its largest surface dimension, where the principal function of the hole is in subsurface placement of fluids.	40 CFR 144.1(g), 144.6, 144.12(a) and (c), 144.24(a), 144.82-.84, 146.8, 146.10(c)	Applicable	These remedial actions will include substrate injections. Permits are not applicable to on-site CERCLA injection wells; however, these remedial actions will comply with the substantive requirements of the regulation.
Toxic Substances Control Act					
PCB management	Governs many aspects of PCB management, including cleanup of spills, storage, and disposal. USEPA has also proposed PCB spill response regulations which utilize self-implementing, performance-based, and risk-based cleanup standards to address various types of PCB releases.	PCB contamination 50 ppm or greater	40 CFR 761.50 and .61	Relevant and Appropriate	PCBs are present in the soil and sediment but the results did not exceed 50 ppm. IDW generated during the remedial action will be characterized prior to disposal.

*Federal Action-Specific ARARs are the substantive requirements found within the referenced citations.

TABLE A-6
Virginia Action-Specific ARARs
Site 2 ROD
St. Juliens Creek Annex
Chesapeake, Virginia

Action	Requirement	Prerequisite	Citation*	ARAR Determination	Comment
State Water Control Law [VA Code Ann. §§ 62.1-44.2 to 62.1-44.34:28 (2003)]					
Dredging, filling, and/or discharging pollutants into, or adjacent to, surface waters (including wetlands)	Permitting requirements in addition to complying with USACE requirements (Nationwide Permits) and *Virginia Wetlands Mitigation Policy*. Administered by VDEQ.	Activities requiring a permit include dredging, filling, or discharging any pollutant into or adjacent to surface waters, or otherwise altering the physical, chemical or biological properties of surface waters, excavating in wetlands, or conducting the following activities in a wetland: 1. New activities to cause draining that significantly alters or degrades existing wetland acreage or functions. 2. Filling or dumping. 3. Permanent flooding or impounding. 4. New activities that cause significant alteration or degradation of existing wetland acreage or functions. This would include any project that requires a *Clean Water Act* Section 404 permit or a R*ivers and Harbors Act* Section 10 permit, or a water withdrawal that also requires a Section 404 permit or a Federal Energy Regulatory Commission license or license re-issuance, as well as the same projects that do not require a Federal permit.	*Virginia Water Protection Permit Program Regulation*, 9 VAC 25-210-45, 50, and 116	Applicable	Construction of a cover will require fill material to be placed over existing wetland areas. Since this is an onsite CERCLA response action, the substantive requirements will be met, but a permit will not be required.

TABLE A-6
Virginia Action-Specific ARARs
Site 2 ROD
St. Juliens Creek Annex
Chesapeake, Virginia

Action	Requirement	Prerequisite	Citation*	ARAR Determination	Comment
Surface water	Mandates the protection of existing high-quality state waters and provides for the restoration of all other state waters so they will permit reasonable public uses and will support the growth of aquatic life. Water quality standards consist of statements that describe water quality requirements. They also contain numeric limits for specific physical, chemical, biological or radiological characteristics of water. These statements and numeric limits describe water quality necessary to meet and maintain uses such as swimming and other water-based recreation, public water supply, and the propagation and growth of aquatic life.	State surface waters designated for aquatic life or human uses. New surface water discharge point created as a result of the remedial action.	*Water Quality Standards*, 9 VAC 25-260 20(A) and 30	Applicable	These remedial actions will include the excavation and offsite disposal of St. Juliens Creek sediment. Additionally, the soil cover will eliminate surface water at Site 2 (Site 2 inlet). Although placement of the soil cover may alter the flow of shallow groundwater contaminants towards St Juliens Creek, the remedy is expected to prevent the offsite migration of contaminants.
Construction and maintenance development activities	Establishes general permit number WP4 to govern impacts related to the construction and maintenance of development activities, and activities directly associated with mining.	Activities requiring a permit include dredging, filling, or discharging any pollutant into or adjacent to surface waters, or otherwise altering the physical, chemical or biological properties of surface waters, excavating in non-tidal wetlands, or conducting the following activities in a non-tidal wetland: 1. New activities to cause draining that significantly alters or degrades existing non-tidal wetland acreage or functions. 2. Filling or dumping. 3. Permanent flooding or impounding. 4. New activities that cause significant alteration or degradation of existing non-tidal wetland acreage or functions. This would include any project that requires a *Clean Water Act* Section 404 permit or a *Rivers and Harbors Act* Section 10 permit, or a water withdrawal that also requires a Section 404 permit or a Federal Energy Regulatory Commission license or license re-issuance, as well as the same projects that do not require a Federal permit.	*Virginia Water Protection General Permit for Impacts from Development Activities Regulation*, 9 VAC 25-690-70 and 100	Relevant and Appropriate	Construction of a cover will require fill material to be placed over existing tidal wetland areas.

