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FINAL SITE 5 SUPPLEMENTAL REMEDIAL INVESTIGATION REPORT ST JULIENS CREEK ANNEX VA
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CH2M HILL

Final

Site 5 Supplemental Remedial Investigation Report

St. Juliens Creek Annex
Chesapeake, Virginia

Contract Task Order WE92

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Prepared by

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Acronyms and Abbreviations

amsl	above mean sea level
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	constituent of concern
COPC	constituent of potential concern
CTE	central tendency exposure
DO	dissolved oxygen
ELCR	excess lifetime cancer risk
ERP	Environmental Restoration Program
HHRA	Human Health Risk Assessment
HI	hazard index
IDW	investigation-derived waste
IEUBK	Integrated Exposure Update Biokinetic
mg/kg	milligrams per kilogram
µg/L	micrograms per liter
mg/L	milligrams per liter
MCL	Maximum Contaminant Level
NAVFAC	Naval Facilities Engineering Command
Navy	Department of the Navy
NFA	no further action
NTCRA	Non-time-critical Removal Action
QA	quality assurance
QC	quality control
RI	Remedial Investigation
RME	reasonable maximum exposure
SJCA	St. Juliens Creek Annex
UFP-SAP	Uniform Federal Policy Sampling and Analysis Plan
UL	upper intake level
USEPA	United States Environmental Protection Agency
UTL	upper tolerance limit
VDEQ	Virginia Department of Environmental Quality

SECTION 1
Introduction

This report summarizes the Supplemental Remedial Investigation (RI) that was conducted for Environmental Restoration Program (ERP) Site 5—Burning Grounds, at St. Juliens Creek Annex (SJCA), Chesapeake, Virginia. The Supplemental RI was performed in compliance with the Uniform Federal Policy Sampling and Analysis Plan (UFP-SAP) (Agviq-CH2M HILL, 2014).

The overall objective of the Supplemental RI is to determine whether the current concentrations of the shallow aquifer groundwater constituents of concern (COCs) pose unacceptable risk, and if so, whether they are the result of a Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) release that requires remedial action. The following approach was developed in order to achieve the objective:

- Conduct a primary sampling event, consisting of groundwater and surface water data collection.
  - Collect one round of groundwater samples from the four existing shallow aquifer monitoring wells at Site 5 and four of the SJCA background monitoring wells. These background wells were selected because they are nearest to the site, reflect upgradient conditions, and/or are in locations that have similar characteristics to Site 5.
    - Analyze the groundwater samples for the total and dissolved select metals that were identified as COCs in the shallow aquifer groundwater in the 2007 Expanded RI Addendum human health risk assessment (HHRA) (aluminum, arsenic, beryllium, cadmium, iron, lead, manganese, thallium, and vanadium) (CH2M HILL, 2007a) and the additional COCs identified in the updated 2013 risk calculations (chromium and cobalt) (Agviq-CH2M HILL, 2014). Speciate chromium (that is, analyze for total and hexavalent chromium).
    - In order to help determine the cause of any elevated metals, analyze the samples for the following wet chemistry parameters: pH, acidity, anions (sulfate, chloride, total phosphorus, and nitrate), and dissolved organic carbon. Collect field measurements for water quality parameters at the monitoring wells that are sampled, including pH and specific conductivity.
  - Collect a field pH measurement from one location in the wetland area adjacent to the low pH groundwater area and one location downgradient of the low pH groundwater area to help determine the cause of the low pH in groundwater.
- Calculate human health risks using the metals data collected during the primary event to determine if current metals concentrations pose potential unacceptable risks. If any unacceptable risks are identified, conduct an evaluation using multiple lines of evidence to determine if the risks are the result of a CERCLA release.
- Conduct a contingency sampling event if there are unacceptable risks that warrant further action (taking into consideration multiple lines of evidence evaluation) and data are not adequate to define the extent of the impacted groundwater and/or support development and evaluation of remedial action options.

This report presents the field activities, analytical results, and data evaluation for the Supplemental RI. This report was prepared for Naval Facilities Engineering Command (NAVFAC) Mid-Atlantic under Contract Number N62470-11-D-8012, Contract Task Order WE92, for submittal to NAVFAC Mid-Atlantic, United States Environmental Protection Agency (USEPA), and Virginia Department of Environmental Quality (VDEQ).

SECTION 2

Site Background

2.1 St. Juliens Creek Annex

The SJCA facility is approximately 490 acres and is situated at the confluence of St. Juliens Creek and the Southern Branch of the Elizabeth River in the City of Chesapeake, in southeastern Virginia (**Figure 2-1**). SJCA began operations as a naval facility in 1849. The annex was one of the largest ammunition depots in the United States involving wartime transfer of ammunitions to various other naval facilities. Specific ordnance operations and processes conducted at SJCA included stockpiling Explosive D (ammonium picrate, which was received in lined boxes from the manufacturer) for use in projectiles, manufacturing Mark VI mines, assembling small caliber guns and ammunition, storing torpedoes, filling shells, and testing ordnance. In 1975, all ordnance operations were transferred to the Yorktown Naval Weapons Station. As a result, decontamination was performed in, around, and under ordnance-handling facilities at SJCA in 1977.

SJCA also has been involved in non-ordnance operations, including degreasing operations; paint, machine, vehicle and locomotive maintenance; pest control; battery, print, and electrical shop operations; boiler plant operations; wash rack operations; potable water and salt water fire-protection systems; fire-fighter training operations; and storage of oil and chemicals. The battery shop was located in Building 102 and later in Building 279, both of which are outside of Site 5.

Activity at SJCA has decreased and many of the older structures are being demolished. The current primary mission of SJCA is to provide a radar-testing range and various administrative and warehousing facilities and light industrial shops for nearby Norfolk Naval Shipyard and other local naval activities. Defense Reutilization and Marketing Office storage; Space and Naval Warfare Systems Command; Fleet and Industrial Supply Center, Norfolk Integrated Logistics Support; and a cryogenics school are currently located within SJCA.

2.2 Site 5

Site 5 encompasses an area of approximately 23 acres in the northeastern portion of SJCA (**Figure 2-1**). Currently, the site is seldom used; use is primarily associated with radar testing. Operations began at the Burning Grounds in the 1930s when waste ordnance materials were disposed of by open burning on three main pads. Additional debris, such as large steel plates and metal from buildings, were also disposed of at the site. In mid-1977, the site was used for facility-wide ordnance equipment and material decontamination, which included filling equipment with oil and straw and burning it. After the decontamination process, the ground was covered with oil and straw, burned, disced, and burned again; samples were then collected to certify decontamination was complete. Historical aerial photographs indicated that prior to its use as a burning ground and disposal area, Site 5 and much of the adjacent area had been used for placement of dredge spoil material that reportedly originated from Blows Creek and the Southern Branch of the Elizabeth River. Site 6, a former ERP site that was closed under a no further action (NFA) Record of Decision in September 2003, is located within the east-central portion of Site 5 (**Figure 2-1**).

2.2.1 Summary of Site 5 Environmental Activities Conducted Prior to the Supplemental Remedial Investigation

Table 2-1 summarizes the environmental activities conducted at Site 5 prior to this investigation. Activities that have taken place since the Expanded RI Addendum are also summarized below.

A non-time critical removal action (NTCRA) was conducted based on the removal action alternatives evaluated in the Engineering Evaluation/Cost Analysis (CH2M HILL, 2007b) and as documented in the Action Memorandums (CH2M HILL, 2007c; CH2M HILL, 2010). NTCRA activities began in January 2008 and were completed in July 2012. The NTCRA consisted of source removal through excavation and offsite disposal of waste/burnt soil and impacted soil and sediment with COC concentrations exceeding the cleanup goals.

The limits of excavation (**Figure 2-2**) varied across the site based on the type of media and whether the NTCRA was driven by human health or ecological risks. The horizontal and vertical extents of excavation in the waste/burnt soil area, which was assumed to pose potential human health risk, were determined based on visual inspection during the NTCRA and confirmation sampling for human health COCs (arsenic, copper, and lead). The human health risk-based areas outside of the waste/burnt soil area were excavated to a depth of 1 foot followed by confirmation sampling for the human health COCs. Confirmation sample results confirmed the excavations were adequate and that the cleanup goals were met. The ecological risk-based areas were excavated to a depth of 1 foot and did not require confirmation sampling. Confirmation sampling was not required because previously collected surface soil and sediment samples indicated that the site-wide average ecological COC concentrations that would remain following the NTCRA would be at acceptable risk levels (CH2M HILL, 2007b; CH2M HILL, 2010).

A total of 32,960 tons of waste and contaminated soil and sediment was disposed of. The site was restored with off-site borrow material and graded to provide positive stormwater drainage and prevent ponding. The off-site borrow material was sampled; analyzed for metals, semi-volatile organic compounds, pesticides, polychlorinated biphenyls, benzene, toluene, ethylbenzene, xylene, and total petroleum hydrocarbons; and approved by the Facilities Engineering and Acquisition Division prior to use on site (Agviq-CH2M HILL, 2012). Topsoil was placed and then seeded in disturbed grass areas, and wetland vegetation was replanted in the pre-existing wetland area, to return Site 5 to the same hydrologic, topographic, and vegetative conditions as were present prior to the NTCRA. A Construction Completion Report (Agviq-CH2M HILL, 2012) was prepared to document the completion of the NTCRA. Based on completion of the NTCRA, the contaminant source was removed.

2.2.2 Basis for Further Investigation

Following completion of the NTCRA, which mitigated the unacceptable risks at the site that had required action through source removal of waste and contaminated soil and sediment, a NFA Proposed Plan for the site was drafted and submitted to USEPA and VDEQ for review. During the review, concerns were raised about the hazard index (HI) for exposure to cobalt in the shallow aquifer groundwater and lines of evidence that were used in the Expanded RI Addendum (CH2M HILL, 2007a) to risk manage some of the other COCs in the shallow aquifer groundwater. Based on the 2013 toxicity value for cobalt, which was much more conservative than it was at the time cobalt was risk managed, the HI for exposure to cobalt in the shallow aquifer groundwater was much higher than the HI calculated in the Expanded RI Addendum. Therefore, the human health risk calculations for shallow aquifer groundwater were recalculated using the updated toxicity values. In addition to the metals that were identified as COCs in the Expanded RI Addendum (aluminum, arsenic, beryllium, cadmium, iron, lead, manganese, thallium, and vanadium), the updated risk calculations identified chromium and cobalt as COCs (Agviq-CH2M HILL, 2014). Additional groundwater data were requested to determine if the metals that were identified as COCs in the Expanded RI Addendum and May 2013 risk calculations (Agviq-CH2M HILL, 2014) are currently present in the shallow aquifer groundwater at the site at concentrations that pose unacceptable risks, and if they are, whether they are the result of a CERCLA release.

TABLE 2-1
Studies, Investigations, and Activities Conducted at Site 5
Site 5 Supplemental Remedial Investigation Report
St. Juliens Creek Annex
Chesapeake, Virginia

Previous Study / Investigation/Activity	Purpose and Outcome
Initial Assessment Study (Naval Engineering Environmental Support Activity, 1981)	Archival records were collected and evaluated and an inspection of the site was performed. The evaluation indicated that waste ordnance disposal and equipment decontamination operations, where equipment was placed and filled with straw and oil and ignitied, were performed at the burning grounds. The visual examination of the site revealed ordnance residue, such as old cartridge ends and spacers, as well as non-ordnance residue, such as broken glass.
Phase II RCRA Facility Assessment (A.T. Kearney, Inc. and K.W. Brown and Associates, Inc., 1989)	The assessment recommended additional invesitgation due to the high potential for a release to soil and groundwater from historical activities at the site and the shallow depth of groundwater, a moderate to high potential for a release to surface water due to the close proximity of Blows Creek, and a moderate to high potential for formation of subsurface gas based on the waste disposal activities.
Relative Risk Ranking System Data Collection Report (CH2M HILL, 1996)	Surface soil and groundwater samples were collected and analyzed for volatile organic compounds, semivolatile organic compounds (SVOCs), pesticides, polychlorinated biphenyls (PCBs), inorganics, total phosphorus, and explosives. Pesticides, PCBs, and SVOCs were detected.
Aerial Photographic Site Analysis (USEPA, 1995)	Eight aerial photographs dated between 1937 and 1995 were reviewed to assess conditions and changes at Site 5. The historical aerial review identified ground scarring, stained soils, disturbed ground, small trenches, historical excavation activities, and outside storage of construction materials, containers and potential debris.
Remedial Investigation (RI)/Human Health Risk Assessment (HHRA)/ Ecological Risk Assessment (ERA) Report for Sites 3, 4, 5, and 6 (CH2M HILL, 2003)	The RI field investigation activities conducted for Site 5 included geophysical investigations; monitoring well installation; water-level monitoring; waste delineation; and the collection of surface and subsurface soil, groundwater, drainage sediment, and drainage surface water samples. Based on the waste delineation activities, the RI concluded that the extent of waste was greater than previously identified and the Site 5 boundary was expanded to include the extent of the waste encountered. An HHRA and an ERA were conducted. Potential unacceptable risks to human and ecological receptors were identified from exposure to chemicals in soil and upland drainage ditch sediment. Because surface water is transient at the site and the drainage ditches provide minimal ecological habitat, no significant risks to human health and the environment were identified for surface water. No human health risks were identified from exposure to shallow aquifer; however, only the construction worker scenario was evaluated and there were isolated detections of metals at concentrations above maximum contaminant levels (MCLs). Although unacceptable risks to human health from exposure to metals in the deep aquifer groundwater were identified, they were risk managed by the partnering team based on consideration of a varying combination of factors including the sporadic frequency of detections, metals concentrations below background concentrations, and metals concentrations below the MCLs. The RI recommended additional soil and groundwater sampling to further define the nature and extent of contamination, and additional investigation into the sediment in Blows Creek to determine the potential for adverse effects to aquatic life.
Expanded RI/HRRA/ERA for Site 5 (CH2M HILL, 2006)	Surface soil samples were collected to fill spatial data gaps, better evaluate areas posing potential unacceptable human health and/or ecological risks, and evaluate potential remedial alternatives. Groundwater samples were also collected from existing monitoring wells to verify screening criteria and background exceedances identified during the RI. The HHRA was revised to include residential scenarios for groundwater, and evaluate the historical RI data and the additional groundwater samples. Potential unacceptable risks were identified for potable use of shallow aquifer groundwater associated with metals; however, based on the variability of the groundwater data, collection of two additional rounds of groundwater data were agreed on.
Addendum to the Expanded RI/HRRA/ERA for Site 5 (CH2M HILL, 2007)	The additional rounds of shallow aquifer groundwater data were collected and resulted in identification of potential unacceptable risks from potable use of shallow aquifer groundwater associated with metals. However, no further action was deemed necessary to address shallow aquifer groundwater as a result of consideration of a combination of factors, including the planned removal of the waste/burnt soil area, historical placement of dredge fill in the area, lack of a discernable plume, acceptable/minimal central tendency exposure hazards/risks, metals concentrations inconsistently above MCLs/action levels, and metals concentrations below background concentrations.

TABLE 2-1
Studies, Investigations, and Activities Conducted at Site 5
Site 5 Supplemental Remedial Investigation Report
St. Juliens Creek Annex
Chesapeake, Virginia

Previous Study / Investigation/Activity	Purpose and Outcome
Engineering Evaluation/Cost Analysis (EE/CA) and Action Memorandum (AM) for Site 5 Waste/Burnt Soil Area and Impacted Surface Soil and Sediment Areas (CH2M HILL, 2007)	An EE/CA was prepared to evaluate non-time critical removal action (NTCRA) alternatives to mitigate potential unacceptable human health and ecological risks in the waste/burnt soil area and impacted surface soil and drainage sediment. The recommended alternative was Excavation and Restoration/Wetland Creation. This alternative included excavation of waste/burnt soil and impacted surface soil and drainage sediment, disposal of excavated material, limited grading and backfill, and restoration as a mixed wetland/upland habitat. In addition, cleanup goals for soil and sediment were established to be protective of human receptors. A notice was issued to inform the public of the availability of the EE/CA for review and no comments were received, and the Action Memorandum was signed to implement the alternative recommended in the EE/CA.
Change in Scope of the Response and Ceiling Increase Action Memorandum for Site 5 Waste/Burnt Soil Area and Impacted Surface Soil and Sediment Areas (CH2M HILL, 2010)	In order to allow for a more flexible future land use, a supplemental Action Memorandum was prepared to document changes to the initial recommended alternative in the EE/CA. The new site restoration plan included additional backfill within the excavated areas to achieve pre-removal action grade and restoring it with the same vegetation present prior to the NTCRA. A notice was issued to inform the public of the change in scope and no feedback was provided, and the Supplemental Action Memorandum was signed to implement the change.
NTCRA and Construction Completion Report for Site 5 (AGVIQ-CH2M HILL, 2012)	NTCRA activities began in January 2008 and were completed in July 2012. The limits of excavation varied across the site, based on the type of media and whether or not the NTCRA was driven by human health or ecological risks. The horizontal and vertical extents of excavation in the waste/burnt soil area were determined based on visual inspection during the NTCRA and/or confirmation sampling (See **Section 2.2.1** for additional detail). A total of 32,960 tons of waste and contaminated soil and sediment was disposed. The site was restored with off-site borrow material graded to provide positive stormwater drainage and prevent ponding. Topsoil was placed and then seeded in disturbed grass areas, and wetland vegetation was replanted in the pre-existing wetland area, to return Site 5 to the same hydrologic, topographic, and vegetative conditions as were present prior to the NTCRA.

R:\USNavFacEngCom405450\387405StJuliensCreek\MapFiles\411510_Site5_SRI\Figure 2-1 - Site 5 Location.mxd10/14/2014cbowman

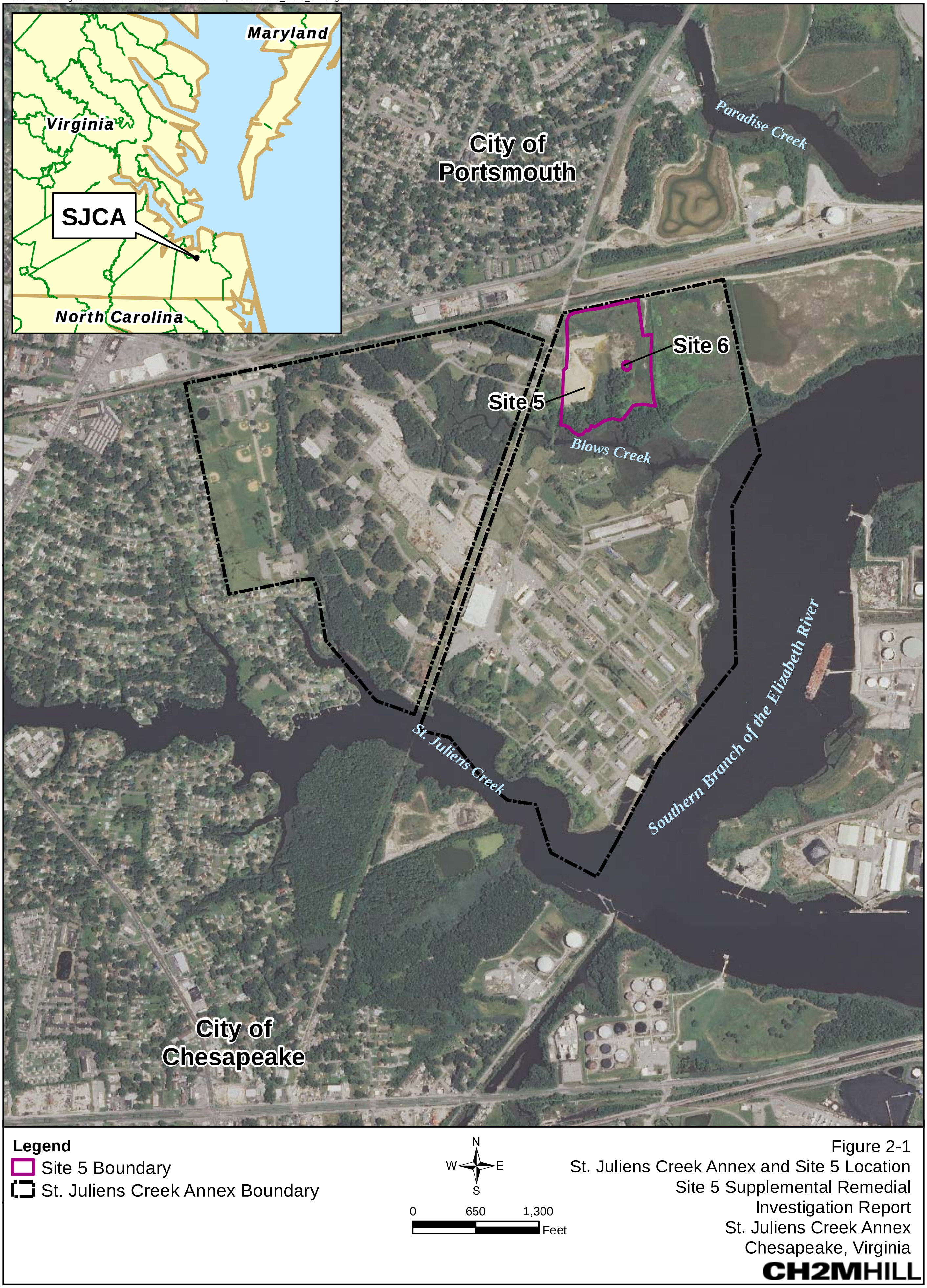

Figure 2-1
St. Juliens Creek Annex and Site 5 Location
Site 5 Supplemental Remedial Investigation Report
St. Juliens Creek Annex
Chesapeake, Virginia

CH2MHILL

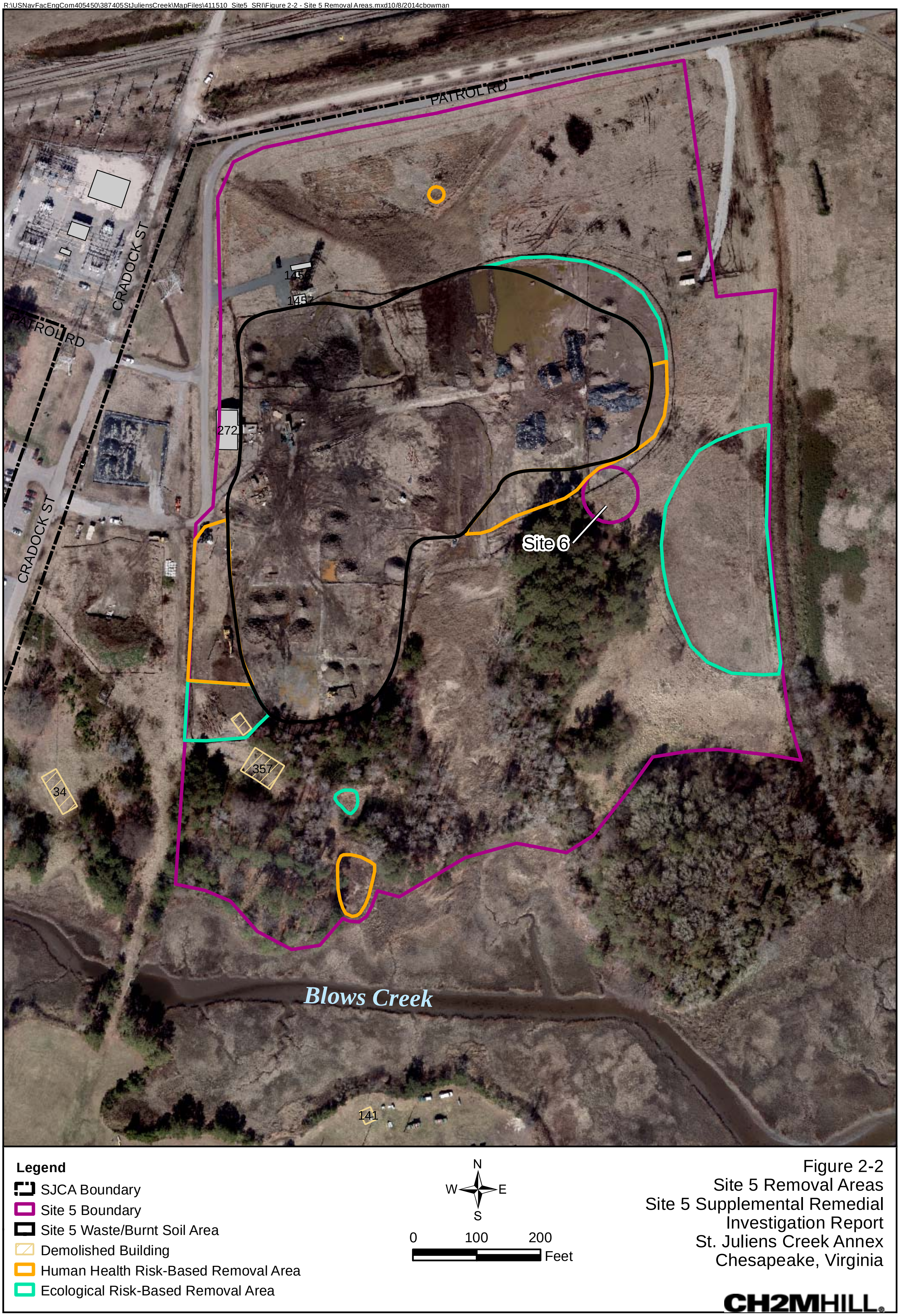

Figure 2-2
Site 5 Removal Areas
Site 5 Supplemental Remedial Investigation Report
St. Juliens Creek Annex
Chesapeake, Virginia

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SECTION 3

Physical Characteristics

3.1 Regional Characteristics

SJCA is located in the eastern part of the Atlantic Coastal Plain Physiographic Province in Chesapeake, Virginia, within the Tidewater Region. The Southern Branch of the Elizabeth River defines the eastern boundary of the land occupied by SJCA. St. Juliens Creek, which is a west-to-east flowing tributary of the Southern Branch of the Elizabeth River, defines the southern boundary of SJCA (**Figure 2-1**). Blows Creek, also a tributary of the Southern Branch of the Elizabeth River, flows through the center of SJCA and drains into the Southern Branch of the Elizabeth River. The Southern Branch of the Elizabeth River and its tributaries (including Blows Creek and St. Juliens Creek) are part of a tidal estuary system.

Public water is supplied to SJCA and the surrounding area by the City of Chesapeake Waterworks. Groundwater in the shallow aquifer (Columbia aquifer) generally is not utilized as a potable water supply in the area because it typically has a poorer quality and lower yield than underlying aquifers. Groundwater in the deeper aquifer (Yorktown-Eastover aquifer) also generally is not utilized as a potable water supply in the area. The nearest groundwater well to SJCA is approximately 1 mile upgradient of SJCA in the Potomac aquifer (which is located approximately 500 feet below ground surface [bgs]), and is used for industrial activities. There are no potential downgradient sources for groundwater use in both the Columbia and Yorktown aquifers (the two aquifers that pertain to environmental investigation at SJCA) because groundwater discharges to the surface water bodies located within or immediately downgradient of SJCA (i.e., Blows Creek, St. Juliens Creek, Southern Branch of Elizabeth River). No surrounding water bodies serve as a water supply to the surrounding areas.

The Tidewater Region has a maritime climate that is characterized by long, temperate summers and mild winters. Precipitation averages 43 inches annually and is slightly higher from June to August because of the prevalence of conductive thunderstorms. The average pH of rain in Virginia is 4.3 (extremely acidic), which is about 10 times more acidic than natural precipitation; however, the pH can vary from week to week (and rainstorm to rainstorm) from 3.5 to 5.0 (Virginia Department of Conservation & Recreation, 2014). Between 50 percent and 70 percent (22 to 30 inches) of the precipitation is removed from the area via runoff along the relatively flat topography and via evapotranspiration. The remaining 30 percent to 50 percent (13 to 22 inches) of precipitation recharges the surficial aquifer system by percolation through the upper soils (Siudyala, 1981).

3.2 Site 5 Characteristics

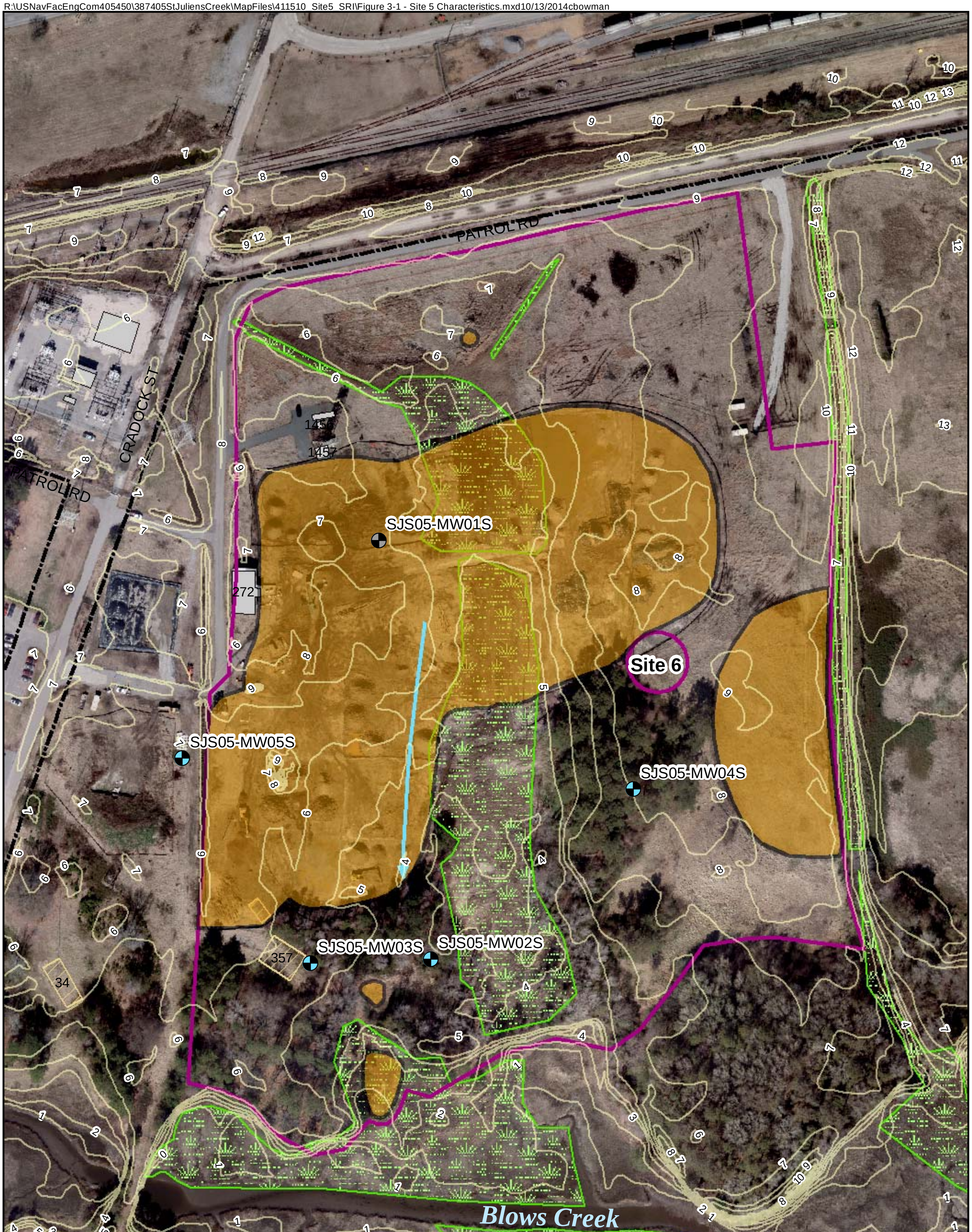
Site 5 consists of mixed land cover including a forested area in the southern portion, a wetland in the central portion, and open fields. The wetland area extends beyond the border of Site 5 to Blows Creek (**Figure 3-1**). The wetland area within Site 5 is predominantly supported by surface water runoff and does not typically maintain standing water, except during and after storm events. The topography is generally level and slopes gently towards Blows Creek, with elevations ranging from 8 feet above mean sea level (amsl) in the northern portion of the site to 0 feet amsl in the southern portion of the site at Blows Creek. Surface water at Site 5 drains either naturally via overland flow or through unlined man made drainage ditches to Blows Creek. Vegetated drainage ditches (1 to 3 feet deep) reduce runoff onto the site from adjacent areas.

Based on the background study conducted for SJCA, Site 5 is located in the Dredge Fill and Munden-Tetotum soil types (CH2M HILL, 2001). The Munden-Tetotum soils are defined as moderately well-drained soils that have a subsoil of sandy loam or clayey loam. Dredge fill consists of poorly sorted silt and clay with thin lenses of fine sand. Based on uncertainty in the U.S. Department of Agriculture soil classification mapping and the results of the RI, dredge filling was suspected over the entire site area and the SJCA Project Management Team (representatives from the Navy, USEPA, and VDEQ) agreed to evaluate all of Site 5 soil as dredge fill soil (CH2M HILL, 2006). The dredge fill reportedly originated from the Southern Branch of the Elizabeth River and Blows Creek. There are sporadic areas of low pH in the groundwater and soil at Site 5, which is consistent with pH levels facility-wide. **Figures 3-2, 3-3, and 3-4** depict the pH in soil and shallow aquifer groundwater in the vicinity of Site 5 and facility-wide. A threshold pH level of 5 was used on the figures to visually distinguish areas of relatively low pH. The majority of the low pH levels are located in the dredge fill and munden-tetotum soil types.

Below the dredge fill soil, the subsurface geology at Site 5 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 14 to 22 feet bgs (CH2M HILL, 2003). Based on groundwater levels collected from the Site 5 monitoring wells during the various field activities that have been conducted, shallow groundwater is generally encountered from less than 1 to approximately 6 feet bgs and flows predominantly south towards Blows Creek (CH2M HILL, 2007a) (**Figure 3-1**). The horizontal hydraulic gradient is fairly flat and ranges from approximately 0.006 to 0.01 foot/foot (CH2M HILL, 2003). The average hydraulic conductivity in the Site 5 vicinity is approximately 8 feet/day with a standard deviation of 4 feet/day (CH2M HILL, 2003).

The groundwater at Site 5, and throughout SJCA, is not currently and is not expected to be used as a potable water supply. Public water is supplied to SJCA and the surrounding area by the City of Chesapeake Waterworks. The groundwater within the unconfined Columbia aquifer beneath Site 5 is encountered at relatively shallow depths. Groundwater at the site discharges primarily to Blows Creek (**Figure 3-1**).

R:\USNavFacEngCom405450\387405StJuliensCreek\MapFiles\411510_Site5_SRI\Figure 3-1 - Site 5 Characteristics.mxd10/13/2014cbowman



Legend

- Shallow Aquifer Monitoring Well
- Abandoned Shallow Aquifer Monitoring Well
- General Direction of Shallow Aquifer Groundwater Flow in Site 5 Vicinity
- Elevation Contour
- St. Juliens Creek Annex Boundary
- Site 5 Boundary
- Delineated Wetland Boundary
- Demolished Building
- Removal Area

N W E S

0 100 200 Feet

Elevation Contour Source = U.S Navy GeoReadiness Center

Figure 3-1
Site 5 Characteristics
Site 5 Supplemental Remedial Investigation Report
St. Juliens Creek Annex
Chesapeake, Virginia

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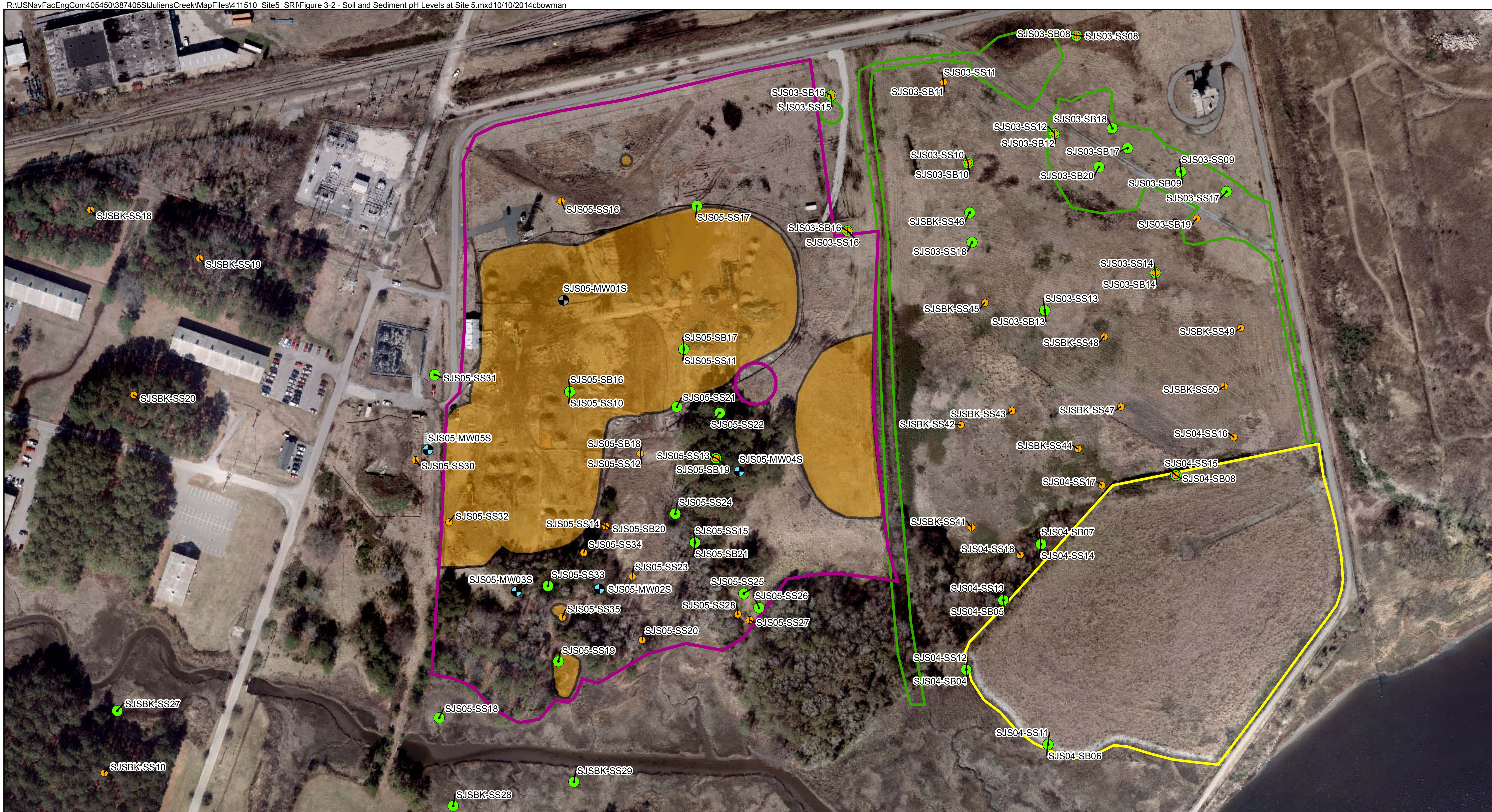
R:\USNavFacEngCom405450\387405StJuliensCreek\MapFiles\411510_Site5_SRI\Figure 3-2 - Soil and Sediment pH Levels at Site 5.mxd10/10/2014cbowman



Legend

- Soil Sample Location with pH < 5
- Soil Sample Location with pH ≥ 5
- Site 5 Shallow Aquifer Monitoring Well
- Site 5 Abandoned Shallow Aquifer Monitoring Well
- Site 5 Boundary
- Site 3 (No Further Action)
- Site 4 (Response Complete - LUCs)
- Site 5 Removal Area

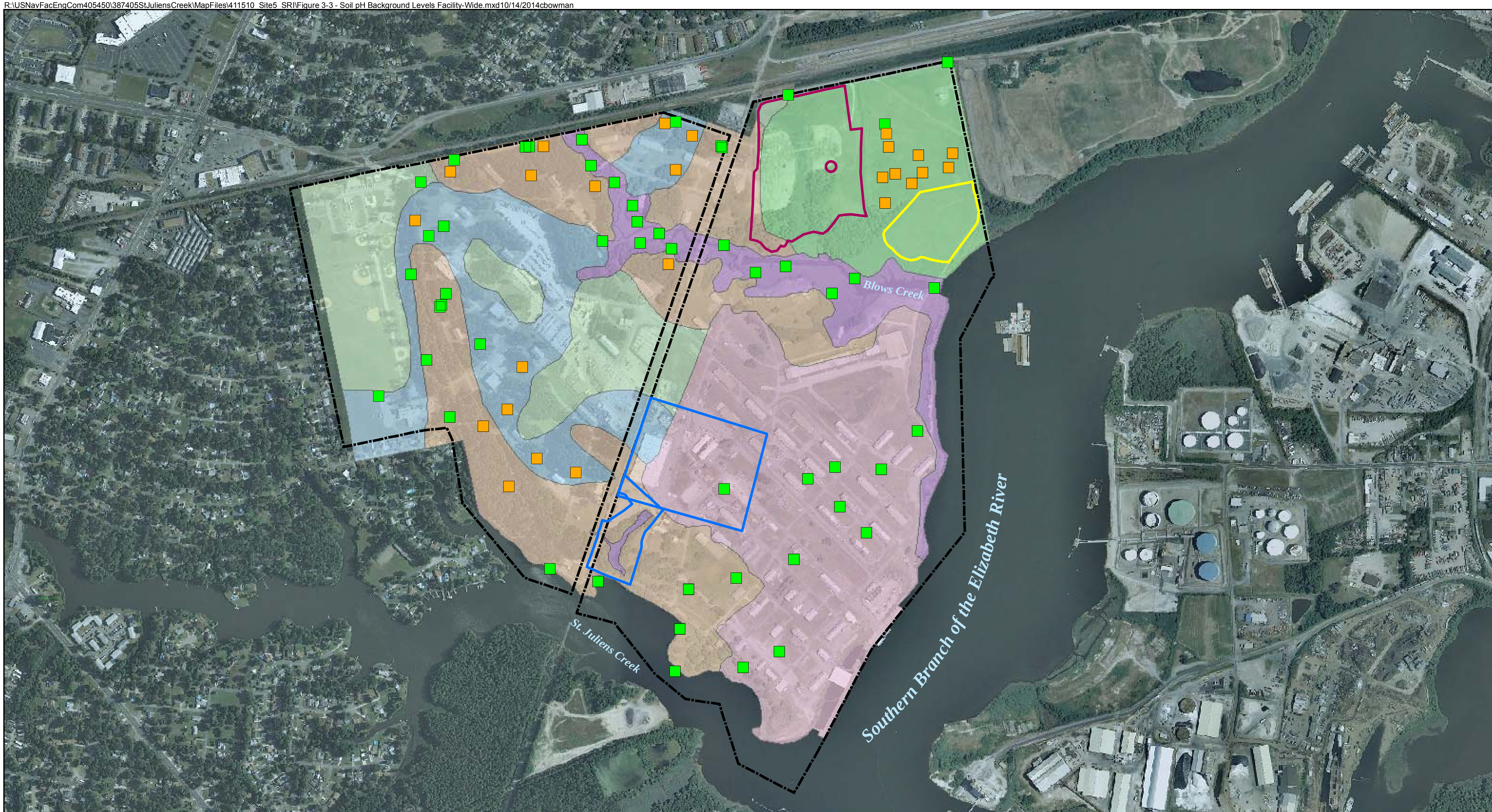
N
W E
S

0 200 400
Feet

Note:
Only soil sample locations with pH vales shown on figure

Figure 3-2
Site 5 Vicinity Background and Site Soil pH
Site 5 Supplemental Remedial
Investigation Report
St. Juliens Creek Annex
Chesapeake, Virginia

CH2MHILL



Legend

Soil Class

- Bohicket
- Dragston-Augusta Association
- Dredge Fill
- Munden-Tetotum
- Nimmo
- Urban-Udorthents

- Background Soil Sample Location with pH < 5
- Background Soil Sample Location with pH ≥ 5
- Remedial Investigation/Feasibility Study Site
- Response Complete Site with Land Use Controls
- Remedial Design/Remedial Action Site with Land Use Controls

N W E S

0 400 800 1,600 Feet

Figure 3-3
Facility-wide Background Soil pH
Site 5 Supplemental Remedial Investigation Report
St. Juliens Creek Annex
Chesapeake, Virginia

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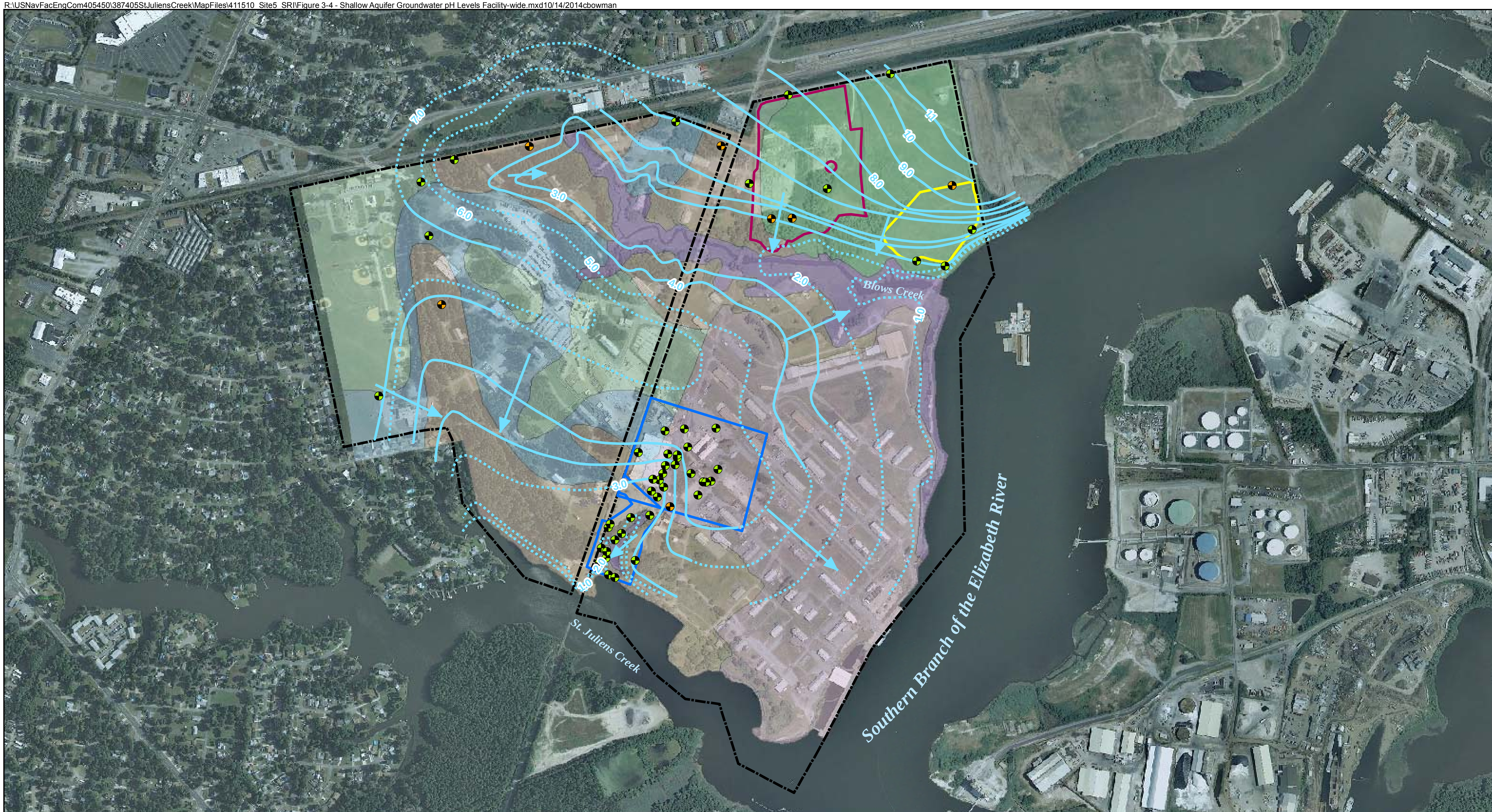
R:\USNavFacEngCom405450\387405StJuliensCreek\MapFiles\411510_Site5_SRI\Figure 3-4 - Shallow Aquifer Groundwater pH Levels Facility-wide.mxd10/14/2014cbowman



Legend

- Shallow Aquifer Groundwater Sample Location with pH < 5
- Shallow Aquifer Groundwater Sample Location with pH ≥ 5
- Groundwater Contour
- Groundwater Contour (inferred)
- Groundwater Flow Direction
- Remedial Investigation/Feasibility Study Site
- Response Complete Site with Land Use Controls
- Remedial Design/Remedial Action Site with Land Use Controls

Soil Class

- Bohicket
- Dragston-Augusta Association
- Dredge Fill
- Munden-Tetotum
- Nimmo
- Urban-Udorthents

Note:
An average pH used for locations with more than one pH measurement

N W E S

0 400 800 1,600 Feet

Figure 3-4
Facility-wide Shallow Groundwater Aquifer pH
Site 5 Supplemental Remedial Investigation Report
St. Juliens Creek Annex
Chesapeake, Virginia

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SECTION 4
Field Investigation Activities and Results

4.1 Field Investigation Activities

The field activities described below were conducted in accordance with the Final Site 5 Supplemental RI UFP-SAP (Agviq-CH2M HILL, 2014). Copies of the field notes are provided in **Appendix A**.