TABLE A-6
Virginia Action-Specific ARARs
Site 2 ROD
St. Juliens Creek Annex
Chesapeake, Virginia

Action	Requirement	Prerequisite	Citation*	ARAR Determination	Comment
Erosion and Sediment Control Law [VA Code Ann. §§ 10.1-560 to 571 (2003)]					
Construction activities that disturb at least 10,000 sq ft of land.	Regulations for the effective control of soil erosion, sediment deposition and nonagricultural runoff which must be met in any control program to prevent the unreasonable degradation of properties, stream channels, waters and other natural resources.	Construction activities that disturb at least 10,000 sq ft of land.	Erosion and Sediment Control Regulations, 4 VAC 50-30-40, 60	Applicable	Erosion and sediment control measures will be followed for the implementation of remedial activities.
Air Pollution Control Board [VA Code Ann. §§ 10.1-1300 to 1328 (1998)]					
Fugitive Dust caused by O&M or construction activities	Reasonable precautions will be taken to prevent particulate matter from becoming airborne.	Fugitive Dust emission from disturbance of soil, treatment of soil or water, or other pollutant management activities.	*Standards for Fugitive Dust/Emissions* 9 VAC 5-50-90	Applicable	No discharges to air are anticipated other than fugitive dust during excavation or filling activities.
Storm water Management Act [VA Code Ann. §§ 10.1-603.1 to 603.15 (2001)]					
O&M and construction activities that disturb one acre or more of land.	Procedures and requirements to be followed in connection with stormwater management and erosion/sedimentation control practices for land disturbing activities.	O&M or construction activities that disturb one acre or more of land.	*Stormwater Management Regulations,* 4 VAC 50-60-30, 50 to 80, 300, 310, 420, 430, 1100 to 1140, 1160, 1170, 1182 to 1188	Relevant and Appropriate	As a result of the potential for storm water runoff during construction, a storm water management program may be required.

TABLE A-6
Virginia Action-Specific ARARs
Site 2 ROD
St. Juliens Creek Annex
Chesapeake, Virginia

Action	Requirement	Prerequisite	Citation*	ARAR Determination	Comment
Virginia Waste Management Act [VA Code Ann. §§ 10.1-1400 to 1457 (2004)]					
Handling, storage, treatment, disposal, and/or transportation of hazardous waste	Wastes to be managed must be sampled for TCLP analyses to determine the appropriate waste characterization. TCLP regulatory levels and definition of RCRA hazardous waste.	Management of wastes that meet the definition of hazardous waste.	*Hazardous Waste Regulations*, 9 VAC 20-60-262 (incorporating 40CFR Parts 262.11 and 262.34 (generator requirements); Solid Waste Management Regulations, 9 VAC 20-80-140, 150, 240.(c)	Applicable	These remedial actions will generate water and soil IDW which will be characterized for offsite disposal. Based on site history, some IDW may be characterized as hazardous waste. If characterization results indicate this material is hazardous, it will be disposed of accordingly.
State Board of Health [VA Code Ann. §§ 32.1-12 and 21.1-176 (1992)]					
Monitoring Well Abandonment	Establishes requirements for the abandonment of observation and monitoring wells, governed jointly by the State Board of Health and Department of Environmental Quality.	Observation or monitoring wells must be properly abandoned in accordance with Virginia regulations within 90 days of cessation of use to prevent contamination from reaching ground water resources via the well.	*Private Well Regulations,* 12 VAC 5-630-420(c) and 450 (c)(1),(2),(4),(5), and (7) to (9)	Applicable	Monitoring wells will be abandoned in accordance with the Virginia regulations.

*Virginia Action-Specific ARARs are the substantive requirements found within the referenced citations.

TABLE A-7
Acronyms and Abbreviations
Site 2 ROD
St. Juliens Creek Annex
Chesapeake, Virginia

ARAR	Applicable or relevant and appropriate requirement	SDWA	Safe Drinking Water Act
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act	TCLP	Toxicity Characteristic Leaching Procedure
CFR	Code of Federal Regulations	USACE	US Army Corps of Engineers
IDW	Investigation derived waste	USC	United States Code
MCL	Maximum Contaminant Level	USEPA	United States Environmental Protection Agency
PCB	Polychlorinated biphenyls	VA	Virginia
ppm	Parts per Million	VAC	Virginia Administrative Code
RCRA	Resource Conservation and Recovery Act	VMRC	Virginia Marine Resource Commission

References

Commonwealth of Virginia, 2004. Preliminary Identification, Applicable or Relevant and Appropriate Requirements.