4.1.1 Groundwater Sampling

One round of groundwater samples was collected from the four existing shallow aquifer Site 5 monitoring wells (SJS05-MW02S, SJS05-MW03S, SJS05-MW04S, and SJS05-MW05S) and four of the shallow aquifer SJCA background monitoring wells that are nearest to the site, reflect upgradient conditions, and/or are in locations that have similar characteristics (SJSBK-MW01S, SJSBK-MW02S, SJSBK-MW03S, and SJSBK-MW06S) (**Figure 4-1**).

Because they had not been sampled in almost 10 years, the monitoring wells were redeveloped prior to sampling in order to allow groundwater to flow through the well as readily as hydraulic conditions in the aquifer allow (i.e. remove sediments that may have built up in the sand pack), remove standing water from the well casing, and remove any build-up of sediment in the well casing to ensure a representative sample would be obtained from each location. Redevelopment consisted of removing water from each well using a submersible Whale pump, and surging the screened interval with a surge block. Development continued until at least three well volumes of water were removed, the water quality parameters stabilized, and the turbidity of the discharge water was reduced to the extent practical. Water quality information, including turbidity, pH, specific conductivity, and temperature, was measured using a YSI meter during development and recorded in the field logbook. The development water was contained in 55-gallon drums for characterization and offsite disposal.

Prior to sample collection, depth to groundwater was measured and recorded at each monitoring well (**Table 4-1**). Groundwater samples were collected using a peristaltic pump following a low-flow sampling protocol (USEPA, 1996). All samples were collected by placing the sample tubing intake in the middle of the screened interval. Water quality parameters (dissolved oxygen [DO], oxidation reduction potential, pH, temperature, conductivity, turbidity, and salinity) were field-measured with a YSI and flow-through cell to confirm aquifer stability prior to sample collection, and recorded in the field notebook. Additionally, CHEMetrics DO field test kits were used to obtain more accurate DO measurements. The aquifer was considered stable after at least one well volume was purged and water quality readings collected 5 minutes apart were stabilized to within 10 percent of one another, with the exception of turbidity, which was reduced to the extent practical. Measurements indicated stabilization of most water quality parameters prior to sample collection. If all water quality parameters did not stabilize, at least one well volume was purged prior to sample collection in order to ensure a sample representative of the aquifer was collected. The water quality parameters at the time of sample collection are noted in **Table 4-2**.

The groundwater samples were collected into laboratory-prepared sample containers for the following analyses: select total and dissolved inorganics (aluminum, arsenic, beryllium, cadmium, chromium, cobalt, iron, manganese, lead, thallium, and vanadium), pH, acidity, anions (sulfate, chloride, total phosphorus, and nitrate), and dissolved organic carbon. The dissolved inorganics samples were field filtered. Quality assurance (QA) and quality control (QC) samples, consisting of duplicates, equipment blanks, and matrix spike and matrix spike duplicates, were collected in accordance with Navy CLEAN and CH2M HILL protocols. The samples were packed on ice and shipped overnight with a chain of custody to an offsite laboratory.

4.1.2 Surface Water Monitoring

According to the UFP-SAP (Agviq-CH2M HILL, 2014), field pH measurements were to be collected from one location in the wetland area adjacent to the low pH groundwater area and one location downgradient of the low pH groundwater area to aid in determining the cause of the low pH in groundwater. However, an additional field pH measurement was collected based on the site conditions that were encountered (**Figure 4-1**), as further discussed in subsection 4.2.2.

4.1.3 Investigation-Derived Waste Management

Investigation-derived waste (IDW) generated consisted of Supplemental RI well redevelopment and purge water. IDW was containerized in 55-gallon drums, stored on secondary containment at an approved IDW staging location, and properly labeled. The IDW were sampled for waste characterization and disposed of at an approved disposal facility (Clearfield MMG., Inc.) as nonhazardous waste based on the results.

4.1.4 Data Management

Field samples and their corresponding analytical tests were recorded on chain-of-custody forms, which were submitted with the samples to the laboratories. Chain-of-custody entries were checked against the site-specific project instructions and work plans to verify that all designated field samples were collected and submitted for the appropriate analysis. Upon receipt of the samples by the laboratories, a comparison to the field information was conducted to verify that each sample was analyzed for the correct parameters.

4.2 Investigation Results

The groundwater data were internally validated by CH2M HILL. During the data validation process, QA/QC criteria established in the UFP-SAP (Agviq-CH2M HILL, 2014) or in the analytical method were used to evaluate the data quality in a process similar to that outlined in *Region III Modifications to Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses* (USEPA, 1993). A data usability assessment of the validated data was performed to evaluate the overall measurement performance results (reliability) and their potential effects on data availability for decision making. The data usability assessment indicated that the laboratory reporting limits met the data quality objectives of the UFP-SAP, and the entire dataset is available for use, exceeding the data completeness goal of 95 percent. The data usability assessment is provided in **Appendix B**. As further discussed in the data usability assessment, although the limits of detections for some of the analytes were above the project action limits established in the UFP-SAP, the uncertainty does not affect the outcome of the investigation and does not prevent conclusions from being drawn with respect to the objectives of the Supplemental RI.

4.2.1 Shallow Aquifer Groundwater

Figure 4-2 depicts the potentiometric surface of shallow aquifer groundwater observed during the field investigation activities. **Figure 4-3** presents the analytes that were detected in the Site 5 and background shallow aquifer groundwater monitoring wells that were sampled during the investigation.

Table 4-3 presents the analytical results for the metals and geochemical parameters that were analyzed for in the shallow aquifer groundwater in the Site 5 monitoring wells. All of the total and dissolved metals that were analyzed for except total and dissolved thallium were detected.

Table 4-4 presents the analytical results for the metals and geochemical parameters that were analyzed for in the shallow aquifer groundwater in the background monitoring wells. All of the total and dissolved metals that were analyzed for except cadmium, lead, and thallium were detected.

4.2.2 Surface Water

Figure 4-2 presents the pH measurements collected in surface water within Site 5. Although the UFP-SAP called for collection of pH field measurements at two locations (one in the wetland area adjacent to the low pH groundwater area and one downgradient of the low pH groundwater), additional field measurements were collected in association with both of the planned locations in consideration of actual field conditions.

Location in the Wetland Adjacent to the Low pH Groundwater Area

During the field event, a drainage ditch that is not reflected in the U.S. Navy GeoReadiness Center topography was observed between monitoring well SJS05-MW02S and the wetland (**Figure 4-4**). The drainage ditch initiated at the wetland northeast of monitoring well SJS05-MW02S and flowed south toward Blows Creek. The ditch contained surface water, which was, therefore, the nearest surface water to where groundwater with low pH had been observed. A field decision was made to measure the pH in the drainage ditch, in addition to the surface water pH measurement in the wetland adjacent to the site identified in the UFP-SAP.

Location Downgradient of the Low pH Groundwater Area

During the field event, the wetland area downgradient (i.e., south) of the low pH groundwater area was observed to be relatively dry. A measurement of the pH of surface water encountered nearest to the low pH groundwater was collected; however, the water was in what appeared to be a tire rut and more likely a puddle of precipitation from a recent rain event (April 26, 2014, 0.31 inch of rain 2 days prior to the measurement) rather than wetland surface water[1]. Therefore, a second surface pH measurement was collected farther south in surface water that was more clearly associated with the wetland.

[1] Because this measurement does not likely reflect "surface water," it is not presented on Figure 4-2. The result of the measurement was pH 4.28 at 13°C, which is consistent with the average pH of rain in Virginia presented in Section 3.1.

TABLE 4-1

Monitoring Well Groundwater Elevations

Site 5 Supplemental Remedial Investigation Report

St. Juliens Creek Annex

Chesapeake, Virginia

Well Identification	Top of PVC Elevation (ft msl)	May-14	
		Depth to Water (ft)	Water Elevation (ft msl)
Site 5 Monitoring Wells			
SJS05-MW02S	7.89	3.41	4.48
SJS05-MW03S	9.32	3.53	5.79
SJS05-MW04S	11.09	3.73	7.36
SJS05-MW05S	9.99	3.00	6.99
Background Monitoring Wells			
SJSBK-MW01S	9.52	2.83	6.69
SJSBK-MW02S	9.5	3.81	5.69
SJSBK-MW03S	11.56	4.33	7.23
SJSBK-MW06S	9.37	0.35	9.02

Notes:
Water level measurements shown were collected immediately prior to purging the well for sample collection.
msl - mean sea level
ft - feet

TABLE 4-2

Monitoring Well Groundwater Quality Parameters

Site 5 Supplemental Remedial Investigation Report

St. Juliens Creek Annex

Chesapeake, Virginia

	Site 5 Wells				Background Wells			
Station ID	SJS05-MW02S	SJS05-MW03S	SJS05-MW04S	SJS05-MW05S	SJSBK-MW1S	SJSBK-MW2S	SJSBK-MW3S	SJSBK-MW6S
Sample Date	05/02/14	05/02/14	05/02/14	05/02/14	05/01/14	05/02/14	05/02/14	05/01/14
Water Quality Readings								
Dissolved Oxygen (mg/L)	0.16	0.19	0.69	0.13	0.13	0.44	3.51	0.14
Dissolved Oxygen Field Test Kit (mg/L)	0.2	0.2	0.8	0.8	0.8	0.6	4.0	1.0
Oxidation-Reduction Potential (mV)	101.5	233	192.4	-81.7	227.1	269	236.6	-48.2
Gallons purged (gal)	4.5	4.5	1.9	3.0	6.1	2.15	5.6	4.4
pH (pH)	4.03	3.53	6.35	5.67	4.25	4.54	4.88	5.81
Salinity (ppt)	1.36	1.03	0.85	0.19	0.08	0.29	0.2	1.17
Specific Conductivity (ms/cm)	2.607	2	1.662	0.394	0.179	0.592	0.414	2.258
Temperature (deg/C)	12.98	13.18	13.13	14.85	15.41	13.73	14.44	16.19
Turbidity (NTU)	0.6	1.7	1.2	2.7	9.6	1.3	9.5	6.8

Notes:
deg/C - Degrees Celsius
ft - Feet
gal - gallons
mV - millivolts
ppt - parts per thousand
PH - pH units
ms/cm - millisiemens per centimeter
NTU - Nephelometric Turbidity Unit

TABLE 4-3

Site 5 Shallow Aquifer Groundwater Detections

Site 5 Supplemental Remedial Investigation Report

St. Juliens Creek Annex

Chesapeake, Virginia

Station ID	SJS05-MW02S*	SJS05-MW03S	SJS05-MW04S	SJS05-MW05S
Sample ID	SJS05-MW02S-14B	SJS05-MW03S-14B	SJS05-MW04S-14B	SJS05-MW05S-14B
Sample Date	5/2/14	5/2/14	5/2/14	5/2/14
Chemical Name				
Total Metals (UG/L)				
Aluminum	**1,520**	**5,300**	**231 J**	**667**
Arsenic	**10.1 J**	**2.21 J**	20 U	**11 J**
Beryllium	**0.996 J**	**3.87**	0.5 U	0.5 U
Cadmium	8 U	**1.78 J**	8 U	**1.16 J**
Chromium	**2.01 J**	**1.5 J**	6 U	**1.97 J**
Chromium (Hexavalent)	**0.081 J**	**0.059**	**0.029 L**	**0.039 J**
Cobalt	**23.2**	**40.9**	1.68 U	**1.63 J**
Iron	**21,300**	**52,100**	**229**	**3,860**
Lead	20 U	**3.45 J**	20 U	**17.2 J**
Manganese	**922**	**1,430**	**18.1 J**	**268**
Thallium	0.46 U	0.46 U	0.46 U	0.46 U
Vanadium	**4.07 J**	**1.31 J**	**0.814 J**	**9.25 J**
Dissolved Metals (UG/L)				
Aluminum	**1,490**	**5,260**	200 U	**176 J**
Arsenic	**9.97 J**	**2.32 J**	20 U	**8.92 J**
Beryllium	**0.965 J**	**3.86**	0.5 U	0.5 U
Cadmium	8 U	**1.8 J**	8 U	**0.345 J**
Chromium	**2.13 J**	**1.51 J**	6 U	**1.16 J**
Chromium (Hexavalent)	**0.028 J**	**0.055**	0.025 UL	**0.088**
Cobalt	**23.2**	**41.3**	1.68 U	**1.35 J**
Iron	**22,300**	**52,700**	**20.7 J**	**3,160**
Lead	**2.35 J**	**2.96 J**	20 U	**5.95 J**
Manganese	**957**	**1,450**	**17.5 J**	**275**
Thallium	0.46 U	0.46 U	0.46 U	0.46 U
Vanadium	**4.13 J**	**1.47 J**	10 U	**7.4 J**
Wet Chemistry (PH)				
pH	**4.4**	**3.9**	**7.2**	**6.5**
Wet Chemistry (MG/L)				
Acidity	**64**	**140**	5 U	5 U
Chloride	**180 D**	**100 D**	**33**	**2.7 J**
Nitrate	0.21 U	0.21 U	0.21 U	0.21 U
Phosphorus	0.04 U	0.04 U	0.04 U	**0.29**
Sulfate	**390 D**	**370 D**	**110 D**	**6**
Dissolved organic carbon	**5.3**	**3.4**	**9.8**	**17**

Notes:
*Duplicate sample collected at this location, most conservative value between the parent and duplicate sample shown in table
Metals data were validated; wet chemistry data were not validated
Bold font indicates detection
MG/L - Milligrams per liter
UG/L - Micrograms per liter
PH - pH units
D - Detected in an analysis at a secondary dilution factor
J - Value may or may not be accurate or precise
L - Value may be biased low; value may be higher
U - Analyzed for, but not detected
UL - Not detected, quantitation limit is
probably higher

TABLE 4-4

Shallow Aquifer Groundwater Background Detections

Site 5 Supplemental Remedial Investigation Report

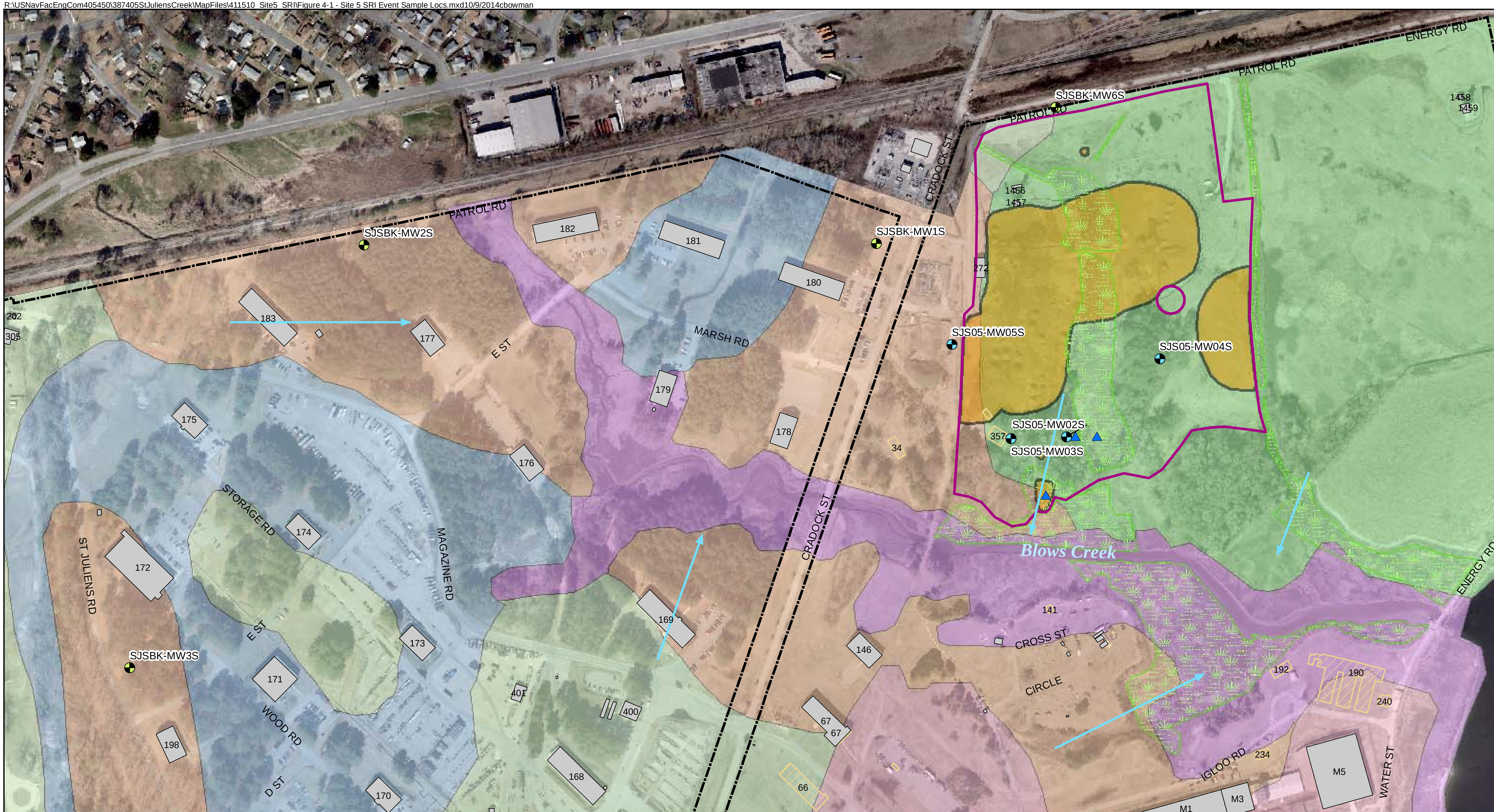
St. Juliens Creek Annex

Chesapeake, Virginia

Station ID	SJSBK-MW01	SJSBK-MW02	SJSBK-MW03	SJSBK-MW06
Sample ID	SJSBK-MW01-14B	SJSBK-MW02-14B	SJSBK-MW03-14B	SJSBK-MW06-14B
Sample Date	5/1/14	5/2/14	5/2/14	5/1/14
Chemical Name				
Total Metals (UG/L)				
Aluminum	**630**	**239 J**	**1,170**	**369 J**
Arsenic	20 U	20 U	20 U	**1.85 J**
Beryllium	**0.163 J**	**0.169 J**	**0.167 J**	0.5 U
Cadmium	8 U	8 U	8 U	8 U
Chromium	6 U	6 U	**1.05 J**	**1.68 J**
Chromium (Hexavalent)	0.025 U	**0.042 J**	**0.048 J**	0.125 U
Cobalt	**2.57**	**13.3**	1.68 U	**0.48 J**
Iron	**1,410**	**184**	**710**	**35,400**
Lead	20 U	20 U	20 U	20 U
Manganese	**160**	**283**	**21.4**	**3,740**
Thallium	0.46 U	0.46 U	0.46 U	0.46 U
Vanadium	**1.44 J**	10 U	**1.29 J**	**0.892 J**
Dissolved Metals (UG/L)				
Aluminum	**166 J**	200 U	**181 J**	200 U
Arsenic	20 U	20 U	20 U	**1.81 J**
Beryllium	0.5 U	**0.203 J**	**0.156 J**	0.5 U
Cadmium	8 U	8 U	8 U	8 U
Chromium	6 U	6 U	6 U	**1.6 J**
Chromium (Hexavalent)	0.025 U	0.025 U	**0.02 J**	0.125 U
Cobalt	**2.55**	**12.6**	1.68 U	**0.461 J**
Iron	**1,220**	**31.3 J**	**77 J**	**35,500**
Lead	20 U	20 U	20 U	20 U
Manganese	**165**	**275**	**20**	**3,780**
Thallium	0.46 U	0.46 U	0.46 U	0.46 U
Vanadium	10 U	10 U	10 U	**0.584 J**
Wet Chemistry (PH)				
pH	**5.1**	**5.3**	**5.6**	**6.9**
Wet Chemistry (MG/L)				
Acidity	**5**	5 U	5 U	5 U
Chloride	**9**	**45**	**26**	**99**
Nitrate	0.21 U	0.21 U	0.21 U	0.21 U
Phosphorus	0.04 U	**0.029 J**	0.04 U	**0.23**
Sulfate	**42**	**61**	**40**	**530 D**
Dissolved organic carbon	**3.2**	**1**	**1.4**	**23**

Notes:
Wet chemistry analytes were not validated.
Bold font indicates a detection
UG/L - Micrograms per liter
MG/L - Milligrams per liter
PH - pH units
D - Analyte identified in an analysis at a secondary dilution factor.
J - Analyte present. Value may or may not be accurate or precise
U - Analyte not detected

R:\USNavFacEngCom405450\387405StJuliensCreek\MapFiles\411510_Site5_SRI\Figure 4-1 - Site 5 SRI Event Sample Locs.mxd10/9/2014cbowman



Legend

- Surface Water Measurement Location
- Background Shallow Aquifer Monitoring Well Sample Location
- Site 5 Shallow Aquifer Monitoring Well Sample Location
- Groundwater Flow Direction in Shallow Aquifer across Facility based on October 2003 Data
- Site 5 Boundary
- Building
- Demolished Building
- Delineated Wetland Boundary
- Removal Area

Soil Class

- Bohicket
- Dragston-Augusta Association
- Dredge Fill
- Munden-Tetotum
- Nimmo
- Urban-Udorthents

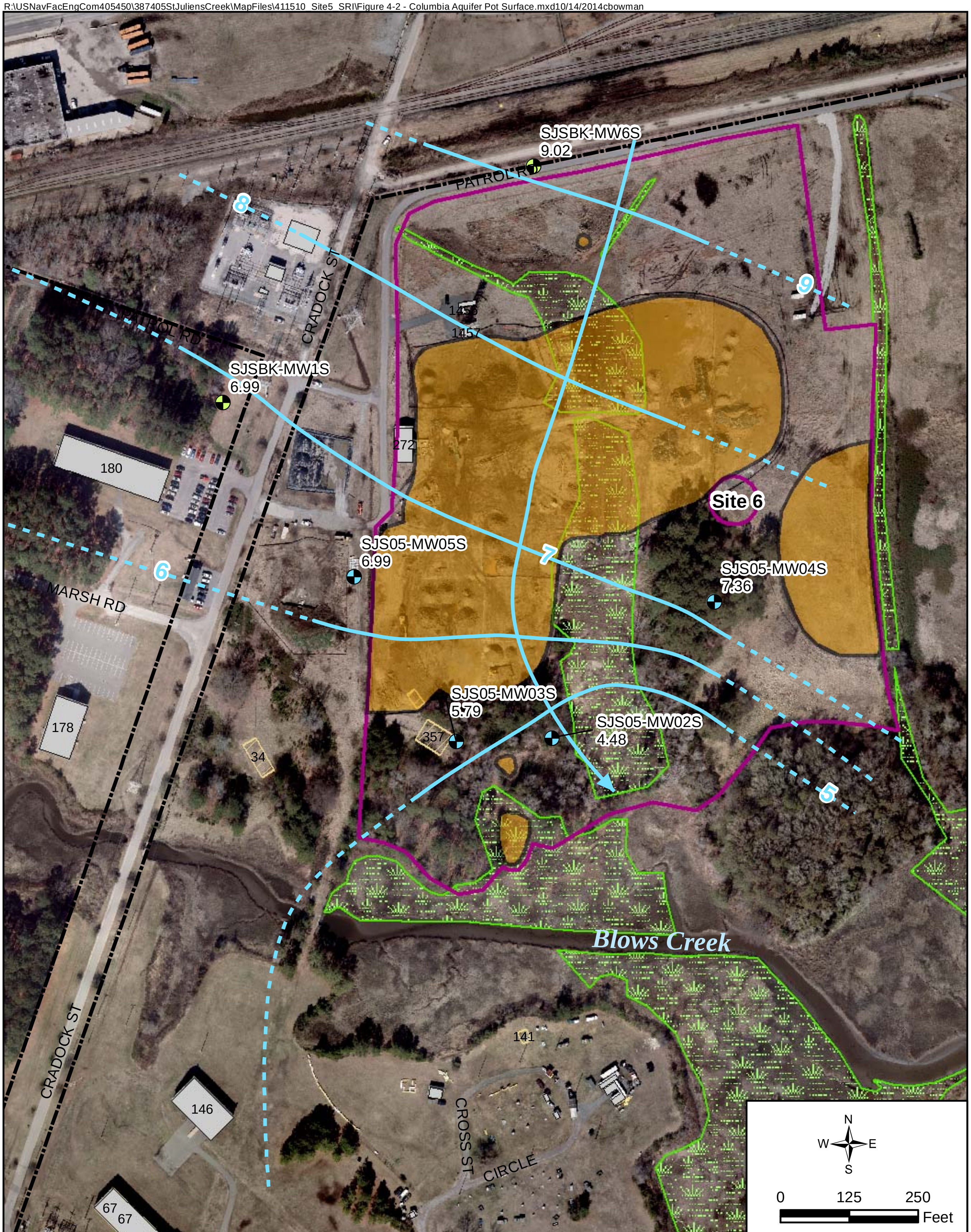
N
W E
S

0 150 300 600
Feet

Figure 4-1
Site 5 Supplemental Remedial Investigation
Sample and Measurement Locations
Site 5 Supplemental Remedial Investigation Report
St. Juliens Creek Annex
Chesapeake, Virginia

CH2MHILL.

R:\USNavFacEngCom405450\387405StJuliensCreek\MapFiles\411510_Site5_SRI\Figure 4-2 - Columbia Aquifer Pot Surface.mxd10/14/2014cbowman



Legend

- Background Monitoring Well
- Site 5 Monitoring Well
- Potentiometric Surface Contour
- Potentiometric Surface Contour - Inferred
- Groundwater Flow Direction in Shallow Aquifer
- St. Juliens Creek Annex Boundary
- Site 5 Boundary
- Delineated Wetland Boundary
- Demolished Building
- Removal Area

Figure 4-2
Site 5 Shallow Groundwater Aquifer
Potentiometric Surface
Site 5 Supplemental Remedial
Investigation Report
St. Juliens Creek Annex
Chesapeake, Virginia

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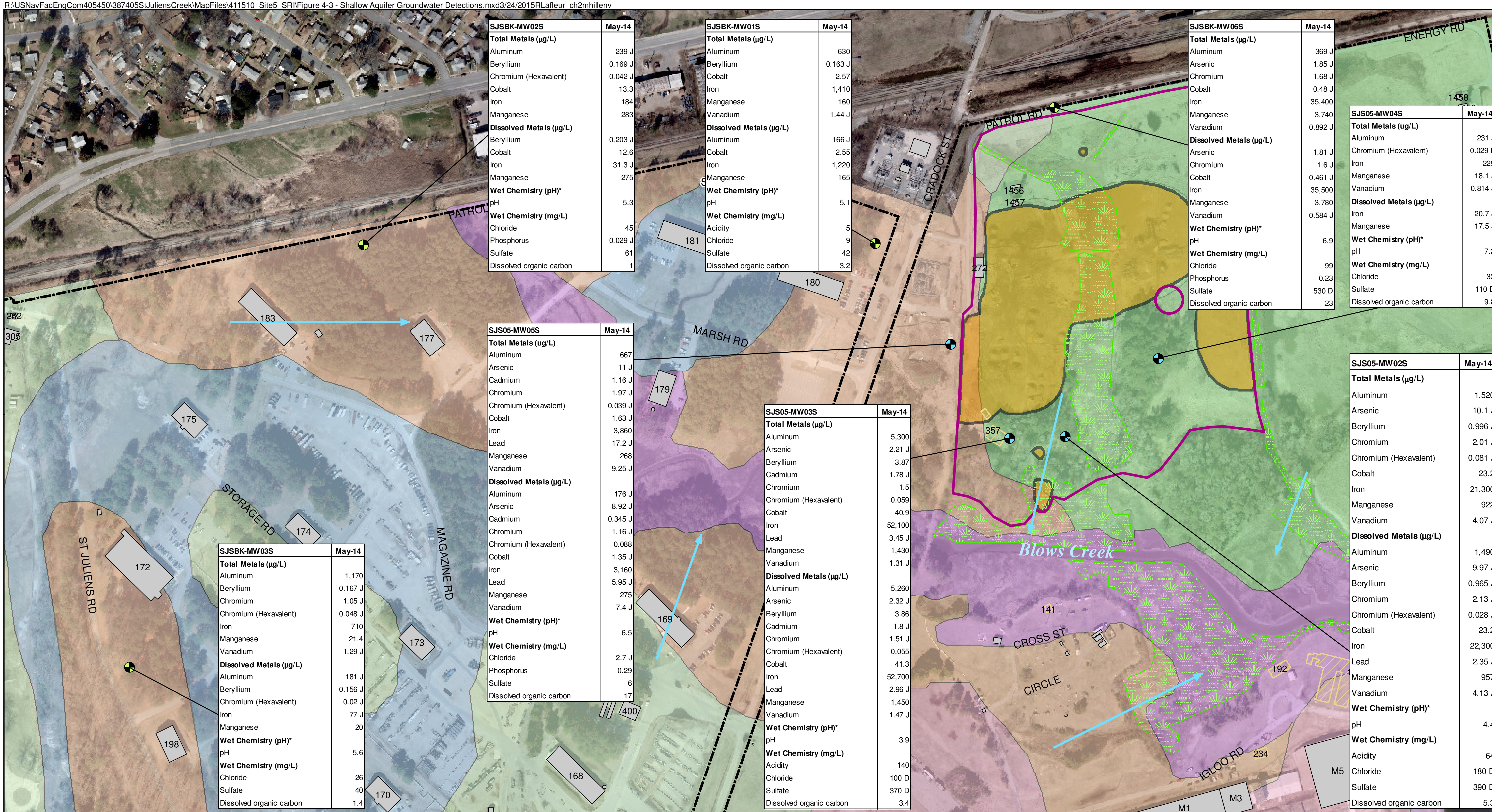
R:\USNavFacEngCom405450\387405StJuliensCreek\MapFiles\411510_Site5_SRI\Figure 4-3 - Shallow Aquifer Groundwater Detections.mxd3/24/2015RLafleur_ch2mhillenv



SJSBK-MW02S	May-14
Total Metals (µg/L)	
Aluminum	239 J
Beryllium	0.169 J
Chromium (Hexavalent)	0.042 J
Cobalt	13.3
Iron	184
Manganese	283
Dissolved Metals (µg/L)	
Beryllium	0.203 J
Cobalt	12.6
Iron	31.3 J
Manganese	275
Wet Chemistry (pH)*	
pH	5.3
Wet Chemistry (mg/L)	
Chloride	45
Phosphorus	0.029 J
Sulfate	61
Dissolved organic carbon	1

SJSBK-MW01S	May-14
Total Metals (µg/L)	
Aluminum	630
Beryllium	0.163 J
Cobalt	2.57
Iron	1,410
Manganese	160
Vanadium	1.44 J
Dissolved Metals (µg/L)	
Aluminum	166 J
Cobalt	2.55
Iron	1,220
Manganese	165
Wet Chemistry (pH)*	
pH	5.1
Wet Chemistry (mg/L)	
Acidity	5
Chloride	9
Sulfate	42
Dissolved organic carbon	3.2

SJSBK-MW06S	May-14
Total Metals (µg/L)	
Aluminum	369 J
Arsenic	1.85 J
Chromium	1.68 J
Cobalt	0.48 J
Iron	35,400
Manganese	3,740
Vanadium	0.892 J
Dissolved Metals (µg/L)	
Arsenic	1.81 J
Chromium	1.6 J
Cobalt	0.461 J
Iron	35,500
Manganese	3,780
Vanadium	0.584 J
Wet Chemistry (pH)*	
pH	6.9
Wet Chemistry (mg/L)	
Chloride	99
Phosphorus	0.23
Sulfate	530 D
Dissolved organic carbon	23

SJS05-MW04S	May-14
Total Metals (ug/L)	
Aluminum	231 J
Chromium (Hexavalent)	0.029 L
Iron	229
Manganese	18.1 J
Vanadium	0.814 J
Dissolved Metals (µg/L)	
Iron	20.7 J
Manganese	17.5 J
Wet Chemistry (pH)*	
pH	7.2
Wet Chemistry (mg/L)	
Chloride	33
Sulfate	110 D
Dissolved organic carbon	9.8

SJS05-MW05S	May-14
Total Metals (ug/L)	
Aluminum	667
Arsenic	11 J
Cadmium	1.16 J
Chromium	1.97 J
Chromium (Hexavalent)	0.039 J
Cobalt	1.63 J
Iron	3,860
Lead	17.2 J
Manganese	268
Vanadium	9.25 J
Dissolved Metals (µg/L)	
Aluminum	176 J
Arsenic	8.92 J
Cadmium	0.345 J
Chromium	1.16 J
Chromium (Hexavalent)	0.088
Cobalt	1.35 J
Iron	3,160
Lead	5.95 J
Manganese	275
Vanadium	7.4 J
Wet Chemistry (pH)*	
pH	6.5
Wet Chemistry (mg/L)	
Chloride	2.7 J
Phosphorus	0.29
Sulfate	6
Dissolved organic carbon	17

SJS05-MW03S	May-14
Total Metals (µg/L)	
Aluminum	5,300
Arsenic	2.21 J
Beryllium	3.87
Cadmium	1.78 J
Chromium	1.5
Chromium (Hexavalent)	0.059
Cobalt	40.9
Iron	52,100
Lead	3.45 J
Manganese	1,430
Vanadium	1.31 J
Dissolved Metals (µg/L)	
Aluminum	5,260
Arsenic	2.32 J
Beryllium	3.86
Cadmium	1.8 J
Chromium	1.51 J
Chromium (Hexavalent)	0.055
Cobalt	41.3
Iron	52,700
Lead	2.96 J
Manganese	1,450
Vanadium	1.47 J
Wet Chemistry (pH)*	
pH	3.9
Wet Chemistry (mg/L)	
Acidity	140
Chloride	100 D
Sulfate	370 D
Dissolved organic carbon	3.4

SJSBK-MW03S	May-14
Total Metals (µg/L)	
Aluminum	1,170
Beryllium	0.167 J
Chromium	1.05 J
Chromium (Hexavalent)	0.048 J
Iron	710
Manganese	21.4
Vanadium	1.29 J
Dissolved Metals (µg/L)	
Aluminum	181 J
Beryllium	0.156 J
Chromium (Hexavalent)	0.02 J
Iron	77 J
Manganese	20
Wet Chemistry (pH)*	
pH	5.6
Wet Chemistry (mg/L)	
Chloride	26
Sulfate	40
Dissolved organic carbon	1.4

SJS05-MW02S	May-14
Total Metals (µg/L)	
Aluminum	1,520
Arsenic	10.1 J
Beryllium	0.996 J
Chromium	2.01 J
Chromium (Hexavalent)	0.081 J
Cobalt	23.2
Iron	21,300
Manganese	922
Vanadium	4.07 J
Dissolved Metals (µg/L)	
Aluminum	1,490
Arsenic	9.97 J
Beryllium	0.965 J
Chromium	2.13 J
Chromium (Hexavalent)	0.028 J
Cobalt	23.2
Iron	22,300
Lead	2.35 J
Manganese	957
Vanadium	4.13 J
Wet Chemistry (pH)*	
pH	4.4
Wet Chemistry (mg/L)	
Acidity	64
Chloride	180 D
Sulfate	390 D
Dissolved organic carbon	5.3

Legend

- Background Shallow Aquifer Monitoring Well Sample Location
- Site 5 Shallow Aquifer Monitoring Well Sample Location
- Groundwater Flow Direction in Shallow Aquifer across Facility based on October 2003 Data
- Site 5 Boundary
- Building
- Demolished Building
- Delineated Wetland Boundary
- Removal Area

Soil Class

- Bohicket
- Dragston-Augusta Association
- Dredge Fill
- Munden-Tetotum
- Nimmo
- Urban-Udorthents

Notes:
pH levels shown are the levels from the samples analyzed by the laboratory; field measurements are provided in Table 4-2

N W E S

0 150 300 600 Feet

Figure 4-3
Site 5 Supplemental Remedial Investigation Shallow Aquifer Groundwater Detections
Site 5 Supplemental Remedial Investigation Report
St. Juliens Creek Annex
Chesapeake, Virginia

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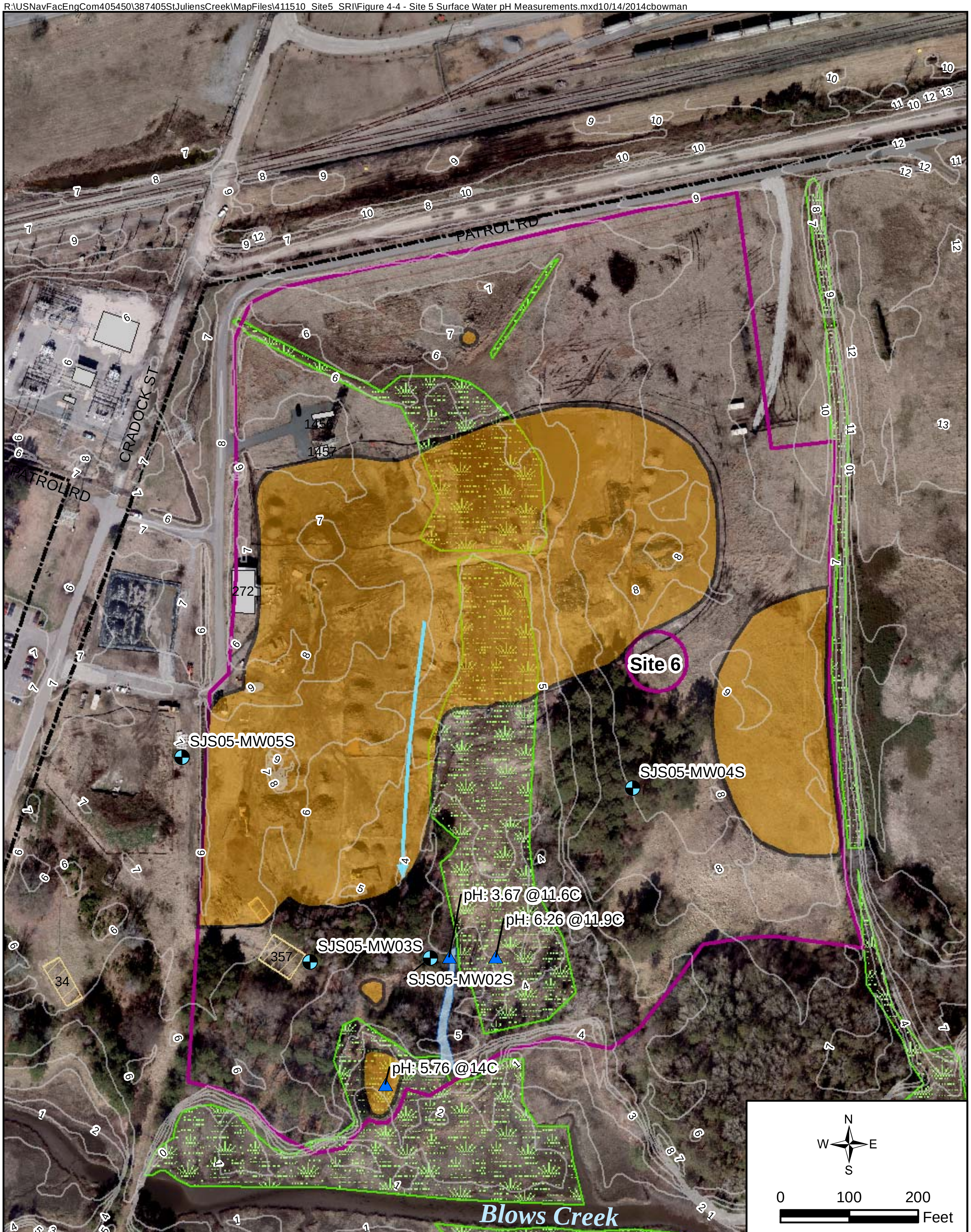
R:\USNavFacEngCom405450\387405StJuliensCreek\MapFiles\411510_Site5_SRI\Figure 4-4 - Site 5 Surface Water pH Measurements.mxd10/14/2014cbowman



Legend

- Surface Water Measurement Location
- Shallow Monitoring Well
- General Direction of Shallow Aquifer Groundwater Flow in Site 5 Vicinity
- Elevation Contour
- St. Juliens Creek Annex Boundary
- Site 5 Boundary
- Delineated Wetland Boundary
- Demolished Building
- Removal Area
- Drainage

Elevation Contour Source = U.S Navy GeoReadiness Center
Drainage Source = Engineering Evaluation and Cost Analysis for Site 5 Waste/Burnt Soil Area and Impacted Surface Soil and Sediment Areas (CH2M HILL, 2007)

Figure 4-4
Site 5 Supplemental Remedial Investigation Surface Water pH Measurements
Site 5 Supplemental Remedial Investigation Report
St. Juliens Creek Annex
Chesapeake, Virginia

CH2MHILL.

SECTION 5

Human Health Risk Assessment

This section summarizes the updated HHRA conducted to assess the potential future health risks from exposure to Site 5 shallow aquifer groundwater. The baseline HHRA is presented as **Appendix C.** All of the data used in the risk assessment were validated and are assumed to represent current conditions. **Table C-1** in **Appendix C** lists the samples evaluated in the HHRA. The full set of data evaluated in the risk assessment are included in **Table 4-3**.

The risk assessment evaluated carcinogenic risks and non-carcinogenic hazards to potential receptors at Site 5 under a reasonable maximum exposure (RME) scenario, which is consistent with the methodologies provided in USEPA Superfund risk assessment guidance documents (USEPA, 1989, 2001, 2004) and the Chief of Naval Operations guidance document (2001). The RME scenario is the highest exposure that is reasonably expected to occur at a site (USEPA, 1989). When the RME risk exceeds USEPA target risk levels, the central tendency exposure (CTE) scenario is evaluated. The CTE risk is the risk to individuals who have average or typical exposure to environmental media.

The conceptual site model for human exposures presents an overview of site conditions, potential sources of contamination, potential contaminant-migration pathways, and potential exposure pathways at the site. The conceptual site model for human exposures to Site 5 shallow aquifer groundwater is discussed in **Appendix C**.