USEPA, 1998. *CERCLA Compliance with Other Laws Manual: Interim Final*. Office of Emergency and Remedial Response. EPA/540/G-89/006.

USEPA, 1998. *CERCLA Compliance with Other Laws Manual: Part II. Clean Air Act and Other Environmental Statutes.* Office of Emergency and Remedial Response. EPA/540/G-89/009.

USEPA, 1998. RCRA, Superfund & EPCRA Hotline Training Manual. Introduction to Applicable or Relevant and Appropriate Requirements. EPA540-R-98-020.

Appendix B
Acronyms and Abbreviations

Acronyms and Abbreviations

ABM	abrasive blast material
AOC	area of concern
ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
COC	chemical of concern
CSM	conceptual site model
CTE	central tendency exposure
DCE	dichloroethene
DNAPL	dense non-aqueous phase liquid
ECD	electron capture device
EOS	emulsified oil substrate
ERD	enhanced reductive dechlorination
ERI	Expanded Remedial Investigation
ERP	Environmental Restoration Program
FFA	Federal Facilities Agreement
FS	Feasibility Study
HHRA	Human Health Risk Assessment
HI	hazard index
HQ	hazard quotient
IAS	Initial Assessment Study
LOAEL	Lowest Observed Adverse Effects Level
LUC	land use control
µg/kg	micrograms per kilogram
µg/L	micrograms per Liter
MATC	Maximum Acceptable Threshold Concentration
MCL	maximum contaminant level
MEC	munitions and explosives of concern
MNA	monitored natural attenuation
NAC	natural attenuation capacity
NAPL	non-aqueous phase liquid
Navy	Department of the Navy
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NOAEL	No Observed Adverse Effects Level
NPL	National Priorities List
O&M	operation and maintenance
PA	Preliminary Assessment
PAH	polyaromatic hydrocarbon
PCB	polychlorinated biphenyls
PRB	permeable reactive barrier

PRG	preliminary remediation goals
RAB	Restoration Advisory Board
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RI	Remedial Investigation
RME	reasonable maximum exposure
ROD	Record of Decision
RRR	Relative Risk Ranking
SARA	Superfund Amendments and Reauthorization Act
SI	site investigation
SJCA	St. Juliens Creek Annex
SMP	Site Management Plan
SVOC	semi-volatile organic compound
SWMU	solid waste management units
TCE	trichloroethene
USEPA	United States Environmental Protection Agency
VC	vinyl chloride
VDEQ	Virginia Department of Environmental Quality
VOC	volatile organic compound
VWQS	Virginia Water Quality Standards
yd^3	cubic yards

References

Item	Reference Phrase in ROD	Location in ROD	Identification of Referenced Document Available in the Administrative Record
1	**Site Management Plan**	Section 1.2	CH2M HILL. 2010. *Site Management Plan Fiscal Years 2011 through 2015. St. Juliens Creek Annex, Chesapeake, Virginia.*
2	**Site 17**	Section 2.2	CH2M HILL. 2008, Revised. *Expanded Remedial Investigation Report for Site 2, St. Juliens Creek Annex, Chesapeake, Virginia.* Section 2.3.7.
3	**Site visits**	Section 2.2	A.T. Kearney, Inc. and K.W. Brown and Associates, Inc., 1989. *Phase II RCRA Facility Assessment of the St. Juliens Creek Annex Facility, Chesapeake, Virginia.* Section 4.
4	**vapor intrusion**	Section 2.2, Table 1	CH2M HILL. 2008, Revised 2010. *Expanded Remedial Investigation Report for Site 2, St. Juliens Creek Annex, Chesapeake, Virginia.* Section 7.4.2.
5	**COCs in soil, shallow groundwater, sediment, and surface water**	Section 2.2, Table 1	CH2M HILL. 2009, Revised 2010. *Final Feasibility Study Report for Site 2, St. Juliens Creek Annex, Chesapeake, Virginia.* Section 2 (including Table 2-1).
6	**no further evaluation of deep groundwater**	Section 2.2, Table 1	CH2M HILL. 2008, Revised 2010. *Expanded Remedial Investigation Report for Site 2, St. Juliens Creek Annex, Chesapeake, Virginia.* Section 10.3.
7	**DNAPL**	Section 2.5.1	CH2M HILL. 2008, Revised 2010. *Expanded Remedial Investigation Report for Site 2, St. Juliens Creek Annex, Chesapeake, Virginia.* Section 5.1.6.
8	**beneficial uses**	Section 2.6	USEPA. 1994. *National Oil and Hazardous Substances Pollution Contingency Plan.* 40 CFR 300.430 (a) (1)(iii)(f). VA. Code § 62.1-44.2.
9	**potential human health risks**	Section 2.7.1	CH2M HILL. 2008. *Expanded Remedial Investigation Report for Site 2, St. Juliens Creek Annex, Chesapeake, Virginia.* Appendix M, Table 9s.
10	**current receptor**	Section 2.7.1	CH2M HILL. 2008, Revised 2010. *Expanded Remedial Investigation Report for Site 2, St. Juliens Creek Annex, Chesapeake, Virginia.* Table 7.3.
11	**hypothetical future receptor**	Section 2.7.1	CH2M HILL. 2008, Revised 2010. *Expanded Remedial Investigation Report for Site 2, St. Juliens Creek Annex, Chesapeake, Virginia.* Table 7.3.
12	**exposure scenarios**	Section 2.7.1	CH2M HILL. 2008, Revised 2010. *Expanded Remedial Investigation Report for Site 2, St. Juliens Creek Annex, Chesapeake, Virginia.* Table 7.3.