There are no current exposures to shallow aquifer groundwater at Site 5. Groundwater is not used as a potable resource at SJCA; however, it could be considered for beneficial use in the future if the site is closed with NFA. Based on potential future site use, the following receptors and potentially complete exposure pathways were quantitatively evaluated in the HHRA for potential exposure:

- **Resident (adult and child):** ingestion of shallow aquifer groundwater, and dermal contact with shallow aquifer groundwater while bathing/showering
- **Construction worker:** dermal contact with shallow aquifer groundwater in an open excavation

Metals detected in shallow aquifer groundwater at concentrations that exceeded their respective USEPA Region 3 Regional Screening Levels for tap water or federal Action Level (lead only) were identified as constituents of potential concern (COPCs). The COPCs identified and used to calculate the RME and CTE (when calculated) non-carcinogenic hazards and carcinogenic risks are identified in **Table C-2 in Appendix C**. The risk calculations are presented in **Tables 7.1.RME through 7.4.RME and 7.1.CTE through 7.3.CTE in Attachment 1 of Appendix C**. CTE risks were calculated only when the RME hazards exceeded the non-carcinogenic target HI of 1, or the RME carcinogenic risks exceeded USEPA's acceptable risk range of 1×10^{-6} to 1×10^{-4}. **Tables 9.1.RME through 9.4.RME and 9.1.CTE through 9.3.CTE in Attachment 1 of Appendix C** summarize the estimated hazards and risks for each receptor. Human health COCs are identified for the scenarios with potentially unacceptable risks. The COCs are those COPCs that contribute an HI greater than 0.1 to a cumulative target organ HI that exceeds 1 or a carcinogenic risk greater than 1×10^{-6} to a cumulative carcinogenic risk that exceeds 1×10^{-4}. The risk estimates for Site 5 are summarized below by receptor. The RME non-carcinogenic hazards and carcinogenic risks are presented by receptor in **Table 5-1**, and the CTE results are summarized in **Table 5-2**.

5.1 Risk Estimate

5.1.1 Future Adult Resident

- Cumulative HI (RME) = 10, exceeds target HI, primarily associated with cobalt, iron, and manganese, which each contribute HIs above 1.
- Cumulative HI (CTE) = 4, exceeds target HI, primarily associated with cobalt, which contributes an HI above 1.

5.1.2 Future Child Resident

- Cumulative HI (RME) = 16, exceeds target HI, primarily associated with arsenic, cobalt, iron, and manganese, which each contribute HIs above 1, with a smaller contribution from aluminum and beryllium.
- Cumulative HI (CTE) = 6, exceeds target HI, primarily associated with cobalt, which contributes an HI above 1.
- Integrated Exposure Update Biokinetic (IEUBK) model (Tables 11.1a and 11.1b, Figure 11-1, Attachment 1, Appendix C) demonstrated a typical child, exposed to average concentrations of lead in site groundwater, will have a blood lead level less than the level associated with adverse health effects (i.e., 10 micrograms per deciliter).

5.1.3 Future Lifetime Resident

- Cumulative excess lifetime cancer risk (ELCR) (RME) = 2×10^{-4}, exceeds target risk range, primarily associated arsenic, with a smaller contribution from hexavalent chromium.
- Cumulative ELCR (CTE) = 6×10^{-5}, within target risk range.

5.1.4 Future Construction Worker

- Cumulative HI (RME) = 0.4, below target HI.
- Cumulative ELCR (RME) = 6×10^{-8}, below target risk range.

5.2 Risk Summary

The results of the risks for each receptor are summarized as follows:

- Future Resident (adult and child): noncarcinogenic hazards and carcinogenic risks associated with potable use of shallow aquifer groundwater exceed USEPA target risk levels.
  - COCs are aluminum, arsenic, beryllium, hexavalent chromium, cobalt, iron, and manganese.
- Future Construction Worker: noncarcinogenic hazards and carcinogenic risks associated with dermal contact with shallow aquifer in an open excavation are within USEPA target risk levels.
  - No COCs.

In summary, if shallow aquifer groundwater is used as a future potable water supply, there would be potential unacceptable risks to residents from exposure to the COCs aluminum, arsenic, beryllium, hexavalent chromium, cobalt, iron, and manganese. If construction workers are exposed to shallow aquifer groundwater during excavation activities, there would be no unacceptable risks. However, several of the COCs (aluminum, beryllium, hexavalent chromium, iron, and manganese) can be eliminated as COCs because they are not site-related and/or pose minimal risk. The following provides the rationale for elimination of those COCs.

- **Manganese**
  - Current concentrations (maximum concentration of 1,430 micrograms per liter [µg/L]) are less than the SJCA 95 percent background upper tolerance limit (UTL) (13,700 µg/L).
  - Manganese is an essential human nutrient.
    - The ingestion of manganese from groundwater if groundwater used as a potable water supply by an adult resident (0.042 mg/kg-day from Table 7.1.RME in Appendix C, Attachment 1, multiplied by the adult body weight of 80 kg, for an intake of 3.4 mg/kg) would exceed the adequate intake range for manganese of 1.6 mg/kg to 2.3 mg/kg for male and female adults (Food and Nutrition Board, 2001). However, the intake would be below the tolerable upper intake level (UL) range of 6 mg/kg to 11 mg/kg for male and female adults (Food and Nutrition Board, 2001). The UL is the highest level of daily nutrient intake that is likely to pose no risk of adverse health effects to almost all individuals in the general population.

    - The ingestion of manganese from groundwater if groundwater used as a potable water supply by a child resident (0.07 mg/kg-day from Table 7.2.RME in Appendix C, Attachment 1, multiplied by the child body weight of 15 kg, for an intake of 1.1 mg/kg) would be within the range of adequate intakes for manganese of 0.003 mg/kg to 1.5 mg/kg for children and below the UL range for children of 2 mg/kg to 3 mg/kg (Food and Nutrition Board, 2001).

- **Aluminum**
  - The RME and CTE HIs for aluminum are less than the target level of 1.
  - Although aluminum contributes an RME HI (0.23) greater than 0.1 to a target organ that has an HI greater than 1, manganese alone has an HI greater than 1 (3.2) for that target organ (neurological). If manganese was not factored in because its concentrations are associated with background, aluminum would not be identified as a risk driver.
- **Iron**
  - Current concentrations (maximum concentration of 52,100 µg/L) are less than the SJCA 95 percent background UTL (107,000 µg/L).
- **Beryllium**
  - The RME and CTE HIs for beryllium are less than the target level 1.
  - Although beryllium contributes an RME HI (0.15) greater than 0.1 to a target organ that has an HI greater than 1, iron alone has an HI greater than 1 (3.3) for that target organ (gastrointestinal). If iron was not factored in because its concentrations are associated with background, beryllium would not be identified as a risk driver.
- **Hexavalent Chromium**
  - Although hexavalent chromium contributes to a cumulative RME ELCR (2×10^{-4}) greater than 1×10^{-4}, arsenic is the primary contributor (2×10^{-4}); hexavalent chromium contributes 1×10^{-6} and alone does not pose unacceptable risk.
  - The CTE ELCR is less than 1×10^{-4}.

TABLE 5-1

Summary of RME Carcinogenic Risks and Non-carcinogenic Hazards

Site 5 Supplemental Remedial Investigation Report

St. Juliens Creek Annex

Chesapeake, Virginia

Receptor	Media	Exposure Route	Cancer Risk	Chemicals with Cancer Risks >10^{-6}	Hazard Index	Chemicals with HI>1	Chemicals of Concern (Chemicals Contributing HI > 0.1 to Target Organ HI >1 or carcinogenic risk>10^{-6} to total carcinogenic risk >10^{-4})
Future Resident Adult	Groundwater (Shallow Aquifer)	Ingestion	NA		9	Cobalt (4), Iron (2), Manganese (2)	Cobalt, Iron, Manganese
		Dermal Contact	NA		0.4		
		Inhalation	NA		NA		
		Total	NA		10		
Future Resident Child	Groundwater (Shallow Aquifer)	Ingestion	NA		15	Arsenic (2), Cobalt (7), Iron (3), Manganese (3)	Aluminum, Arsenic, Beryllium, Cobalt, Iron, Manganese
		Dermal Contact	NA		0.4		
		Inhalation	NA		NA		
		Total	NA		16		
Future Resident Child/Adult	Groundwater (Shallow Aquifer)	Ingestion	2E-04	Arsenic (2E-04)	NA		Arsenic, Chromium (hexavalent)
		Dermal Contact	2E-06		NA		
		Inhalation	NA		NA		
		Total	2E-04		NA		
Future Construction Worker	Groundwater (Shallow Aquifer)	Ingestion	NA		NA		
		Dermal Contact	6E-08		0.4		
		Inhalation	NA		NA		
		Total	6E-08		0.4		

Incremental cancer risks and hazard quotients are identified in parenthesis
NA - Not applicable

TABLE 5-2

Summary of CTE Carcinogenic Risks and Non-carcinogenic Hazards

Site 5 Supplemental Remedial Investigation Report

St. Juliens Creek Annex

Chesapeake, Virginia

Receptor	Media	Exposure Route	Cancer Risk	Chemicals with Cancer Risks >10^{-6}	Hazard Index	Chemicals with HI>1	Chemicals of Concern (Chemicals Contributing HI > 0.1 to Target Organ HI >1 or carcinogenic risk>10^{-6} to total carcinogenic risk >10^{-4})
Future Resident Adult	Groundwater	Ingestion	NA		4	Cobalt (2)	Cobalt
		Dermal Contact	NA		0.1		
		Inhalation	NA		NA		
		Total	NA		4		
Future Resident Child	Groundwater	Ingestion	NA		6	Cobalt (3)	Cobalt
		Dermal Contact	NA		0.3		
		Inhalation	NA		NA		
		Total	NA		6		
Future Resident Child/Adult	Groundwater	Ingestion	5E-05	Arsenic (5E-05)	NA		
		Dermal Contact	7E-07		NA		
		Inhalation	NA		NA		
		Total	6E-05		NA		

Incremental cancer risks and hazard quotients are identified in parenthesis
NA - Not applicable

SECTION 6

Data Evaluation

Based on the results of the updated HHRA, metals pose potential unacceptable risks. In accordance with the data evaluation process developed in the UFP-SAP (Agviq-CH2M HILL, 2014), multiple lines of evidence are evaluated in this section to determine if the risks are the results of a CERCLA release and require action. While all site data are presented in this section, the content focuses on the COCs at the conclusion of the HHRA: cobalt and arsenic.

The Site 5 shallow aquifer groundwater data collected during this investigation were compared to the SJCA 95 percent UTLs and the maximum concentrations from the select background monitoring wells sampled during this investigation. The Site 5 shallow aquifer groundwater data were also compared to the Maximum Contaminant Levels (MCLs) (or Action Level for lead), as the Navy acknowledges the Commonwealth of Virginia's and USEPA's expectation to return usable groundwaters to their beneficial uses wherever practicable. **Table 6-1** presents the comparison and **Figure 6-1** depicts the exceedances of the screening criteria. Concentrations of metals in the shallow aquifer groundwater at Site 5 have varied over time and between monitoring wells, indicating there is no discernable plume (CH2M HILL, 2007a; **Table 6-1**).The analytes that were retained as COCs at the conclusion of the HHRA, arsenic and cobalt, and those that exceeded their respective MCL and Action Level during this investigation (arsenic and lead, respectively) are further evaluated below to determine whether they are the result of the CERCLA release and require remedial action.

6.1 Arsenic

Although total arsenic concentrations were detected above the MCL (10 µg/L), the concentrations only slightly exceeded the MCL (10.1 µg/L at SJS05-MW02S and 11 µg/L at SJSS05-MW05S), the concentrations are similar in magnitude to the SJCA 95 percent background UTL (8 µg/L), and the dissolved arsenic concentrations are below the MCL. Additionally, the highest arsenic concentration was detected at SJS05-MW05S, which is sidegradient of the area where waste disposal and burning operations occurred. Furthermore, although arsenic was identified as a potential risk driver because the RME HIs are greater than 1 and the RME ELCR is greater than 1×10^{-4}, the CTE HIs are less than 1 and the CTE ELCR is less than 1×10^{-4}. Therefore, arsenic can be eliminated as a COC.

6.2 Lead

The detected concentration of total lead that exceeded the Action Level of 15 µg/L is only slightly above the Action Level (17.2 µg/L at SJS05-MW05S); however, the dissolved lead concentration at that location is below the action level and lead was not identified as a COC in the HHRA. The IEUBK model demonstrated a typical child, exposed to average concentrations of lead in site groundwater, will have a blood lead level less than the level associated with adverse health effects (i.e., 10 micrograms per deciliter). Additionally, the location of the detection that exceeded the Action Level is sidegradient of the area where waste disposal and burning operations occurred. Therefore, lead should not be identified as a COC.

6.3 Cobalt

The highest detected concentrations of total cobalt (23.3 µg/L and 40.9 µg/L) are greater than but within the same order of magnitude to the SJCA 95 percent background UTL (15.8 µg/L). If cobalt concentrations in the groundwater were the result of the CERCLA release, it is expected that cobalt concentrations in the groundwater and the soil within the waste disposal/burning area would have been elevated. However, five samples were collected from the monitoring well within the waste disposal/burning area (SJS05-MW01S) between 1997 and 2006, and cobalt was only detected during one sampling event (1 J µg/L in June 2006) (CH2M HILL, 2007a); the monitoring well was abandoned during the NTCRA hence no data could be collected during this event. Additionally, cobalt, which had a maximum detected concentration of 36 mg/kg in Site 5 soil, was not identified as a soil COC in the RI and Expanded RI (CH2M HILL, 2003; CH2M HILL, 2006), and based on review of that data, cobalt would not currently be identified as a soil COC when considering the current toxicity factor.

Furthermore, the highest concentrations of cobalt that were detected in the shallow aquifer groundwater during this investigation were detected at the monitoring wells with the lowest pH (**Figure6-2**). The cause of the low pH in groundwater is unknown and likely the result of a combination of factors, including the low pH of rainfall in the region (average of 4.3) (Virginia Department of Conservation & Recreation, 2014) and the historical placement of dredge fill. Because of the shallow water table at Site 5 (at times less than 1 foot below the ground surface), it is particularly susceptible to short-term impacts following rain events. It should also be noted that the measured acidity in this area was relatively low, given the low pH (**Table 4-3**), which means that there is a lack of alkalinity in that area. If any alkalinity was present, the low pH would have been neutralized. This area coincides with historical placement of dredge spoil material from Blows Creek and the Southern Branch of the Elizabeth River. Estuarine soils excavated via dredging and subsequent oxidation can evolve into an acid sulphate soil (Fanning, D.S. and S.N. Burch, 1997), resulting in lower soil pH which can drastically reduce the pH of water moving through the sediment and mobilize metals. Metal mobility and availability are generally higher in more acidic conditions. The geochemical behavior of cobalt generally follows that of the iron-manganese system, and its concentration in sediment and soil systems is mainly controlled by adsorption and coprecipitation reactions (Hem, 1985). Given the low pH of the groundwater, the minerals that cobalt adsorbs to become increasingly soluble as pH and Eh decrease (Sherameti and Varma, 2010), thus creating the more soluble Co conditions observed at Site 5. Sulfate levels at monitoring wells SJS05-MW02S (390 milligrams per liter [mg/L]) and SJS05-MW03S (370 mg/L) (**Table 4-3**) are elevated (greater than 250 mg/L), indicating that the acidity in the groundwater in that area is possibly due to oxidation of sulfate minerals or acid soils associated with the dredge fill. The low pH is causing the mobilization of the cobalt and is not associated with a historical CERCLA release. Therefore, cobalt can be eliminated as a COC.

TABLE 6-1

Site 5 Shallow Aquifer Groundwater Exceedances

Site 5 Supplemental Remedial Investigation Report

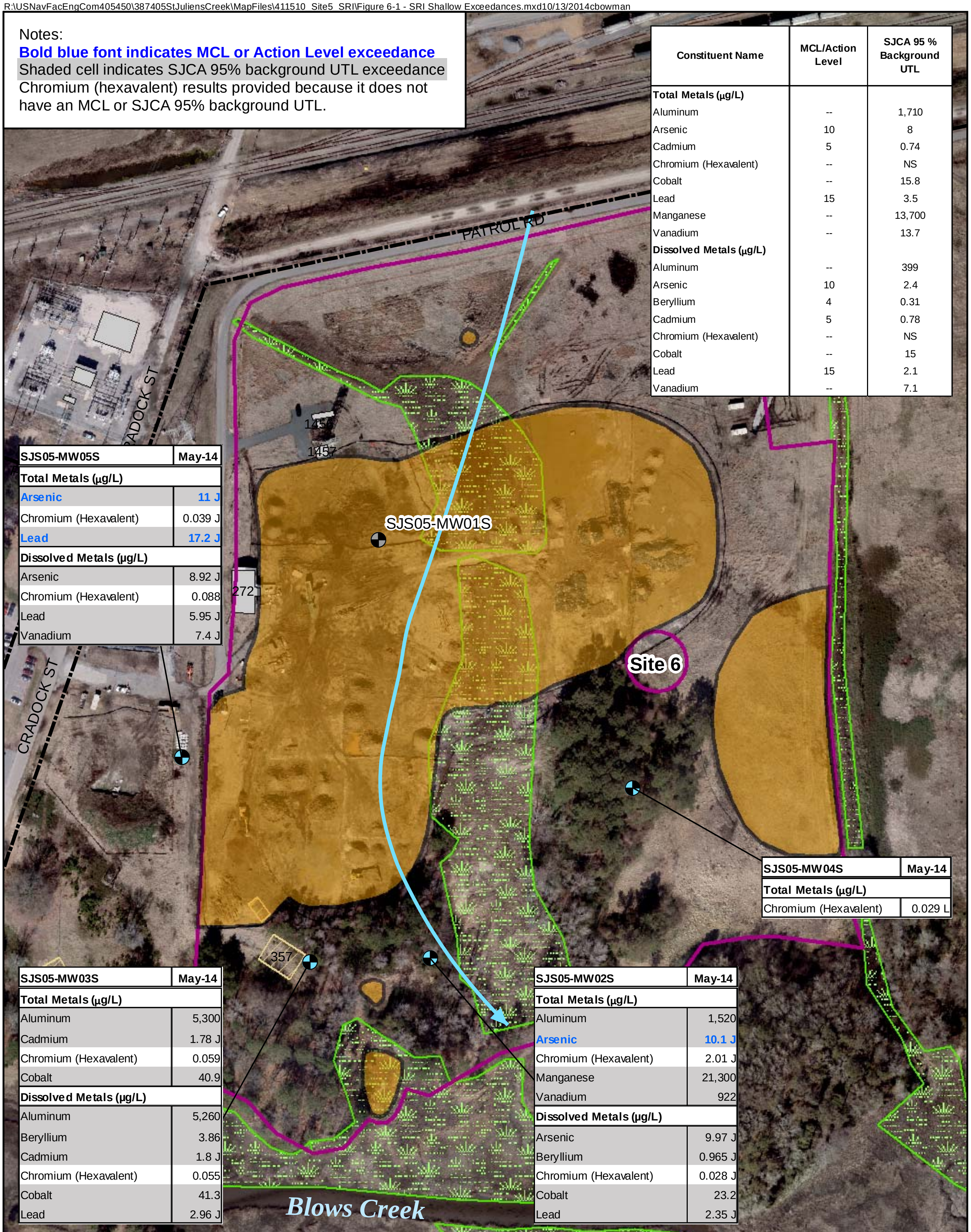
St. Juliens Creek Annex

Chesapeake, Virginia

Station ID	**MCL/ Action Level**	**SJCA 95% UTL Background**	**Maximum 2014 Background**	SJS05-MW02S*	SJS05-MW03S	SJS05-MW04S	SJS05-MW05S
Sample ID				SJS05-MW02S-14B	SJS05-MW03S-14B	SJS05-MW04S-14B	SJS05-MW05S-14B
Sample Date				5/2/14	5/2/14	5/2/14	5/2/14
Chemical Name							
Total Metals (UG/L)							
Aluminum	--	1,710	1,170	**1,520**	**5,300**	**231 J**	**667**
Arsenic	10	8	1.85	**10.1 J**	**2.21 J**	20 U	**11 J**
Beryllium	4	1.4	0.169	**0.996 J**	**3.87**	0.5 U	0.5 U
Cadmium	5	0.74	ND	8 U	**1.78 J**	8 U	**1.16 J**
Chromium	100	3.2	1.68	**2.01 J**	**1.5 J**	6 U	**1.97 J**
Chromium (Hexavalent)	--	--	0.048	**0.081 J**	**0.059**	**0.029 L**	**0.039 J**
Cobalt	--	15.8	13.3	**23.2**	**40.9**	1.68 U	**1.63 J**
Iron	--	107,000	35,400	**21,300**	**52,100**	**229**	**3,860**
Lead	15	3.5	ND	20 U	**3.45 J**	20 U	**17.2 J**
Manganese	--	13,700	3,740	**922**	**1,430**	**18.1 J**	**268**
Vanadium	--	13.7	1.44	**4.07 J**	**1.31 J**	**0.814 J**	**9.25 J**
Dissolved Metals (UG/L)							
Aluminum	--	399	181	**1,490**	**5,260**	200 U	**176 J**
Arsenic	10	2.4	1.81	**9.97 J**	**2.32 J**	20 U	**8.92 J**
Beryllium	4	0.31	0.203	**0.965 J**	**3.86**	0.5 U	0.5 U
Cadmium	5	0.78	8	8 U	**1.8 J**	8 U	**0.345 J**
Chromium	100	5.8	1.6	**2.13 J**	**1.51 J**	6 U	**1.16 J**
Chromium (Hexavalent)	--	--	0.02	**0.028 J**	**0.055**	0.025 UL	**0.088**
Cobalt	--	15	12.6	**23.2**	**41.3**	1.68 U	**1.35 J**
Iron	--	94,000	35,500	**22,300**	**52,700**	**20.7 J**	**3,160**
Lead	15	2.1	ND	**2.35 J**	**2.96 J**	20 U	**5.95 J**
Manganese	--	11,800	3,780	**957**	**1,450**	**17.5 J**	**275**
Vanadium	--	7.1	0.584	**4.13 J**	**1.47 J**	10 U	**7.4 J**

Notes:
*Duplicate sample collected from this location; most conservative value between parent and duplicate sample shown in table
Bold font indicates detection
Blue font indicates MCL or Action Level exceedance
Shaded cell indicates SJCA 95% Background UTL exceedance
Bold box indicates Maximum 2014 Background exceedance
-- - Criteria not established for analyte
UG/L - Micrograms per liter
J - Value may or may not be accurate or precise
L - Value may be biased low; value may be higher
U - Analyzed for, but not detected
UL - Not detected, quantitation limit is probably higher

Notes:
Bold blue font indicates MCL or Action Level exceedance
Shaded cell indicates SJCA 95% background UTL exceedance
Chromium (hexavalent) results provided because it does not have an MCL or SJCA 95% background UTL.



Constituent Name	MCL/Action Level	SJCA 95 % Background UTL
Total Metals (µg/L)		
Aluminum	--	1,710
Arsenic	10	8
Cadmium	5	0.74
Chromium (Hexavalent)	--	NS
Cobalt	--	15.8
Lead	15	3.5
Manganese	--	13,700
Vanadium	--	13.7
Dissolved Metals (µg/L)		
Aluminum	--	399
Arsenic	10	2.4
Beryllium	4	0.31
Cadmium	5	0.78
Chromium (Hexavalent)	--	NS
Cobalt	--	15
Lead	15	2.1
Vanadium	--	7.1

SJS05-MW05S	May-14
Total Metals (µg/L)	
Arsenic	**11 J**
Chromium (Hexavalent)	0.039 J
Lead	**17.2 J**
Dissolved Metals (µg/L)	
Arsenic	8.92 J
Chromium (Hexavalent)	0.088
Lead	5.95 J
Vanadium	7.4 J

SJS05-MW04S	May-14
Total Metals (µg/L)	
Chromium (Hexavalent)	0.029 L

SJS05-MW03S	May-14
Total Metals (µg/L)	
Aluminum	5,300
Cadmium	1.78 J
Chromium (Hexavalent)	0.059
Cobalt	40.9
Dissolved Metals (µg/L)	
Aluminum	5,260
Beryllium	3.86
Cadmium	1.8 J
Chromium (Hexavalent)	0.055
Cobalt	41.3
Lead	2.96 J

SJS05-MW02S	May-14
Total Metals (µg/L)	
Aluminum	1,520
Arsenic	**10.1 J**
Chromium (Hexavalent)	2.01 J
Manganese	21,300
Vanadium	922
Dissolved Metals (µg/L)	
Arsenic	9.97 J
Beryllium	0.965 J
Chromium (Hexavalent)	0.028 J
Cobalt	23.2
Lead	2.35 J

Legend

- Shallow Aquifer Monitoring Well
- Abandoned Shallow Aquifer Monitoring Well
- St. Juliens Creek Annex Boundary
- General Direction of Shallow Aquifer Groundwater Flow in Site 5 Vicinity
- Site 5 Boundary
- Delineated Wetland Boundary
- Demolished Building
- Removal Area

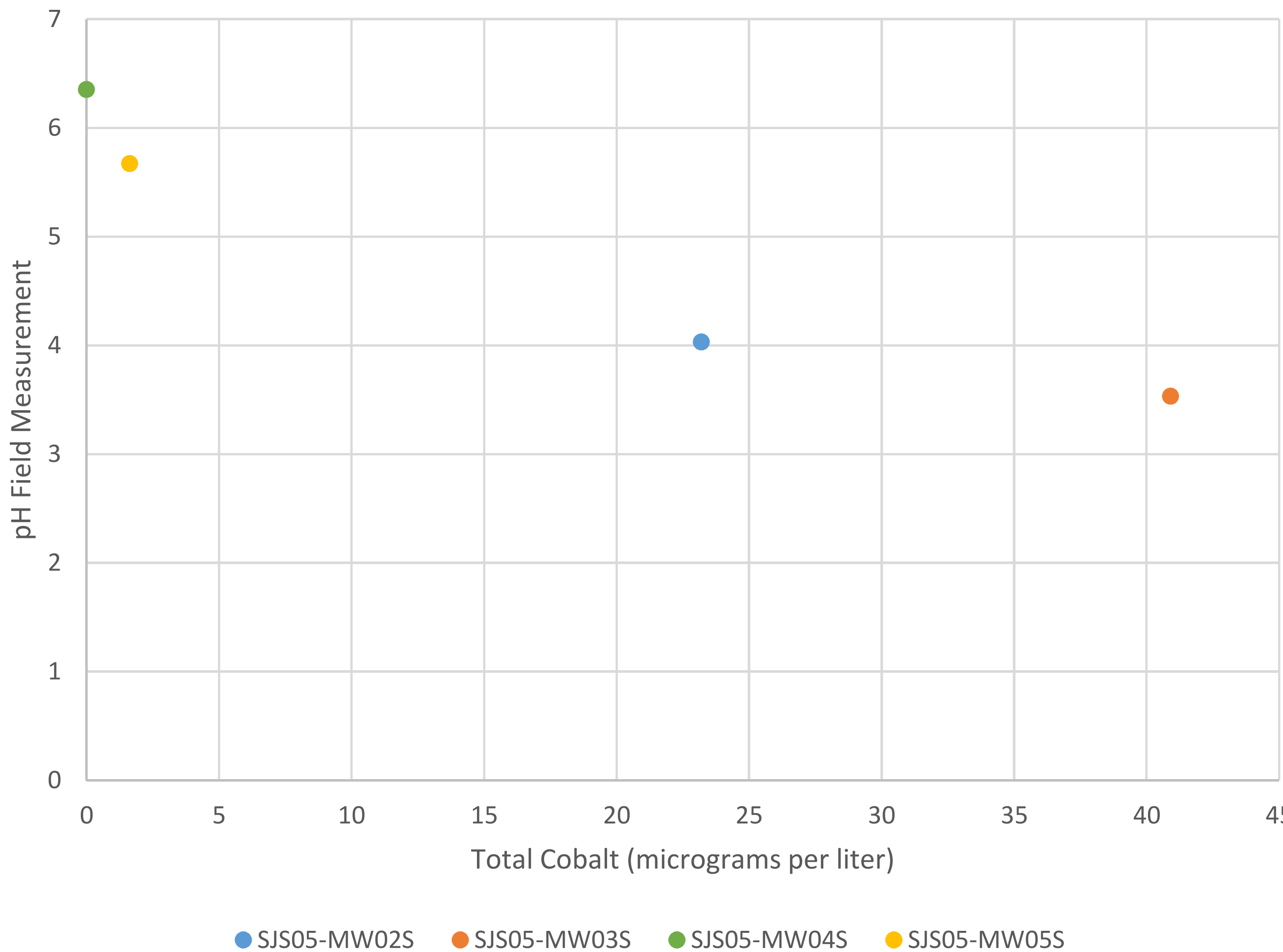
N W E S

0 100 200 Feet

Figure 6-1
Site 5 Supplemental Remedial Investigation
Shallow Aquifer Groundwater Exceedances
Site 5 Supplemental Remedial Investigation Report
St. Juliens Creek Annex
Chesapeake, Virginia

CH2MHILL

Figure 6-2
Site 5 Shallow Aquifer Groundwater pH/Cobalt Relationship
Site 5 Supplemental Remedial Investigation Report
St. Juliens Creek Annex
Chesapeake, Virginia



SECTION 7

Conclusions and Recommendations

This Supplemental RI was conducted to determine whether the current concentrations of the shallow aquifer groundwater COCs identified in the 2007 Expanded RI Addendum HHRA (CH2M HILL, 2007a) and updated 2013 risk calculations (Agviq-CH2M HILL, 2014) pose unacceptable risk, and if so, whether they are the result of a CERCLA release that requires remedial action.

Samples were collected to determine current concentrations of the COCs and the HHRA was updated to reflect the latest data. Potential unacceptable risks were identified from potable exposure to select metals (aluminum, arsenic, beryllium, cobalt, iron, hexavalent chromium, and manganese) in the shallow aquifer groundwater.

Aluminum, beryllium, iron, hexavalent chromium, and manganese were not retained as COCs at the conclusion of the HHRA based on a combination of the following:

- Constituent concentrations are less than background concentrations (SJCA 95 percent background UTLs) (iron and manganese).
- Constituent is an essential human nutrient (iron and manganese).
- Constituent contributes to a cumulative HI greater than 1 or an ELCR greater than 1×10^{-4} but is not the primary contributor and alone would not be identified as a risk driver (aluminum, beryllium, and hexavalent chromium).
- Constituent CTE HI is less than 1 and/or CTE ELCR is less than 1×10^{-4} (aluminum, beryllium, and hexavalent chromium).

The COCs that were retained at the conclusion of the HHRA (arsenic and cobalt), and constituents that exceeded their respective MCL and Action Level (arsenic and lead, respectively) were further evaluated to determine whether they are the result of the CERCLA release and require remedial action.

Arsenic, cobalt, and lead were not retained as COCs based on the following:

- Arsenic
  - The detected concentrations of total arsenic that exceed the MCL are only slightly above the MCL.
  - The detected concentrations of total arsenic are less than or similar in magnitude to the SJCA 95 percent background UTL.
  - The highest detected arsenic concentration is side-gradient of the CERCLA source.
  - The arsenic CTE HI is less than 1 and the CTE ELCR is less than 1×10^{-4}.
- Lead
  - The detected concentration of total lead that exceeds the Action Level is only slightly above the Action Level.
  - Lead is not identified as a COC in the updated HHRA.
  - The highest detected lead concentration is side-gradient of the CERCLA source.
- Cobalt
  - The highest detected concentrations of total cobalt are similar in magnitude to the SJCA 95 percent background UTL.
  - Cobalt concentrations in the groundwater within the waste disposal/burning area were not elevated and cobalt was not identified as a COC in the soil.

- The highest detected concentrations of cobalt are located within the area of shallow aquifer groundwater that has low pH; the low pH is attributed to historical placement of dredge fill in the area and/or relatively low pH in the rainfall. It is the low pH that is mobilizing cobalt. A contributing factor is the lack of any significant alkalinity in the area; if alkalinity was present, the low pH would be neutralized.

Evaluation of the data indicates that the CERCLA release (waste disposal and burning) has not significantly impacted the shallow aquifer groundwater at Site 5, and that the concentrations of metals in the shallow aquifer groundwater are the result of naturally occurring site conditions and/or non-CERCLA related historical activities. Therefore, NFA is recommended for the shallow aquifer groundwater at Site 5.

SECTION 8
References

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Appendix A
Field Notes

Location SJCA Date 4-28-14

Project / Client SITE 5 SUPPLEMENTAL RI

PN: 411510.04.07.09.00

0700 ARRIVE AT OFFICE, PACK TRUCK
PERSONNEL: JOE McCLOUD/UBO
TOBY STEWART/UBO
WEATHER: HIGH 59°F, PARTLY CLOUDY, 80% CHANCE OF RAIN
H+S: BIOLOGICALS IN TALL GRASS AROUND WELLS TAPE UP/ PERFORM TICK CHECKS
OBJECTIVE: COLLECT SURFACE WATER QUALITY FIELD MEASUREMENTS, STAGE IOW AND BEGIN DEVELOPING MONITORING WELLS

0800 MOB TO SJCA

0830 ARRIVE AT SITE 5

0835 CALIBRATE YSI #

			LOT #	EXP
COND (4.49mS/cm)		4.485	10704	07/14
pH4	4.09	4.00	"	"
pH7	6.89	7.00	3112552	11/15
pH10	9.84	10.00	3102456	11/15
ORP (240mV)	243.1		4159	03/17
@16.5°C				
DO%	100.5%	10.38mg/L		
TURB (0NTU)	4.9	0.0	10704	07/14
TURB (126NTU)	110	126	1336376	09/14

0850 MOB TO COLLECT SURFACE WATER QUALITY PARAMETERS

Location SSCA Date 4-28-14

Project / Client SITE 5 SUPPLEMENTAL RI

PN: 411510.04.07.09.00

WETLAND AREA ADJACENT TO MW02S

pH: 6.26 @ 11.9°C ≈100' E OF MW02S

pH: 3.67 @ 11.16°C IN DITCH 10' E MW02S

WETLAND AREA SOUTH OF MW02S/MW03S

pH: 4.28 @ 13°C

pH: 5.76 @ 14.04°C 10' CLOSER TO BLOWS CREEK

1045 MOB TO PICK UP DRUMS/SUPPLIES

1300 CONSTRUCT SECONDARY CONTAINMENT PAD WITH PALLETS FROM SHAW

1400 MOB TO MW01S TO BEGIN DEVELOPMENT

DTW: 3.92' btoc DTB: 15.68' btoc

1445 BEGIN SURGING WITH SURGE BLOCK FULL 10' LENGTH OF WELL SCREEN; 3 WELL VOL = 5.75 gal

~~1500~~

1500 BEGIN PURGING MW15 DTW = 4.04

TIME	TEMP °C	COND mS/cm	SAL PPT	DO %	pH	ORP mV	TURB NTU	DTW ft 4.04	VOL
1505	13.67	0.386	0.19	2.81	5.26	159.4	1473.8	6.82	~~8 gal~~ [illegible]
VERY FINE GRAINED NATIVE SAND									
1515	13.42	0.254	0.15	3.14	5.14	130.2	14.34	12.82	15 gal
FLOW REDUCED FROM 1.54 gal/min TO 0.75 gal/min									
1525	13.79	0.405	0.20	3.98	4.97	111.0	418.5	5.91	23 gal
1535	13.69	0.423	0.20	1.78	4.91	58.4	57.1	6.21	30 gal
1540	13.67	0.427	0.21	1.55	4.90	47.3	39.4	6.30	34 gal
1545	13.66	0.428	0.21	1.38	4.90	37.5	26.3	6.25	38 gal

Location SJCA Date 4-28-14

Project / Client SITE 5 SUPPLEMENTAL RI

PN: 411510.04.07.09.00

TIME	TEMP	COND	SAL	DO	pH	ORP	TURB	DTW	VOL
1550	13.65	0.431	0.21	1.26	4.89	31.6	19.8	6.86	40gal
1555	13.62	0.429	0.21	1.19	4.89	28.1	22.0	6.90	45gal
1600	13.65	0.452	0.22	1.11	4.92	17.8	34.0	5.48	50gal
	FLOW REDUCED TO ≈ 0.5 gal/min								
1605	13.77	0.425	0.21	1.26	4.87	19.9	42.4	5.31	55gal
1610	13.77	0.424	0.21	1.12	4.86	25.1	22.3	5.29	60gal
1615	13.78	0.426	0.21	1.05	4.85	27.0	11.2	5.26	63gal
1620	13.84	0.429	0.21	0.90	4.84	27.9	8.5	5.25	66gal
1625	13.73	0.430	0.21	0.80	4.83	27.8	7.7	5.27	69gal
1630	13.68	0.432	0.21	0.78	4.83	28.3	7.9	5.27	72gal

1633 PUMP OFF TOTAL PURGE VOLUME ≈ 75gal

1645 MOB TO IDW STAGING AREA AT BLDG 1456 TO DROP OFF PURGE WATER

1715 MOB BACK TO OFFICE

4-28-14

Location: SSLA

Project / Client: SITE 5 SUPPLEMENTAL RI   Date: 4-29-14

PN 411510.0067.09.00

0700 PURCHASE ADDITIONAL DRUMS

0730 ARRIVE AT OFFICE

PERSONNEL: TOBY STEWART/VBO

JOE MCCLANAHAN/VBO

WEATHER: HIGH 68F SCATTERED SHOWERS

60% CHANCE OF RAIN

H+S: SLIPS, TRIPS, FALLS WORKING AROUND

WELLS IN HEAVY VEGETATION AND GETTING

INTO AND OUT OF THE TRUCK BED

OBJECTIVE: DEVELOP BACKGROUND AND

SITE 5 SHALLOW MONITORING WELLS

0830 MOB TO LOWES TO BUY RING CLAMPS

0900 ARRIVE AT STAGING AREA

0930 CALIBRATE YSI # 1113496

COND (4.49 mS/cm)	4.067	4.490
pH_4	4.41	4.00
TURB (0 NTU)	~~7.77~~ 0.4	~~7.95~~ 0.0
pH_7	7.17	7.00
pH_{10}	9.87	9.98
TURB (126 NTU)	120.1	125.9
DO	98.4% 10.52 mg/L	100.96 10.79 mg/L
ORP	239.4 @ 11.9°C	

0950 MOB TO LOCATE MW009S

PATH FROM NORTH ROAD TO FLOODED TO DRIVE

Location: SSLA   Date: 4-29-14

Project / Client: SITE 5 SUPPLEMENTAL RI

1050 CLEAR AROUND SSS05-MW02S

DTW: 3.05 btoc   DTB: 16.05' btoc

SCREEN INT: 3.5-13.5 bgs, WELL VOL: 2.12 gal

1050 BEGIN SURGING SSS05-MW02S WITH

SURGE BLOCK OVER LENGTH OF SCREEN

1105 DISCONTINUE SURGING INITIAL WATER

1115 VERY DARK REDDISH BROWN. BEGIN PURGING

TIME	TEMP	COND	SAL	pH	ORP	TURB	DO	DTW	VOL
1118	13.06	2727	1.92	4.60	15.5	1526.7	2.13	4.25	5gal
					CHEMICAL LIKE ROTTEN ~~EGG~~ ODOR				10gal
1124	12.58	2932	1.53	4.32	+5.3	43.8	0.98	4.29	15gal
1129	12.58	2464	1.55	4.36	-28.2	21.3	2.36	4.31	25gal

INITIAL FLOW RATE ≈ 2gpm

1132 FLOW REDUCED TO 0.6gpm

TIME	TEMP	COND	SAL	pH	ORP	TURB	DO	DTW	VOL
1135	12.91	3017	1.58	4.34	-31.8	10.2	0.30	3.42	[illegible]gal
1140	12.84	2984	1.57	4.35	-47.8	5.8	0.19	3.44	30gal
1145	12.90	2992	1.57	4.35	-54.0	4.8	0.15	3.46	33gal
1150	12.90	2990	1.57	4.35	-56.2	4.8	0.14	3.48	35gal

1200 MOB TO DUMP PURGE WATER / LUNCH

1300 MOB TO SSS05-MW03S

DTW 3.53' btoc   DTB: 16.76' btoc

SCREEN INT: 3.2-13.2' bgs   WELL VOL: 2.16

1310 BEGIN SURGING

1330 BEGIN PURGING SSS05-MW03S

PUNGENT ODOR

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Location SJCA

Project / Client SITE 5 SUPPLEMENTAL RI Date 4-29-14

PN: 411510.04.07.09.00

PURGE RATE INITIALLY ≈ 2gal pm

TIME	TEMP	COND	SAL	pH	ORP	NTU	DO	VOL	DTW
1335	12.65	2.450	1.27	3.65	~~785.2~~ 99.8	1853	2.78	15gal	4.65
1340	12.68	2.423	1.26	3.61	72.5	89.5	0.81	20gal	4.70
1345	13.27	2.394	1.24	3.64	49.6	67.5	0.37	30gal	4.72
1350	13.32	2.309	1.19	3.65	31.2	95.2	0.21	32gal	3.85

FLOW REDUCED TO ≈ 0.6gpm

TIME	TEMP	COND	SAL	pH	ORP	NTU	DO	VOL	DTW
1355	13.11	2.317	1.20	3.67	27.7	85.7	0.14	35gal	3.92
1400	13.14	2.329	1.20	3.67	30.4	16.1	0.13	38gal	3.94
1405	13.11	2.337	1.21	3.68	33.1	14.7	0.11	41gal	3.96
1410	13.12	2.347	1.21	3.68	37.4	12.0	0.10	44gal	4.00

DISCONTINUE PURGING

1420 MOB TO DUMP PURGE WATER

1430 MOB TO SJSBK-MW35

DTW: 3.90' btoc   DTB ≈ 14' btoc VERY SOFT

SCREEN INT: 3-13' bgs   WELL VOL: 1.64

1445 BEGIN SURGING SJSBK-MW35 WITH SURGE BLOCK

~~1455~~ 1500 BEGIN PURGING SJSBK-MW35

PURGE RATE ≈ 2gpm

PURGE WATER REDDISH BROWN

TIME	TEMP	COND	SAL	pH	ORP	NTU	DO	VOL	DTW
1505	13.3	0.474	0.23	5.32	97.3	1570	5.17	10	11.90
1508	13.31	0.480	0.23	5.25	105.8	1570	4.72	15	12.35

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Location SJCA Date 4-29-14

Project / Client SITE 5 SUPPLEMENTAL RI

PN: 411510.04.07.09.00

FLOW REDUCED TO ALLOW WELL TO RECHARGE

FLOW ≈ 0.4gpm PUMP RAISED TO CENTER OF SCREEN

TIME	TEMP	COND	SAL	pH	ORP	TURB	DO	VOL	DTW
1520	13.94	0.489	0.24	5.39	108.5	834.9	1.72	28gal	6.50

1530 PURGE RATE INCREASED TO 2gpm PUMP DROPPED TO BOTTOM OF WELL

TIME	TEMP	COND	SAL	pH	ORP	TURB	DO	VOL	DTW
1535	13.53	0.478	0.23	5.31	109.1	1572	5.67	35gal	11.35
1540	13.40	0.500	0.24	5.45	111.9	1571	3.25	50gal	13.90
1550	13.42	0.541	0.26	5.60	110.9	443.6	3.67	65gal	15.40

1551 PUMP OFF TO ALLOW WELL TO RECHARGE

1600 MOB TO DUMP PURGE WATER

1630 MOB TO SJSBK-MW25

DTW: 3.30 btoc   DTB: 15.70' btoc

SCREEN INT: 3.5-13.5' bgs   WELL VOL: 2.02

1650 BEGIN SURGING W/ BLOCK

1700 BEGIN PURGING ≈ 2gpm

TIME	TEMP	COND	SAL	pH	ORP	TURB	DO	VOL	DTW
1708	12.06	0.588	0.29	4.99	124.2	1553	2.56	12	5.35'
1713	12.01	0.595	0.29	4.95	136.2	309.9	2.04	22	6.15'
1718	11.99	0.610	0.30	4.95	146.1	180.5	2.30	35	6.19

1720 REDUCE FLOW TO ≈ 0.6gpm

TIME	TEMP	COND	SAL	pH	ORP	TURB	DO	VOL	DTW
1730	12.22	0.667	0.33	4.90	153.7	170.8	1.08	40	3.90
1735	12.27	0.664	0.33	4.91	156.3	93.2	1.05	43	3.89
1740	12.26	0.662	0.32	4.91	158.6	50.7	1.01	46	3.89

Location SJCA Date 4-29-14

Project / Client SITE 5 SUPPLEMENTAL RI

PN: 411510.04.07.09.00

TIME	TEMP	COND	SAL	pH	ORP	NTU	DO	VOL	DTW
1745	12.25	0.661	0.32	4.90	162.0	31.6	0.99	49	3.89
1750	12.21	0.659	0.32	4.89	164.9	21.1	0.97	51	3.89
1755	12.23	0.658	0.32	4.88	168.4	15.2	0.92	54	3.89
1800	12.25	0.658	0.32	4.88	171.0	11.3	0.88	57	3.89
1805	12.24	0.659	0.32	4.87	173.1	9.7	0.86	60	3.90

1807 PUMP OFF DTB: 15.70' btoc

1820 MOB TO DUMP PURGE WATER

1845 MOB TO OFFICE

4-29-14

Location SJCA Date 4-30-14

Project / Client SITE 5 SUPPLEMENTAL RI

PN: 411510.04.07.09.00

0700 ARRIVE AT OFFICE, PICK UP BATTERY

0730 MOB TO SJCA

WEATHER: HIGH 79°F, CLOUDY 80% CHANCE OF RAIN, THUNDERSTORMS POSSIBLE

H+S: SLIPS, TRIPS, FALLS WHEN WALKING THROUGH VEGETATION. BIOLOGICAL HAZARDS

OBJECTIVE: FINISH DEVELOPING SJSBK-BW03S DEVELOP SJS05-MW55, LOCATE AND DEVELOP SJSBK-MW AND SJS05-MW45

0800 ARRIVE ON SITE AT SJCA

CALIBRATE YSI # 11L2496

COND (4.49 mS/cm)	4.890	4.491
pH_4	3.93	4.00
TURB (0 NTU)	-0.2	0.1
pH_7	6.91	7.00
pH_{10}	9.86	10.00
TURB (126 NTU)	120.2	126.1
DO	100.4 9.18	100.6 9.20
ORP	234.9	

0825 MOB TO CLEAR AROUND SJS05-MW55

DTW: 2.60' BTOC DTB: 16.56

SCREEN INT: WELL VOL:

0845 SURGE WITH SURG BLOCK

0855 DISCONTINUE SURGING

Location SJCA

Project / Client SITE 5 SUPPLEMENTAL RE

Date 4-30-14

PN: 411510.04.07.09.00

0856 BEGIN PURGING SJS05-MW53

RATE ≈ 2gpm

TIME	TEMP	COND	SAL	pH	ORP	NTU	DO	VOL	DTW
0900	12.84	0.278	0.13	6.20	-10.9	1547	4.31	9	8.60
0906	12.86	0.274	0.13	5.94	-26.4	1596	1.82	24	12.84
0911	13.05	0.338	0.16	6.08	-43.7	1597	2.69	35	13.51
0917	13.08	0.445	0.22	6.04	-22.2	1491	2.63	45	
~~0925~~	FLOW REDUCED ≈ [illegible] gpm								6.95
0936	13.67	0.611	0.30	5.94	-30.3	1298	2.05	55	6.95
0946	13.66	0.657	0.32	5.88	-34.7	1126	2.40	60	6.99
0952	FLOW REDUCED TO ≈ 0.5gpm								
0957	14.20	0.780	0.38	5.73	-46.1	90.2	1.95	70	6.20
1005	14.26	0.760	0.37	5.60	-28.8	91.5	2.17	74	5.95
1012	14.42	0.786	0.39	5.52	-24.6	61.2	2.22	~~80~~ 77	5.94
1020	14.51	0.812	0.40	5.39	-20.5	49.2	2.21	81	5.95
1026	14.53	0.834	0.41	5.28	-17.7	50.6	2.18	84	5.94
1031	14.64	0.851	0.42	5.22	-15.0	14.4	2.15	~~88~~ 86	5.68

TURBIDITY REDUCED AS LOW AS POSSIBLE

1045 MOB TO DUMP PURGE WATER

1115 MOB TO LOCATE SJS05-MW04S

1220 MOB TO SJS8K-MW63

DTW: 0.35 bgs DTB: 14.79' bgs

1240 BEGIN SURGING

PVC CASING PULLED UP ≈3" WHEN THE

Date 4-30-14

Location SJCA

Project / Client SITE 5 SUPPLEMENTAL RI

PN: 411510.04.07.09.00

SURGE BLOCK WAS REMOVED FROM THE WELL IT WAS HAMMERED BACK DOWN INTO PLACE THE SURGE BLOCK WAS RE-INSERTED TO CHECK THAT THE PIPE WAS NOT WARPED, AND CAREFULLY REMOVED

1257 BEGIN PURGING

FLOW RATE ≈ 2gpm

TIME	TEMP	COND	SAL	pH	ORP	NTU	DO	VOL	DTW
1302	16.05	2174	1.12	5.86	-28.9	1637	3.25	10	5.72
1312	16.01	2352	1.22	5.69	-24.1	1072.0	3.84	20	5.78
1322	16.03	2387	1.24	5.85	-26.7	44.1	4.54	30	5.84
1324	FLOW REDUCED TO ≈ 0.5gpm								
1334	16.64	2356	1.22	5.78	-54.0	23.7	0.26	45	4.50
1344	16.65	2389	1.24	5.65	-57.9	8.7	0.21	50	4.28
1350	16.49	2386	1.23	5.47	-55.2	3.6	0.17	55	4.27

1400 MOB TO DUMP PURGE WATER

1430 MOB TO SJS8K-MW35

DTW = 4.33' BTOC, 16.83' BTOC TOTAL DEPTH

1446 RESUME PURGING SJS8K-MW35

FLOW RATE ≈ 0.55gpm

TIME	TEMP	COND	SAL	pH	ORP	TURB	DO	DTW	VOL
1455	14.37	0.757	0.12	4.42	176.5	1134.6	5.68	6.37	3.75
	VERY CLOUDY, SUSPENDED SILTS AND CLAY PARTICLES								
1502	14.33	0.261	0.12	4.47	187.3	499.1	5.57	6.55	7.6
1511	14.34	0.261	0.12	4.53	197.8	214.0	5.63	6.56	12.55

Location SJCA Date 4-30-14

Project / Client SITE 5 SUPPLEMENTAL RI

PN: 411510.04.07.09.00

TIME	TEMP	COND	SAL	pH	ORP	TURB	DO	DTW	VOL
1520	14.32	0.261	0.12	4.55	208.5	140.2	5.57	6.59	17.5
1530	14.30	0.262	0.13	4.64	220.4	101.8	5.24	6.64	23
1540	14.31	0.267	0.13	4.70	231.7	77.8	4.61	6.75	28.5
1550	14.34	0.272	0.13	4.73	242.7	57.9	4.92	6.77	34

1555 PUMP OFF DEVELOPED TO EXTENT PRACTIBLE
SUSPENDED SOLIDS ?45 min TO SETTLE
WHEN LEFT UNDISTURBED

1615 MOB TO PUMP PURG WATER

1650 MOB TO OFFICE

[signature] 4-30-14

Location SJCA Date 5-1-14

Project / Client SITE 5 SUPPLEMENTAL RI

PN: 411510.04.07.09.00

0700 ARRIVE AT OFFICE

0730 MOB TO SITE

0800 ARRIVE AT SITE 5

WEATHER: UPPER 70's, 80% CHANCE RAIN POSSIBLE THUNDERSTORMS IN THE AFTERNOON.

H+S: MONITOR CHANGING WEATHER CONDITIONS

OBJECTIVE: DEVELOP SJS05-MW4S, SAMPLE WELLS AS TIME PERMITS

0805 CALIBRATE YSI # 1113496

COND (4.49mS/cm)	4.17	4.49
pH_4	3.99	4.00
pH_7	7.04	7.00
pH_{10}	10.08	10.00
TURB (0NTU)	0.5	0.0
TURB (126NTU)	117.4	126.5
DO (%) 101.1	9.02mg/L	100.0 8.90mg/L
ORP(mV) 20.5°C	235.5mV	

MOB TO SJS05-MW4S

DTW: 3.36' btoc DTB: 16.89' btoc

SCREEN INT: WELL VOL: 2.20gal

0936 BEGIN SURGING WELL

0943 BEGIN PURGING

FLOW RATE ≈ 1.25gal/min

Location SJCA Date 5-1-14

Project / Client SITE 5 SUPPLEMENTAL RI

PN: 411510.04.07.09.00

TIME	TEMP	COND	SAL	pH	ORP	TURB	DO	VOL	DTW
0950	14.16	1.000	0.50	6.54	166.7	1765	2.05	8.75	8.36
1000	15.92	1.090	0.54	6.55	21.8	1602	0.69	17.0	3.86
1005	15.28	1.120	0.56	6.55	18.2	453.6	0.58	20.0	—

– flow reduced to ≈ 0.5-0.6 gal/min @ 15 gal purged, pump relocated from bottom of well casing to mid-screen.

TIME	TEMP	COND	SAL	pH	ORP	TURB	DO	VOL	DTW
1015	15.27	1.111	0.56	6.43	6.5	114.0	0.53	25	4.78
1020	15.11	1.114	0.56	6.36	5.4	50.2	0.54	28	4.80
1030	15.16	1.113	0.56	6.34	1.6	25.3	0.57	31	4.80
1035	15.03	1.126	0.56	6.21	2.5	17.4	0.58	34	4.80
1040	15.10	1.131	0.57	6.17	2.1	12.2	0.56	37	4.80
1045	15.67	1.140	0.57	6.18	-0.3	9.6	0.55	41	4.80
1050	15.27	1.139	0.57	6.11	-0.5	8.2	0.56	45	4.80
1055	15.68	1.149	0.57	6.05	-0.6	6.3	0.54	48	4.80

1100 PUMP OFF ≈ 55 gal PURGED

1200 MOB TO DUMP PURG WATER

CALL IN TO SAFETY MEETING

1300 MOB TO SJSBK-MW15

DTW: 2.83 DTB: 15.68

SCREEN INT: 3-13' WELL VOL: 2.09 gal

TUBING SET @ ≈ 11' bTOC

1335 BEGIN PURGING SJSBK-MW15

PURGE RATE = 250 ml/min

PARAMETERS →

Location SJCA Date 5-1-14

Project / Client SITE 5 SUPPLEMENTAL RI

PN: 411510.04.07.09.00

TIME	TEMP	COND	SAL	pH	ORP	TURB	DO	VOL	DTW
1340	16.54	0.146	0.07	4.97	140.7	1171	0.87	0.30	2.88
1345	15.88	0.139	0.07	4.39	182.5	132.0	0.46	0.60	2.88
	PUMPED WATER FROM FLOW THRU CELL								2.94 ↓
1355	15.68	0.146	0.07	4.36	198.5	55.9	0.56	1.25	
1400	15.81	0.153	0.07	4.25	206.3	34.7	0.30	1.75	2.94
1405	15.71	0.160	0.08	4.38	200.2	33.8	0.82	2.25	2.94
1410	15.93	0.164	0.08	4.31	207.6	23.4	0.28	2.60	2.94
1418	15.91	0.169	0.08	4.33	210.1	24.1	0.41	3.00	2.94
1420	16.01	0.170	0.08	4.35	211.6	21.7	0.22	3.40	2.94
1425	16.17	0.171	0.08	4.37	213.1	20.9	0.22	3.60	2.99
1430	16.19	0.173	0.08	4.37	214.6	17.3	0.24	3.80	2.94
1435	16.12	0.174	0.08	4.33	216.7	14.9	0.18	4.00	2.94
1440	16.42	0.176	0.08	4.37	216.9	14.9	0.19	4.20	2.94
1445	15.85	0.177	0.08	4.38	218.1	14.1	0.14	4.40	2.96
1450	15.45	0.179	0.08	4.28	222.2	11.9	0.13	5.00	2.99
1455	15.58	0.181	0.09	4.28	224.2	12.6	0.13	5.50	2.99
1500	15.41	0.179	0.08	4.25	227.1	9.6	0.13	6.10	3.00

1505 COLLECT SJSBK-~~MW01~~ MW01-14B

ANALYSIS: TOTAL/DISSOLVED METALS, DISSOLVED ORGANIC CARBON, TOTAL/DISSOLVED CR6, ANIONS, PH, TOTAL PHOSPHORUS, ACIDITY

DO: 0.8 mg/L

1530 MOB TO SJSBK-MW6S

DTW: 0.35' bgs DTB: 14.79' bgs

Location SJCA Date 5-1-14

Project / Client SITE 5 SUPPLEMENTAL RI

PN: 411510.04.07.09.00

SCREEN INT: 5-15' WELL VOL = 2.35 gal

TUBING SET @ 10'

1540 BEGIN PURGING SJSBK-MW6S

TIME	TEMP	COND	SAL	pH	ORP	TURB	DO	DTW	VOL
1545	16.55	2.208	1.14	5.79	-18.1	168.5	0.50	0.99	0.4
1550	16.38	2.222	1.15	5.73	-28.9	143.5	0.66	1.10	0.8
1555	16.25	2.242	1.16	5.70	-40.4	53.6	0.32	1.11	1.2
1600	16.22	2.244	1.16	5.70	-44.2	47.8	0.26	—	1.6
1605	16.23	2.245	1.16	5.72	-37.0	36.7	0.38	—	2.0
1610	16.13	2.245	1.16	5.74	-42.0	22.6	0.23	1.34	2.40
1615	16.08	2.231	1.15	5.75	-41.0	19.0	0.21	1.28	2.80
1620	16.17	2.243	1.16	5.77	-45.2	21.7	0.19	1.25	3.20
1625	16.20	2.260	1.17	5.80	-46.9	13.4	0.16	1.26	3.60
1630	16.16	2.258	1.17	5.80	-47.6	9.9	0.15	1.26	4.00
1635	16.19	2.258	1.17	5.81	-48.2	6.8	0.14	1.25	4.40

1640 COLLECT SJSBK-MW06-14B

SJSBK-MW06-14B-MS

SJSBK-MW06-14B-SD

ANALYSIS: DISSOLVED/TOTAL METALS, TOTAL/DISS CR6

ANIONS, pH, TOTAL PHOSPHORUS, DISS. ORGANIC CARBON

DO = 1.0 mg/L

1700 MOB TO DUMP PURGE WATER

1735 MOB TO OFFICE TO PACK/SHIP COOLERS

[signature] 5-1-14

Location SJCA Date 5-2-14

Project / Client SITE 5 SUPPLEMENTAL RI

PN: 411510.04.07.09.00

0800 ARRIVE AT OFFICE

0815 MOB TO SITE PERSONNEL: MARK OST, JOE ALLUMS

0850 ARRIVE AT SJCA SITE 5

WEATHER: HIGH 71°F, PARTLY CLOUDY

NO RAIN EXPECTED

H+S: BIOLOGICAL HAZARDS ESPECIALLY IN TALL GRASS. SLIPS, TRIPS, FALLS WALKING TO MW'S THROUGH THE SWAMP

OBJECTIVE: SAMPLE REMAINING 6 MONITORING WELLS, COLLECT EQUIPMENT BLANK, SAMPLE IDW.

0855 CALIBRATE YSI # 1113496

COND (4.49 ms/cm)	2.708	4.49
pH_4	4.14	4.00
pH_7	7.01	7.00
pH_{10}	9.98	10.00
TURB (0NTU)	2.3	0.0
TURB (126NTU)	124.8	126.5
DO	102.8 9.81	100.5 9.14
ORP	238.9 @ 20°C	

0915 MOB TO SJS05-MW02S-

DTW: 3.41 DTB: 16.05 btoc

SCREEN INT: 3.5-13.5 WELL VOL: 2.12 gal

TUBING @ ≈ 10' btoc PURGE RATE ≈ 500 ml/min

Location SJCA Date 5-2-14

Project / Client SITE 5 SUPPLEMENTAL RI

PN: 411510.04.07.09.00

0920 BEGIN PURGING SJS05-MW02S

TIME	TEMP	COND	SAL	pH	ORP	TURB	DO	DTW	VOL
0925	13.01	2.634	1.37	4.00	102.5	0.8	0.46	3.49	1.00
0930	13.03	2.632	1.37	3.99	109.0	1.4	0.30	3.49	1.5
0935	12.98	2.626	1.37	4.00	106.5	1.8	0.26	3.49	2.25
0940	12.93	2.619	1.36	4.01	105.0	1.4	0.21	3.49	3.0
0945	12.93	2.611	1.36	4.02	103.0	0.8	0.18	3.49	3.75
0950	12.98	2.607	1.36	4.03	101.5	0.6	0.16	3.49	4.50

0955 COLLECT SJS05-MW02S-14B

1000 COLLECT SJS05-MW02SP-14B

~~1015 MOB TO SJS05-MW0~~

ANALYSIS: TOTAL/DISSOLVED METALS, CR6, DISSOLVED ORGANIC CARBON, pH, ACIDITY, ANIONS TOTAL PHOSPHORUS

DO: 0.20 mg/L

1015 MOB TO SJS05-MW03S-14B

DTW: 3.53 btoc DTB: 16.76 btoc

SCREEN INT: 3.2-13.2' WELL VOL: ~~16.76~~ 2.16

TUBING @ 11' btoc

1020 BEGIN PURGING FLOW: 350 ml/min

TIME	TEMP	COND	SAL	pH	ORP	TURB	DO	DTW	VOL
1025	13.15	2.147	1.10	3.46	239.7	6.8	0.44	4.20	0.75
1030	13.15	2.035	1.04	3.49	239.7	2.1	0.31	4.20	1.00
1035	13.22	2.020	1.04	3.52	237.8	2.1	0.24	4.20	1.50
1040	13.16	2.011	1.03	3.64	235.1	2.6	0.21	4.20	1.85

Location SJCA Date 5-2-14

Project / Client SITE 5 SUPPLEMENTAL RI

PN: 411570.04.07.09.00

TIME	TEMP	COND	SAL	pH	ORP	TURB	DO	DTW	VOL
1045	13.12	2.00	1.03	3.54	233.3	2.6	0.19	4.20	2.5
1050	13.18	2.00	1.03	3.54	232.2	1.9	0.20	4.20	3.5
1055	13.18	2.00	1.03	3.53	233	1.7	0.19	4.20	4.5

1100 Collect SJ05-MW03S-14B

DO by CHEMets 0.2 mg/L

1100 MOB TO SJSS05-MW05S

DTW: 3.00' btoc DTB: 16.56' btoc

SCREEN INT: WELL VOL: 2.21 gal

TUBING @ ≈11' btoc

1120 BEGIN PURGING MW05S Flux

Time	Temp	Cond	Sal	pH	ORP	Turb	DO	DTW	Vol
1125	16.42	0.394	0.19	5.81	-51.9	6.9	0.74	3.50	
1130	15.91	0.388	0.19	5.81	-68.3	3.7	0.39	3.50	
1135	16.37	0.388	0.19	5.81	-72.1	3.8	0.37	3.50	
1140	15.70	0.392	0.19	5.78	-83.2	3.1	0.25	3.50	
1145	15.39	0.391	0.19	5.72	-82.5	4.6	0.19	3.50	
1150	14.91	0.391	0.19	5.70	-81.9	4.7	0.18	3.50	
1155	14.85	0.394	0.19	5.67	-81.7	2.7	0.19	3.50	3 gal

1200 Collect SJ05-MW05S-14B

ANALYSIS: DISSOLVED/TOTAL METALS, CR6, ANIONS, pH

ALKALINITY, DISS ORGANIC CARBON, TOTAL PHOSPHOROUS

DO: 0.8 mg/L

1215 MOB TO SJSSBK-MW3S

Location SJCA Date 5-2-14

Project / Client SITE 5 SUPPLEMENTAL RI

PN: 411510.04.07.09.00

DTW: 4.33' bTOC DTB: 16.83' bTOC

SCREEN INT: 3-13' [redacted] WELL VOL: 2.04 gal

TUBING @ ≈ 11' bTOC

1225 BEGIN PURGING SJSBK-MW03S

PURGE RATE ≈ 150 ml/min

TIME	TEMP	COND	SAL	pH	ORP	TURB	D.O.	DTW	VOL
1230	14.18	0.393	0.19	4.67	118.4	185.6	3.87	5.09	0.40
1235	14.47	0.390	0.19	4.61	142.2	272.2	3.81	5.09	0.60
1240	14.34	0.389	0.19	4.60	153.5	334.2	3.82	4.99	0.80
1245	14.35	0.392	0.19	4.59	163.4	370.9	3.75	4.97	1.00
1250	14.37	0.395	0.19	4.62	176.0	304.3	3.71	4.96	1.20
1255	14.44	0.399	0.19	4.64	183.5	267.0	3.59	4.96	1.40
1300	14.60	0.401	0.19	4.68	196.0	197.4	3.69	4.96	1.70
1305	14.59	0.402	0.19	4.70	198.4	141.1	3.64	4.96	2.00
1310	14.66	0.411	0.20	4.71	203.2	92.2	3.52	4.96	2.30
1315	14.44	0.415	0.20	4.73	208.0	69.5	3.55	4.96	2.60
1320	14.36	0.411	0.20	4.74	214.3	49.8	3.60	4.96	2.90
1325	14.46	0.409	0.20	4.75	219.1	43.3	3.59	4.96	3.20
1330	14.50	0.409	0.20	4.77	221.4	33.3	3.61	4.96	3.50
1335	14.51	0.409	0.20	4.80	224.1	27.4	3.62	4.96	3.80
1340	14.59	0.410	0.20	4.83	228.2	19.8	3.56	4.96	4.10
1345	14.61	0.410	0.20	4.84	229.6	20.4	3.52	4.96	4.40
1350	14.47	0.412	0.20	4.84	231.9	15.7	3.55	4.97	4.70
1355	14.42	0.414	0.20	4.55	234.6	13.0	3.46	4.98	5.00

Location SJCA Date 5-2-14

Project / Client SITE 5 SUPPLEMENTAL RI

PN: 411510.04.07.09.00

TIME	TEMP	COND	SAL	pH	ORP	TURB	DO	DTW	VOL
1400	14.44	0.414	0.20	4.87	236.0	12.8	3.46	5.00	5.30
1405	14.49	0.414	0.20	4.88	236.6	9.5	3.51	5.01	5.60

1410 COLLECT SJSBK-MW3-14B

ANALYSIS: DISSOLVED/TOTAL METALS, CR6, DISSOLVED ORGANIC CARBON, ANIONS, pH, ACIDITY TOTAL PHOSPHORUS

DO: 4.0mg/L

1425 MOB TO DUMP PURGE WATER

1435 MOB TO SJSBK-MW2S

DTW: 3.81' btoc DTB: 15.70' btoc

SCREEN INT: 3.5-13.5 WELL VOL: 1.94 gal

TUBING @ 10' btoc FLOW RATE ≈ 200ml/min

1440 BEGIN PURGING SJSBK-MW2S

TIME	TEMP	COND	SAL	pH	ORP	TURB	DO	DTW	VOL
1445	13.42	0.611	0.30	4.77	216.5	3.2	1.83	3.88	0.25
1450	13.17	0.600	0.29	4.58	238.8	7.4	0.67	3.86	0.50
1455	13.25	0.590	0.29	4.53	251.2	4.4	0.59	3.86	0.75
1500	13.40	0.590	0.29	4.54	257.3	1.5	0.58	3.86	1.00
1505	13.42	0.595	0.29	4.53	263.6	0.6	0.49	3.86	1.35
1510	13.36	0.594	0.29	4.52	266.4	1.4	0.45	3.86	1.60
1515	13.38	0.593	0.29	4.52	268.5	1.6	0.46	3.86	1.85
1520	13.73	0.592	0.29	4.54	269.0	1.3	0.44	3.86	2.15

1525 COLLECT SJSBK-MW2S-14B

Location SJCA Date 5-2-14

Project / Client SITE 5 SUPPLEMENTAL

PN: 411510.04.07.09.00

ANALYSIS: DISSOLVED/TOTAL METALS, CR6, ANIONS, PH, ACIDITY, DISS ORGANIC CARBON, TOTAL PHOSPHORUS

DO: 0.6 mg/L

~~1335~~ 1535 MOB TO SJS05-MW04S

DTW: 3.73' btoc DTB: 16.81' btoc

SCREEN INT WELL VOL: 2.15 gal

TUBING @ 11' btoc

~~1407~~ 1607 BEGIN PURGING SJS05-MW04S

TIME	TEMP	COND	SAL	pH	ORP	TURB	DO	DTW	VOL
~~1410~~ 1610	13.08	1.647	0.84	6.27	168.6	51.5	1.22	4.02	0.50
~~1415~~ 1615	13.12	1.662	0.85	6.31	179.8	37.2	0.84	3.91	0.80
~~1420~~ 1620	13.20	1.663	0.85	6.33	188.8	16.0	0.72	3.92	1.10
~~1425~~ 1625	13.19	1.662	0.85	6.34	18	8.4	0.70	3.92	1.50
~~1430~~ 1630	13.13	1.662	0.85	6.35	192.4	1.2	0.69	3.92	1.90

~~1435~~ 1635 COLLECT SJS05-MW04S-14B

ANALYSIS: DISSOLVED/TOTAL METALS, CR6, TOTAL P, pH, ANIONS, ACIDITY, DISSOLVED ORGANIC CARBON

DO: 0.8 mg/L

1645 Collect SJS05-~~FA~~ EB 050214

1700 Collect SJS05 IDW 050214

1718 MOB TO SHIP COOLERS

1755 MOB TO OFFICE TO UNLOAD TRUCK

1830 END DAY

5-2

Appendix B
Data Usability Assessment

APPENDIX B

Data Usability Assessment

Agviq-CH2M HILL staff collected groundwater samples on May 1 and 2, 2014 for the St. Juliens Creek Annex Site 5 Supplemental Remedial Investigation (RI) following the standard operating procedures outlined in the project-specific uniform federal policy – sampling and analysis plan (UFP-SAP) (Agviq-CH2M HILL, 2014). The samples were submitted to independent offsite laboratories for analysis. Samples collected for analysis of select total and dissolved metals, acidity, chloride, nitrate, sulfate, dissolved organic carbon, pH, and total phosphorus were sent to Environmental Conservation Laboratories (ENCO) in Orlando, Florida. Samples collected for total and dissolved hexavalent chromium analysis were sent to EMAX Laboratories (EMAX) in Torrance, California.

In accordance with the UFP-SAP, a data usability assessment was performed for the data collected during the Supplemental RI sampling event. As described in the UFP-SAP Worksheets 34 through 36, these data have gone through several levels of data verification and validation. This includes internal laboratory quality control (QC) checks, Agviq-CH2M HILL verification procedures, internal Agviq-CH2M HILL Level III validation on definitive analytical results, and internal Agviq-CH2M HILL Level IV validation (re-calculation of results) on 10 percent of the analytical results (excluding wet chemistry).

This data usability assessment evaluates the overall measurement performance results and their potential effects on data availability for decision-making. “Availability” in this context refers to whether results can be used by the project team based on their analytical soundness. If a result is analytically sound, it is available to use for evaluating the potential releases, nature and extent of contamination, and estimating potentially associated human health and ecological risks.

B.1 Quality Assurance/Quality Control Samples

Field quality assurance (QA)/ QC samples, including one field duplicate, one matrix spike/ matrix spike duplicate (MS/MSD), and one equipment blank, were collected and sent to the laboratory for analysis of select total and dissolved metals. The field duplicate was also collected for pH analysis. The field duplicate was collected to assess precision between the parent sample and it’s duplicate. The MS/MSD was collected to assess accuracy and bias in the field samples when injected with a known amount of target analytes. Additionally, precision is measured between the MS and MSD. The equipment blank was collected to assess the potential bias and contamination that may affect field samples due to the sampling and analytical process. The analytical results for the field duplicate and equipment blank are provided in Attachment 1.

Laboratory QA/QC samples were prepared and analyzed to measure the precision and accuracy of their analytical results and aid in the usability assessment process. The laboratory QA/QC samples consisted of method blanks, laboratory control samples, internal standards, and laboratory duplicates.

B.2 Data Validation Process

During the data validation process, QA/QC criteria established in the UFP-SAP or in the analytical method were used to evaluate the data quality in a process similar to that outlined in *Contract Laboratory Program Region III Modifications to National Functional Guidelines for Evaluating Inorganic Analyses* (USEPA, 1993).

The data validation included a recalculation of 10 percent of the analytical results and consisted of review of the following:

- Holding times
- Completeness
- Method and equipment blank contamination
- Initial and continuing calibration accuracy and precision
- Post-spike sample recovery
- Laboratory control sample accuracy and precision

- Internal standard response and retention time accuracy
- Field and laboratory duplicate precision

In cases where acceptance criteria for these aspects of data quality were not met, the validator applied a data qualifier to the data. The qualifiers that may be used are defined in Section 1.2.1.

B.2.1 Primary Validation Qualifiers

Validation qualifiers were assigned to the data subsequent to the laboratory analysis; the list of qualifiers available to the validator is defined in Table 1; not all available qualifiers were applied to this data set.

TABLE 1
Primary Validation Qualifiers

Qualifier	Description
[none]	Analyte is present at the concentration reported.
U	Analyte not detected at a concentration greater than the detection limit.
J	Analyte is present; concentration is estimated because it is below the quantitation limit or because of an associated QC exceedance and may be inaccurate or imprecise.
K	Analyte is present; concentration is estimated and may be biased high.
B	Analyte is present; concentration is not significantly greater than that found in an associated field or laboratory blank and the result is usable as a non-detect.
L	Analyte is present; concentration is estimated and may be biased low.
UL	Analyte is not present; quantitation limit is biased low.
UJ	Analyte is not present; quantitation limit may be inaccurate or imprecise.
R	Presence of analyte unknown; result is rejected because the data is unreliable and not available for decision-making.

B.3 Data Usability Assessment Findings

B.3.1 Validated Analytical Results

The Agviq-CH2M HILL validator completed a review of the total and dissolved metals data according to the guidelines in the UFP-SAP. Excluding lab QA/QC, 273 data results were validated. Table 2 shows the distribution of qualified results. All data were considered usable.

TABLE 2
Validation Qualifiers Applied to Site 5 Supplemental RI Data

Validator Qualifier	Secondary Qualifier	Result Count	Percent
[none]	[none]	112	41.03
U	[none]	85	31.1
J	[none]	72	26.4
J	FD	2	0.73
L	MSL	1	0.37
UL	MSL	1	0.37
TOTAL:		273	100%

100% not R-flagged and available for use

Data that have a U- or a J-qualifier or were not qualified are usable as reported by the laboratory. The 85 U-qualified results represent analytes that were not detected by the laboratory and were reported at the laboratory limit of detection. The 72 J-qualified results with no secondary qualifier represent analytes that were detected between the laboratory limit of quantitation and detection limit. Additionally, 112 results were detected by the laboratory and were not qualified by the data validator. The data validator J-qualified 2 results because of poor field duplicate precision. These were given the "FD" secondary qualifier. Because of low matrix spike recovery, 1 result was L-qualified as detected but potentially biased low. Also due to low MS recovery, another result was UL-qualified as the analyte was not detected and the quantitation is potentially biased low. The "MSL" secondary qualifier was applied to both of these results.

B.3.2 Unvalidated Wet Chemistry Analytical Results

Acidity, chloride, nitrate, sulfate, dissolved organic carbon, pH, and total phosphorus were analyzed by ENCO. Excluding laboratory QC samples, 74 distinct data points were generated. Although wet chemistry data were not formally validated, the data were still subject to many of the verification and validation steps outlined in the UFP-SAP. The project chemist excluded redundant data points resulting from reanalysis or dilution. A field duplicate was analyzed for pH; the relative percent difference between the parent and duplicate samples was 1.12 percent, which is below the project specific criteria of <25 percent. No other qualifiers were applied and the wet chemistry data set is 100 percent complete; all results are available for use as reported.

B.3.3 Achievement of Project Action Limits

Non-detected analytes were evaluated to ensure that the project action limits (PALs) listed in the SAP were achieved. If PALs were not achieved the impact on data usability was determined.

The limit of detection (LOD) is the level at which a laboratory reports U-qualified, non-detected constituents; it is verified quarterly by the laboratory using spiked QC samples. The detection limit (DL) is a statistically derived level that represents the lowest level the laboratory instrument can detect with 99 percent confidence that there are no false negatives. Analytical results are not reported below the DL; however, results above the DL but less than the LOQ (the lowest point of the calibration curve) are J-qualified as estimated. The following presents the analytes with LODs above the PALs and evaluation of impacts on data usability:

- Arsenic: The laboratory's LOD (20 micrograms per liter [µg/L]) was above the PAL (8 µg/L). However, the DL (1.22 µg/L) for all of the samples was below the PAL. If arsenic was present at a concentration above the PAL, it would have been detected by the laboratory and reported with a J qualifier.
- Cadmium: The laboratory's LOD (8 µg/L) was above the PAL (0.74 µg/L). However, the DL (0.22 µg/L) for all of the samples was below the PAL. If cadmium was present at a concentration above the PAL, it would have been detected by the laboratory and reported with a J qualifier.
- Lead: The laboratory's LOD (20 ug/L) was above the PAL (15 µg/L). However, the DL (2.2 µg/L) for all of the samples was below the PAL. If lead was present at a concentration above the PAL, it would have been detected by the laboratory and reported with a J qualifier.

Therefore, although the LODs for some of the analytes were above their PALs, that uncertainty does not affect the outcome of the investigation and does not prevent conclusions from being drawn with respect to the objectives of the Supplemental RI.

B.3.4 Conclusions

The quality of the data reported for the St. Juliens Creek Annex Site 5 Supplemental RI is of excellent quality. The entire data set is available for use as reported/ qualified.

B.4 References

Agviq-CH2M HILL. 2014. *Final Sampling and Analysis Plan (Field Sampling Plan and Quality Assurance Project Plan) Site 5 Supplemental Remedial Investigation, St. Juliens Creek Annex, Chesapeake, Virginia.* April.

USEPA. 1993. *USEPA Contract Laboratory Program Region III Modification to National Functional Guidelines for Evaluating Inorganic Analyses.* April.

Attachment 1

ATTACHMENT 1

Quality Assurance Quality Control Analytical Data

Site 5 Supplemental Remedial Investigation Report

St. Juliens Creek Annex

Chesapeake, Virginia

Station ID	SJS05-QC	SJS05-MW02S
Sample ID	SJS05-EB-050214	SJS05-MW02SP-14B*
Sample Date	05/02/14	05/02/14
Chemical Name		
Total Metals (UG/L)		
Aluminum	200 U	**1,520**
Arsenic	10 U	**9.91 J**
Beryllium	0.5 U	**0.993 J**
Cadmium	4 U	8 U
Chromium (hexavalent)	**0.26**	**2.01 J**
Chromium	3 U	**0.036 J**
Cobalt	0.84 U	**22.8**
Iron	50 U	**21,300**
Lead	20 U	20 U
Manganese	**0.227 J**	**922**
Thallium	0.23 U	0.46 U
Vanadium	10 U	**3.98 J**
Dissolved Metals (UG/L)		
Aluminum, Dissolved	200 U	**1,490**
Arsenic, Dissolved	10 U	**9.55 J**
Beryllium, Dissolved	0.5 U	**0.965 J**
Cadmium, Dissolved	4 U	8 U
Chromium (hexavalent), Dissolved	**0.239**	**2.13 J**
Chromium, Dissolved	3 U	0.025 U
Cobalt, Dissolved	0.84 U	**23.2**
Iron, Dissolved	50 U	**22,300**
Lead, Dissolved	20 U	20 U
Manganese, Dissolved	**0.241 J**	**957**
Thallium, Dissolved	0.23 U	0.46 U
Vanadium, Dissolved	10 U	**4.13 J**
Wet Chemistry (PH)		
pH	NA	**4.4**

Notes:
*Field Duplicate
Bold font indicates detections
NA - Not analyzed
J - Analyte present, value may or may not be accurate or precise
U - The material was analyzed for, but not detected
UG/L - Micrograms per liter

Appendix C
Human Health Risk Assessment

APPENDIX C

Baseline Human Health Risk Assessment

C.1 Introduction

This baseline human health risk assessment (HHRA) was prepared for the Site 5 shallow aquifer groundwater. The primary objective of the baseline HHRA is to assess the site-related human health risks from potential future exposure to metals in groundwater at Site 5. The text in this appendix includes references to sections (for example, Section 3) that appear in the main body of the Supplemental Remedial Investigation (RI) report, to which this section appends, as well as tables (for example, Table C-1) that are part of and presented only in this appendix. Attachment 1 to this appendix includes the risk calculation tables.

In accordance with USEPA guidance documents, this HHRA consists of the following components: identification of constituents of potential concern (COPCs), exposure assessment, toxicity assessment, and risk characterization.

The HHRA incorporates the general methodology described in the following guidance documents:

- *Risk Assessment Guidance for Superfund (RAGS), Volume 1, Human Health Evaluation Manual, Part A* (United States Environmental Protection Agency [USEPA], 1989)
- *Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual, Part D* (USEPA, 2001)
- *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment)* (USEPA, 2004)
- *USEPA Region III Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening* (USEPA, 1993)
- *Conducting Human Health Risk Assessments Under the Environmental Restoration Program* (Chief of Naval Operations [CNO], 2001)

There are differences between the Navy policy and USEPA Region 3 guidance for addressing background conditions in baseline risk assessment. The Navy policy (CNO, 2001) allows constituents present at background to be removed from the quantitative risk assessment and then be presented and discussed in the risk characterization. Conversely, USEPA Region 3 prefers to obtain a quantitative baseline risk assessment that includes background conditions. The more conservative USEPA guidance was followed, and a background comparison was performed after the risks were quantified for the constituents identified as constituents of concern (COCs) to determine if they are associated with background conditions or are site-related. The final list of site-related COCs remains the same following either approach.

C.2 Human Health Conceptual Site Model

The human health conceptual site model (CSM) provides a current understanding of the source(s) of contamination, the release and transport mechanisms, and the current and potential future land use; and identifies potentially complete human exposure pathways. Detailed information on the source(s) of contamination, release and transport mechanisms, and current land use are provided in Section 2.2 and Section 3.2; therefore, only a summary is provided here.

Site 5 and much of the adjacent area had been used for placement of dredge spoil material that reportedly originated from Blows Creek and the Southern Branch of the Elizabeth River. Following dredge placement operations, the site was used for disposal of munitions and other general refuse. The waste and soil impacted by the disposal operations were removed during a non-time critical removal action (NTCRA); the excavations were then backfilled with borrow material from an offsite source.

Currently, the site is seldom used; use is primarily associated with radar testing. Groundwater is not used as a potable resource at SJCA. However, it could be considered for beneficial use in the future if the site is closed with no further action (NFA). The groundwater within the unconfined Columbia aquifer beneath Site 5 (referred to in this report as the shallow aquifer) is encountered at relatively shallow depths (i.e., less than 1 to 6 feet below the ground surface). Therefore, in addition to potable use of groundwater, contact with groundwater could occur during potential future excavation and construction activities.

The primary release mechanisms of transporting the COPCs from the original source, through environmental media, and to potential receptors that have been considered are:

- Direct release of disposed munitions and general refuse to surface soil
- Leaching of chemicals or metals from surface soil to subsurface soil and subsequently to groundwater via infiltrating precipitation
- Surface runoff from source areas to surface soil, surface water, and sediment
- Future household use of groundwater from wells

As discussed above, a NTCRA to mitigate the potential unacceptable risks associated with waste, soil, and sediment was conducted. Therefore, transport from waste, soil, and sediment to groundwater and exposure to waste, soil, and sediment, are no longer a concern at Site 5. The remaining transport mechanisms being considered are:

- Contaminant migration within shallow aquifer groundwater with groundwater flow (advection), if contaminants previously present (i.e., in waste, soil, sediment) leached into groundwater; however, some metals are naturally elevated
- Future household use of groundwater from wells

Although groundwater beneath the site is not currently used as a potable water supply, it is conservatively assumed that groundwater could be used as a future residential potable water supply.

C.3 Identification of COPCs

The identification of COPCs includes data collection, evaluation, and screening steps. The data collection and evaluation steps involve gathering and reviewing the available site data and identifying a data set for the risk assessment that meets project-specific data quality objectives. This data set is then further screened against concentrations that are protective of human health to identify those constituents and media of potential concern.

C.3.1 Data Used in the HHRA

Shallow aquifer groundwater data were evaluated in the HHRA to characterize potential future human health risks based on current site conditions (current concentrations). The analytical data used in the risk assessment were validated and are provided in Tables 4-3 and 4-4. Table C-1 lists the groundwater samples evaluated in the HHRA. The most recent round of groundwater samples collected at Site 5, collected in May 2014 for the Supplemental RI, were included in the risk assessment. Groundwater samples were analyzed for both total and dissolved select metals. The total and dissolved concentrations of aluminum, iron, and manganese were compared for each monitoring well to note if there were significant differences (over an order of magnitude) between the two in any of the wells, following USEPA guidance (USEPA, 1992). Because no significant differences were noted between total and dissolved concentrations of these indicator metals in any of the wells, the total metals data were used to evaluate risks associated with potable use of groundwater. Use of total metals data is consistent with USEPA's *Determining Groundwater Exposure Point Concentrations* (USEPA, 2014a).

A review of the data and past discussions with the USEPA and Navy identified the following criteria for data usability and usage of qualified data:

- Data qualified with a J or L (estimated) were treated as unqualified detected concentrations.
- For duplicate samples, the maximum concentration between the two samples was used as the sample concentration. If the analyte was only detected in one of the samples, the detected concentration was used as

the sample concentration. If the analyte was not detected in either of the samples, the maximum detection limit between the two samples was used as the sample detection limit.

- Non-detected values were included in the risk assessment and exposure point concentration calculation at the detection limit using ProUCL (USEPA, 2013a).

Detailed results of the sampling are presented in Section 4.

C.3.2 COPC Screening Criteria

The detected constituents were screened following the procedures described below. The selection of COPCs was based on the criteria presented in the USEPA Region III technical guidance manual (USEPA, 1993) and *Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual, Part D* (USEPA, 2001).

The maximum detected concentration of each constituent was compared to the criteria discussed below to select the COPCs. If the maximum concentration exceeded the criteria, the constituent was selected as a COPC. Constituents that were not detected in any of the samples or were detected at concentrations less than the criteria were not retained as COPCs. The following screening criteria were used in the HHRA, as presented in Table 2.1 in Attachment 1:

- **Comparison with Health-Based Criteria for Groundwater:** Groundwater data were compared to the USEPA Regional Screening Levels (RSLs) for tap water (USEPA, 2014b). RSLs that are based on noncarcinogenic effects were based on a hazard quotient of 0.1 to account for exposure to multiple constituents. RSLs based on carcinogenic effects were based on a carcinogenic risk of 1×10^{-6}. Groundwater lead concentrations were compared to the federal action level of 15 micrograms per liter (μg/L) (USEPA, 2009).
- **Comparison to Background Concentrations**: Background concentrations were not used to identify/eliminate any of the COPCs. However, background concentrations are included in the screening tables, if available, and are discussed in the risk summary, if applicable (i.e., constituents resulting in risks above target risk levels may be associated with background conditions). The background concentrations are the unfiltered background upper tolerance limits presented in the 2004 *Final Background Investigation Report Addendum for Groundwater* (CH2M HILL, 2004). Site-specific background wells were also sampled during the Supplemental RI, as identified in Table C-1. The analytical data from these wells are not shown on the HHRA screening tables; however, they are included in Table 3-4 of the Supplemental RI, and also discussed in the risk summary, if applicable.

The groundwater samples were analyzed for both total chromium and hexavalent chromium. Therefore, because hexavalent chromium data were available for groundwater, the hexavalent chromium concentrations were screened using the hexavalent chromium RSL and total chromium concentrations were screened using the trivalent chromium RSL.

C.3.3 COPC Screening Results

Results of the COPC screening process are presented in Table 2.1 in Attachment 1 and are summarized in Table C-2. The shallow aquifer groundwater COPCs are:

- Aluminum
- Arsenic
- Beryllium
- Cadmium
- Chromium (hexavalent)
- Cobalt
- Iron
- Lead
- Manganese
- Vanadium

C.4 Exposure Assessment

Exposure refers to the potential contact of an individual with a constituent. The exposure assessment identifies pathways and routes by which an individual may be exposed to the COPCs, and estimates the magnitude, frequency, and duration of potential exposure. Constituent intakes and associated health risks are quantified for complete exposure pathways only. The components of exposure assessment include the following:

- Development of the CSM for human health
- Calculation of exposure point concentrations (EPCs)
- Development of exposure assumptions for potentially complete exposure pathways
- Calculation of intake for COPCs

C.4.1 Conceptual Site Model for Human Health

The human health CSM was presented in Section C.2.

The potentially exposed populations evaluated in the risk assessment are shown on Attachment 1, Table 1. Currently, the site is seldom used; use is primarily associated with radar testing. Groundwater is not used as a potable resource at SJCA; public water is supplied to SJCA and the surrounding area by the City of Chesapeake Waterworks. Therefore, there is no current exposure to Site 5 shallow groundwater.

Future site use and future receptors most likely will remain the same as the current site use and receptors. Although groundwater beneath the site is not currently used as a potable water supply, and it is unlikely shallow groundwater will be used as a future potable water supply, it was conservatively assumed that groundwater could be used as a future residential potable water supply. Additionally, because of the relatively shallow depth to groundwater, it was assumed that construction workers could be exposed to groundwater during future excavation activities.

Future receptors and potentially completely exposure routes include the following:

- **Resident (adult and child):** ingestion of shallow groundwater and dermal contact with shallow groundwater while bathing/showering
- **Construction worker:** dermal contact with shallow groundwater in an open excavation

C.4.2 Calculation of Exposure Point Concentrations

Exposure is quantified by estimating the EPCs for COPCs in environmental media and constituent intake (ingestion, dermal absorption) by the receptor. EPCs are the estimated constituent concentrations that a receptor may contact. The EPCs are provided in Table 3.1.RME of Attachment 1.

ProUCL software Version 5.0 (USEPA, 2013a) was used to calculate the EPCs. The recommendations outlined in the ProUCL software documentation (USEPA, 2013a) were followed to select the appropriate 95 percent upper confidence levels (95 percent UCLs) used as the reasonable maximum exposure (RME) and central tendency exposure (CTE) EPCs. The maximum detected concentration was used as the EPC when the estimated 95 percent UCL was greater than the maximum detected concentration. ProUCL indicates that a minimum of eight samples are adequate to perform the statistical tests and calculate the EPCs. The Site 5 groundwater data set includes only four samples, resulting in significant uncertainty in the results of the statistical tests and calculated EPCs. However, USEPA groundwater guidance (2014a), indicates a minimum of three wells in the core of the plume should generally be used to calculate the groundwater EPC. Therefore, although there is no groundwater plume at the site, the four groundwater samples collected at Site 5 were used to calculate a 95 percent UCL for all groundwater COPCs. The arithmetic mean concentration, including one-half the detection limit for the non-detected samples, was used as the EPC for lead. The ProUCL output file is included at the end of Attachment 1.