Item	Reference Phrase in ROD	Location in ROD	Identification of Referenced Document Available in the Administrative Record
13	**potential risks**	Section 2.7.2	CH2M HILL. 2008, Revised 2010. *Expanded Remedial Investigation Report for Site 2, St. Juliens Creek Annex, Chesapeake, Virginia.* Table 8s.
14	**ecological receptors**	Section 2.7.2	CH2M HILL. 2008, Revised 2010. *Expanded Remedial Investigation Report for Site 2, St. Juliens Creek Annex, Chesapeake, Virginia.* Table 8.2.
15	**urbanized soil and sediment**	Section 2.7.2	CH2M HILL. 2008, Revised 2010. *Expanded Remedial Investigation Report for Site 2, St. Juliens Creek Annex, Chesapeake, Virginia.* Section 8.3.3.
16	**preliminary remediation goals**	Section 2.8	CH2M HILL. 2009, Revised 2010. *Final Feasibility Study Report for Site 2. St. Juliens Creek Annex, Chesapeake, Virginia.* Section 3.2.1 (including Tables 3-1 and 3-6) and Appendix A.
17	**natural attenuation capacity**	Section 2.9	CH2M HILL. 2008, Revised 2010. *Expanded Remedial Investigation Report for Site 2, St. Juliens Creek Annex, Chesapeake, Virginia.* Section 6.3.
18	**screening of technologies**	Section 2.9.1	CH2M HILL. 2009, Revised 2010. *Final Feasibility Study Report for Site 2. St. Juliens Creek Annex, Chesapeake, Virginia.* Section 4.1 and Table 4.1.
19	**nine evaluation criteria**	Section 2.9.2	CH2M HILL. 2009, Revised 2010. *Final Feasibility Study Report for Site 2. St. Juliens Creek Annex, Chesapeake, Virginia.* Section 5.2.
20	**qualitative comparative analysis ratings**	Section 2.11.5	CH2M HILL. 2009, Revised 2010. *Final Feasibility Study Report for Site 2. St. Juliens Creek Annex, Chesapeake, Virginia.* Table 5-2.
21	**ARARs**	Section 2.9.2	CH2M HILL. 2009, Revised 2010. *Final Feasibility Study Report for Site 2. St. Juliens Creek Annex, Chesapeake, Virginia.* Appendix B.
22	**estimated capitol costs**	Section 2.9.2	CH2M HILL. 2009, Revised 2010. *Final Feasibility Study Report for Site 2. St. Juliens Creek Annex, Chesapeake, Virginia.* Appendix C.
23	**total present values**	Section 2.9.2	CH2M HILL. 2009, Revised 2010. *Final Feasibility Study Report for Site 2. St. Juliens Creek Annex, Chesapeake, Virginia.* Appendix C.
24	**natural degradation of contamination**	Section 2.11.2	CH2M HILL. 2008, Revised 2010. *Expanded Remedial Investigation Report for Site 2, St. Juliens Creek Annex, Chesapeake, Virginia.* Section 6.1.3.

Detailed site information referenced in this ROD in bold blue text is contained in the Administrative Record.

For access to information contained in the Administrative Record for SJCA please contact:

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