C.4.3 Estimation of Chemical Intakes for Individual Pathways

Chemical intake is the amount of the chemical entering the receptor’s body. The quantification of exposure is based on an estimate of the chronic daily intake (CDI), which is the average amount of the chemical contaminant entering the receptor's body per day. Chemical intake estimates for the ingestion and dermal exposure pathways are generally expressed as follows:

$$CDI = \frac{C \times CR \times EF \times ED}{BW \times AT}$$

Where:

CDI = chronic daily intake (mg/kg-day)
C = chemical concentration (mg/L)
CR = contact rate (L/day)
EF = exposure frequency (days/year)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time (days)

For the dermal pathway, the contact rate incorporates the skin surface area in contact with the exposure medium (groundwater) and a permeability factor. The contact rate is calculated as follows:

$$CR = DAevent \times SA$$

Where

DAevent = dermally absorbed dose per event (mg/cm^2-event)
SA = Skin surface area in contact with water (cm^2)

The dermally absorbed dose per event is calculated using chemical-specific permeability constants and additional chemical specific parameters which are shown in supplemental tables to the Table 7 series in Attachment 1.

The intake and exposure equations require exposure parameters that are specific to each exposure pathway. Many of the exposure parameters have default values, which were used for this assessment. These assumptions, based on estimates of body weights, media intake levels, and exposure frequencies and duration are provided in USEPA guidance (USEPA, 1989; 1991; 2004; 2011; 2014c). Other assumptions (e.g., for the construction worker scenario) require consideration of location-specific information and were determined using professional judgment. Tables 4.1.RME and 4.1.CTE of Attachment 1 present the exposure parameters that were used for the exposure scenarios evaluated in the risk assessment. RME scenario exposure parameters were compiled for all scenarios; CTE parameters were compiled only for scenarios where the RME risk for an environmental medium is greater than the non-carcinogenic hazard or carcinogenic risk target levels (cumulative hazard index [HI] >1, and excess lifetime cancer risk [ELCR] >1 × 10^{-4}).

C.5 Toxicity Assessment

Toxicity assessment defines the relationship between the magnitude of exposure and possible severity of adverse effects, and weighs the quality of available toxicological evidence. Toxicity assessment generally consists of two steps: hazard identification and dose-response assessment. Hazard identification is the process of characterizing the potential adverse effects from exposure to the chemical and the type of health effect involved. Dose-response assessment is the process of quantitatively evaluating the toxicity information and characterizing the relationship between the dose of the constituent administered or received and the incidence of adverse health effects in the exposed population. Toxicity criteria (e.g., reference doses [RfDs] and cancer slope factors [CSFs]) are derived from the dose-response relationship.

USEPA recommends that a tiered approach be used to obtain the toxicity values (RfDs and CSFs) that are used to estimate non-carcinogenic hazards and carcinogenic risks (USEPA, 2003). The hierarchy of toxicity value sources is the following:

- Integrated Risk Information System (IRIS) (USEPA, 2014d);
- Provisional Peer-Reviewed Toxicity Values (PPRTVs); and

- Other peer-reviewed USEPA and non-USEPA sources (USEPA, 2013b), including the Health Effects Assessment Summary Tables (HEAST) (USEPA, 1997), California Environmental Protection Agency (Cal/EPA) Toxicity Criteria Database (Cal/EPA, 2014), New Jersey Department of Environmental Protection (NJDEP) chromium workgroup (New Jersey Department of Environmental Protection [NJDEP], 2009), and Agency for Toxic Substances and Disease Registry (ATSDR).

Some of the COPCs elicit both systemic (non-carcinogenic) toxic effects and cancer (carcinogenic) effects. Because of this, these constituents are evaluated as both non-carcinogens and carcinogens. The health risks for carcinogenic and non-carcinogenic effects were estimated separately based on different toxicity values.

The non-carcinogenic toxicity values are provided in Table 5.1 of Attachment 1 and the carcinogenic toxicity values are provided in Table 6.1 of Attachment 1.

C.5.1 Toxicity Information for Non-carcinogenic Effects

Non-carcinogenic health effects include a variety of toxic effects on body systems, ranging from toxicity to the kidneys to central nervous system disorders. The toxicity of a chemical is assessed through a review of toxic effects noted in short-term (acute) animal studies, long-term (chronic) animal studies, and epidemiological investigations.

USEPA (1989) defines the chronic RfD as a dose that is likely to be without appreciable risk of deleterious effects during a lifetime of exposure. Chronic RfDs are specifically developed to be protective for long-term exposure to a compound (for example, 7 years to a lifetime), and consider uncertainty in the toxicological database and sensitive receptors. Subchronic RfDs (applicable for exposures less than 7 years), which are all provisional values, were used for the construction worker scenario, if available. Chronic RfDs were used to evaluate non-carcinogenic risks to all other receptors evaluated in the HHRA.

In the development of RfDs, all available studies examining the toxicity of a chemical following exposure are considered on the basis of scientific merit. The lowest dose level at which an observed toxic effect occurs is identified as the lowest observed adverse effect level (LOAEL), and the dose at which no effect is observed is identified as the no observed adverse effect level (NOAEL). Several uncertainty factors (UFs) may be applied to the LOAEL or NOAEL to account for uncertainties such as limited data, extrapolation of data from animal studies to human exposures, or the use of subchronic studies to develop chronic criteria. These UFs range from 10 to 10,000, and are based on professional judgment. Consequently, there are varying degrees of uncertainty in the toxicity criteria, which range from 1 to 3,000 for the COPCs identified for this site.

In accordance with USEPA guidance (USEPA, 2004), oral RfDs were adjusted from administered dose (oral) to absorbed dose (dermal) to evaluate dermal toxicity. When appropriate, the RfDs were adjusted using oral absorption factors (USEPA, 2004). The oral RfD was multiplied by the oral absorption factor to calculate the dermal RfD. This adjustment is presented in the Table 5.1 in Attachment 1.

C.5.2 Toxicity Information for Carcinogenic Effects

Potential carcinogenic effects are quantified as CSFs that convert estimated exposures directly to incremental lifetime carcinogenic risks. CSFs may be derived from the results of chronic animal bioassays, human epidemiological studies, or both. Animal bioassays are usually conducted at dose levels that are much higher than are likely to be encountered in the environment. This design detects possible adverse effects in the relatively small test populations used in the studies. The actual risks from exposure to a potential carcinogen are not likely to exceed the estimated risks and are probably much lower or even zero.

As was done for oral RfDs, oral CSFs were adjusted from administered dose (oral) to absorbed dose (dermal) to evaluate dermal toxicity (USEPA, 2004). When appropriate, the CSFs were adjusted using oral absorption factors (USEPA, 2004). The oral CSF was divided by the oral absorption factor to calculate the dermal CSF. This adjustment is shown in Table 6.1 in Attachment 1.

C.5.3 Approach for Potential Mutagenic Effects

Consistent with the cancer guidelines and supplemental guidance (USEPA, 2005a and 2005b), cancer risks were estimated using age-dependent adjustment factors (ADAFs) for COPCs, which may act via a mutagenic mode of action (MMOA). Hexavalent chromium was the only COPC that is categorized as a chemical with a potential MMOA.

The calculation of cancer risk using ADAFs is presented in the Tables 7.3.RME Supplement A and 7.3.CTE Supplement A, in Attachment 1. As chemical-specific data are not available for hexavalent chromium, default ADAFs, as included in the *Derivation of RBCs for Carcinogens that Act Via a Mutagenic Mode of Action and Incorporate Default ADAFs* (USEPA, 2006), were used for the MMOA evaluation. The default ADAFs used to adjust the CSF for hexavalent chromium are 10 for 0 to 2 year olds, 3 for 2 to 6 year olds, 3 used for 6 to 12 year olds, and 1 for 16 to 26 year olds. The CSF was multiplied by the appropriate ADAF to derive the age-specific CSF for a receptor to calculate the total carcinogenic risk. Additionally, the exposure factors for children 0 to 2 years old and 2 to 6 years old were assumed to be the same as the parameters for a child 0 to 6 years old, with the exception of the exposure duration, which was 2 years and 4 years, respectively. The exposure factors for the adult residential receptor were used for receptors ages 6 to 16 years and 16 to 26 years, with the exception of the exposure durations, which were 10 years for both.

C.5.4 Constituents without USEPA Toxicity Values

Quantitative oral toxicity criteria are not available for lead. As a screening tool, lead is screened against 15 μg/L in groundwater, based on potable use of the groundwater. The potential risks associated with residential exposures to lead are addressed using the Integrated Exposure Uptake Biokinetic (IEUBK) Lead Model as described in Section C.6.1.3.

C.6 Risk Characterization

Risk characterization combines the results of the previous elements of the risk assessment to evaluate the potential health risks associated with exposure to the COPCs. The risk characterization is then used as an integral component in remedial decision making and selection of potential remedies or actions, as necessary.

C.6.1 Methods for Estimating Risks

Potential human health risks are discussed independently for carcinogenic and non-carcinogenic constituents because of the different toxicological endpoints, exposure duration, and methods used to characterize risk. Exposure to some constituents may result in both non-carcinogenic and carcinogenic effects (e.g., arsenic), and therefore, these constituents were evaluated in both groups.

C.6.1.1 Non-carcinogenic Hazard Estimation

Non-carcinogenic health risks are estimated by comparing the calculated exposures to RfDs. The calculated intake divided by the RfD is equal to the hazard quotient (HQ):

$$HQ = Intake / RfD$$

The intake and RfD represent the same exposure route (i.e., oral intakes are divided by oral RfDs). An HQ that exceeds 1 (i.e., intake exceeds the RfD) indicates that there is a potential for adverse health effects associated with exposure to that constituent.

To assess the potential for noncarcinogenic health effects posed by exposure to multiple constituents, an HI approach is used (USEPA, 1986). This approach assumes that noncarcinogenic hazards associated with exposure to more than one constituent are additive (HI = sum of the HQs). Synergistic or antagonistic interactions between constituents are not considered. HIs may be added across exposure routes to estimate the total noncarcinogenic health effects to a receptor posed by exposure through multiple routes. If the HI is greater than 1, separate HIs are estimated for each target organ to assess whether the HI for a specific target organ is greater than 1. A target organ-specific HI greater than 1 indicates there is some potential for adverse noncarcinogenic health effects associated with exposure to the COPCs. If the HI for each target organ does not exceed 1, noncarcinogenic hazards are not expected.

C.6.1.2 Carcinogenic Risk Estimation

The potential for carcinogenic effects due to exposure to site-related constituents is evaluated by estimating the ELCR. ELCR is the incremental increase in the probability of developing cancer during one's lifetime (as a result of exposure to site media) above the probability of developing cancer from non-site exposures.

Carcinogenic risk is calculated by multiplying the chronic daily intake by the CSF.

$$ELCR = CDI \times CSF$$

where:

ELCR	=	unitless probability of developing cancer
CDI	=	chronic daily intake averaged over 70 years
CSF	=	cancer slope factor

The combined risk from exposure to multiple constituents was evaluated by adding the risks from individual constituents. Risks also were added across the exposure routes if an individual would be exposed through multiple routes.

As required under the *National Oil and Hazardous Substances Contingency Plan* (USEPA, 1994a), "[f]or known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} to 10^{-6} using information on the relationship between dose and response." When a cumulative carcinogenic risk to a receptor under the assumed RME exposure conditions exceeds 1 in 10 thousand (10^{-4} ELCR), the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) generally requires remedial action to reduce risks at the site.

C.6.1.3 Approach for Lead

Lead concentrations less than 15 µg/L in groundwater (the Safe Drinking Water Act action level for lead in potable water) are considered adequately protective of human health under residential land-use conditions. Lead was retained as a COPC when exceeding this value, and therefore, lead was identified as a COPC for shallow aquifer groundwater. Lead does not have available published toxicity factors, and therefore potential risks associated with lead are evaluated differently than the other COPCs. The Integrated Exposure Uptake Biokinetic (IEUBK) model is used to predict the risk of elevated blood lead levels in children exposed to lead.

The potential risks associated with residential exposure to lead in groundwater by children were addressed using the IEUBK lead model for Windows, Version 1.1, Build 11 (USEPA, 2010). The IEUBK model provides predictions of the probability of elevated blood lead levels for children from ages 0 to 7 years with potential exposure to lead in various media. The arithmetic mean of the lead concentration in groundwater was used with the default input parameters to represent site-specific exposures to lead. The IEUBK model results are expressed as the predicted geometric mean blood lead level for children and the percent of the population potentially experiencing concentrations above USEPA's recommended level of 10 micrograms per deciliter (µg/dL), below which adverse manifestations are not expected. USEPA's target level for lead is less than 5 percent of the population exceeding the 10 µg /dL blood lead level (USEPA, 1994b).

C.6.2 Risk Estimates

The risk estimates for Site 5 are summarized below by receptor. A summary of the RME results is presented in Table C-3, and the CTE results are summarized in Table C-4. The risk calculations are presented in Tables 7.1.RME through 7.4.RME and 7.1.CTE through 7.3.CTE in Attachment 1. CTE risks were calculated only when the RME hazards exceeded the non-carcinogenic target HI of 1, or the RME carcinogenic risks exceeded the acceptable risk range of 1×10^{-6} to 1×10^{-4}. Tables 9.1.RME through 9.4.RME and 9.1.CTE through 9.3.CTE in Attachment 1 summarize the hazards and risks to each receptor. The COCs are identified below for each receptor. The COCs are those COPCs that contribute an HI greater than 0.1 to a RME cumulative target organ HI that exceeds 1 or a carcinogenic risk greater than 1×10^{-6} to a RME cumulative carcinogenic risk that exceeds 1×10^{-4}.

Lead is identified as a COC if the probability of BLLs exceeding 10 µg/dL is greater than 5 percent for potentially exposed children, estimated using the IEUBK (USEPA, 2010). This is consistent with the Office of Solid Waste and Emergency Response (OSWER) directive, which attempts to limit exposure to lead such that a typical (or hypothetical) child or group of similarly exposed children would have an estimated risk of no more than 5 percent of the exposed populations exceeding a 10 µg/dl BLL (USEPA, 1994b).

C.6.2.1 Future Adult Resident (Non-carcinogenic Hazard, Tables 9.1.RME and 9.1.CTE, Attachment 1)

The risk assessment assumed a future adult resident could be exposed to shallow groundwater through ingestion and through dermal contact while showering. Carcinogenic risks were not calculated for an adult resident but were calculated for a lifetime child/adult resident following USEPA guidance.

- Cumulative HI (RME) = 10, exceeds target HI, primarily associated with cobalt, iron, and manganese, which each contribute HIs above 1.
- Cumulative HI (CTE) = 4, exceeds target HI, primarily associated with cobalt, which contributes an HI above 1.
- Lead evaluated for the more-conservative child resident using IEUBK model, see Section C.6.2.2.
- COCs cobalt, iron, and manganese (based on RME).
- Maximum detected concentrations of iron and manganese are below the background upper tolerance limits from the 2004 *Final Background Investigation Report Addendum for Groundwater* (CH2M HILL, 2004). Therefore, the potential hazards associated with these two metals are most likely not site-related but associated with background conditions.

C.6.2.2 Future Child Resident (Non-carcinogenic Hazard, Tables 9.2.RME and 9.2.CTE, Attachment 1)

The risk assessment assumed a future child resident could be exposed to shallow groundwater through ingestion and through dermal contact while bathing. Carcinogenic risks were not calculated for a child resident but were calculated for a lifetime child/adult resident following USEPA guidance.

- Cumulative HI (RME) = 16, exceeds target HI, primarily associated with arsenic, cobalt, iron, and manganese, which each contribute HIs above 1.
- Cumulative HI (CTE) = 6, exceeds target HI, primarily associated with cobalt, which contributes an HI above 1.
- IEUBK model (Tables 11.1a and 11.1b, Figure 11-1, Attachment 1) demonstrated a typical child, exposed to average concentrations of lead in site groundwater, will have a blood lead level less than the level associated with adverse health effects (i.e., 10 µg/dL).
- COCs are aluminum, arsenic, beryllium, cobalt, iron, and manganese (based on RME).
- Maximum detected concentrations of iron and manganese are below the background concentrations from the 2004 *Final Background Investigation Report Addendum for Groundwater* (CH2M HILL, 2004). Therefore, the potential hazards associated with these two metals are most likely not site-related but associated with background conditions.

C.6.2.3 Future Lifetime Resident (Carcinogenic Risk, Tables 9.3.RME and 9.3.CTE, Attachment 1)

The risk assessment assumed a future lifetime child/adult resident could be exposed to shallow groundwater through ingestion and through dermal contact while bathing/showering.

- Cumulative ELCR (RME) = 2×10^{-4}, exceeds target risk range, primarily associated arsenic, with a smaller contribution from hexavalent chromium.
- Cumulative ELCR (CTE) = 6×10^{-5}, within target risk range.
- Lead evaluated for the child resident using IEUBK model, see Section C.6.2.2.

- COCs are arsenic and hexavalent chromium (based on RME).

C.6.2.4 Future Construction Worker (Table 9.4.RME, Attachment 1)

The risk assessment assumed a future construction worker could be exposed to groundwater in an excavation through dermal contact.

- Cumulative HI (RME) = 0.4, below target HI.
- Cumulative ELCR (RME) = 6×10^{-8}, below target risk range.
- There is no method available to evaluate construction worker exposure to lead in groundwater. However, evaluation of the more conservative lead exposure for child resident demonstrated no adverse effects above acceptable levels associated with exposure to lead.

C.7 Uncertainty Associated with Human Health Assessment

The risk measures used in CERCLA site risk assessments are not fully probabilistic estimates of risk, but are conditional estimates given that a set of assumptions about exposure and toxicity are realized. Thus, it is important to specify the assumptions and uncertainties inherent in the risk assessment to place the risk estimates in proper perspective.

C.7.1 Uncertainty in COPC Selection

A comparison of site concentrations to background concentrations was not used to select the COPCs in accordance with USEPA Region III guidance. It is noted that Navy policy (2001) does allow such comparisons to be performed during the COPC screening process. Following the USEPA approach may result in the inclusion of risks that may be associated with background conditions and are not necessarily site-related. If warranted, a background comparison and discussion is performed for the constituents identified as risk drivers in the risk characterization and risk summary sections. As discussed in Section C.9, the maximum detected concentrations of iron and manganese are below the SJCA 95 percent background UTL.

Constituents with limits of detection (LODs) above their respective screening levels can result in uncertainty in the identification of COPCs, and in the EPCs for those that are identified as COPCs based on a detected concentration. The uncertainty for those constituents was evaluated as follows:

- Lead: The LOD for lead in groundwater, 20 μg/L, exceeds the human health screening level for lead of 15 μg/L, the Safe Drinking Water Act action level for lead in potable water. However, the detection limit (DL) (2.2 μg/L) for all of the samples was below the screening level. Therefore, if lead was present at a concentration between the LOD and DL, it was detected by the laboratory and reported with a J qualifier. Additionally, lead was identified as a COPC based on a detected concentration exceeding the screening level.
- Arsenic: The LOD for arsenic in groundwater, 20 μg/L, exceeds the human health screening level for arsenic of 0.052 μg/L, the tap water RSL based on cancer risk of $1x10^{-6}$. However, the DL for arsenic (1.22 μg/L) for all of the samples was below the RSL based on a cancer risk of $1x10^{-4}$ (5.2 μg/L). Therefore, if arsenic was present at a concentration between the LOD and DL, it was detected by the laboratory and reported with a J qualifier. Additionally, arsenic was identified as a COPC based on a detected concentration exceeding the tap water RSL.
- Cadmium: The LOD for cadmium in groundwater, 8 μg/L, exceeds the human health screening level for cadmium of 0.92 μg/L, the tap water RSL based on an HQ of 0.1. However, the DL for cadmium (0.22 μg/L) for all of the samples was below the RSL based on an HQ of 0.1. Therefore, if cadmium was present at a concentration between the LOD and DL, it was detected by the laboratory and reported with a J qualifier. Additionally, cadmium was identified as a COPC based on a detected concentration exceeding the tap water RSL.
- Cobalt: The LOD for cobalt in groundwater, 20 μg/L, exceeds the human health screening level for cobalt of 0.6 μg/L, the tap water RSL based on an HQ of 0.1. However, the DL for cobalt (0.42 μg/L) for all of the

samples was below the RSL based on an HQ of 0.1. Therefore, if cobalt was present at a concentration between the LOD and DL, it was detected by the laboratory and reported with a J qualifier. Additionally, cobalt was identified as a COPC based on a detected concentration exceeding the tap water RSL.

- Thallium: Thallium was not detected in the four groundwater samples evaluated in the HHRA. However, the LOD for thallium, 0.46 µg/L, exceeds the human health screening level for thallium of 0.02 µg/L, the tap water RSL based on an HQ of 0.1. However, the DL for thallium (0.116 µg/L) for all of the samples was below the tap water RSL based on a HQ of 1 (0.2 µg/L). Therefore, if thallium was present at a concentration between the LOD and DL, it would have been detected by the laboratory and reported with a J qualifier.

C.7.2 Uncertainty Associated with Exposure Assessment

Uncertainty in the exposure assessment was generally treated with conservative decision rules and assumptions, and therefore the uncertainty likely overestimates actual exposure to COPCs. Exposure pathways evaluated by this HHRA, such as residential land use, are hypothetical and are not anticipated to occur in the future at Site 5. Most of the exposure factors used for quantitation of exposure generally are conservative and reflect worst-case, or upper-bound, assumptions for the exposure.

There is uncertainty in the EPCs used to calculate the risks as only four groundwater samples were used to calculate the EPCs. ProUCL indicates that a minimum of eight samples are adequate to perform statistical evaluations and calculate the 95 percent UCLs used as the EPCs. The limited number of samples resulted in the maximum detected concentration of arsenic and cadmium being used as the EPC.

It is not likely that groundwater from the shallow aquifer will ever be used as a potable water supply because of the availability of better water supplies with respect to both water quality and quantity. Groundwater is not used as a potable resource anywhere at SJCA; public water is supplied to SJCA and the surrounding area by the City of Chesapeake Waterworks.

C.7.3 Uncertainty Associated with Toxicity Assessment

Uncertainty associated with the non-carcinogenic toxicity factors is included in the toxicity tables for Site 5 in Attachment 1. Several UFs were applied to extrapolate dose points from animal studies to humans. These UFs range between 1 and 3,000. Additional modification factors are used on the basis of USEPA's professional judgment. Therefore, there is a high degree of uncertainty in the non-carcinogenic toxicity criteria based on the available scientific data for each constituent. The non-carcinogenic toxicity factors are most likely an overestimate of actual toxicity.

The uncertainty associated with CSFs is mostly due to the low dose extrapolation where carcinogenicity at low doses is assumed to be a linear response. This is a conservative assumption, which introduces a high uncertainty into slope factors and unit risk factors that are extrapolated from this area of the dose-response curve. The CSFs are based on the assumption that there is no threshold level for carcinogenicity; however, most of the experimental studies indicate the existence of a threshold level. Therefore, CSFs developed by USEPA represent upper bound estimates. Carcinogenic risks generated in this assessment should be regarded as an upper bound estimate on potential carcinogenic risks, rather than an accurate representation of carcinogenic risk. The true carcinogenic risk is likely to be less than the predicted value (USEPA, 1989). Uncertainty is also associated with the application of the MMOA for hexavalent chromium; this may over-estimate or under-estimate risks. Additionally, the generic ADAFs were used in the MMOA calculations for hexavalent chromium, as no chemical-specific ADAFs are available.

Use of provisional toxicity factors increases the uncertainty of the quantitative hazard and risk estimates. Provisional toxicity values were used for three of the COCs, aluminum, cobalt, and iron. These provisional values were used to provide a quantitative estimate rather than a merely qualitative risk discussion.

There is additional uncertainty associated with the oral-to-dermal adjustment factors (based on constituent-specific gastrointestinal absorption factors) used to transform the oral RfDs based on administered doses to dermal RfDs based on absorbed doses. It is not known if the adjustment factor results in an underestimate or overestimate of the actual toxicity associated with dermal exposure.

The Centers for Disease Control and Prevention (CDC) Children's Health Protection Advisory Committee sent a letter on March 29, 2012 to the USEPA administrator (CDC, 2012) recommending that USEPA lower the blood lead reference value for children from 10 μg/dL to 5 μg/dL based on a review of recent health studies. The CDC blood lead reference value is used as the basis for assessing human health risks and to evaluate appropriate response actions under many USEPA regulatory programs. Although there is some uncertainty as to whether lead would be identified as a COC based on use of the recommended value, USEPA has not announced plans to update the blood lead reference value for children for lead.

C.7.4 Uncertainty in Risk Characterization

The uncertainties identified in each component of risk assessment ultimately contribute to uncertainty in risk characterization. The addition of risks and HIs across pathways and constituents contributes to uncertainty based on chemical interactions such as additivity, synergism, potentiation, and susceptibility of exposed receptors.

C.8 Human Health Risk Summary

The HHRA was conducted to evaluate the future potential human health risks associated with exposure to shallow aquifer groundwater at Site 5 based on potential receptor populations and exposure scenarios, assuming no additional remedial action is implemented at the site.

Tables C-3 and C-4, and Tables 9.1.RME through 9.4.RME and 9.1.CTE through 9.3.CTE in Attachment 1 summarize the RME and CTE potential hazards and risks to each receptor. Tables 10.1.RME through 10.3.RME and Tables 10.1.CTE and 10.3.CTE in Attachment 1 show the receptor scenarios with cumulative target organ HIs greater than 1, or total carcinogenic risks greater than 1×10^{-4}. The COCs, the COPCs that contribute HIs greater than 0.1 to target organ HIs that are greater than 1 or carcinogenic risks greater than 1×10^{-6} to cumulative carcinogenic risk that exceeds 1×10^{-4}, are included in these tables. COCs are identified for the scenarios with potentially unacceptable risks. Risk estimates are summarized below.

- **Future resident (adult and child) exposure to shallow aquifer groundwater**
  - HIs (RME) for both child and adult exceed the target HI of 1. Aluminum, arsenic, beryllium, cobalt, iron, and manganese were identified as COCs; however, iron and manganese are essential nutrients.
  - HIs (CTE) for both child and adult exceed the target HI of 1.
  - ELCR (RME) for child/adult resident exceeds target risk range. COCs are arsenic and hexavalent chromium.
  - ELCR (CTE) for child/adult resident is within acceptable risk level.
  - COCs for groundwater based on residential potable use are: aluminum, arsenic, beryllium, hexavalent chromium, cobalt, iron, and manganese (based on RME).
- **Future construction worker exposure to shallow aquifer groundwater**
  - HIs and ELCRs (RME) are within acceptable levels.

C.9 Risk Management Discussion for COCs Identified in HHRA

Several of the COCs that were identified in the HHRA can be eliminated as COCs because they are not site-related and/or pose minimal risk. An additional set of RAGS D Table 9s have been generated to present the results of the quantitative risk estimates if the constituents below background concentrations (iron and manganese) had not been included in the estimates (Attachment 2). The following provides the rationale for elimination of those COCs.

- **Manganese**
  - Current concentrations (maximum concentration of 1,430 μg/L) are less than the SJCA 95 percent background UTL (13,700 μg/L).
  - Manganese is an essential human nutrient.

  - The ingestion of manganese from groundwater if groundwater used as a potable water supply by an adult resident (0.042 mg/kg-day from Table 7.1.RME in Attachment 1 multiplied by the adult body weight of 80 kg, for an intake of 3.4 mg/kg) would exceed the adequate intake range for manganese of 1.6 mg/kg to 2.3 mg/kg for male and female adults (Food and Nutrition Board, 2001). However, the intake would be below the tolerable upper intake level (UL) range of 6 mg/kg to 11 mg/kg for male and female adults (Food and Nutrition Board, 2001). The UL is the highest level of daily nutrient intake that is likely to pose no risk of adverse health effects to almost all individuals in the general population.
  - The ingestion of manganese from groundwater if groundwater used as a potable water supply by a child resident (0.07 mg/kg-day from Table 7.2.RME in Attachment 1 multiplied by the child body weight of 15 kg, for an intake of 1.1 mg/kg) would be within the range of adequate intakes for manganese of 0.003 mg/kg to 1.5 mg/kg for children and below the UL range for children of 2 mg/kg to 3 mg/kg (Food and Nutrition Board, 2001).

- **Aluminum**
  - The RME and CTE HIs for aluminum are less than the target level of 1.
  - Although aluminum contributes an RME HI greater than 0.1 to a target organ that has an HI greater than 1, manganese, which alone has an HI greater than 1, drives the risk for that target organ (neurological). If manganese was not factored in because it concentrations are associated with background, aluminum would not be identified as a risk driver.
- **Iron**
  - Current concentrations (maximum concentration of 52,100 µg/L) are less than the SJCA 95 percent background UTL (107,000 µg/L).
- **Beryllium**
  - The RME and CTE HIs for beryllium are less than the target level 1.
  - Although beryllium contributes an RME HI greater than 0.1 to a target organ that has an HI greater than 1, iron, which alone has HI greater than 1, drives this risk for that target organ (gastrointestinal). If iron was not factored in because it concentrations are associated with background, beryllium would not be identified as a risk driver.
- **Hexavalent Chromium**
  - Although hexavalent chromium contributes to a cumulative RME ELCR (2x10-4) greater than 1x10-4, arsenic is the primary contributor (2×10^{-4}); hexavalent chromium contributes 1x10-6 and alone does not pose unacceptable risk.
  - The CTE ELCR is less than 1×10^{-4}.

C.10 References

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Tables

TABLE C-1

Summary of Data Used in Baseline Human Health Risk Assessment

Site 5 Supplemental Remedial Investigation

St. Juliens Creek Annex

Chesapeake, Virginia

Medium / Sample ID	Date of Sampling	Sample Location	Parameters
Shallow Aquifer Groundwater - Site-Related			
SJS05-MW02S-14B	5/2/2014	SJS05-MW02S	Aluminum, Arsenic, Beryllium, Cadmium, Chromium, Chromium (Hexavalent), Cobalt, Iron, Lead, Manganese, Thallium, Vanadium
SJS05-MW02SP-14B[1]	5/2/2014	SJS05-MW02S	Aluminum, Arsenic, Beryllium, Cadmium, Chromium, Chromium (Hexavalent), Cobalt, Iron, Lead, Manganese, Thallium, Vanadium
SJS05-MW03S-14B	5/2/2014	SJS05-MW03S	Aluminum, Arsenic, Beryllium, Cadmium, Chromium, Chromium (Hexavalent), Cobalt, Iron, Lead, Manganese, Thallium, Vanadium
SJS05-MW04S-14B	5/2/2014	SJS05-MW04S	Aluminum, Arsenic, Beryllium, Cadmium, Chromium, Chromium (Hexavalent), Cobalt, Iron, Lead, Manganese, Thallium, Vanadium
SJS05-MW05S-14B	5/2/2014	SJS05-MW05S	Aluminum, Arsenic, Beryllium, Cadmium, Chromium, Chromium (Hexavalent), Cobalt, Iron, Lead, Manganese, Thallium, Vanadium
Shallow Aquifer Groundwater - Site-Specific Background[2]			
SJSBK-MW01-14B	5/1/2014	SJSBK-MW01	Aluminum, Arsenic, Beryllium, Cadmium, Chromium, Chromium (Hexavalent), Cobalt, Iron, Lead, Manganese, Thallium, Vanadium
SJSBK-MW02-14B	5/2/2014	SJSBK-MW02	Aluminum, Arsenic, Beryllium, Cadmium, Chromium, Chromium (Hexavalent), Cobalt, Iron, Lead, Manganese, Thallium, Vanadium
SJSBK-MW03-14B	5/2/2014	SJSBK-MW03	Aluminum, Arsenic, Beryllium, Cadmium, Chromium, Chromium (Hexavalent), Cobalt, Iron, Lead, Manganese, Thallium, Vanadium
SJSBK-MW06-14B	5/1/2014	SJSBK-MW06	Aluminum, Arsenic, Beryllium, Cadmium, Chromium, Chromium (Hexavalent), Cobalt, Iron, Lead, Manganese, Thallium, Vanadium

Notes:

[1] Duplicate of previous sample.

[2] Data considered but not used to calculate risk numbers in the HHRA

TABLE C-2

Summary of COPCs

Site 5 Supplemental Remedial Investigation

St. Juliens Creek Annex

Chesapeake, Virginia

Shallow Aquifer Groundwater (unfiltered metals)
Aluminum
Arsenic
Beryllium
Cadmium
Chromium (hexavalent)
Cobalt
Iron
Lead
Manganese
Vanadium

TABLE C-3

Summary of RME Carcinogenic Risks and Non-carcinogenic Hazards

Site 5 Supplemental Remedial Investigation

St. Juliens Creek Annex

Chesapeake, Virginia

Receptor	Media	Exposure Route	Cancer Risk	Chemicals with Cancer Risks >10^{-6}	Hazard Index	Chemicals with HI>1	Chemicals of Concern (Chemicals Contributing HI > 0.1 to Target Organ HI >1 or carcinogenic risk>10^{-6} to total carcinogenic risk >10^{-4})
Future Resident Adult	Groundwater (Shallow Aquifer)	Ingestion	NA		9	Cobalt (4), Iron (2), Manganese (2)	Cobalt, Iron, Manganese
		Dermal Contact	NA		0.4		
		Inhalation	NA		NA		
		Total	NA		10		
Future Resident Child	Groundwater (Shallow Aquifer)	Ingestion	NA		15	Arsenic (2), Cobalt (7), Iron (3), Manganese (3)	Aluminum, Arsenic, Beryllium, Cobalt, Iron, Manganese
		Dermal Contact	NA		0.4		
		Inhalation	NA		NA		
		Total	NA		16		
Future Resident Child/Adult	Groundwater (Shallow Aquifer)	Ingestion	2E-04	Arsenic (2E-04)	NA		Arsenic, Chromium (hexavalent)
		Dermal Contact	2E-06		NA		
		Inhalation	NA		NA		
		Total	2E-04		NA		
Future Construction Worker	Groundwater (Shallow Aquifer)	Ingestion	NA		NA		
		Dermal Contact	6E-08		0.4		
		Inhalation	NA		NA		
		Total	6E-08		0.4		

Incremental cancer risks and hazard quotients are identified in parenthesis
NA - Not applicable

TABLE C-4

Summary of CTE Carcinogenic Risks and Non-carcinogenic Hazards

Site 5 Supplemental Remedial Investigation

St. Juliens Creek Annex

Chesapeake, Virginia

Receptor	Media	Exposure Route	Cancer Risk	Chemicals with Cancer Risks $>10^{-6}$	Hazard Index	Chemicals with HI>1	Chemicals of Concern (Chemicals Contributing HI > 0.1 to Target Organ HI >1 or carcinogenic risk$>10^{-6}$ to total carcinogenic risk $>10^{-4}$)
Future Resident Adult	Groundwater	Ingestion	NA		4	Cobalt (2)	Cobalt
		Dermal Contact	NA		0.1		
		Inhalation	NA		NA		
		Total	NA		4		
Future Resident Child	Groundwater	Ingestion	NA		6	Cobalt (3)	Cobalt
		Dermal Contact	NA		0.3		
		Inhalation	NA		NA		
		Total	NA		6		
Future Resident Child/Adult	Groundwater	Ingestion	5E-05	Arsenic (5E-05)	NA		
		Dermal Contact	7E-07		NA		
		Inhalation	NA		NA		
		Total	6E-05		NA		

Incremental cancer risks and hazard quotients are identified in parenthesis
NA - Not applicable

Attachment 1

ProUCL Output, Shallow Groundwater			
UCL Statistics for Data Sets with Non-Detects			
User Selected Options			
Date/Time of Computation	5/21/2014 1:43:22 PM		
From File	ProUCL input.xls		
Full Precision	OFF		
Confidence Coefficient	95%		
Number of Bootstrap Operations	2000		
Aluminum			
General Statistics			
Total Number of Observations	4	Number of Distinct Observations	4
		Number of Missing Observations	0
Minimum	231	Mean	1930
Maximum	5300	Median	1094
SD	2310	Std. Error of Mean	1155
Coefficient of Variation	1.197	Skewness	1.
Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use			
guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.			
For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).			
Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0			
Normal GOF Test			
Shapiro Wilk Test Statistic	0.822	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.748	Data appear Normal at 5% Significance Level	
Lilliefors Test Statistic	0.32	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.443	Data appear Normal at 5% Significance Level	
Data appear Normal at 5% Significance Level			
Assuming Normal Distribution			
95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	4648	95% Adjusted-CLT UCL (Chen-1995)	4874
		95% Modified-t UCL (Johnson-1978)	4811
Gamma GOF Test			
A-D Test Statistic	0.247	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.667	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.2	**Kolmogrov-Smirnoff Gamma GOF Test**	
5% K-S Critical Value	0.403	Detected data appear Gamma Distributed at 5% Significance Level	
Detected data appear Gamma Distributed at 5% Significance Level			
Gamma Statistics			

ProUCL Output, Shallow Groundwater			
k hat (MLE)	0.961	k star (bias corrected MLE)	0.
Theta hat (MLE)	2007	Theta star (bias corrected MLE)	474
nu hat (MLE)	7.691	nu star (bias corrected)	3.
MLE Mean (bias corrected)	1930	MLE Sd (bias corrected)	3024
		Approximate Chi Square Value (0.05)	0.
Adjusted Level of Significance	N/A	Adjusted Chi Square Value	N/A
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50))	13895	95% Adjusted Gamma UCL (use when n<50)	N/A
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.999	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.748	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.141	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.443	Data appear Lognormal at 5% Significance Level	
Data appear Lognormal at 5% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	5.442	Mean of logged Data	6.
Maximum of Logged Data	8.575	SD of logged Data	1.
Assuming Lognormal Distribution			
95% H-UCL	2013015	90% Chebyshev (MVUE) UCL	522
95% Chebyshev (MVUE) UCL	6726	97.5% Chebyshev (MVUE) UCL	881
99% Chebyshev (MVUE) UCL	12916		
Nonparametric Distribution Free UCL Statistics			
Data appear to follow a Discernible Distribution at 5% Significance Level			
Nonparametric Distribution Free UCLs			
95% CLT UCL	3829	95% Jackknife UCL	464
95% Standard Bootstrap UCL	N/A	95% Bootstrap-t UCL	N/A
95% Hall's Bootstrap UCL	N/A	95% Percentile Bootstrap UCL	N/A
95% BCA Bootstrap UCL	N/A		
90% Chebyshev(Mean, Sd) UCL	5394	95% Chebyshev(Mean, Sd) UCL	696
97.5% Chebyshev(Mean, Sd) UCL	9142	99% Chebyshev(Mean, Sd) UCL	1342
Suggested UCL to Use			
95% Student's-t UCL	4648		
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)			
and Singh and Singh (2003). However, simulations results will not cover all Real World data sets.			
For additional insight the user may want to consult a statistician.			

ProUCL Output, Shallow Groundwater			
Arsenic			
General Statistics			
Total Number of Observations	4	Number of Distinct Observations	4
Number of Detects	3	Number of Non-Detects	1
Number of Distinct Detects	3	Number of Distinct Non-Detects	1
Minimum Detect	2.21	Minimum Non-Detect	20
Maximum Detect	11	Maximum Non-Detect	20
Variance Detects	23.39	Percent Non-Detects	25
Mean Detects	7.77	SD Detects	4.
Median Detects	10.1	CV Detects	0.
Skewness Detects	-1.665	Kurtosis Detects	N/A
Mean of Logged Detects	1.834	SD of Logged Detects	0.
Warning: Data set has only 3 Detected Values.			
This is not enough to compute meaningful or reliable statistics and estimates.			
Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use			
guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.			
For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).			
Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0			
Normal GOF Test on Detects Only			
Shapiro Wilk Test Statistic	0.826	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.767	Detected Data appear Normal at 5% Significance Level	
Lilliefors Test Statistic	0.352	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.512	Detected Data appear Normal at 5% Significance Level	
Detected Data appear Normal at 5% Significance Level			
Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs			
Mean	7.77	Standard Error of Mean	2.
SD	3.949	95% KM (BCA) UCL	N/A
95% KM (t) UCL	14.34	95% KM (Percentile Bootstrap) UCL	N/A
95% KM (z) UCL	12.36	95% KM Bootstrap t UCL	N/A
90% KM Chebyshev UCL	16.15	95% KM Chebyshev UCL	19
97.5% KM Chebyshev UCL	25.21	99% KM Chebyshev UCL	35
Gamma GOF Tests on Detected Observations Only			
Not Enough Data to Perform GOF Test			
Gamma Statistics on Detected Data Only			
k hat (MLE)	2.471	k star (bias corrected MLE)	N/A
Theta hat (MLE)	3.145	Theta star (bias corrected MLE)	N/A
nu hat (MLE)	14.83	nu star (bias corrected)	N/A

ProUCL Output, Shallow Groundwater			
MLE Mean (bias corrected)	N/A	MLE Sd (bias corrected)	N/A
Gamma Kaplan-Meier (KM) Statistics			
k hat (KM)	3.872	nu hat (KM)	30
		Adjusted Level of Significance (β)	0.0
Approximate Chi Square Value (30.98, α)	19.26	Adjusted Chi Square Value (30.98, β)	14
95% Gamma Approximate KM-UCL (use when n>=50)	12.5	95% Gamma Adjusted KM-UCL (use when n<50)	16
Lognormal GOF Test on Detected Observations Only			
Shapiro Wilk Test Statistic	0.79	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.767	Detected Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.368	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.512	Detected Data appear Lognormal at 5% Significance Level	
Detected Data appear Lognormal at 5% Significance Level			
Lognormal ROS Statistics Using Imputed Non-Detects			
Mean in Original Scale	7.393	Mean in Log Scale	1.
SD in Original Scale	4.02	SD in Log Scale	0.
95% t UCL (assumes normality of ROS data)	12.12	95% Percentile Bootstrap UCL	N/A
95% BCA Bootstrap UCL	N/A	95% Bootstrap t UCL	N/A
95% H-UCL (Log ROS)	69.83		
UCLs using Lognormal Distribution and KM Estimates when Detected data are Lognormally Distributed			
KM Mean (logged)	1.834	95% H-UCL (KM -Log)	69
KM SD (logged)	0.737	95% Critical H Value (KM-Log)	5.
KM Standard Error of Mean (logged)	0.521		
DL/2 Statistics			
DL/2 Normal		**DL/2 Log-Transformed**	
Mean in Original Scale	8.328	Mean in Log Scale	1.
SD in Original Scale	4.103	SD in Log Scale	0.
95% t UCL (Assumes normality)	13.16	95% H-Stat UCL	99
DL/2 is not a recommended method, provided for comparisons and historical reasons			
Nonparametric Distribution Free UCL Statistics			
Detected Data appear Normal Distributed at 5% Significance Level			
Suggested UCL to Use			
95% KM (t) UCL	14.34	95% KM (Percentile Bootstrap) UCL	N/A
Warning: One or more Recommended UCL(s) not available!			
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
Recommendations are based upon data size, data distribution, and skewness.			
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).			
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.			

ProUCL Output, Shallow Groundwater

Beryllium

General Statistics

Total Number of Observations	4	Number of Distinct Observations	3
Number of Detects	2	Number of Non-Detects	2
Number of Distinct Detects	2	Number of Distinct Non-Detects	1
Minimum Detect	0.996	Minimum Non-Detect	0.
Maximum Detect	3.87	Maximum Non-Detect	0.
Variance Detects	4.13	Percent Non-Detects	50
Mean Detects	2.433	SD Detects	2.
Median Detects	2.433	CV Detects	0.
Skewness Detects	N/A	Kurtosis Detects	N/A
Mean of Logged Detects	0.675	SD of Logged Detects	0.

Warning: Data set has only 2 Detected Values.

This is not enough to compute meaningful or reliable statistics and estimates.

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use

guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.

For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).

Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test on Detects Only

Not Enough Data to Perform GOF Test

Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs

Mean	1.467	Standard Error of Mean	0.
SD	1.402	95% KM (BCA) UCL	N/A
95% KM (t) UCL	3.8	95% KM (Percentile Bootstrap) UCL	N/A
95% KM (z) UCL	3.098	95% KM Bootstrap t UCL	N/A
90% KM Chebyshev UCL	4.441	95% KM Chebyshev UCL	5.
97.5% KM Chebyshev UCL	7.659	99% KM Chebyshev UCL	11

Gamma GOF Tests on Detected Observations Only

Not Enough Data to Perform GOF Test

Gamma Statistics on Detected Data Only

k hat (MLE)	2.485	k star (bias corrected MLE)	N/A
Theta hat (MLE)	0.979	Theta star (bias corrected MLE)	N/A
nu hat (MLE)	9.94	nu star (bias corrected)	N/A
MLE Mean (bias corrected)	N/A	MLE Sd (bias corrected)	N/A

Gamma Kaplan-Meier (KM) Statistics

ProUCL Output, Shallow Groundwater			
k hat (KM)	1.094	nu hat (KM)	8.
		Adjusted Level of Significance (β)	0.0
Approximate Chi Square Value (8.75, α)	3.176	Adjusted Chi Square Value (8.75, β)	1.
95% Gamma Approximate KM-UCL (use when n>=50)	4.04	95% Gamma Adjusted KM-UCL (use when n<50)	7.
Lognormal GOF Test on Detected Observations Only			
Not Enough Data to Perform GOF Test			
Lognormal ROS Statistics Using Imputed Non-Detects			
Mean in Original Scale	1.252	Mean in Log Scale	-1.0
SD in Original Scale	1.799	SD in Log Scale	2.
95% t UCL (assumes normality of ROS data)	3.369	95% Percentile Bootstrap UCL	N/A
95% BCA Bootstrap UCL	N/A	95% Bootstrap t UCL	N/A
95% H-UCL (Log ROS)	2.597E+8		
DL/2 Statistics			
DL/2 Normal		**DL/2 Log-Transformed**	
Mean in Original Scale	1.342	Mean in Log Scale	-0.3
SD in Original Scale	1.722	SD in Log Scale	1.
95% t UCL (Assumes normality)	3.368	95% H-Stat UCL	1180
DL/2 is not a recommended method, provided for comparisons and historical reasons			
Nonparametric Distribution Free UCL Statistics			
Data do not follow a Discernible Distribution at 5% Significance Level			
Suggested UCL to Use			
95% KM (t) UCL	3.8	95% KM (% Bootstrap) UCL	N/A
Warning: One or more Recommended UCL(s) not available!			
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
Recommendations are based upon data size, data distribution, and skewness.			
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).			
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.			
Cadmium			
General Statistics			
Total Number of Observations	4	Number of Distinct Observations	3
Number of Detects	2	Number of Non-Detects	2
Number of Distinct Detects	2	Number of Distinct Non-Detects	1
Minimum Detect	1.16	Minimum Non-Detect	8
Maximum Detect	1.78	Maximum Non-Detect	8
Variance Detects	0.192	Percent Non-Detects	50
Mean Detects	1.47	SD Detects	0.
Median Detects	1.47	CV Detects	0.

ProUCL Output, Shallow Groundwater			
Skewness Detects	N/A	Kurtosis Detects	N/A
Mean of Logged Detects	0.363	SD of Logged Detects	0.
Warning: Data set has only 2 Detected Values.			
This is not enough to compute meaningful or reliable statistics and estimates.			
Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use			
guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.			
For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).			
Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0			
Normal GOF Test on Detects Only			
Not Enough Data to Perform GOF Test			
Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs			
Mean	1.47	Standard Error of Mean	0.
SD	0.31	95% KM (BCA) UCL	N/A
95% KM (t) UCL	2.2	95% KM (Percentile Bootstrap) UCL	N/A
95% KM (z) UCL	1.98	95% KM Bootstrap t UCL	N/A
90% KM Chebyshev UCL	2.4	95% KM Chebyshev UCL	2.
97.5% KM Chebyshev UCL	3.406	99% KM Chebyshev UCL	4.
Gamma GOF Tests on Detected Observations Only			
Not Enough Data to Perform GOF Test			
Gamma Statistics on Detected Data Only			
k hat (MLE)	22.15	k star (bias corrected MLE)	N/A
Theta hat (MLE)	0.0664	Theta star (bias corrected MLE)	N/A
nu hat (MLE)	88.59	nu star (bias corrected)	N/A
MLE Mean (bias corrected)	N/A	MLE Sd (bias corrected)	N/A
Gamma Kaplan-Meier (KM) Statistics			
k hat (KM)	22.49	nu hat (KM)	179
		Adjusted Level of Significance (β)	0.0
Approximate Chi Square Value (179.89, α)	149.9	Adjusted Chi Square Value (179.89, β)	134
95% Gamma Approximate KM-UCL (use when n>=50)	1.764	95% Gamma Adjusted KM-UCL (use when n<50)	1.
Lognormal GOF Test on Detected Observations Only			
Not Enough Data to Perform GOF Test			
Lognormal ROS Statistics Using Imputed Non-Detects			
Mean in Original Scale	1.47	Mean in Log Scale	0.
SD in Original Scale	0.358	SD in Log Scale	0.
95% t UCL (assumes normality of ROS data)	1.891	95% Percentile Bootstrap UCL	N/A

ProUCL Output, Shallow Groundwater			
95% BCA Bootstrap UCL	N/A	95% Bootstrap t UCL	N/A
95% H-UCL (Log ROS)	2.148		
DL/2 Statistics			
DL/2 Normal		DL/2 Log-Transformed	
Mean in Original Scale	2.735	Mean in Log Scale	0.
SD in Original Scale	1.482	SD in Log Scale	0.
95% t UCL (Assumes normality)	4.479	95% H-Stat UCL	13
DL/2 is not a recommended method, provided for comparisons and historical reasons			
Nonparametric Distribution Free UCL Statistics			
Data do not follow a Discernible Distribution at 5% Significance Level			
Suggested UCL to Use			
95% KM (t) UCL	2.2	95% KM (% Bootstrap) UCL	N/A
Warning: One or more Recommended UCL(s) not available!			
Warning: Recommended UCL exceeds the maximum observation			
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
Recommendations are based upon data size, data distribution, and skewness.			
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).			
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.			
Chromium (Hexavalent)			
General Statistics			
Total Number of Observations	4	Number of Distinct Observations	4
		Number of Missing Observations	0
Minimum	0.029	Mean	0.(
Maximum	0.081	Median	0.(
SD	0.023	Std. Error of Mean	0.(
Coefficient of Variation	0.442	Skewness	0.
Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use			
guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.			
For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).			
Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0			
Normal GOF Test			
Shapiro Wilk Test Statistic	0.962	Shapiro Wilk GOF Test	
5% Shapiro Wilk Critical Value	0.748	Data appear Normal at 5% Significance Level	
Lilliefors Test Statistic	0.214	Lilliefors GOF Test	
5% Lilliefors Critical Value	0.443	Data appear Normal at 5% Significance Level	
Data appear Normal at 5% Significance Level			

ProUCL Output, Shallow Groundwater			
Assuming Normal Distribution			
95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	0.0791	95% Adjusted-CLT UCL (Chen-1995)	0.0
		95% Modified-t UCL (Johnson-1978)	0.0
Gamma GOF Test			
A-D Test Statistic	0.23	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.658	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.22	**Kolmogrov-Smirnoff Gamma GOF Test**	
5% K-S Critical Value	0.396	Detected data appear Gamma Distributed at 5% Significance Level	
Detected data appear Gamma Distributed at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	6.782	k star (bias corrected MLE)	1.
Theta hat (MLE)	0.00767	Theta star (bias corrected MLE)	0.0
nu hat (MLE)	54.26	nu star (bias corrected)	14
MLE Mean (bias corrected)	0.052	MLE Sd (bias corrected)	0.0
		Approximate Chi Square Value (0.05)	7.
Adjusted Level of Significance	N/A	Adjusted Chi Square Value	N/A
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50))	0.108	95% Adjusted Gamma UCL (use when n<50)	N/A
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.98	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.748	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.181	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.443	Data appear Lognormal at 5% Significance Level	
Data appear Lognormal at 5% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	-3.54	Mean of logged Data	-3.0
Maximum of Logged Data	-2.513	SD of logged Data	0.
Assuming Lognormal Distribution			
95% H-UCL	0.13	90% Chebyshev (MVUE) UCL	0.0
95% Chebyshev (MVUE) UCL	0.102	97.5% Chebyshev (MVUE) UCL	0.
99% Chebyshev (MVUE) UCL	0.167		
Nonparametric Distribution Free UCL Statistics			
Data appear to follow a Discernible Distribution at 5% Significance Level			
Nonparametric Distribution Free UCLs			
95% CLT UCL	0.0709	95% Jackknife UCL	0.0
95% Standard Bootstrap UCL	N/A	95% Bootstrap-t UCL	N/A

ProUCL Output, Shallow Groundwater			
95% Hall's Bootstrap UCL	N/A	95% Percentile Bootstrap UCL	N/A
95% BCA Bootstrap UCL	N/A		
90% Chebyshev(Mean, Sd) UCL	0.0865	95% Chebyshev(Mean, Sd) UCL	0.
97.5% Chebyshev(Mean, Sd) UCL	0.124	99% Chebyshev(Mean, Sd) UCL	0.
Suggested UCL to Use			
95% Student's-t UCL	0.0791		
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)			
and Singh and Singh (2003). However, simulations results will not cover all Real World data sets.			
For additional insight the user may want to consult a statistician.			
Cobalt			
General Statistics			
Total Number of Observations	4	Number of Distinct Observations	4
Number of Detects	3	Number of Non-Detects	1
Number of Distinct Detects	3	Number of Distinct Non-Detects	1
Minimum Detect	1.63	Minimum Non-Detect	1.
Maximum Detect	40.9	Maximum Non-Detect	1.
Variance Detects	386.8	Percent Non-Detects	25
Mean Detects	21.91	SD Detects	19
Median Detects	23.2	CV Detects	0.
Skewness Detects	-0.294	Kurtosis Detects	N/A
Mean of Logged Detects	2.448	SD of Logged Detects	1.
Warning: Data set has only 3 Detected Values.			
This is not enough to compute meaningful or reliable statistics and estimates.			
Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use			
guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.			
For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).			
Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0			
Normal GOF Test on Detects Only			
Shapiro Wilk Test Statistic	0.997	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.767	Detected Data appear Normal at 5% Significance Level	
Lilliefors Test Statistic	0.193	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.512	Detected Data appear Normal at 5% Significance Level	
Detected Data appear Normal at 5% Significance Level			
Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs			
Mean	16.84	Standard Error of Mean	10

ProUCL Output, Shallow Groundwater			
SD	16.45	95% KM (BCA) UCL	N/A
95% KM (t) UCL	40.54	95% KM (Percentile Bootstrap) UCL	N/A
95% KM (z) UCL	33.41	95% KM Bootstrap t UCL	N/A
90% KM Chebyshev UCL	47.06	95% KM Chebyshev UCL	60
97.5% KM Chebyshev UCL	79.74	99% KM Chebyshev UCL	117
Gamma GOF Tests on Detected Observations Only			
Not Enough Data to Perform GOF Test			
Gamma Statistics on Detected Data Only			
k hat (MLE)	0.913	k star (bias corrected MLE)	N/A
Theta hat (MLE)	23.99	Theta star (bias corrected MLE)	N/A
nu hat (MLE)	5.479	nu star (bias corrected)	N/A
MLE Mean (bias corrected)	N/A	MLE Sd (bias corrected)	N/A
Gamma Kaplan-Meier (KM) Statistics			
k hat (KM)	1.048	nu hat (KM)	8.
		Adjusted Level of Significance (β)	0.0
Approximate Chi Square Value (8.39, α)	2.961	Adjusted Chi Square Value (8.39, β)	1.
95% Gamma Approximate KM-UCL (use when n>=50)	47.7	95% Gamma Adjusted KM-UCL (use when n<50)	94
Lognormal GOF Test on Detected Observations Only			
Shapiro Wilk Test Statistic	0.877	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.767	Detected Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.324	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.512	Detected Data appear Lognormal at 5% Significance Level	
Detected Data appear Lognormal at 5% Significance Level			
Lognormal ROS Statistics Using Imputed Non-Detects			
Mean in Original Scale	16.88	Mean in Log Scale	1.
SD in Original Scale	18.94	SD in Log Scale	1.
95% t UCL (assumes normality of ROS data)	39.18	95% Percentile Bootstrap UCL	N/A
95% BCA Bootstrap UCL	N/A	95% Bootstrap t UCL	N/A
95% H-UCL (Log ROS)	1406470		
UCLs using Lognormal Distribution and KM Estimates when Detected data are Lognormally Distributed			
KM Mean (logged)	1.958	95% H-UCL (KM -Log)	9110
KM SD (logged)	1.483	95% Critical H Value (KM-Log)	9.
KM Standard Error of Mean (logged)	0.908		
DL/2 Statistics			
DL/2 Normal		**DL/2 Log-Transformed**	
Mean in Original Scale	16.64	Mean in Log Scale	1.
SD in Original Scale	19.21	SD in Log Scale	1.
95% t UCL (Assumes normality)	39.24	95% H-Stat UCL	44816

ProUCL Output, Shallow Groundwater			
DL/2 is not a recommended method, provided for comparisons and historical reasons			
Nonparametric Distribution Free UCL Statistics			
Detected Data appear Normal Distributed at 5% Significance Level			
Suggested UCL to Use			
95% KM (t) UCL	40.54	95% KM (Percentile Bootstrap) UCL	N/A
Warning: One or more Recommended UCL(s) not available!			
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
Recommendations are based upon data size, data distribution, and skewness.			
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).			
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.			
Iron			
General Statistics			
Total Number of Observations	4	Number of Distinct Observations	4
		Number of Missing Observations	0
Minimum	229	Mean	1937
Maximum	52100	Median	1258
SD	23678	Std. Error of Mean	1183
Coefficient of Variation	1.222	Skewness	1.
Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use			
guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.			
For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).			
Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0			
Normal GOF Test			
Shapiro Wilk Test Statistic	0.885	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.748	Data appear Normal at 5% Significance Level	
Lilliefors Test Statistic	0.244	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.443	Data appear Normal at 5% Significance Level	
Data appear Normal at 5% Significance Level			
Assuming Normal Distribution			
95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	47233	95% Adjusted-CLT UCL (Chen-1995)	4656
		95% Modified-t UCL (Johnson-1978)	4843
Gamma GOF Test			
A-D Test Statistic	0.214	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.68	Detected data appear Gamma Distributed at 5% Significance Level	

ProUCL Output, Shallow Groundwater			
K-S Test Statistic	0.204	**Kolmogrov-Smirnoff Gamma GOF Test**	
5% K-S Critical Value	0.41	Detected data appear Gamma Distributed at 5% Significance Level	
Detected data appear Gamma Distributed at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	0.51	k star (bias corrected MLE)	0.
Theta hat (MLE)	37987	Theta star (bias corrected MLE)	6585
nu hat (MLE)	4.08	nu star (bias corrected)	2.
MLE Mean (bias corrected)	19372	MLE Sd (bias corrected)	3571
		Approximate Chi Square Value (0.05)	0.
Adjusted Level of Significance	N/A	Adjusted Chi Square Value	N/A
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50))	217280	95% Adjusted Gamma UCL (use when n<50)	N/A
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.942	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.748	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.212	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.443	Data appear Lognormal at 5% Significance Level	
Data appear Lognormal at 5% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	5.434	Mean of logged Data	8.
Maximum of Logged Data	10.86	SD of logged Data	2.
Assuming Lognormal Distribution			
95% H-UCL	2.226E+14	90% Chebyshev (MVUE) UCL	9852
95% Chebyshev (MVUE) UCL	130436	97.5% Chebyshev (MVUE) UCL	17472
99% Chebyshev (MVUE) UCL	261725		
Nonparametric Distribution Free UCL Statistics			
Data appear to follow a Discernible Distribution at 5% Significance Level			
Nonparametric Distribution Free UCLs			
95% CLT UCL	38846	95% Jackknife UCL	4723
95% Standard Bootstrap UCL	N/A	95% Bootstrap-t UCL	N/A
95% Hall's Bootstrap UCL	N/A	95% Percentile Bootstrap UCL	N/A
95% BCA Bootstrap UCL	N/A		
90% Chebyshev(Mean, Sd) UCL	54889	95% Chebyshev(Mean, Sd) UCL	7097
97.5% Chebyshev(Mean, Sd) UCL	93306	99% Chebyshev(Mean, Sd) UCL	13716
Suggested UCL to Use			
95% Student's-t UCL	47233		

ProUCL Output, Shallow Groundwater

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.

These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)

and Singh and Singh (2003). However, simulations results will not cover all Real World data sets.

For additional insight the user may want to consult a statistician.

Lead

General Statistics

Total Number of Observations	4	Number of Distinct Observations	3
Number of Detects	2	Number of Non-Detects	2
Number of Distinct Detects	2	Number of Distinct Non-Detects	1
Minimum Detect	3.45	Minimum Non-Detect	20
Maximum Detect	17.2	Maximum Non-Detect	20
Variance Detects	94.53	Percent Non-Detects	50
Mean Detects	10.33	SD Detects	9.
Median Detects	10.33	CV Detects	0.
Skewness Detects	N/A	Kurtosis Detects	N/A
Mean of Logged Detects	2.042	SD of Logged Detects	1.

Warning: Data set has only 2 Detected Values.

This is not enough to compute meaningful or reliable statistics and estimates.

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use

guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.

For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).

Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test on Detects Only

Not Enough Data to Perform GOF Test

Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs

Mean	10.33	Standard Error of Mean	6.
SD	6.875	95% KM (BCA) UCL	N/A
95% KM (t) UCL	26.5	95% KM (Percentile Bootstrap) UCL	N/A
95% KM (z) UCL	21.63	95% KM Bootstrap t UCL	N/A
90% KM Chebyshev UCL	30.95	95% KM Chebyshev UCL	40
97.5% KM Chebyshev UCL	53.26	99% KM Chebyshev UCL	78

Gamma GOF Tests on Detected Observations Only

Not Enough Data to Perform GOF Test

Gamma Statistics on Detected Data Only

k hat (MLE)	1.856	k star (bias corrected MLE)	N/A
Theta hat (MLE)	5.562	Theta star (bias corrected MLE)	N/A

ProUCL Output, Shallow Groundwater			
nu hat (MLE)	7.425	nu star (bias corrected)	N/A
MLE Mean (bias corrected)	N/A	MLE Sd (bias corrected)	N/A
Gamma Kaplan-Meier (KM) Statistics			
k hat (KM)	2.255	nu hat (KM)	18
		Adjusted Level of Significance (β)	0.0
Approximate Chi Square Value (18.04, α)	9.422	Adjusted Chi Square Value (18.04, β)	6.
95% Gamma Approximate KM-UCL (use when n>=50)	19.77	95% Gamma Adjusted KM-UCL (use when n<50)	29
Lognormal GOF Test on Detected Observations Only			
Not Enough Data to Perform GOF Test			
Lognormal ROS Statistics Using Imputed Non-Detects			
Mean in Original Scale	10.33	Mean in Log Scale	2.
SD in Original Scale	7.939	SD in Log Scale	0.
95% t UCL (assumes normality of ROS data)	19.67	95% Percentile Bootstrap UCL	N/A
95% BCA Bootstrap UCL	N/A	95% Bootstrap t UCL	N/A
95% H-UCL (Log ROS)	329.6		
DL/2 Statistics			
DL/2 Normal		DL/2 Log-Transformed	
Mean in Original Scale	10.16	Mean in Log Scale	2.
SD in Original Scale	5.617	SD in Log Scale	0.
95% t UCL (Assumes normality)	16.77	95% H-Stat UCL	66
DL/2 is not a recommended method, provided for comparisons and historical reasons			
Nonparametric Distribution Free UCL Statistics			
Data do not follow a Discernible Distribution at 5% Significance Level			
Suggested UCL to Use			
95% KM (BCA) UCL	N/A		
Warning: One or more Recommended UCL(s) not available!			
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
Recommendations are based upon data size, data distribution, and skewness.			
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).			
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.			
Manganese			
General Statistics			
Total Number of Observations	4	Number of Distinct Observations	4
		Number of Missing Observations	0
Minimum	18.1	Mean	659

ProUCL Output, Shallow Groundwater			
Maximum	1430	Median	595
SD	639.6	Std. Error of Mean	319
Coefficient of Variation	0.97	Skewness	0.
Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use			
guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.			
For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).			
Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0			
Normal GOF Test			
Shapiro Wilk Test Statistic	0.95	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.748	Data appear Normal at 5% Significance Level	
Lilliefors Test Statistic	0.23	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.443	Data appear Normal at 5% Significance Level	
Data appear Normal at 5% Significance Level			
Assuming Normal Distribution			
95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	1412	95% Adjusted-CLT UCL (Chen-1995)	1252
		95% Modified-t UCL (Johnson-1978)	1422
Gamma GOF Test			
A-D Test Statistic	0.285	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.672	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.255	**Kolmogrov-Smirnoff Gamma GOF Test**	
5% K-S Critical Value	0.406	Detected data appear Gamma Distributed at 5% Significance Level	
Detected data appear Gamma Distributed at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	0.712	k star (bias corrected MLE)	0.
Theta hat (MLE)	926.3	Theta star (bias corrected MLE)	1914
nu hat (MLE)	5.696	nu star (bias corrected)	2.
MLE Mean (bias corrected)	659.5	MLE Sd (bias corrected)	1123
		Approximate Chi Square Value (0.05)	0.
Adjusted Level of Significance	N/A	Adjusted Chi Square Value	N/A
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50))	5976	95% Adjusted Gamma UCL (use when n<50)	N/A
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.89	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.748	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.239	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.443	Data appear Lognormal at 5% Significance Level	
Data appear Lognormal at 5% Significance Level			

ProUCL Output, Shallow Groundwater			
Lognormal Statistics			
Minimum of Logged Data	2.896	Mean of logged Data	5.
Maximum of Logged Data	7.265	SD of logged Data	1.
Assuming Lognormal Distribution			
95% H-UCL	4.330E+9	90% Chebyshev (MVUE) UCL	298
95% Chebyshev (MVUE) UCL	3926	97.5% Chebyshev (MVUE) UCL	523
99% Chebyshev (MVUE) UCL	7793		
Nonparametric Distribution Free UCL Statistics			
Data appear to follow a Discernible Distribution at 5% Significance Level			
Nonparametric Distribution Free UCLs			
95% CLT UCL	1186	95% Jackknife UCL	141
95% Standard Bootstrap UCL	N/A	95% Bootstrap-t UCL	N/
95% Hall's Bootstrap UCL	N/A	95% Percentile Bootstrap UCL	N/
95% BCA Bootstrap UCL	N/A		
90% Chebyshev(Mean, Sd) UCL	1619	95% Chebyshev(Mean, Sd) UCL	205
97.5% Chebyshev(Mean, Sd) UCL	2657	99% Chebyshev(Mean, Sd) UCL	384
Suggested UCL to Use			
95% Student's-t UCL	1412		
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)			
and Singh and Singh (2003). However, simulations results will not cover all Real World data sets.			
For additional insight the user may want to consult a statistician.			
Vanadium			
General Statistics			
Total Number of Observations	4	Number of Distinct Observations	4
		Number of Missing Observations	0
Minimum	0.814	Mean	3.
Maximum	9.25	Median	2.
SD	3.868	Std. Error of Mean	1.
Coefficient of Variation	1.002	Skewness	1.
Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use			
guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.			
For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).			
Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0			

ProUCL Output, Shallow Groundwater			
Normal GOF Test			
Shapiro Wilk Test Statistic	0.873	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.748	Data appear Normal at 5% Significance Level	
Lilliefors Test Statistic	0.245	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.443	Data appear Normal at 5% Significance Level	
Data appear Normal at 5% Significance Level			
Assuming Normal Distribution			
95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	8.412	95% Adjusted-CLT UCL (Chen-1995)	8.
		95% Modified-t UCL (Johnson-1978)	8.
Gamma GOF Test			
A-D Test Statistic	0.291	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.664	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.269	**Kolmogrov-Smirnoff Gamma GOF Test**	
5% K-S Critical Value	0.401	Detected data appear Gamma Distributed at 5% Significance Level	
Detected data appear Gamma Distributed at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	1.31	k star (bias corrected MLE)	0.
Theta hat (MLE)	2.946	Theta star (bias corrected MLE)	7.
nu hat (MLE)	10.48	nu star (bias corrected)	3.
MLE Mean (bias corrected)	3.861	MLE Sd (bias corrected)	5.
		Approximate Chi Square Value (0.05)	0.
Adjusted Level of Significance	N/A	Adjusted Chi Square Value	N/A
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50))	21.7	95% Adjusted Gamma UCL (use when n<50)	N/A
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.954	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.748	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.224	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.443	Data appear Lognormal at 5% Significance Level	
Data appear Lognormal at 5% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	-0.206	Mean of logged Data	0.
Maximum of Logged Data	2.225	SD of logged Data	1.
Assuming Lognormal Distribution			
95% H-UCL	473.9	90% Chebyshev (MVUE) UCL	9.
95% Chebyshev (MVUE) UCL	12.2	97.5% Chebyshev (MVUE) UCL	15
99% Chebyshev (MVUE) UCL	22.96		

ProUCL Output, Shallow Groundwater			
Nonparametric Distribution Free UCL Statistics			
Data appear to follow a Discernible Distribution at 5% Significance Level			
Nonparametric Distribution Free UCLs			
95% CLT UCL	7.042	95% Jackknife UCL	8.
95% Standard Bootstrap UCL	N/A	95% Bootstrap-t UCL	N/A
95% Hall's Bootstrap UCL	N/A	95% Percentile Bootstrap UCL	N/A
95% BCA Bootstrap UCL	N/A		
90% Chebyshev(Mean, Sd) UCL	9.663	95% Chebyshev(Mean, Sd) UCL	12
97.5% Chebyshev(Mean, Sd) UCL	15.94	99% Chebyshev(Mean, Sd) UCL	23
Suggested UCL to Use			
95% Student's-t UCL	8.412		
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)			
and Singh and Singh (2003). However, simulations results will not cover all Real World data sets.			
For additional insight the user may want to consult a statistician.			

TABLE 1

SELECTION OF EXPOSURE PATHWAYS

SITE 5 SUPPLEMENTAL REMEDIAL INVESTIGATION REPORT

ST. JULIENS CREEK ANNEX

CHESAPEAKE, VIRGINIA

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	On-Site/ Off-Site	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Future	Groundwater	Shallow Groundwater	Tap Water	Resident	Adult	Dermal	On-Site	Quant	Although unlikely, future resident may use shallow groundwater as a potable source.
						Ingestion	On-Site	Quant	
					Child	Dermal	On-Site	Quant	
						Ingestion	On-Site	Quant	
					Adult/Child	Dermal	On-Site	Quant	
						Ingestion	On-Site	Quant	
		Air	Shallow Aquifer - Water Vapors at Showerhead	Resident	Adult	Inhalation	On-site	None	Volatile compounds not a concern for Site 5, and not included in most recent groundwater sampling.
					Child	Inhalation	On-site	None	
					Adult/Child	Inhalation	On-site	None	
		Shallow Groundwater	Excavation Pit	Construction Worker	Adult	Dermal	On-Site	Quant	Construction workers may have exposed skin surfaces come into contact with groundwater.
		Air	Shallow Aquifer - Water Vapors in Excavation	Construction Worker	Adult	Inhalation	On-site	None	Volatile compounds not a concern for Site 5, and not included in most recent groundwater sampling.

Table 2.1
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
SITE 5 SUPPLEMENTAL REMEDIAL INVESTIGATION REPORT
ST. JULIENS CREEK ANNEX
CHESAPEAKE, VIRGINIA

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Shallow Groundwater

Exposure Point	CAS Number	Chemical	Minimum [1] Concentration Qualifier	Maximum [1] Concentration Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration [2] Used for Screening	Background [3] Value	Screening [4] Toxicity Value	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for [5] Contaminant Deletion or Selection
Tap Water and Excavation Pit	7429-90-5	Aluminum	2.3E+02 J	5.3E+03	UG/L	SJS05-MW03S-14B	4/4	NA	5.3E+03	1.7E+03	2.0E+03 N	50 to 200	SMCL	YES	ASL
	7440-38-2	Arsenic	2.2E+00 J	1.1E+01 J	UG/L	SJS05-MW05S-14B	3/4	2.0E+01	1.1E+01	8.0E+00	5.2E-02 C	1.0E+01	MCL	YES	ASL
	7440-41-7	Beryllium	1.0E+00 J	3.9E+00	UG/L	SJS05-MW03S-14B	2/4	5.0E-01	3.9E+00	1.4E+00	2.5E+00 N	4.0E+00	MCL	YES	ASL
	7440-43-9	Cadmium	1.2E+00 J	1.8E+00 J	UG/L	SJS05-MW03S-14B	2/4	8.0E+00	1.8E+00	7.4E-01	9.2E-01 N	5.0E+00	MCL	YES	ASL
	7440-47-3	Chromium	1.5E+00 J	2.0E+00 J	UG/L	SJS05-MW02SP-14B	3/4	6.0E+00	2.0E+00	3.2E+00	2.2E+03 N	1.0E+02	MCL	NO	BSL
	18540-29-9	Chromium (Hexavalent)	2.9E-02 L	8.1E-02 J	UG/L	SJS05-MW02S-14B	4/4	NA	8.1E-02	NA	3.5E-02 C	1.0E+02	MCL	YES	ASL
	7440-48-4	Cobalt	1.6E+00 J	4.1E+01	UG/L	SJS05-MW03S-14B	3/4	1.7E+00	4.1E+01	1.6E+01	6.0E-01 N	NA	NA	YES	ASL
	7439-89-6	Iron	2.3E+02	5.2E+04	UG/L	SJS05-MW03S-14B	4/4	NA	5.2E+04	1.1E+05	1.4E+03 N	3.0E+02	SMCL	YES	ASL
	7439-92-1	Lead	3.5E+00 J	1.7E+01 J	UG/L	SJS05-MW05S-14B	2/4	2.0E+01	1.7E+01	3.5E+00	1.5E+01 N	1.5E+01	MCL	YES	ASL
	7439-96-5	Manganese	1.8E+01 J	1.4E+03	UG/L	SJS05-MW03S-14B	4/4	NA	1.4E+03	1.4E+04	4.3E+01 N	5.0E+01	SMCL	YES	ASL
	7440-62-2	Vanadium	8.1E-01 J	9.3E+00 J	UG/L	SJS05-MW05S-14B	4/4	NA	9.3E+00	1.4E+01	8.6E+00 N	NA	NA	YES	ASL

[1] Minimum/Maximum detected concentrations, unfiltered groundwater data.
[2] Maximum concentration is used for screening.
[3] Unfiltered background values are presented in 2004 Final Background Investigation Report Addendum for Groundwater.
[4] Oak Ridge National Laboratory (ORNL). May, 2014. Regional Screening Levels for Chemical Contaminants at Superfund Sites. [Online].
Tap Water. Available: http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm
Concentrations based on non-carcinogenic health effects are based on HQ=0.1
The screening value of 15 ug/L for lead is the action level provided in the Drinking Water Regulations and Health Advisories.
RSL value for chromium (III) used as for total chromium since also analyzed groundwater for hexavalent chromium.
[5] Rationale Codes
Selection Reason: Above Screening Levels (ASL)
Deletion Reason: No Toxicity Information (NTX)
Essential Nutrient (NUT)
Below Screening Level (BSL)

COPC = Chemical of Potential Concern
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/ To Be Considered
J = Estimated Value
L = Biased Low
C = Carcinogenic
N = Noncarcinogenic
MCL = Maximum Contaminant Level
SMCL = Secondary Maximum Contaminant Level
NA = Not applicable or Not available
UG/L = microgram per liter

Table 3.1.RME
MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATION SUMMARY
SITE 5 SUPPLEMENTAL REMEDIAL INVESTIGATION REPORT
ST. JULIENS CREEK ANNEX
CHESAPEAKE, VIRGINIA

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Shallow Groundwater

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)		Maximum Concentration (Qualifier)		Exposure Point Concentration			
								Value	Units	Statistic	Rationale
Tap Water and Excavation Pit	Aluminum	UG/L	1.9E+03	4.6E+03	N	5.3E+03		4.6E+03	UG/L	95% Stud-t	1, 2, 3
	Arsenic	UG/L	7.8E+00	1.4E+01	NP	1.1E+01	J	1.1E+01	UG/L	Max	1, 2, 5
	Beryllium	UG/L	1.5E+00	3.8E+00	NP	3.9E+00		3.8E+00	UG/L	95% KM-t	4
	Cadmium	UG/L	1.5E+00	2.2E+00	NP	1.8E+00	J	1.8E+00	UG/L	Max	4, 5
	Chromium (Hexavalent)	UG/L	5.2E-02	7.9E-02	N	8.1E-02	J	7.9E-02	UG/L	95% Stud-t	1, 2, 3
	Cobalt	UG/L	1.7E+01	4.1E+01	NP	4.1E+01		4.1E+01	UG/L	95% KM-t	1, 2
	Iron	UG/L	1.9E+04	4.7E+04	N	5.2E+04		4.7E+04	UG/L	95% Stud-t	1, 2, 3
	Lead	UG/L	1.0E+01	NA		1.7E+01	J	1.0E+01	UG/L	Mean-N	6
	Manganese	UG/L	6.6E+02	1.4E+03	N	1.4E+03		1.4E+03	UG/L	95% Stud-t	1, 2, 3
	Vanadium	UG/L	3.9E+00	8.4E+00	N	9.3E+00	J	8.4E+00	UG/L	95% Stud-t	1, 2, 3

ProUCL, Version 5.0.00 used to determine distribution of data and calculate 95% UCL, following recommendations in users guide (USEPA. September 2013. Prepared by Lockheed Martin Environmental Services).

Options: 95% Student's-T test UCL (95% Stud-t); 95% Kaplan-Meier (t) UCL (95% KM-t); Arithmetic mean (Mean-N); Maximum Detected Value (Max)

UCL Rationale:
(1) Shapiro-Wilk W Test/Lilliefors test indicates data are log-normally distributed.
(2) Shapiro-Wilk W Test/Lilliefors indicates data are normally distributed.
(3) Test indicates data are gamma distributed.
(4) Not enough data to perform goodness of fit test.
(5) Maximum detected concentration used because calculated 95% UCL greater than maximum detected concentration.
(6) The arithmetic mean concentration is used for lead.

µg/L = micrograms per liter
N = Normal distribution.
NP = Non-parametric distribution.
J = Estimated Value
NA = Not applicable/Not available

TABLE 4.1.RME
VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURE
SITE 5 SUPPLEMENTAL REMEDIAL INVESTIGATION REPORT
ST. JULIENS CREEK ANNEX
CHESAPEAKE, VIRGINIA

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Shallow Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Resident	Adult	Tap Water	CW	Chemical Concentration in Water	See Table 3.1.RME	µg/l	See Table 3.1.RME	Chronic Daily Intake (CDI) (mg/kg-day) =
				IR-W	Ingestion Rate of Water	2.5	liters/day	EPA, 2014	CW x IR-W x EF x ED x CF1 x 1/BW x 1/AT
				EF	Exposure Frequency	350	days/year	EPA, 2014	
				ED	Exposure Duration	20	years	EPA, 2014	
				CF1	Conversion Factor 1	0.001	mg/µg	- -	
				BW	Body Weight	80	kg	EPA, 2014	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	7,300	days	EPA, 2014	
		Child	Tap Water	CW	Chemical Concentration in Water	See Table 3.1.RME		See Table 3.1.RME	CDI (mg/kg-day) =
				IR-W	Ingestion Rate of Water	0.78	liters/day	EPA, 2014	CW x IR-W x EF x ED x CF1 x 1/BW x 1/AT
				EF	Exposure Frequency	350	days/year	EPA, 2014	
				ED	Exposure Duration	6	years	EPA, 2014	
				CF1	Conversion Factor 1	0.001	mg/µg	- -	
				BW	Body Weight	15	kg	EPA, 2014	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	2,190	days	EPA, 1989	
		Child/Adult	Tap Water	CW	Chemical Concentration in Water	See Table 3.1.RME		See Table 3.1.RME	CDI (mg/kg-day) =
				IR-W-A	Ingestion Rate of Water, Adult	2.5	liters/day	See Table 3.1.RME	CW x IR-W-Adj x EF x CF1 x 1/AT
				IR-W-C	Ingestion Rate of Water, Child	0.78	liters/day	EPA, 2014	
				IR-W-Adj	Ingestion Rate of Water, Age-adjusted	0.94	liter-year/kg-day	calculated	IR-W-Adj (liter-year/kd-day) =
				EF	Exposure Frequency	350	days/year	EPA, 2014	(ED-C x IR-W-C / BW-C) +
				ED-A	Exposure Duration, Adult	20	years	EPA, 2014	(ED-A x IR-W-A / BW-A)
				ED-C	Exposure Duration, Child	6	years	EPA, 2014	
				CF1	Conversion Factor 1	0.001	mg/µg	- -	
				BW-A	Body Weight , Adult	80	kg	- -	
				BW-C	Body Weight, Child	15	kg	EPA, 2014	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	

TABLE 4.1.RME
VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURE
SITE 5 SUPPLEMENTAL REMEDIAL INVESTIGATION REPORT
ST. JULIENS CREEK ANNEX
CHESAPEAKE, VIRGINIA

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Shallow Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Dermal	Resident	Adult	Tap Water	CW	Chemical Concentration in Water	See Table 3.1.RME		See Table 3.1.RME	CDI (mg/kg-day) =
				DAevent	Dermally Absorbed Dose per Event	Calculated	mg/cm^2-event	calculated	DAevent x SA x EV x EF x ED x 1/BW x 1/AT
				FA	Fraction absorbed water	Chemical-specific	dimensionless	EPA, 2004	
				K_p	Permeability Coefficient	Chemical-specific	cm/hr	EPA, 2004	Inorganics: DAevent (mg/cm^2-event) =
				τ	Lag Time	Chemical-specific	hr/event	EPA, 2004	Kp x CW x t_{event} x CF1x CF2
				t*	Time to Reach Steady-state	Chemical-specific	hours	EPA, 2004	
				B	Ratio of Permeability of Stratum Corneum to Epidermis	Chemical-specific	dimensionless	EPA, 2004	Organics :
				t_{event}	Event Time	0.71	hr/event	EPA, 2014	$t_{event} < t^*$: DAevent (mg/cm^2-event) =
				SA	Skin Surface Area Available for Contact	20,900	cm^2	EPA, 2014	2 x FA x Kp x CW x (sqrt((6 x τ x t_{event})/π))
				EV	Event Frequency	1	events/day	EPA, 2004	x CF1 x CF2
				EF	Exposure Frequency	350	days/year	EPA, 2014	
				ED	Exposure Duration	20	years	EPA, 2014	$t_{event} > t^*$: DAevent (mg/cm^2-event) =
				BW	Body Weight	80	kg	EPA, 2014	FA x Kp x CW x (t_{event}/(1+B) + 2 x τ x
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	((1 + 3B + $3B^2$)/$(1+B)^2$)) x CF1 x CF2
				AT-N	Averaging Time (Non-Cancer)	7,300	days	EPA, 2014	
				CF1	Conversion Factor 1	0.001	mg/µg	- -	
				CF2	Conversion Factor 2	0.001	l/cm^3	- -	
		Child	Tap Water	CW	Chemical Concentration in Water	See Table 3.1.RME		See Table 3.1.RME	CDI (mg/kg-day) =
				DAevent	Dermally Absorbed Dose per Event	Calculated	mg/cm^2-event	calculated	DAevent x SA x EV x EF x ED x 1/BW x 1/AT
				FA	Fraction absorbed water	Chemical-specific	dimensionless	EPA, 2004	
				K_p	Permeability Coefficient	Chemical-specific	cm/hr	EPA, 2004	Inorganics: DAevent (mg/cm^2-event) =
				τ	Lag Time	Chemical-specific	hr/event	EPA, 2004	Kp x CW x t_{event} x CF1x CF2
				t*	Time to Reach Steady-state	Chemical-specific	hours	EPA, 2004	
				B	Ratio of Permeability of Stratum Corneum to Epidermis	Chemical-specific	dimensionless	EPA, 2004	Organics :
				t_{event}	Event Time	0.54	hr/event	EPA, 2014	$t_{event} < t^*$: DAevent (mg/cm^2-event) =
				SA	Skin Surface Area Available for Contact	6,378	cm^2	EPA, 2014	2 x FA x Kp x CW x (sqrt((6 x τ x t_{event})/π))
				EV	Event Frequency	1	events/day	EPA, 2004	x CF1 x CF2
				EF	Exposure Frequency	350	days/year	EPA, 2014	
				ED	Exposure Duration	6	years	EPA, 2014	$t_{event} > t^*$: DAevent (mg/cm^2-event) =
				BW	Body Weight	15	kg	EPA, 2014	FA x Kp x CW x (t_{event}/(1+B) + 2 x τ x
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	((1 + 3B + $3B^2$)/$(1+B)^2$)) x CF1 x CF2
				AT-N	Averaging Time (Non-Cancer)	2,190	days	EPA, 1989	
				CF1	Conversion Factor 1	0.001	mg/µg	- -	
				CF2	Conversion Factor 2	0.001	l/cm^3	- -	

TABLE 4.1.RME
VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURE
SITE 5 SUPPLEMENTAL REMEDIAL INVESTIGATION REPORT
ST. JULIENS CREEK ANNEX
CHESAPEAKE, VIRGINIA

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Shallow Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Dermal	Resident	Child/Adult	Tap Water	CW	Chemical Concentration in Water	See Table 3.1.RME		See Table 3.1.RME	CDI (mg/kg-day) = DA-Adj x EF x 1/AT
				DAevent-A	Dermally Absorbed Dose per Event, Adult	Calculated	mg/cm^2-event	calculated	
				DAevent-C	Dermally Absorbed Dose per Event, Child	Calculated	mg/cm^2-event	calculated	DA-Adj = (DAevent-A x SA-A x ED-A x 1/BW-A)
				DA-Adj	Dermally Absorbed Dose, Age-adjusted	Calculated	mg-year/event-kg	calculated	+ (DAevent-C x SA-C x ED-C x 1/BW-C)
				FA	Fraction absorbed water	Chemical-specific	dimensionless	EPA, 2004	
				K_p	Permeability Coefficient	Chemical-specific	cm/hr	EPA, 2004	Inorganics: DAevent (mg/cm^2-event) =
				τ	Lag Time	Chemical-specific	hr/event	EPA, 2004	Kp x CW x t_{event} x CF1 x CF2
				t*	Time to Reach Steady-state	Chemical-specific	hours	EPA, 2004	
				B	Ratio of Permeability of Stratum Corneum to Epidermis	Chemical-specific	dimensionless	EPA, 2004	Organics :
				t_{event}-A	Event Time, Adult	0.71	hr/event	EPA, 2014	t_{event}<t*: DAevent (mg/cm^2-event) =
				t_{event}-C	Event Time, Child	0.54	hr/event	EPA, 2014	2 x FA x Kp x CW x (sqrt((6 x τ x t_{event})/π))
				SA-A	Skin Surface Area, Adult	20,900	cm^2	EPA, 2014	x CF1 x CF2
				SA-C	Skin Surface Area, Child	6,378	cm^2	EPA, 2014	
				EV	Event Frequency	1	events/day	EPA, 2004	t_{event}>t*: DAevent (mg/cm^2-event) =
				EF	Exposure Frequency	350	days/year	EPA, 2014	FA x Kp x CW x (t_{event}/(1+B) + 2 x τ x
				ED-A	Exposure Duration, Adult	20	years	EPA, 2014	((1 + 3B + 3B^2)/(1+B)^2)) x CF1 x CF2
				ED-C	Exposure Duration, Child	6	years	EPA, 2014	
				BW-A	Body Weight, Adult	80	kg	EPA, 2014	
				BW-C	Body Weight, Child	15	kg	EPA, 2014	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				CF1	Conversion Factor 1	0.001	mg/µg	- -	
				CF2	Conversion Factor 2	0.001	l/cm^3	- -	

TABLE 4.1.RME
VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURE
SITE 5 SUPPLEMENTAL REMEDIAL INVESTIGATION REPORT
ST. JULIENS CREEK ANNEX
CHESAPEAKE, VIRGINIA

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Shallow Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
	Construction Worker	Adult	Excavation Pit	CW	Chemical Concentration in Water	See Table 3.1.RME		See Table 3.1.RME	CDI (mg/kg-day) =
				DAevent	Dermally Absorbed Dose per Event	calculated	mg/cm^2-event	calculated	DAevent x SA x EV x EF x ED x 1/BW x 1/AT
				FA	Fraction absorbed water	chemical specific	dimensionless	EPA, 2004	
				K_p	Permeability Coefficient	chemical specific	cm/hr	EPA, 2004	Inorganics: DAevent (mg/cm^2-event) =
				τ	Lag Time	chemical specific	hr/event	EPA, 2004	Kp x CW x t_{event} x CF2 x CF3
				t*	Time to Reach Steady-state	chemical specific	hours	EPA, 2004	
				B	Ratio of Permeability of Stratum Corneum to Epidermis	chemical specific	dimensionless	EPA, 2004	Organics :
				t_{event}	Event Time	8	hr/day	(1)	t_{event}<t*: DAevent (mg/cm^2-event) =
				SA	Skin Surface Area Available for Contact	6,032	cm^2	EPA, 2014 (2)	2 x FA x Kp x CW x (sqrt((6 x τ x t_{event})/π))
				EV	Event Frequency	1	events/day	EPA, 2004	x CF2 x CF3
				EF	Exposure Frequency	125	days/year	VDEQ, 2003	
				ED	Exposure Duration	1	years	EPA, 1991	t_{event}>t*: DAevent (mg/cm^2-event) =
				BW	Body Weight	80	kg	EPA, 2014	FA x Kp x CW x (t_{event}/(1+B) + 2 x τ x
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	((1 + 3B + $3B^2$)/$(1+B)^2$)) x CF2 x CF3
				AT-N	Averaging Time (Non-Cancer)	365	days	EPA, 1989	
				CF2	Conversion Factor 2	0.001	mg/µg	- -	
				CF3	Conversion Factor 3	0.001	l/cm^3	- -	

(1) Professional judgment based on construction activities that would occur 8 hrs per day for the RME.

(2) Surface area for adult resident exposed to soil from EPA, 2014, and includes weighted average of mean values for head, hands, forearms, lower legs, and feet.

Sources:

EPA, 1989: Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.

EPA, 1991: Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual - Supplemental Guidance, Standard Default Exposure Factors. Interim Final. OSWER Directive 9285.6-03.

EPA, 2004 . Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment (Final). EPA/540/R/99/005. July 2004.

EPA, 2014: Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors, OSWER Directive 9200.1-120, February 6, 2014.

VDEQ, 2003: Virginia Department of Environmental Quality, Voluntary Remediation Program Risk Assessment Guidance. Dec. 2003.

TABLE 4.1.CTE
VALUES USED FOR DAILY INTAKE CALCULATIONS
CENTRAL TENDENCY EXPOSURE
SITE 5 SUPPLEMENTAL REMEDIAL INVESTIGATION REPORT
ST. JULIENS CREEK ANNEX
CHESAPEAKE, VIRGINIA

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Shallow Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Resident	Adult	Tap Water	CW	Chemical Concentration in Water	See Table 3.1.RME		See Table 3.1.RME	CDI (mg/kg-day) =
				IR-W	Ingestion Rate of Water	0.99	liters/day	EPA, 2011	CW x IR-W x EF x ED x CF1 x 1/BW x 1/AT
				EF	Exposure Frequency	350	days/year	EPA, 2004	
				ED	Exposure Duration	9	years	EPA, 2011 (1)	
				CF1	Conversion Factor 1	0.001	mg/µg	- -	
				BW	Body Weight	80	kg	EPA, 2014	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	3,285	days	EPA, 2014	
		Child	Tap Water	CW	Chemical Concentration in Water	See Table 3.1.RME		See Table 3.1.RME	CDI (mg/kg-day) =
				IR-W	Ingestion Rate of Water	0.31	liters/day	EPA, 2011	CW x IR-W x EF x ED x CF1 x 1/BW x 1/AT
				EF	Exposure Frequency	350	days/year	EPA, 2004	
				ED	Exposure Duration	6	years	EPA, 2014	
				CF1	Conversion Factor 1	0.001	mg/µg	- -	
				BW	Body Weight	15	kg	EPA, 2014	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	2,190	days	EPA, 1989	
		Child/Adult	Tap Water	CW	Chemical Concentration in Water	See Table 3.1.RME		See Table 3.1.RME	CDI (mg/kg-day) =
				IR-W-A	Ingestion Rate of Water, Adult	0.99	liters/day	EPA, 2011	CW x IR-W-Adj x EF x CF1 x 1/AT
				IR-W-C	Ingestion Rate of Water, Child	0.31	liters/day	EPA, 2011	
				IR-W-Adj	Ingestion Rate of Water, Age-adjusted	0.24	liter-year/kg-day	calculated	IR-W-Adj (liter-year/kd-day) =
				EF	Exposure Frequency	350	days/year	EPA, 2004	(ED-C x IR-W-C / BW-C) +
				ED-A	Exposure Duration, Adult	9	years	EPA, 2011 (1)	(ED-A x IR-W-A / BW-A)
				ED-C	Exposure Duration, Child	6	years	EPA, 2014	
				CF1	Conversion Factor 1	0.001	mg/µg	- -	
				BW-A	Body Weight , Adult	80	kg	EPA, 2014	
				BW-C	Body Weight, Child	15	kg	EPA, 2014	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	

TABLE 4.1.CTE
VALUES USED FOR DAILY INTAKE CALCULATIONS
CENTRAL TENDENCY EXPOSURE
SITE 5 SUPPLEMENTAL REMEDIAL INVESTIGATION REPORT
ST. JULIENS CREEK ANNEX
CHESAPEAKE, VIRGINIA

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Shallow Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Dermal	Resident	Adult	Tap Water	CW	Chemical Concentration in Water	See Table 3.1.RME		See Table 3.1.RME	CDI (mg/kg-day) =
				DAevent	Dermally Absorbed Dose per Event	Calculated	mg/cm2-event	calculated	DAevent x SA x EV x EF x ED x 1/BW x 1/AT
				FA	Fraction absorbed water	Chemical-specific	dimensionless	EPA, 2004	
				Kp	Permeability Coefficient	Chemical-specific	cm/hr	EPA, 2004	Inorganics: DAevent (mg/cm2-event) =
				τ	Lag Time	Chemical-specific	hr/event	EPA, 2004	Kp x CW x tevent x CF1x CF2
				t*	Time to Reach Steady-state	Chemical-specific	hours	EPA, 2004	
				B	Ratio of Permeability of Stratum Corneum to Epidermis	Chemical-specific	dimensionless	EPA, 2004	Organics :
				tevent	Event Time	0.28	hr/event	EPA, 2011 (2)	tevent<t*: DAevent (mg/cm2-event) =
				SA	Skin Surface Area Available for Contact	20,900	cm2	EPA, 2014	2 x FA x Kp x CW x (sqrt((6 x t x tevent)/p))
				EV	Event Frequency	1	events/day	EPA, 2004	x CF1 x CF2
				EF	Exposure Frequency	350	days/year	EPA, 2004	
				ED	Exposure Duration	9	years	EPA, 2011 (1)	tevent>t*: DAevent (mg/cm2-event) =
				BW	Body Weight	80	kg	EPA, 2014	FA x Kp x CW x (tevent/(1+B) + 2 x t x
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	((1 + 3B + 3B2)/(1+B)2)) x CF1 x CF2
				AT-N	Averaging Time (Non-Cancer)	3,285	days	EPA, 2014	
				CF1	Conversion Factor 1	0.001	mg/µg	- -	
				CF2	Conversion Factor 2	0.001	l/cm3	- -	
		Child	Tap Water	CW	Chemical Concentration in Water	See Table 3.1.RME		See Table 3.1.RME	CDI (mg/kg-day) =
				DAevent	Dermally Absorbed Dose per Event	Calculated	mg/cm2-event	calculated	DAevent x SA x EV x EF x ED x 1/BW x 1/AT
				FA	Fraction absorbed water	Chemical-specific	dimensionless	EPA, 2004	
				Kp	Permeability Coefficient	Chemical-specific	cm/hr	EPA, 2004	Inorganics: DAevent (mg/cm2-event) =
				τ	Lag Time	Chemical-specific	hr/event	EPA, 2004	Kp x CW x tevent x CF1x CF2
				t*	Time to Reach Steady-state	Chemical-specific	hours	EPA, 2004	
				B	Ratio of Permeability of Stratum Corneum to Epidermis	Chemical-specific	dimensionless	EPA, 2004	Organics :
				tevent	Event Time	0.37	hr/event	EPA, 2011 (3)	tevent<t*: DAevent (mg/cm2-event) =
				SA	Skin Surface Area Available for Contact	6,378	cm2	EPA, 2014	2 x FA x Kp x CW x (sqrt((6 x t x tevent)/p))
				EV	Event Frequency	1	events/day	EPA, 2004	x CF1 x CF2
				EF	Exposure Frequency	350	days/year	EPA, 2004	
				ED	Exposure Duration	6	years	EPA, 2014	tevent>t*: DAevent (mg/cm2-event) =
				BW	Body Weight	15	kg	EPA, 2014	FA x Kp x CW x (tevent/(1+B) + 2 x t x
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	((1 + 3B + 3B2)/(1+B)2)) x CF1 x CF2
				AT-N	Averaging Time (Non-Cancer)	2,190	days	EPA, 1989	
				CF1	Conversion Factor 1	0.001	mg/µg	- -	
				CF2	Conversion Factor 2	0.001	l/cm3	- -	

TABLE 4.1.CTE

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURE

SITE 5 SUPPLEMENTAL REMEDIAL INVESTIGATION REPORT

ST. JULIENS CREEK ANNEX

CHESAPEAKE, VIRGINIA

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Shallow Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Dermal (continued)	Resident	Child/Adult	Tap Water	CW	Chemical Concentration in Water	See Table 3.1.RME	µg/l	See Table 3.1.RME	CDI (mg/kg-day) = DA-Adj x EF x 1/AT
				DAevent-A	Dermally Absorbed Dose per Event, Adult	Calculated	mg/cm2-event	calculated	
				DAevent-C	Dermally Absorbed Dose per Event, Child	Calculated	mg/cm2-event	calculated	DA-Adj = (DAevent-A x SA-A x ED-A x 1/BW-A)
				DA-Adj	Dermally Absorbed Dose, Age-adjusted	Calculated	mg-year/event-kg	calculated	+ (DAevent-C x SA-C x ED-C x 1/BW-C)
				FA	Fraction absorbed water	Chemical-specific	dimensionless	EPA, 2004	
				Kp	Permeability Coefficient	Chemical-specific	cm/hr	EPA, 2004	Inorganics: DAevent (mg/cm2-event) =
				τ	Lag Time	Chemical-specific	hr/event	EPA, 2004	Kp x CW x tevent x CF1 x CF2
				t*	Time to Reach Steady-state	Chemical-specific	hours	EPA, 2004	
				B	Ratio of Permeability of Stratum Corneum to Epidermis	Chemical-specific	dimensionless	EPA, 2004	Organics :
				tevent-A	Event Time, Adult	0.28	hr/event	EPA, 2011 (2)	tevent<t*: DAevent (mg/cm2-event) =
				tevent-C	Event Time, Child	0.37	hr/event	EPA, 2011 (3)	2 x FA x Kp x CW x (sqrt((6 x t x tevent)/p))
				SA-A	Skin Surface Area, Adult	20,900	cm2	EPA, 2014	x CF1 x CF2
				SA-C	Skin Surface Area, Child	6,378	cm2	EPA, 2014	
				EV	Event Frequency	1	events/day	EPA, 2004	tevent>t*: DAevent (mg/cm2-event) =
				EF	Exposure Frequency	350	days/year	EPA, 2004	FA x Kp x CW x (tevent/(1+B) + 2 x t x
				ED-A	Exposure Duration, Adult	9	years	EPA, 2011 (1)	((1 + 3B + 3B2)/(1+B)2)) x CF1 x CF2
				ED-C	Exposure Duration, Child	6	years	EPA, 2014	
				BW-A	Body Weight, Adult	80	kg	EPA, 2014	
				BW-C	Body Weight, Child	15	kg	EPA, 2014	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				CF1	Conversion Factor 1	0.001	mg/µg	- -	
				CF2	Conversion Factor 2	0.001	l/cm3	- -	

(1) Table 16-108, 50th percentile value for both sexes.

(2) Table 16-1, mean value for time spent bathing/showering (ages 18 years and older). 17 minutes/day divided by 60 minutes/hour.

(3) Table 16-1, mean value for time spent bathing (birth to <6 years). 22 minutes/day divided by 60 minutes/hour.

Sources:

EPA, 1989: Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.

EPA, 2004 . Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment (Final). EPA/540/R/99/005. July 2004.

EPA, 2011. Exposure Factors Handbook: 2011 Edition. National Center for Environmental Assessment, Washington, DC; EPA/600/R-09/052F. Available from the National Technical Information Service, Springfield, VA, and online at http://www.epa.gov/ncea/efh.

EPA, 2014: Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors, OSWER Directive 9200.1-120, February 6, 2014.

TABLE 5.1

NON-CANCER TOXICITY DATA -- ORAL/DERMAL

SITE 5 SUPPLEMENTAL REMEDIAL INVESTIGATION REPORT

ST. JULIENS CREEK ANNEX

CHESAPEAKE, VIRGINIA

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD Value	Oral RfD Units	Oral to Dermal Adjustment Factor (1)	Adjusted Dermal RfD (2)	Units	Primary Target Organ	Combined Uncertainty/Modifying Factors	Sources of RfD: Target Organ	Dates of RfD: Target Organ (MM/DD/YY)
Aluminum	Chronic	1.0E+00	mg/kg-day	NA	1.0E+00	mg/kg-day	Neurotoxicity	100	PPRTV	10/23/2006
	Subchronic	1.0E+00	mg/kg-day	NA	1.0E+00	mg/kg-day	Neurotoxicity	30	ATSDR	9/1/2008
Arsenic	Chronic	3.0E-04	mg/kg-day	95%	3.0E-04	mg/kg-day	Skin, Vascular	3/1	IRIS	5/21/2014
	Subchronic	3.0E-04	mg/kg-day	95%	3.0E-04	mg/kg-day	Skin, Vascular	3	HEAST	7/1/1997
Beryllium	Chronic	2.0E-03	mg/kg-day	0.7%	1.4E-05	mg/kg-day	Gastrointestinal	300/1	IRIS	5/21/2014
	Subchronic	5.0E-03	mg/kg-day	0.7%	3.5E-05	mg/kg-day	Lifetime	100	HEAST	7/1/1997
Cadmium (water)	Chronic	5.0E-04	mg/kg-day	5%	2.5E-05	mg/kg-day	Kidney	10/1	IRIS	5/21/2014
	Subchronic	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chromium (hexavalent)	Chronic	3.0E-03	mg/kg-day	2.5%	7.5E-05	mg/kg-day	NOE	300/1	IRIS	5/21/2014
	Subchronic	5.0E-03	mg/kg-day	2.5%	1.3E-04	mg/kg-day	Blood	100	ATSDR	9/2012
Cobalt	Chronic	3.0E-04	mg/kg-day	N/A	3.0E-04	mg/kg/day	Thyroid	3000	PPRTV	8/25/2008
	Subchronic	3.0E-03	mg/kg-day	N/A	3.0E-03	mg/kg/day	Thyroid	300	PPRTV	8/25/2008
Iron	Chronic	7.0E-01	mg/kg-day	NA	7.0E-01	mg/kg-day	Gastrointestinal	1.5	PPRTV	9/11/2006
	Subchronic	7.0E-01	mg/kg-day	NA	7.0E-01	mg/kg-day	Gastrointestinal	1.5	PPRTV	9/11/2006
Lead	Chronic	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Subchronic	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese (nonfood)	Chronic	2.4E-02	mg/kg-day	4%	9.6E-04	mg/kg-day	CNS	1/1	IRIS	5/21/2014
	Subchronic	NA	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	Chronic	5.0E-03	mg/kg-day	2.6%	1.3E-04	mg/kg-day	Hair	300	RSL/IRIS	5/21/2014
	Subchronic	1.0E-02	mg/kg-day	2.6%	2.6E-04	mg/kg-day	Blood	10	ATSDR	9/2012

Notes:

(1) Source: Risk Assessment Guidance for Superfund. Volume 1: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. Section 4.2 and Exhibit 4-1. USEPA recommends that the oral RfD should not be adjusted to estimate the absorbed dose for compounds when the absorption efficiency is greater than 50%. Constituents that do not have oral absorption efficiencies reported on this table were assumed to have an oral absorption efficiency of 100%.

(2) Adjusted based on RAGS Part E. (dermal RfD = Oral RfD x oral absorption efficiency)

Definitions:
ATSDR = Agency for Toxic Substances and Disease Registry
CNS = Central Nervous System
HEAST = Health Effects Assessment Summary Tables
IRIS = Integrated Risk Information System
NA = Not Available
NOE = No Observed Effects
PPRTV = Provisional Peer-Reviewed Toxicity Value
RSL = Regional Screening Level Table

TABLE 6.1
CANCER TOXICITY DATA -- ORAL/DERMAL
SITE 5 SUPPLEMENTAL REMEDIAL INVESTIGATION REPORT
ST. JULIENS CREEK ANNEX
CHESAPEAKE, VIRGINIA

Chemical of Potential Concern	Oral Cancer Slope Factor	Oral to Dermal Adjustment Factor (1)	Adjusted Dermal Cancer Slope Factor (2)	Units	EPA Carcinogen Group	Source	Date (MM/DD/YY)
Aluminum	NA						
Arsenic	1.5E+00	95%	1.5E+00	$(mg/kg\text{-}day)^{-1}$	A	IRIS	5/21/2014
Beryllium	NA						
Cadmium-Water	NA						
Chromium (hexavalent) (3)	5.0E-01	2.5%	2.0E+01	$(mg/kg\text{-}day)^{-1}$	D	NJ DEP	4/8/2009
Cobalt	NA						
Iron	NA						
Lead	NA						
Manganese (nonfood)	NA						
Vanadium	NA						

(1) Source: Risk Assessment Guidance for Superfund. Volume 1: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. Section 4.2 and Exhibit 4-1. USEPA recommends that the oral slope factor should not be adjusted to estimate the absorbed dose for compounds when the absorption efficiency is greater than 50%. Constituents that do not have oral absorption efficiencies reported on this table were assumed to have an oral absorption efficiency of 100%.

(2) Adjusted based on RAGS Part E. (dermal CSF = Oral CSF / oral absorption efficiency)

(3) This chemical operates with a mutagenic mode of action.
Chemical-specific data are not available; therefore, default age-dependent adjustment factors (ADAF) will be applied to the slope factor as follows:

AGE	AGE ADAF	Exposure Duration
0-<2	10	2
2-<6	3	4
6-<16	3	10
16-<26	1	10

Definitions:
IRIS = Integrated Risk Information System
N/A = Not Available
NJ DEP = New Jersey Department of Environmental Protection

Weight of Evidence definitions:
Group A chemicals (known human carcinogens) are agents for which there is sufficient evidence to support the causal association between exposure to the agents in humans and cancer.
Group D chemicals (not classifiable as to human carcinogenicity) are agents with inadequate human and animal evidence of carcinogenicity or for which no data are available.

TABLE 7.1.RME
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
SITE 5 SUPPLEMENTAL REMEDIAL INVESTIGATION REPORT
ST. JULIENS CREEK ANNEX
CHESAPEAKE, VIRGINIA

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Shallow Groundwater	Tap Water	Ingestion	Aluminum	4.6E+03	ug/L	NA	NA	NA	NA	NA	1.4E-01	mg/kg/day	1.0E+00	mg/kg/day	1.4E-01
				Arsenic	1.1E+01	ug/L	NA	NA	NA	NA	NA	3.3E-04	mg/kg/day	3.0E-04	mg/kg/day	1.1E+00
				Beryllium	3.8E+00	ug/L	NA	NA	NA	NA	NA	1.1E-04	mg/kg/day	2.0E-03	mg/kg/day	5.7E-02
				Cadmium	1.8E+00	ug/L	NA	NA	NA	NA	NA	5.3E-05	mg/kg/day	5.0E-04	mg/kg/day	1.1E-01
				Chromium (hexavalent)	7.9E-02	ug/L	NA	NA	NA	NA	NA	2.4E-06	mg/kg/day	3.0E-03	mg/kg/day	7.9E-04
				Cobalt	4.1E+01	ug/L	NA	NA	NA	NA	NA	1.2E-03	mg/kg/day	3.0E-04	mg/kg/day	4.0E+00
				Iron	4.7E+04	ug/L	NA	NA	NA	NA	NA	1.4E+00	mg/kg/day	7.0E-01	mg/kg/day	2.0E+00
				Lead	1.0E+01	ug/L	NA	NA	NA	NA	NA	3.0E-04	mg/kg/day	NA	mg/kg/day	NA
				Manganese	1.4E+03	ug/L	NA	NA	NA	NA	NA	4.2E-02	mg/kg/day	2.4E-02	mg/kg/day	1.8E+00
				Vanadium	8.4E+00	ug/L	NA	NA	NA	NA	NA	2.5E-04	mg/kg/day	5.0E-03	mg/kg/day	5.0E-02
			Exp. Route Total								NA					9.3E+00
			Dermal Absorption	Aluminum	4.6E+03	ug/L	NA	NA	NA	NA	NA	8.3E-04	mg/kg/day	1.0E+00	mg/kg/day	8.3E-04
				Arsenic	1.1E+01	ug/L	NA	NA	NA	NA	NA	2.0E-06	mg/kg/day	3.0E-04	mg/kg/day	6.5E-03
				Beryllium	3.8E+00	ug/L	NA	NA	NA	NA	NA	6.8E-07	mg/kg/day	1.4E-05	mg/kg/day	4.8E-02
				Cadmium	1.8E+00	ug/L	NA	NA	NA	NA	NA	3.2E-07	mg/kg/day	2.5E-05	mg/kg/day	1.3E-02
				Chromium (hexavalent)	7.9E-02	ug/L	NA	NA	NA	NA	NA	2.8E-08	mg/kg/day	7.5E-05	mg/kg/day	3.8E-04
				Cobalt	4.1E+01	ug/L	NA	NA	NA	NA	NA	2.9E-06	mg/kg/day	3.0E-04	mg/kg/day	9.6E-03
				Iron	4.7E+04	ug/L	NA	NA	NA	NA	NA	8.4E-03	mg/kg/day	7.0E-01	mg/kg/day	1.2E-02
				Lead	1.0E+01	ug/L	NA	NA	NA	NA	NA	1.8E-07	mg/kg/day	NA	mg/kg/day	NA
				Manganese	1.4E+03	ug/L	NA	NA	NA	NA	NA	2.5E-04	mg/kg/day	9.6E-04	mg/kg/day	2.6E-01
				Vanadium	8.4E+00	ug/L	NA	NA	NA	NA	NA	1.5E-06	mg/kg/day	1.3E-04	mg/kg/day	1.2E-02
			Exp. Route Total								NA					3.6E-01
		Exposure Point Total									NA					9.7E+00
	Exposure Medium Total										NA					9.7E+00
Medium Total											NA					9.7E+00
									Total of Receptor Risks Across All Media		NA			Total of Receptor Hazards Across All Media		9.7E+00

Notes-
DAevent for exposure to groundwater calculated on Table 7.1.RME Supplement A.
NA = Not applicable.

Table 7.1.RME Supplement A
Calculation of DAevent
Resident Adult Groundwater
SITE 5, ST. JULIENS CREEK ANNEX, CHESAPEAKE, VIRGINIA

Chemical of Potential Concern	Water Concentration (CW) (µg/L)	Permeability Coefficient (Kp) (cm/hr)	B (dimensionless)	Lag Time (τ_{event}) (hr)	t* (hr)	Fraction Absorbed Water (FA) (dimensionless)	Duration of Event (t_{event}) (hr)	DAevent (mg/cm^2-event)	Eq
Aluminum	4.6E+03	1.0E-03	NA	NA	NA	NA	0.71	3.3E-06	1
Arsenic	1.1E+01	1.0E-03	NA	NA	NA	NA	0.71	7.8E-09	1
Beryllium	3.8E+00	1.0E-03	NA	NA	NA	NA	0.71	2.7E-09	1
Cadmium	1.8E+00	1.0E-03	NA	NA	NA	NA	0.71	1.3E-09	1
Chromium (hexavalent)	7.9E-02	2.0E-03	NA	NA	NA	NA	0.71	1.1E-10	1
Cobalt	4.1E+01	4.0E-04	NA	NA	NA	NA	0.71	1.2E-08	1
Iron	4.7E+04	1.0E-03	NA	NA	NA	NA	0.71	3.4E-05	1
Lead	1.0E+01	1.0E-04	NA	NA	NA	NA	0.71	7.2E-10	1
Manganese	1.4E+03	1.0E-03	NA	NA	NA	NA	0.71	1.0E-06	1
Vanadium	8.4E+00	1.0E-03	NA	NA	NA	NA	0.71	6.0E-09	1

Inorganics: DAevent (mg/cm2-event) =
Kp x CW x t_{event} x 0.001 mg/ug x 0.001 l/cm^3 (eq 1)

Notes:
Permeability constants from EPA 2004, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment - Final).* EPA/540/R/99/005. The default value of 0.001 was assigned to inorganics not listed in this document.
NA - not applicable.

TABLE 7.2.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

SITE 5 SUPPLEMENTAL REMEDIAL INVESTIGATION REPORT

ST. JULIENS CREEK ANNEX

CHESAPEAKE, VIRGINIA

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Shallow Groundwater	Tap Water	Ingestion	Aluminum	4.6E+03	ug/L	NA	NA	NA	NA	NA	2.3E-01	mg/kg/day	1.0E+00	mg/kg/day	2.3E-01
				Arsenic	1.1E+01	ug/L	NA	NA	NA	NA	NA	5.5E-04	mg/kg/day	3.0E-04	mg/kg/day	1.8E+00
				Beryllium	3.8E+00	ug/L	NA	NA	NA	NA	NA	1.9E-04	mg/kg/day	2.0E-03	mg/kg/day	9.5E-02
				Cadmium	1.8E+00	ug/L	NA	NA	NA	NA	NA	8.9E-05	mg/kg/day	5.0E-04	mg/kg/day	1.8E-01
				Chromium (hexavalent)	7.9E-02	ug/L	NA	NA	NA	NA	NA	3.9E-06	mg/kg/day	3.0E-03	mg/kg/day	1.3E-03
				Cobalt	4.1E+01	ug/L	NA	NA	NA	NA	NA	2.0E-03	mg/kg/day	3.0E-04	mg/kg/day	6.7E+00
				Iron	4.7E+04	ug/L	NA	NA	NA	NA	NA	2.4E+00	mg/kg/day	7.0E-01	mg/kg/day	3.4E+00
				Lead	1.0E+01	ug/L	NA	NA	NA	NA	NA	5.1E-04	mg/kg/day	NA	mg/kg/day	NA
				Manganese	1.4E+03	ug/L	NA	NA	NA	NA	NA	7.0E-02	mg/kg/day	2.4E-02	mg/kg/day	2.9E+00
				Vanadium	8.4E+00	ug/L	NA	NA	NA	NA	NA	4.2E-04	mg/kg/day	5.0E-03	mg/kg/day	8.4E-02
			Exp. Route Total								NA					1.5E+01
			Dermal Absorption	Aluminum	4.6E+03	ug/L	NA	NA	NA	NA	NA	1.0E-03	mg/kg/day	1.0E+00	mg/kg/day	1.0E-03
				Arsenic	1.1E+01	ug/L	NA	NA	NA	NA	NA	2.4E-06	mg/kg/day	3.0E-04	mg/kg/day	8.1E-03
				Beryllium	3.8E+00	ug/L	NA	NA	NA	NA	NA	8.4E-07	mg/kg/day	1.4E-05	mg/kg/day	6.0E-02
				Cadmium	1.8E+00	ug/L	NA	NA	NA	NA	NA	3.9E-07	mg/kg/day	2.5E-05	mg/kg/day	1.6E-02
				Chromium (hexavalent)	7.9E-02	ug/L	NA	NA	NA	NA	NA	3.5E-08	mg/kg/day	7.5E-05	mg/kg/day	4.6E-04
				Cobalt	4.1E+01	ug/L	NA	NA	NA	NA	NA	3.6E-06	mg/kg/day	3.0E-04	mg/kg/day	1.2E-02
				Iron	4.7E+04	ug/L	NA	NA	NA	NA	NA	1.0E-02	mg/kg/day	7.0E-01	mg/kg/day	1.5E-02
				Lead	1.0E+01	ug/L	NA	NA	NA	NA	NA	2.2E-07	mg/kg/day	NA	mg/kg/day	NA
				Manganese	1.4E+03	ug/L	NA	NA	NA	NA	NA	3.1E-04	mg/kg/day	9.6E-04	mg/kg/day	3.2E-01
				Vanadium	8.4E+00	ug/L	NA	NA	NA	NA	NA	1.9E-06	mg/kg/day	1.3E-04	mg/kg/day	1.4E-02
			Exp. Route Total								NA					4.5E-01
		Exposure Point Total									NA					1.6E+01
	Exposure Medium Total										NA					1.6E+01
Medium Total											NA					1.6E+01
										Total of Receptor Risks Across All Media	NA				Total of Receptor Hazards Across All Media	1.6E+01

Notes-

DAevent for exposure to groundwater calculated on Table 7.2.RME Supplement A.

NA = Not applicable.

Table 7.2.RME Supplement A
Calculation of DAevent
Resident Child Groundwater
SITE 5, ST. JULIENS CREEK ANNEX, CHESAPEAKE, VIRGINIA

Chemical of Potential Concern	Water Concentration (CW) (µg/L)	Permeability Coefficient (Kp) (cm/hr)	B (dimensionless)	Lag Time (τ_{event}) (hr)	t* (hr)	Fraction Absorbed Water (FA) (dimensionless)	Duration of Event (tevent) (hr)	DAevent (mg/cm^2-event)	Eq
Aluminum	4.6E+03	1.0E-03	NA	NA	NA	NA	0.54	2.5E-06	1
Arsenic	1.1E+01	1.0E-03	NA	NA	NA	NA	0.54	5.9E-09	1
Beryllium	3.8E+00	1.0E-03	NA	NA	NA	NA	0.54	2.1E-09	1
Cadmium	1.8E+00	1.0E-03	NA	NA	NA	NA	0.54	9.6E-10	1
Chromium (hexavalent)	7.9E-02	2.0E-03	NA	NA	NA	NA	0.54	8.5E-11	1
Cobalt	4.1E+01	4.0E-04	NA	NA	NA	NA	0.54	8.8E-09	1
Iron	4.7E+04	1.0E-03	NA	NA	NA	NA	0.54	2.6E-05	1
Lead	1.0E+01	1.0E-04	NA	NA	NA	NA	0.54	5.5E-10	1
Manganese	1.4E+03	1.0E-03	NA	NA	NA	NA	0.54	7.6E-07	1
Vanadium	8.4E+00	1.0E-03	NA	NA	NA	NA	0.54	4.5E-09	1

Inorganics: DAevent (mg/cm2-event) =
Kp x CW x tevent x 0.001 mg/ug x 0.001 l/cm^3 (eq 1)

Notes:
Permeability constants from EPA 2004, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment - Final).* EPA/540/R/99/005. The default value of 0.001 was assigned to inorganics not listed in this document.
NA - not applicable.

TABLE 7.3.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

SITE 5 SUPPLEMENTAL REMEDIAL INVESTIGATION REPORT

ST. JULIENS CREEK ANNEX

CHESAPEAKE, VIRGINIA

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult/Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Shallow Groundwater	Tap Water	Ingestion	Aluminum	4.6E+03	ug/L	6.0E-02	mg/kg/day	NA	NA	NA	NA	NA	NA	NA	NA
				Arsenic	1.1E+01	ug/L	1.4E-04	mg/kg/day	1.5E+00	1/(mg/kg-day)	2.1E-04	NA	NA	NA	NA	NA
				Beryllium	3.8E+00	ug/L	4.9E-05	mg/kg/day	NA	NA	NA	NA	NA	NA	NA	NA
				Cadmium	1.8E+00	ug/L	2.3E-05	mg/kg/day	NA	NA	NA	NA	NA	NA	NA	NA
				Chromium (hexavalent)[1]	7.9E-02	ug/L			5.0E-01	1/(mg/kg-day)	1.2E-06	NA	NA	NA	NA	NA
				Cobalt	4.1E+01	ug/L	5.2E-04	mg/kg/day	NA	NA	NA	NA	NA	NA	NA	NA
				Iron	4.7E+04	ug/L	6.1E-01	mg/kg/day	NA	NA	NA	NA	NA	NA	NA	NA
				Lead	1.0E+01	ug/L	1.3E-04	mg/kg/day	NA	NA	NA	NA	NA	NA	NA	NA
				Manganese	1.4E+03	ug/L	1.8E-02	mg/kg/day	NA	NA	NA	NA	NA	NA	NA	NA
				Vanadium	8.4E+00	ug/L	1.1E-04	mg/kg/day	NA	NA	NA	NA	NA	NA	NA	NA
			Exp. Route Total								2.1E-04					NA
			Dermal Absorption	Aluminum	4.6E+03	ug/L	3.2E-04	mg/kg/day	NA	NA	NA	NA	NA	NA	NA	NA
				Arsenic	1.1E+01	ug/L	7.7E-07	mg/kg/day	1.5E+00	1/(mg/kg-day)	1.1E-06	NA	NA	NA	NA	NA
				Beryllium	3.8E+00	ug/L	2.6E-07	mg/kg/day	NA	NA	NA	NA	NA	NA	NA	NA
				Cadmium	1.8E+00	ug/L	1.2E-07	mg/kg/day	NA	NA	NA	NA	NA	NA	NA	NA
				Chromium (hexavalent)[1]	7.9E-02	ug/L			2.0E+01	1/(mg/kg-day)	6.4E-07	NA	NA	NA	NA	NA
				Cobalt	4.1E+01	ug/L	1.1E-06	mg/kg/day	NA	NA	NA	NA	NA	NA	NA	NA
				Iron	4.7E+04	ug/L	3.3E-03	mg/kg/day	NA	NA	NA	NA	NA	NA	NA	NA
				Lead	1.0E+01	ug/L	7.1E-08	mg/kg/day	NA	NA	NA	NA	NA	NA	NA	NA
				Manganese	1.4E+03	ug/L	9.8E-05	mg/kg/day	NA	NA	NA	NA	NA	NA	NA	NA
				Vanadium	8.4E+00	ug/L	5.9E-07	mg/kg/day	NA	NA	NA	NA	NA	NA	NA	NA
			Exp. Route Total								1.8E-06					NA
		Exposure Point Total									2.2E-04					NA
	Exposure Medium Total										2.2E-04					NA
Medium Total											2.2E-04					NA
							Total of Receptor Risks Across All Media				2.2E-04	Total of Receptor Hazards Across All Media				NA

Notes-

DAevent for exposure to groundwater calculated on Tables 7.1.RME Supplement A and Table 7.2.RME Supplement A.

[1] See Table 7.3.RME Supplement A for calculation of intake and cancer risk following MMOA method.

NA = Not applicable.

TABLE 7.3.RME Supplement A

CALCULATION OF CHEMICAL CANCER RISKS FOR COPC WITH MUTAGENIC MODE OF ACTION

REASONABLE MAXIMUM EXPOSURE

SITE 5, ST. JULIENS CREEK ANNEX, CHESAPEAKE, VIRGINIA

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult/Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations										
							Intake					CSF/Unit Risk					Cancer Risk
					Value	Units	Value				Units	Value				Units	
							0-2 yrs	2-6 yrs	6-16 yrs	16-26 yrs		0-2 yrs (ADAF=10)	2-6 yrs (ADAF=3)	6-16 yrs (ADAF=3)	16-26 yrs (ADAF=1)		
Groundwater	Shallow Groundwater	Tap Water	Ingestion	Chromium (hexavalent)	7.9E-02	ug/L	1.1E-07	2.3E-07	7.0E-08	3.4E-07	mg/kg/day	5.0E+00	1.5E+00	1.5E+00	5.0E-01	1/(mg/kg-day)	1.2E-06
			Dermal	Chromium (hexavalent)	7.9E-02	ug/L	1.0E-09	2.0E-09	4.0E-09	4.0E-09	mg/kg/day	2.0E+02	6.0E+01	6.0E+01	2.0E+01	1/(mg/kg-day)	6.4E-07

Cancer risk = $(Intake_{0-2} \times CSF_{0-2}) + (Intake_{2-6} \times CSF_{2-6}) + (Intake_{6-16} \times CSF_{6-16}) + (Intake_{16-30} \times CSF_{16-26})$

TABLE 7.4.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

SITE 5 SUPPLEMENTAL REMEDIAL INVESTIGATION REPORT

ST. JULIENS CREEK ANNEX

CHESAPEAKE, VIRGINIA

Scenario Timeframe: Future
Receptor Population: Construction Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Shallow Groundwater	Excavation Pit	Dermal Absorption	Aluminum	4.6E+03	ug/L	1.4E-05	NA	NA	NA	NA	9.6E-04	mg/kg/day	1.0E+00	mg/kg/day	9.6E-04
				Arsenic	1.1E+01	ug/L	3.2E-08	NA	1.5E+00	NA	4.9E-08	2.3E-06	mg/kg/day	3.0E-04	mg/kg/day	7.6E-03
				Beryllium	3.8E+00	ug/L	1.1E-08	NA	NA	NA	NA	7.8E-07	mg/kg/day	3.5E-05	mg/kg/day	2.2E-02
				Cadmium	1.8E+00	ug/L	5.3E-09	NA	NA	NA	NA	3.7E-07	mg/kg/day	2.5E-05	mg/kg/day	1.5E-02
				Chromium (hexavalent)	7.9E-02	ug/L	4.7E-10	NA	2.0E+01	NA	9.3E-09	3.3E-08	mg/kg/day	1.3E-04	mg/kg/day	2.6E-04
				Cobalt	4.1E+01	ug/L	4.8E-08	NA	NA	NA	NA	3.3E-06	mg/kg/day	3.0E-03	mg/kg/day	1.1E-03
				Iron	4.7E+04	ug/L	1.4E-04	NA	NA	NA	NA	9.8E-03	mg/kg/day	7.0E-01	mg/kg/day	1.4E-02
				Lead	1.0E+01	ug/L	3.0E-09	NA	NA	NA	NA	2.1E-07	mg/kg/day	NA	mg/kg/day	NA
				Manganese	1.4E+03	ug/L	4.2E-06	NA	NA	NA	NA	2.9E-04	mg/kg/day	9.6E-04	mg/kg/day	3.0E-01
				Vanadium	8.4E+00	ug/L	2.5E-08	NA	NA	NA	NA	1.7E-06	mg/kg/day	2.6E-04	mg/kg/day	6.7E-03
			Exp. Route Total								5.8E-08					3.7E-01
		Exposure Point Total									5.8E-08					3.7E-01
	Exposure Medium Total										5.8E-08					3.7E-01
Medium Total											5.8E-08					3.7E-01
										Total of Receptor Risks Across All Media	5.8E-08				Total of Receptor Hazards Across All Media	3.7E-01

Notes-

DAevent for exposure to groundwater calculated on Tables 7.4.RME Supplement A.

NA = Not applicable.

Table 7.4.RME Supplement A
Calculation of DAevent
Construction Worker Groundwater
SITE 5, ST. JULIENS CREEK ANNEX, CHESAPEAKE, VIRGINIA

Chemical of Potential Concern	Water Concentration (CW) (µg/L)	Permeability Coefficient (Kp) (cm/hr)	B (dimensionless)	Lag Time (τ_{event}) (hr)	t* (hr)	Fraction Absorbed Water (FA) (dimensionless)	Duration of Event (tevent) (hr)	DAevent (mg/cm^2-event)	Eq
Aluminum	4.6E+03	1.0E-03	NA	NA	NA	NA	8	3.7E-05	1
Arsenic	1.1E+01	1.0E-03	NA	NA	NA	NA	8	8.8E-08	1
Beryllium	3.8E+00	1.0E-03	NA	NA	NA	NA	8	3.0E-08	1
Cadmium	1.8E+00	1.0E-03	NA	NA	NA	NA	8	1.4E-08	1
Chromium (total)	7.9E-02	2.0E-03	NA	NA	NA	NA	8	1.3E-09	1
Cobalt	4.1E+01	4.0E-04	NA	NA	NA	NA	8	1.3E-07	1
Iron	4.7E+04	1.0E-03	NA	NA	NA	NA	8	3.8E-04	1
Lead	1.0E+01	1.0E-04	NA	NA	NA	NA	8	8.1E-09	1
Manganese	1.4E+03	1.0E-03	NA	NA	NA	NA	8	1.1E-05	1
Vanadium	8.4E+00	1.0E-03	NA	NA	NA	NA	8	6.7E-08	1

Inorganics: DAevent (mg/cm2-event) =
Kp x CW x tevent x 0.001 mg/ug x 0.001 l/cm^3 (eq 1)

Notes:
Permeability constants from EPA 2004, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment - Final).* EPA/540/R/99/005. The default value of 0.001 was assigned to inorganics not listed in this document.
NA - not applicable.

TABLE 7.1.CTE

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

CENTRAL TENDENCY EXPOSURE

SITE 5 SUPPLEMENTAL REMEDIAL INVESTIGATION REPORT

ST. JULIENS CREEK ANNEX

CHESAPEAKE, VIRGINIA

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Shallow Groundwater	Shallow Aquifer - Tap Water	Ingestion	Aluminum	4.6E+03	ug/L	NA	NA	NA	NA	NA	5.5E-02	mg/kg/day	1.0E+00	mg/kg/day	5.5E-02
				Arsenic	1.1E+01	ug/L	NA	NA	NA	NA	NA	1.3E-04	mg/kg/day	3.0E-04	mg/kg/day	4.4E-01
				Beryllium	3.8E+00	ug/L	NA	NA	NA	NA	NA	4.5E-05	mg/kg/day	2.0E-03	mg/kg/day	2.3E-02
				Cadmium	1.8E+00	ug/L	NA	NA	NA	NA	NA	2.1E-05	mg/kg/day	5.0E-04	mg/kg/day	4.2E-02
				Chromium (hexavalent)	7.9E-02	ug/L	NA	NA	NA	NA	NA	9.4E-07	mg/kg/day	3.0E-03	mg/kg/day	3.1E-04
				Cobalt	4.1E+01	ug/L	NA	NA	NA	NA	NA	4.8E-04	mg/kg/day	3.0E-04	mg/kg/day	1.6E+00
				Iron	4.7E+04	ug/L	NA	NA	NA	NA	NA	5.6E-01	mg/kg/day	7.0E-01	mg/kg/day	8.0E-01
				Lead	1.0E+01	ug/L	NA	NA	NA	NA	NA	1.2E-04	mg/kg/day	NA	NA	NA
				Manganese	1.4E+03	ug/L	NA	NA	NA	NA	NA	1.7E-02	mg/kg/day	2.4E-02	mg/kg/day	7.0E-01
				Vanadium	8.4E+00	ug/L	NA	NA	NA	NA	NA	1.0E-04	mg/kg/day	5.0E-03	mg/kg/day	2.0E-02
			Exp. Route Total								NA					3.7E+00
			Dermal Absorption	Aluminum	4.6E+03	ug/L	NA	NA	NA	NA	NA	3.3E-04	mg/kg/day	1.0E+00	mg/kg/day	3.3E-04
				Arsenic	1.1E+01	ug/L	NA	NA	NA	NA	NA	7.7E-07	mg/kg/day	3.0E-04	mg/kg/day	2.6E-03
				Beryllium	3.8E+00	ug/L	NA	NA	NA	NA	NA	2.7E-07	mg/kg/day	1.4E-05	mg/kg/day	1.9E-02
				Cadmium	1.8E+00	ug/L	NA	NA	NA	NA	NA	1.2E-07	mg/kg/day	2.5E-05	mg/kg/day	5.0E-03
				Chromium (hexavalent)	7.9E-02	ug/L	NA	NA	NA	NA	NA	1.1E-08	mg/kg/day	7.5E-05	mg/kg/day	1.5E-04
				Cobalt	4.1E+01	ug/L	NA	NA	NA	NA	NA	1.1E-06	mg/kg/day	3.0E-04	mg/kg/day	3.8E-03
				Iron	4.7E+04	ug/L	NA	NA	NA	NA	NA	3.3E-03	mg/kg/day	7.0E-01	mg/kg/day	4.7E-03
				Lead	1.0E+01	ug/L	NA	NA	NA	NA	NA	7.1E-08	mg/kg/day	NA	NA	NA
				Manganese	1.4E+03	ug/L	NA	NA	NA	NA	NA	9.9E-05	mg/kg/day	9.6E-04	mg/kg/day	1.0E-01
				Vanadium	8.4E+00	ug/L	NA	NA	NA	NA	NA	5.9E-07	mg/kg/day	1.3E-04	mg/kg/day	4.5E-03
			Exp. Route Total								NA					1.4E-01
		Exposure Point Total									NA					3.8E+00
	Exposure Medium Total										NA					3.8E+00
Medium Total											NA					3.8E+00
							Total of Receptor Risks Across All Media				NA	Total of Receptor Hazards Across All Media				3.8E+00

Notes-

DAevent for exposure to groundwater calculated on Table 7.1.CTE Supplement A.

NA = Not applicable.

Table 7.1.CTE Supplement A
Calculation of DAevent
Resident Adult Groundwater
SITE 5, ST. JULIENS CREEK ANNEX, CHESAPEAKE, VIRGINIA

Chemical of Potential Concern	Water Concentration (CW) (µg/L)	Permeability Coefficient (Kp) (cm/hr)	B (dimensionless)	Lag Time (τ_{event}) (hr)	t* (hr)	Fraction Absorbed Water (FA) (dimensionless)	Duration of Event (tevent) (hr)	DAevent (mg/cm^2-event)	Eq
Aluminum	4.6E+03	1.0E-03	NA	NA	NA	NA	0.28	1.3E-06	1
Arsenic	1.1E+01	1.0E-03	NA	NA	NA	NA	0.28	3.1E-09	1
Beryllium	3.8E+00	1.0E-03	NA	NA	NA	NA	0.28	1.1E-09	1
Cadmium	1.8E+00	1.0E-03	NA	NA	NA	NA	0.28	5.0E-10	1
Chromium (hexavalent)	7.9E-02	2.0E-03	NA	NA	NA	NA	0.28	4.4E-11	1
Cobalt	4.1E+01	4.0E-04	NA	NA	NA	NA	0.28	4.5E-09	1
Iron	4.7E+04	1.0E-03	NA	NA	NA	NA	0.28	1.3E-05	1
Lead	1.0E+01	1.0E-04	NA	NA	NA	NA	0.28	2.8E-10	1
Manganese	1.4E+03	1.0E-03	NA	NA	NA	NA	0.28	4.0E-07	1
Vanadium	8.4E+00	1.0E-03	NA	NA	NA	NA	0.28	2.4E-09	1

Inorganics: DAevent (mg/cm2-event) =
Kp x CW x tevent x 0.001 mg/ug x 0.001 l/cm^3 (eq 1)

Notes:
Permeability constants from EPA 2004, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment - Final).* EPA/540/R/99/005. The default value of 0.001 was assigned to inorganics not listed in this document.
NA - not applicable.

TABLE 7.2.CTE

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

CENTRAL TENDENCY EXPOSURE

SITE 5 SUPPLEMENTAL REMEDIAL INVESTIGATION REPORT

ST. JULIENS CREEK ANNEX

CHESAPEAKE, VIRGINIA

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Shallow Groundwater	Shallow Aquifer - Tap Water	Ingestion	Aluminum	4.6E+03	ug/L	NA	NA	NA	NA	NA	9.2E-02	mg/kg/day	1.0E+00	mg/kg/day	9.2E-02
				Arsenic	1.1E+01	ug/L	NA	NA	NA	NA	NA	2.2E-04	mg/kg/day	3.0E-04	mg/kg/day	7.3E-01
				Beryllium	3.8E+00	ug/L	NA	NA	NA	NA	NA	7.5E-05	mg/kg/day	2.0E-03	mg/kg/day	3.8E-02
				Cadmium	1.8E+00	ug/L	NA	NA	NA	NA	NA	3.5E-05	mg/kg/day	5.0E-04	mg/kg/day	7.1E-02
				Chromium (hexavalent)	7.9E-02	ug/L	NA	NA	NA	NA	NA	1.6E-06	mg/kg/day	3.0E-03	mg/kg/day	5.2E-04
				Cobalt	4.1E+01	ug/L	NA	NA	NA	NA	NA	8.0E-04	mg/kg/day	3.0E-04	mg/kg/day	2.7E+00
				Iron	4.7E+04	ug/L	NA	NA	NA	NA	NA	9.4E-01	mg/kg/day	7.0E-01	mg/kg/day	1.3E+00
				Lead	1.0E+01	ug/L	NA	NA	NA	NA	NA	2.0E-04	mg/kg/day	NA		NA
				Manganese	1.4E+03	ug/L	NA	NA	NA	NA	NA	2.8E-02	mg/kg/day	2.4E-02	mg/kg/day	1.2E+00
				Vanadium	8.4E+00	ug/L	NA	NA	NA	NA	NA	1.7E-04	mg/kg/day	5.0E-03	mg/kg/day	3.3E-02
			Exp. Route Total								NA					6.1E+00
			Dermal Absorption	Aluminum	4.6E+03	ug/L	NA	NA	NA	NA	NA	7.0E-04	mg/kg/day	1.0E+00	mg/kg/day	7.0E-04
				Arsenic	1.1E+01	ug/L	NA	NA	NA	NA	NA	1.7E-06	mg/kg/day	3.0E-04	mg/kg/day	5.5E-03
				Beryllium	3.8E+00	ug/L	NA	NA	NA	NA	NA	5.7E-07	mg/kg/day	1.4E-05	mg/kg/day	4.1E-02
				Cadmium	1.8E+00	ug/L	NA	NA	NA	NA	NA	2.7E-07	mg/kg/day	2.5E-05	mg/kg/day	1.1E-02
				Chromium (hexavalent)	7.9E-02	ug/L	NA	NA	NA	NA	NA	2.4E-08	mg/kg/day	7.5E-05	mg/kg/day	3.2E-04
				Cobalt	4.1E+01	ug/L	NA	NA	NA	NA	NA	2.4E-06	mg/kg/day	3.0E-04	mg/kg/day	8.2E-03
				Iron	4.7E+04	ug/L	NA	NA	NA	NA	NA	7.1E-03	mg/kg/day	7.0E-01	mg/kg/day	1.0E-02
				Lead	1.0E+01	ug/L	NA	NA	NA	NA	NA	1.5E-07	mg/kg/day	NA		NA
				Manganese	1.4E+03	ug/L	NA	NA	NA	NA	NA	2.1E-04	mg/kg/day	9.6E-04	mg/kg/day	2.2E-01
				Vanadium	8.4E+00	ug/L	NA	NA	NA	NA	NA	1.3E-06	mg/kg/day	1.3E-04	mg/kg/day	9.8E-03
			Exp. Route Total								NA					3.1E-01
		Exposure Point Total									NA					6.5E+00
	Exposure Medium Total										NA					6.5E+00
Medium Total											NA					6.5E+00
							Total of Receptor Risks Across All Media				NA	Total of Receptor Hazards Across All Media				6.5E+00

Notes-

DAevent for exposure to groundwater calculated on Table 7.2.CTE Supplement A.

NA = Not applicable.

Table 7.2.CTE Supplement A
Calculation of DAevent
Resident Child Groundwater
SITE 5, ST. JULIENS CREEK ANNEX, CHESAPEAKE, VIRGINIA

Chemical of Potential Concern	Water Concentration (CW) (µg/L)	Permeability Coefficient (Kp) (cm/hr)	B (dimensionless)	Lag Time (τ_{event}) (hr)	t* (hr)	Fraction Absorbed Water (FA) (dimensionless)	Duration of Event (tevent) (hr)	DAevent (mg/cm^2-event)	Eq
Aluminum	4.6E+03	1.0E-03	NA	NA	NA	NA	0.37	1.7E-06	1
Arsenic	1.1E+01	1.0E-03	NA	NA	NA	NA	0.37	4.1E-09	1
Beryllium	3.8E+00	1.0E-03	NA	NA	NA	NA	0.37	1.4E-09	1
Cadmium	1.8E+00	1.0E-03	NA	NA	NA	NA	0.37	6.6E-10	1
Chromium (hexavalent)	7.9E-02	2.0E-03	NA	NA	NA	NA	0.37	5.9E-11	1
Cobalt	4.1E+01	4.0E-04	NA	NA	NA	NA	0.37	6.0E-09	1
Iron	4.7E+04	1.0E-03	NA	NA	NA	NA	0.37	1.7E-05	1
Lead	1.0E+01	1.0E-04	NA	NA	NA	NA	0.37	3.8E-10	1
Manganese	1.4E+03	1.0E-03	NA	NA	NA	NA	0.37	5.2E-07	1
Vanadium	8.4E+00	1.0E-03	NA	NA	NA	NA	0.37	3.1E-09	1

Inorganics: DAevent (mg/cm2-event) =
Kp x CW x tevent x 0.001 mg/ug x 0.001 l/cm^3 (eq 1)

Notes:
Permeability constants from EPA 2004, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment - Final).* EPA/540/R/99/005. The default value of 0.001 was assigned to inorganics not listed in this document.
NA - not applicable.

TABLE 7.3.CTE
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
CENTRAL TENDENCY EXPOSURE
SITE 5 SUPPLEMENTAL REMEDIAL INVESTIGATION REPORT
ST. JULIENS CREEK ANNEX
CHESAPEAKE, VIRGINIA

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult/Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Shallow Groundwater	Shallow Aquifer - Tap Water	Ingestion	Aluminum	4.6E+03	ug/L	1.5E-02	mg/kg/day	NA	NA	NA	NA	NA	NA	NA	NA
				Arsenic	1.1E+01	ug/L	3.6E-05	mg/kg/day	1.5E+00	1/(mg/kg-day)	5.4E-05	NA	NA	NA	NA	NA
				Beryllium	3.8E+00	ug/L	1.2E-05	mg/kg/day	NA	NA	NA	NA	NA	NA	NA	NA
				Cadmium	1.8E+00	ug/L	5.9E-06	mg/kg/day	NA	NA	NA	NA	NA	NA	NA	NA
				Chromium (hexavalent)[1]	7.9E-02	ug/L			5.0E-01	1/(mg/kg-day)	5.4E-07	NA	NA	NA	NA	NA
				Cobalt	4.1E+01	ug/L	1.3E-04	mg/kg/day	NA	NA	NA	NA	NA	NA	NA	NA
				Iron	4.7E+04	ug/L	1.6E-01	mg/kg/day	NA	NA	NA	NA	NA	NA	NA	NA
				Lead	1.0E+01	ug/L	3.3E-05	mg/kg/day	NA	NA	NA	NA	NA	NA	NA	NA
				Manganese	1.4E+03	ug/L	4.6E-03	mg/kg/day	NA	NA	NA	NA	NA	NA	NA	NA
				Vanadium	8.4E+00	ug/L	2.8E-05	mg/kg/day	NA	NA	NA	NA	NA	NA	NA	NA
			Exp. Route Total								5.5E-05					0.0E+00
			Dermal Absorption	Aluminum	4.6E+03	ug/L	1.0E-04	mg/kg/day	NA	NA	NA	NA	NA	NA	NA	NA
				Arsenic	1.1E+01	ug/L	2.4E-07	mg/kg/day	1.5E+00	1/(mg/kg-day)	3.6E-07	NA	NA	NA	NA	NA
				Beryllium	3.8E+00	ug/L	8.3E-08	mg/kg/day	NA	NA	NA	NA	NA	NA	NA	NA
				Cadmium	1.8E+00	ug/L	3.9E-08	mg/kg/day	NA	NA	NA	NA	NA	NA	NA	NA
				Chromium (hexavalent)[1]	7.9E-02	ug/L			2.0E+01	1/(mg/kg-day)	3.0E-07	NA	NA	NA	NA	NA
				Cobalt	4.1E+01	ug/L	3.6E-07	mg/kg/day	NA	NA	NA	NA	NA	NA	NA	NA
				Iron	4.7E+04	ug/L	1.0E-03	mg/kg/day	NA	NA	NA	NA	NA	NA	NA	NA
				Lead	1.0E+01	ug/L	2.2E-08	mg/kg/day	NA	NA	NA	NA	NA	NA	NA	NA
				Manganese	1.4E+03	ug/L	3.1E-05	mg/kg/day	NA	NA	NA	NA	NA	NA	NA	NA
				Vanadium	8.4E+00	ug/L	1.8E-07	mg/kg/day	NA	NA	NA	NA	NA	NA	NA	NA
			Exp. Route Total								6.7E-07					0.0E+00
		Exposure Point Total									5.5E-05					0.0E+00
	Exposure Medium Total										5.5E-05					0.0E+00
Medium Total											5.5E-05					0.0E+00
							Total of Receptor Risks Across All Media				5.5E-05	Total of Receptor Hazards Across All Media				0.0E+00

Notes-

DAevent for exposure to groundwater calculated on Tables 7.1.CTE Supplement A and Table 7.2.CTE Supplement A.

[1] See Table 7.3.CTE Supplement A for calculation of intake and cancer risk following MMOA method.

NA = Not applicable.

TABLE 7.3.CTE Supplement A
CALCULATION OF CHEMICAL CANCER RISKS FOR COPC WITH MUTAGENIC MODE OF ACTION
CENTRAL TENDENCY EXPOSURE
SITE 5, ST. JULIENS CREEK ANNEX, CHESAPEAKE, VIRGINIA

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult/Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations								
							Intake				CSF/Unit Risk				Cancer Risk
					Value	Units	Value			Units	Value			Units	
							0-2 yrs	2-6 yrs	6-15 years		0-2 yrs (ADAF=10)	2-6 yrs (ADAF=3)	6-16 yrs (ADAF=3)		
Groundwater	Shallow Groundwater	Tap Water	Ingestion	Chromium (hexavalent)	7.9E-02	ug/L	4.5E-08	9.0E-08	1.2E-07	mg/kg/day	5.0E+00	1.5E+00	1.5E+00	1/(mg/kg-day)	5.4E-07
			Dermal	Chromium (hexavalent)	7.9E-02	ug/L	6.8E-10	1.4E-09	1.4E-09	mg/kg/day	2.0E+02	6.0E+01	6.0E+01	1/(mg/kg-day)	3.0E-07

Cancer risk = $(Intake_{0-2} \times CSF_{0-2}) + (Intake_{2-6} \times CSF_{2-6}) + (Intake_{6-16} \times CSF_{6-16}) + (Intake_{16-26} \times CSF_{16-26})$

TABLE 9.1.RME

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs

REASONABLE MAXIMUM EXPOSURE

SITE 5, ST. JULIENS CREEK ANNEX, CHESAPEAKE, VIRGINIA

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Shallow Aquifer - Tap Water	Aluminum	NA	NA	NA	NA	Neurotoxicity	1E-01	NA	8E-04	1E-01
			Arsenic	NA	NA	NA	NA	Skin, Vascular	1E+00	NA	7E-03	1E+00
			Beryllium	NA	NA	NA	NA	Gastrointestinal	6E-02	NA	5E-02	1E-01
			Cadmium	NA	NA	NA	NA	Kidney	1E-01	NA	1E-02	1E-01
			Chromium (hexavalent)	NA	NA	NA	NA	NOE	8E-04	NA	4E-04	1E-03
			Cobalt	NA	NA	NA	NA	Thyroid	4E+00	NA	1E-02	4E+00
			Iron	NA	NA	NA	NA	Gastrointestinal	2E+00	NA	1E-02	2E+00
			Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA
			Manganese	NA	NA	NA	NA	CNS	2E+00	NA	3E-01	2E+00
			Vanadium	NA	NA	NA	NA	Hair	5E-02	NA	1E-02	6E-02
			Chemical Total	NA	NA	NA	NA		9E+00	NA	4E-01	1E+01
		Exposure Point Total					NA					1E+01
	Exposure Medium Total						NA					1E+01
Medium Total							NA					1E+01
Receptor Total							NA				Receptor HI Total	1E+01

Total Neurological/CNS HI Across All Media =	**2E+00**
Total Skin HI Across All Media =	1E+00
Total Vascular HI Across All Media =	1E+00
Total Kidney HI Across All Media =	1E-01
Total Thyroid HI Across All Media =	**4E+00**
Total Gastrointestinal HI Across All Media =	**2E+00**
Total Hair HI Across All Media =	6E-02

CNS - Central Nervous System

HI - Hazard Index

NA - Not Applicable

NOE - No Observed Effects

TABLE 9.2.RME

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs

REASONABLE MAXIMUM EXPOSURE

SITE 5, ST. JULIENS CREEK ANNEX, CHESAPEAKE, VIRGINIA

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Shallow Aquifer - Tap Water	Aluminum	NA	NA	NA	NA	Neurotoxicity	2E-01	NA	1E-03	2E-01
			Arsenic	NA	NA	NA	NA	Skin, Vascular	2E+00	NA	8E-03	2E+00
			Beryllium	NA	NA	NA	NA	Gastrointestinal	9E-02	NA	6E-02	2E-01
			Cadmium	NA	NA	NA	NA	Kidney	2E-01	NA	2E-02	2E-01
			Chromium (hexavalent)	NA	NA	NA	NA	NOE	1E-03	NA	5E-04	2E-03
			Cobalt	NA	NA	NA	NA	Thyroid	7E+00	NA	1E-02	7E+00
			Iron	NA	NA	NA	NA	Gastrointestinal	3E+00	NA	1E-02	3E+00
			Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA
			Manganese	NA	NA	NA	NA	CNS	3E+00	NA	3E-01	3E+00
			Vanadium	NA	NA	NA	NA	Hair	8E-02	NA	1E-02	1E-01
			Chemical Total	NA	NA	NA	NA		2E+01	NA	4E-01	2E+01
		Exposure Point Total					NA					2E+01
	Exposure Medium Total						NA					2E+01
Medium Total							NA					2E+01
Receptor Total							NA				Receptor HI Total	2E+01

Total Neurological/CNS HI Across All Media =	**3E+00**
Total Skin HI Across All Media =	**2E+00**
Total Vascular HI Across All Media =	**2E+00**
Total Kidney HI Across All Media =	2E-01
Total Thyroid HI Across All Media =	**7E+00**
Total Gastrointestinal HI Across All Media =	**4E+00**
Total Hair HI Across All Media =	1E-01

CNS - Central Nervous System
HI - Hazard Index
NA - Not Applicable
NOE - No Observed Effects

TABLE 9.3.RME

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs

REASONABLE MAXIMUM EXPOSURE

SITE 5, ST. JULIENS CREEK ANNEX, CHESAPEAKE, VIRGINIA

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child/Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Shallow Aquifer - Tap Water	Aluminum	NA	NA	NA	NA	Neurotoxicity	NA	NA	NA	NA
			Arsenic	2E-04	NA	1E-06	2E-04	Skin, Vascular	NA	NA	NA	NA
			Beryllium	NA	NA	NA	NA	Gastrointestinal	NA	NA	NA	NA
			Cadmium	NA	NA	NA	NA	Kidney	NA	NA	NA	NA
			Chromium (hexavalent)	1E-06	NA	6E-07	2E-06	NOE	NA	NA	NA	NA
			Cobalt	NA	NA	NA	NA	Thyroid	NA	NA	NA	NA
			Iron	NA	NA	NA	NA	Gastrointestinal	NA	NA	NA	NA
			Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA
			Manganese	NA	NA	NA	NA	CNS	NA	NA	NA	NA
			Vanadium	NA	NA	NA	NA	Hair	NA	NA	NA	NA
			Chemical Total	2E-04	NA	2E-06	2E-04		NA	NA	NA	NA
		Exposure Point Total					2E-04					NA
	Exposure Medium Total						2E-04					NA
Medium Total							2E-04					NA
Receptor Total							2E-04				Receptor HI Total	NA

CNS - Central Nervous System

NA - Not Applicable

NOE - No Observed Effects

TABLE 9.4.RME
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
SITE 5, ST. JULIENS CREEK ANNEX, CHESAPEAKE, VIRGINIA

Scenario Timeframe: Future
Receptor Population: Construction Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Shallow Aquifer - Tap Water	Aluminum	NA	NA	NA	NA	Neurotoxicity	NA	NA	1E-03	1E-03
			Arsenic	NA	NA	5E-08	5E-08	Skin, Vascular	NA	NA	8E-03	8E-03
			Beryllium	NA	NA	NA	NA	Lifetime	NA	NA	2E-02	2E-02
			Cadmium	NA	NA	NA	NA	Kidney	NA	NA	1E-02	1E-02
			Chromium (hexavalent)	NA	NA	9E-09	9E-09	Blood	NA	NA	3E-04	3E-04
			Cobalt	NA	NA	NA	NA	Thyroid	NA	NA	1E-03	1E-03
			Iron	NA	NA	NA	NA	Gastrointestinal	NA	NA	1E-02	1E-02
			Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA
			Manganese	NA	NA	NA	NA	CNS	NA	NA	3E-01	3E-01
			Vanadium	NA	NA	NA	NA	Blood	NA	NA	7E-03	7E-03
			Chemical Total	NA	NA	6E-08	6E-08		NA	NA	4E-01	4E-01
		Exposure Point Total					6E-08					4E-01
	Exposure Medium Total						6E-08					4E-01
Medium Total							6E-08					4E-01
Receptor Total							6E-08				Receptor HI Total	4E-01

CNS - Central Nervous System
HI - Hazard Index
NA - Not Applicable

Total Neurological/CNS HI Across All Media =	3E-01
Total Blood HI Across All Media =	7E-03
Total Skin HI Across All Media =	8E-03
Total Vascular HI Across All Media =	8E-03
Total Lifetime HI Across All Media =	2E-02
Total Kidney HI Across All Media =	1E-02
Total Thyroid HI Across All Media =	1E-03
Total Gastrointestinal HI Across All Media =	1E-02

TABLE 9.1.CTE

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs

CENTRAL TENDENCY EXPOSURE

SITE 5, ST. JULIENS CREEK ANNEX, CHESAPEAKE, VIRGINIA

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Shallow Aquifer - Tap Water	Aluminum	NA	NA	NA	NA	Neurotoxicity	6E-02	NA	3E-04	6E-02
			Arsenic	NA	NA	NA	NA	Skin, Vascular	4E-01	NA	3E-03	4E-01
			Beryllium	NA	NA	NA	NA	Gastrointestinal	2E-02	NA	2E-02	4E-02
			Cadmium	NA	NA	NA	NA	Kidney	4E-02	NA	5E-03	5E-02
			Chromium (hexavalent)	NA	NA	NA	NA	NOE	3E-04	NA	1E-04	5E-04
			Cobalt	NA	NA	NA	NA	Thyroid	2E+00	NA	4E-03	2E+00
			Iron	NA	NA	NA	NA	Gastrointestinal	8E-01	NA	5E-03	8E-01
			Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA
			Manganese	NA	NA	NA	NA	CNS	7E-01	NA	1E-01	8E-01
			Vanadium	NA	NA	NA	NA	Hair	2E-02	NA	5E-03	2E-02
			Chemical Total	NA	NA	NA	NA		4E+00	NA	1E-01	4E+00
		Exposure Point Total					NA					4E+00
	Exposure Medium Total						NA					4E+00
Medium Total							NA					4E+00
Receptor Total							NA				Receptor HI Total	4E+00

Total Neurological/CNS HI Across All Media =	9E-01
Total Skin HI Across All Media =	4E-01
Total Vascular HI Across All Media =	4E-01
Total Kidney HI Across All Media =	5E-02
Total Thyroid HI Across All Media =	**2E+00**
Total Gastrointestinal HI Across All Media =	8E-01
Total Hair HI Across All Media =	2E-02

CNS - Central Nervous System

HI - Hazard Index

NA - Not Applicable

NOE - No Observed Effects

TABLE 9.2.CTE

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs

CENTRAL TENDENCY EXPOSURE

SITE 5, ST. JULIENS CREEK ANNEX, CHESAPEAKE, VIRGINIA

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Shallow Aquifer - Tap Water	Aluminum	NA	NA	NA	NA	Neurotoxicity	9E-02	NA	7E-04	9E-02
			Arsenic	NA	NA	NA	NA	Skin, Vascular	7E-01	NA	6E-03	7E-01
			Beryllium	NA	NA	NA	NA	Gastrointestinal	4E-02	NA	4E-02	8E-02
			Cadmium	NA	NA	NA	NA	Kidney	7E-02	NA	1E-02	8E-02
			Chromium (hexavalent)	NA	NA	NA	NA	NOE	5E-04	NA	3E-04	8E-04
			Cobalt	NA	NA	NA	NA	Thyroid	3E+00	NA	8E-03	3E+00
			Iron	NA	NA	NA	NA	Gastrointestinal	1E+00	NA	1E-02	1E+00
			Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA
			Manganese	NA	NA	NA	NA	CNS	1E+00	NA	2E-01	1E+00
			Vanadium	NA	NA	NA	NA	Hair	3E-02	NA	1E-02	4E-02
			Chemical Total	NA	NA	NA	NA		6E+00	NA	3E-01	6E+00
		Exposure Point Total					NA					6E+00
	Exposure Medium Total						NA					6E+00
Medium Total							NA					6E+00
Receptor Total							NA				Receptor HI Total	6E+00

Total Neurological/CNS HI Across All Media =	1E+00
Total Skin HI Across All Media =	7E-01
Total Vascular HI Across All Media =	7E-01
Total Kidney HI Across All Media =	8E-02
Total Thyroid HI Across All Media =	**3E+00**
Total Gastrointestinal HI Across All Media =	1E+00
Total Hair HI Across All Media =	4E-02

CNS - Central Nervous System
HI - Hazard Index
NA - Not Applicable
NOE - No Observed Effects

TABLE 9.3.CTE

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs

CENTRAL TENDENCY EXPOSURE

SITE 5, ST. JULIENS CREEK ANNEX, CHESAPEAKE, VIRGINIA

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child/Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Shallow Aquifer - Tap Water	Aluminum	NA	NA	NA	NA	Neurotoxicity	NA	NA	NA	NA
			Arsenic	5E-05	NA	4E-07	5E-05	Skin, Vascular	NA	NA	NA	NA
			Beryllium	NA	NA	NA	NA	Gastrointestinal	NA	NA	NA	NA
			Cadmium	NA	NA	NA	NA	Kidney	NA	NA	NA	NA
			Chromium (hexavalent)	5E-07	NA	3E-07	8E-07	NOE	NA	NA	NA	NA
			Cobalt	NA	NA	NA	NA	Thyroid	NA	NA	NA	NA
			Iron	NA	NA	NA	NA	Gastrointestinal	NA	NA	NA	NA
			Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA
			Manganese	NA	NA	NA	NA	CNS	NA	NA	NA	NA
			Vanadium	NA	NA	NA	NA	Hair	NA	NA	NA	NA
			Chemical Total	5E-05	NA	7E-07	6E-05		NA	NA	NA	NA
		Exposure Point Total					6E-05					NA
	Exposure Medium Total						6E-05					NA
Medium Total							6E-05					NA
Receptor Total							6E-05				Receptor HI Total	NA

CNS - Central Nervous System

NA - Not Applicable

NOE - No Observed Effects

TABLE 10.1.RME

RISK SUMMARY

REASONABLE MAXIMUM EXPOSURE

SITE 5, ST. JULIENS CREEK ANNEX, CHESAPEAKE, VIRGINIA

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Shallow Aquifer - Tap Water	Aluminum	NA	NA	NA	NA	Neurotoxicity	1.4E-01	NA	8.3E-04	1.4E-01
			Arsenic	NA	NA	NA	NA	Skin, Vascular	1.1E+00	NA	6.5E-03	1.1E+00
			Beryllium	NA	NA	NA	NA	Gastrointestinal	5.7E-02	NA	4.8E-02	1.1E-01
			Cobalt	NA	NA	NA	NA	Thyroid	4.0E+00	NA	9.6E-03	4.1E+00
			Iron	NA	NA	NA	NA	Gastrointestinal	2.0E+00	NA	1.2E-02	2.0E+00
			Manganese	NA	NA	NA	NA	CNS	1.8E+00	NA	2.6E-01	2.0E+00
			Chemical Total	NA	NA	NA	NA		9.1E+00	NA	3.4E-01	9.5E+00
		Exposure Point Total					NA					9.5E+00
	Exposure Medium Total						NA					9.5E+00
Medium Total							NA					9.5E+00
Receptor Total							NA				Receptor HI Total	9.5E+00

Total Neurological/CNS HI Across All Media =	**2.2E+00**
Total Skin HI Across All Media =	**1.1E+00**
Total Vascular HI Across All Media =	**1.1E+00**
Total Thyroid HI Across All Media =	**4.1E+00**
Total Gastrointestinal HI Across All Media =	**2.1E+00**

CNS - Central Nervous System

HI - Hazard Index

NA - Not Applicable

TABLE 10.2.RME
RISK SUMMARY
REASONABLE MAXIMUM EXPOSURE
SITE 5, ST. JULIENS CREEK ANNEX, CHESAPEAKE, VIRGINIA

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Shallow Aquifer - Tap Water	Aluminum	NA	NA	NA	NA	Neurotoxicity	2.3E-01	NA	1.0E-03	2.3E-01
			Arsenic	NA	NA	NA	NA	Skin, Vascular	1.8E+00	NA	8.1E-03	1.8E+00
			Beryllium	NA	NA	NA	NA	Gastrointestinal	9.5E-02	NA	6.0E-02	1.5E-01
			Cobalt	NA	NA	NA	NA	Thyroid	6.7E+00	NA	1.2E-02	6.8E+00
			Iron	NA	NA	NA	NA	Gastrointestinal	3.4E+00	NA	1.5E-02	3.4E+00
			Manganese	NA	NA	NA	NA	CNS	2.9E+00	NA	3.2E-01	3.3E+00
			Chemical Total	NA	NA	NA	NA		1.5E+01	NA	4.2E-01	1.6E+01
		Exposure Point Total					NA					1.6E+01
	Exposure Medium Total						NA					1.6E+01
Medium Total							NA					1.6E+01
Receptor Total							NA				Receptor HI Total	1.6E+01

Total Neurological/CNS HI Across All Media =	**3.5E+00**
Total Skin HI Across All Media =	**1.8E+00**
Total Vascular HI Across All Media =	**1.8E+00**
Total Thyroid HI Across All Media =	**6.8E+00**
Total Gastrointestinal HI Across All Media =	**3.5E+00**

CNS - Central Nervous System
HI - Hazard Index
NA - Not Applicable
NOE - No Observed Effects

TABLE 10.3.RME

RISK SUMMARY

REASONABLE MAXIMUM EXPOSURE

SITE 5, ST. JULIENS CREEK ANNEX, CHESAPEAKE, VIRGINIA

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child/Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Shallow Aquifer - Tap Water	Arsenic	2.1E-04	NA	1.1E-06	2.1E-04	Skin, Vascular	NA	NA	NA	NA
			Chromium (hexavalent)	1.2E-06	NA	6.4E-07	1.8E-06	NOE	NA	NA	NA	NA
			Chemical Total	2.1E-04	NA	1.8E-06	2.2E-04		NA	NA	NA	NA
		Exposure Point Total					2.2E-04					NA
	Exposure Medium Total						2.2E-04					NA
Medium Total							2.2E-04					NA
Receptor Total							2.2E-04				Receptor HI Total	NA

NA - Not Applicable

NOE - No Observed Effects

TABLE 10.1.CTE
RISK SUMMARY
CENTRAL TENDENCY EXPOSURE
SITE 5, ST. JULIENS CREEK ANNEX, CHESAPEAKE, VIRGINIA

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater		Cobalt	NA	NA	NA	NA	Thyroid	1.6E+00	NA	3.8E-03	1.6E+00
			Chemical Total	NA	NA	NA	NA		1.6E+00	NA	3.8E-03	1.6E+00
		Exposure Point Total					NA					1.6E+00
	Exposure Medium Total						NA					1.6E+00
Medium Total							NA					1.6E+00
Receptor Total							NA				Receptor HI Total	1.6E+00

HI - Hazard Index
NA - Not Applicable

Total Thyroid HI Across All Media = **1.6E+00**

TABLE 10.2.CTE

RISK SUMMARY

CENTRAL TENDENCY EXPOSURE

SITE 5, ST. JULIENS CREEK ANNEX, CHESAPEAKE, VIRGINIA

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Shallow Aquifer - Tap Water	Cobalt	NA	NA	NA	NA	Thyroid	2.7E+00	NA	8.2E-03	2.7E+00
			Iron	NA	NA	NA	NA	Gastrointestinal	1.3E+00	NA	1.0E-02	1.3E+00
			Manganese	NA	NA	NA	NA	CNS	1.2E+00	NA	2.2E-01	1.4E+00
			Chemical Total	NA	NA	NA	NA		5.2E+00	NA	2.4E-01	5.4E+00
		Exposure Point Total					NA					5.4E+00
	Exposure Medium Total						NA					5.4E+00
Medium Total							NA					5.4E+00
Receptor Total							NA				Receptor HI Total	5.4E+00

Total Neurological/CNS HI Across All Media =	**1.4E+00**
Total Thyroid HI Across All Media =	**2.7E+00**
Total Gastrointestinal HI Across All Media =	**1.3E+00**

CNS - Central Nervous System
HI - Hazard Index
NA - Not Applicable
NOE - No Observed Effects

TABLE 11.1a
RAGS D IEUBK LEAD WORKSHEET – Site 5, St. Juliens Creek Annex
Child (Age 0 – 84 Months)
Supplemental Remedial Investigation
St. Juliens Creek Annex, Chesapeake, Virginia

1. Lead Screening Questions

Medium	Lead Concentration Used in Model Run		Basis for Lead Concentration Used For Model Run	Lead Screening Concentration		Basis for Lead Screening Level
	Value	Units		Value	Units	
Soil	400	mg/kg	IEUBK Model Default Value	400	mg/kg	Recommended Soil Screening Level
Water	10.16	µg/L	Average site concentration (including ½ detection limit for non-detects)	15	µg/L	Recommended Drinking Water Action Level

2. Lead Model Questions

Question	**Response for Residential Lead Model**
What lead model (version and date was used)?	Lead Model for Windows, Version 1.1 Build 11 (February, 2010)
Where are the input values located in the risk assessment report?	Located in IEUBKwin OUTPUT
What range of media concentrations were used for the model?	3.5 – 17.2 ug/L detected concentrations, detection limit of 20 ug/L (groundwater)
What statistics were used to represent the exposure concentration terms and where are the data on concentrations in the risk assessment that support use of these statistics?	Exposure concentration was the arithmetic mean of lead concentrations in groundwater (including ½ detection limit for non-detects); See Table 3.1.RME
Was soil sample taken from top 2 cm? If not, why?	No soil data, default model value used
Was soil sample sieved? What size screen was used? If not sieved, provide rationale.	No soil data, default model value used
What was the point of exposure/location?	St. Juliens Creek Annex, Site 5
Where are the output values located in the risk assessment report?	IEUBKwin OUTPUT
Was the model run using default values only?	No – Assumed site-specific arithmetic mean concentration of lead in groundwater
Was the default soil bioavailability used?	Yes -- Default is 30%
Was the default soil ingestion rate used?	Yes -- Default values for 7 age groups are 85, 135, 135, 100, 090, and 85 mg/day
If non-default values were used, where is the rationale for the values located in the risk assessment report?	In the HHRA section of the report.

3. Final Result

Medium	**Result**	**Comment/PRG [1]**
Surface Soil	Input value of 10.166 ug/L in groundwater results in <0.76% of children above a blood lead level of 10 µg/dL. Geometric mean blood lead = 3.19 µg/dL. This is below the blood lead goal as described in the 1994 OSWER Directive of no more than 5% of children exceeding 10 µg/dL blood lead.	PRG not calculated.

1. For additional information, see www.epa.gov/superfund/health/contaminants/lead

1. Attach the ALM or IEUBK spreadsheet output file upon which the Risk Based Remediation Goal (RBRG) was based and description of rationale for parameters used. For additional information, see www.epa.gov/superfund/programs/lead

Table 11.1b

LEAD MODEL FOR WINDOWS Version 1.1

==
Model Version: 1.1 Build11
User Name: CH2M HILL
Date: 5/27/2014
Site Name: St. Juliens Creek Annex
Operable Unit: Site 5
Run Mode: Site Risk Assessment
--

 # Water Data
 # Water Data
Average lead concentration (including 1/2 detection limit for non-detects)
 # GSD, Cutoff and Age Type
average lead groundwater concentration (inlcuding 1/2 detection limit for non-detects)
==

******** Air ********

Indoor Air Pb Concentration: 30.000 percent of outdoor.
Other Air Parameters:

Age	Time Outdoors (hours)	Ventilation Rate (m³/day)	Lung Absorption (%)	Outdoor Air Pb Conc (µg Pb/m³)
.5-1	1.000	2.000	32.000	0.100
1-2	2.000	3.000	32.000	0.100
2-3	3.000	5.000	32.000	0.100
3-4	4.000	5.000	32.000	0.100
4-5	4.000	5.000	32.000	0.100
5-6	4.000	7.000	32.000	0.100
6-7	4.000	7.000	32.000	0.100

******** Diet ********

Age	Diet Intake(µg/day)
.5-1	2.260
1-2	1.960
2-3	2.130
3-4	2.040
4-5	1.950
5-6	2.050
6-7	2.220

******** Drinking Water ********

Water Consumption:

Age	Water (L/day)
.5-1	0.200
1-2	0.500
2-3	0.520
3-4	0.530
4-5	0.550
5-6	0.580
6-7	0.590

Drinking Water Concentration: 10.160 µg Pb/L

******** Soil & Dust ********

Multiple Source Analysis Used
Average multiple source concentration: 150.000 µg/g

Mass fraction of outdoor soil to indoor dust conversion factor: 0.700
Outdoor airborne lead to indoor household dust lead concentration: 100.000
Use alternate indoor dust Pb sources? No

Age	Soil (µg Pb/g)	House Dust (µg Pb/g)
.5-1	200.000	150.000
1-2	200.000	150.000
2-3	200.000	150.000
3-4	200.000	150.000
4-5	200.000	150.000
5-6	200.000	150.000
6-7	200.000	150.000

******** Alternate Intake ********

Age	Alternate (µg Pb/day)
.5-1	0.000
1-2	0.000
2-3	0.000
3-4	0.000
4-5	0.000
5-6	0.000
6-7	0.000

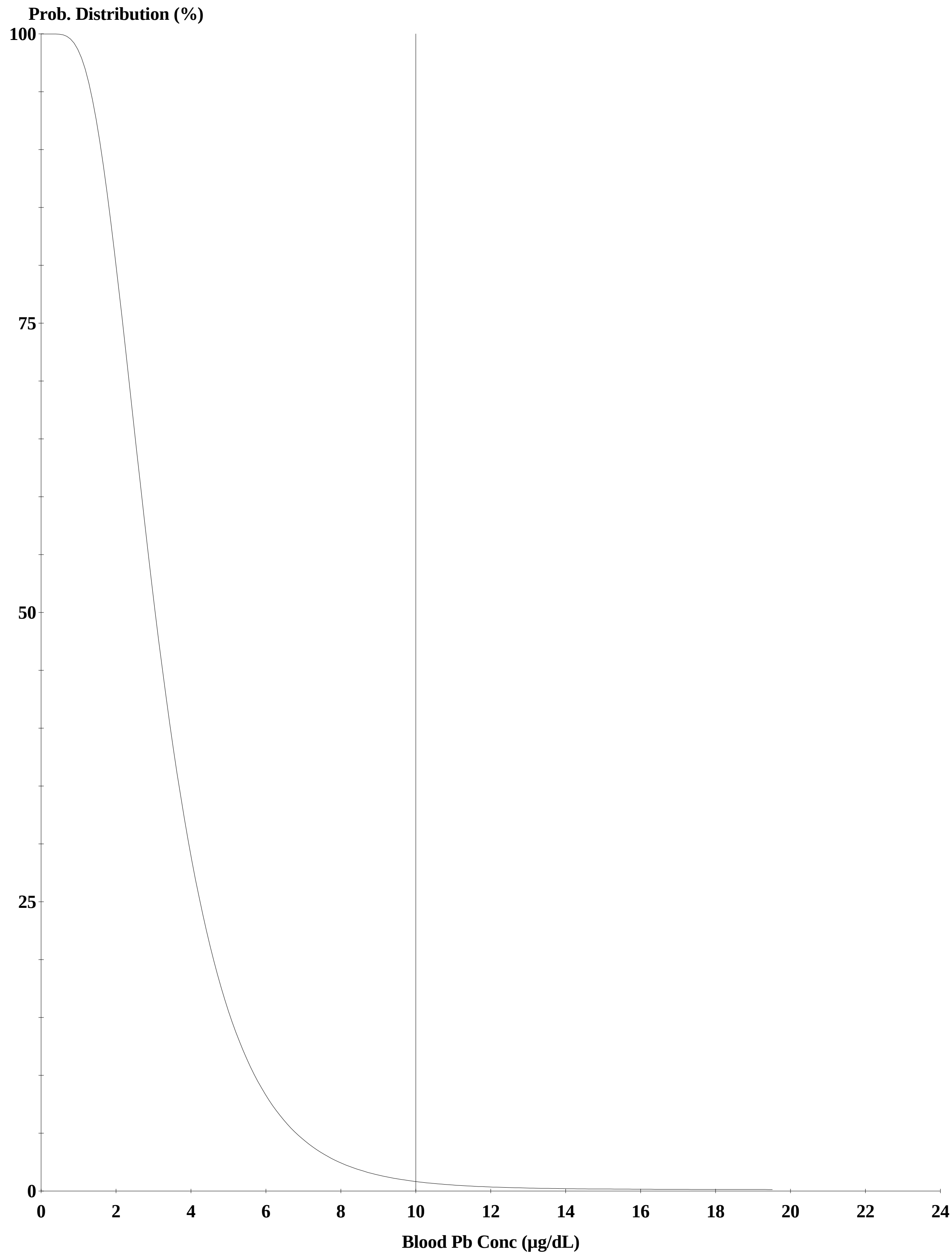
******** Maternal Contribution: Infant Model ********

Maternal Blood Concentration: 1.000 µg Pb/dL

****
CALCULATED BLOOD LEAD AND LEAD UPTAKES:
****

Year	Air (µg/day)	Diet (µg/day)	Alternate (µg/day)	Water (µg/day)
.5-1	0.021	1.054	0.000	0.948
1-2	0.034	0.900	0.000	2.333
2-3	0.062	0.989	0.000	2.453
3-4	0.067	0.957	0.000	2.526
4-5	0.067	0.930	0.000	2.666
5-6	0.093	0.985	0.000	2.830
6-7	0.093	1.070	0.000	2.890

Year	Soil+Dust (µg/day)	Total (µg/day)	Blood (µg/dL)
.5-1	4.103	6.126	3.3
1-2	6.417	9.685	4.0
2-3	6.487	9.991	3.7
3-4	6.554	10.103	3.5
4-5	4.939	8.602	3.0
5-6	4.474	8.382	2.6
6-7	4.241	8.294	2.4



Cutoff = 10.000 µg/dl
Geo Mean = 3.192
GSD = 1.600
% Above = 0.756

Age Range = 0 to 84 months

Run Mode = Site Risk Assessment

Figure 11.1

Attachment 2

TABLE 9.1.RME

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs

REASONABLE MAXIMUM EXPOSURE

SITE 5, ST. JULIENS CREEK ANNEX, CHESAPEAKE, VIRGINIA

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Shallow Aquifer - Tap Water	Aluminum	NA	NA	NA	NA	Neurotoxicity	1E-01	NA	8E-04	1E-01
			Arsenic	NA	NA	NA	NA	Skin, Vascular	1E+00	NA	7E-03	1E+00
			Beryllium	NA	NA	NA	NA	Gastrointestinal	6E-02	NA	5E-02	1E-01
			Cadmium	NA	NA	NA	NA	Kidney	1E-01	NA	1E-02	1E-01
			Chromium (hexavalent)	NA	NA	NA	NA	NOE	8E-04	NA	4E-04	1E-03
			Cobalt	NA	NA	NA	NA	Thyroid	4E+00	NA	1E-02	4E+00
			Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA
			Vanadium	NA	NA	NA	NA	Hair	5E-02	NA	1E-02	6E-02
			Chemical Total	NA	NA	NA	NA		6E+00	NA	9E-02	6E+00
		Exposure Point Total					NA					6E+00
	Exposure Medium Total						NA					6E+00
Medium Total							NA					6E+00
Receptor Total							NA				Receptor HI Total	6E+00

Total Neurological/CNS HI Across All Media =	1E-01
Total Skin HI Across All Media =	1E+00
Total Vascular HI Across All Media =	1E+00
Total Kidney HI Across All Media =	1E-01
Total Thyroid HI Across All Media =	**4E+00**
Total Gastrointestinal HI Across All Media =	1E-01
Total Hair HI Across All Media =	6E-02

CNS - Central Nervous System
HI - Hazard Index
NA - Not Applicable
NOE - No Observed Effects

TABLE 9.2.RME

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs

REASONABLE MAXIMUM EXPOSURE

SITE 5, ST. JULIENS CREEK ANNEX, CHESAPEAKE, VIRGINIA

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Shallow Aquifer - Tap Water	Aluminum	NA	NA	NA	NA	Neurotoxicity	2E-01	NA	1E-03	2E-01
			Arsenic	NA	NA	NA	NA	Skin, Vascular	2E+00	NA	8E-03	2E+00
			Beryllium	NA	NA	NA	NA	Gastrointestinal	9E-02	NA	6E-02	2E-01
			Cadmium	NA	NA	NA	NA	Kidney	2E-01	NA	2E-02	2E-01
			Chromium (hexavalent)	NA	NA	NA	NA	NOE	1E-03	NA	5E-04	2E-03
			Cobalt	NA	NA	NA	NA	Thyroid	7E+00	NA	1E-02	7E+00
			Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA
			Vanadium	NA	NA	NA	NA	Hair	8E-02	NA	1E-02	1E-01
			Chemical Total	NA	NA	NA	NA		9E+00	NA	1E-01	9E+00
		Exposure Point Total					NA					9E+00
	Exposure Medium Total						NA					9E+00
Medium Total							NA					9E+00
Receptor Total							NA				Receptor HI Total	9E+00

Total Neurological/CNS HI Across All Media =	2E-01
Total Skin HI Across All Media =	**2E+00**
Total Vascular HI Across All Media =	**2E+00**
Total Kidney HI Across All Media =	2E-01
Total Thyroid HI Across All Media =	**7E+00**
Total Gastrointestinal HI Across All Media =	2E-01
Total Hair HI Across All Media =	1E-01

CNS - Central Nervous System
HI - Hazard Index
NA - Not Applicable
NOE - No Observed Effects

TABLE 9.3.RME
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
SITE 5, ST. JULIENS CREEK ANNEX, CHESAPEAKE, VIRGINIA

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child/Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Shallow Aquifer - Tap Water	Aluminum	NA	NA	NA	NA	Neurotoxicity	NA	NA	NA	NA
			Arsenic	2E-04	NA	1E-06	2E-04	Skin, Vascular	NA	NA	NA	NA
			Beryllium	NA	NA	NA	NA	Gastrointestinal	NA	NA	NA	NA
			Cadmium	NA	NA	NA	NA	Kidney	NA	NA	NA	NA
			Chromium (hexavalent)	1E-06	NA	6E-07	2E-06	NOE	NA	NA	NA	NA
			Cobalt	NA	NA	NA	NA	Thyroid	NA	NA	NA	NA
			Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA
			Vanadium	NA	NA	NA	NA	Hair	NA	NA	NA	NA
			Chemical Total	2E-04	NA	2E-06	2E-04		NA	NA	NA	NA
		Exposure Point Total					2E-04					NA
	Exposure Medium Total						2E-04					NA
Medium Total							2E-04					NA
Receptor Total							2E-04				Receptor HI Total	NA

CNS - Central Nervous System
NA - Not Applicable
NOE - No Observed Effects

TABLE 9.4.RME

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs

REASONABLE MAXIMUM EXPOSURE

SITE 5, ST. JULIENS CREEK ANNEX, CHESAPEAKE, VIRGINIA

Scenario Timeframe: Future
Receptor Population: Construction Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Shallow Aquifer - Tap Water	Aluminum	NA	NA	NA	NA	Neurotoxicity	NA	NA	1E-03	1E-03
			Arsenic	NA	NA	5E-08	5E-08	Skin, Vascular	NA	NA	8E-03	8E-03
			Beryllium	NA	NA	NA	NA	Lifetime	NA	NA	2E-02	2E-02
			Cadmium	NA	NA	NA	NA	Kidney	NA	NA	1E-02	1E-02
			Chromium (hexavalent)	NA	NA	9E-09	9E-09	Blood	NA	NA	3E-04	3E-04
			Cobalt	NA	NA	NA	NA	Thyroid	NA	NA	1E-03	1E-03
			Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA
			Vanadium	NA	NA	NA	NA	Blood	NA	NA	7E-03	7E-03
			Chemical Total	NA	NA	6E-08	6E-08		NA	NA	5E-02	5E-02
		Exposure Point Total					6E-08					5E-02
	Exposure Medium Total						6E-08					5E-02
Medium Total							6E-08					5E-02
Receptor Total							6E-08				Receptor HI Total	5E-02

Total Neurological/CNS HI Across All Media =	1E-03
Total Blood HI Across All Media =	7E-03
Total Skin HI Across All Media =	8E-03
Total Vascular HI Across All Media =	8E-03
Total Lifetime HI Across All Media =	2E-02
Total Kidney HI Across All Media =	1E-02
Total Thyroid HI Across All Media =	1E-03

CNS - Central Nervous System
HI - Hazard Index
NA - Not Applicable