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FISC WILLIAMSBURG  
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TECHNICAL MEMORANDUM REGARDING FINAL CONSENSUS LETTER FOR SOIL AND  
GROUNDWATER AT AREA OF CONCERN 6 (AOC 6) 1918 DRUM STORAGE AREA  
SUBAREA CHEATHAM ANNEX FISC WILLIAMSBURG VA  
8/29/2013  
CH2M HILL

# Final Consensus Letter for Soil and Groundwater at the Area of Concern 6 1918 Drum Storage Area Subarea, Naval Weapons Station Yorktown Cheatham Annex, Williamsburg, Virginia

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DATE: August 29, 2013

This consensus letter summarizes soil and groundwater data and human health and ecological risks and provides the rationale for the CAX Partnering Team consensus for no further action for soil and groundwater at the 1918 Drum Storage Area (DSA) subarea within Area of Concern (AOC) 6 at Naval Weapons Station Yorktown Cheatham Annex (CAX) (**Figure 1**). The results of a baseline human health risk assessment (HHRA) and an ecological risk assessment (ERA) are presented in this consensus letter, and provide support for the rationale for soil and groundwater risk management considerations to support no further action at the 1918 DSA subarea. The 1918 DSA subarea is the only subarea being evaluated in this consensus letter; the other four subareas of AOC 6 will be evaluated separately.

## Background

The 1918 DSA subarea is one of five subareas that comprise AOC 6 (Penniman AOC). It is a developed area, located south of Antrim Road, consisting mostly of open and maintained grassy areas and a parking lot (**Figure 2**). The 1918 DSA subarea was identified by the United States Environmental Protection Agency (USEPA) from a 1918 overhead photograph (**Photograph 1**). This subarea was once used for the storage of wooden barrels and/or drums of unknown content when the shell loading facility was active (ATSDR, 2004).

## Previous Investigations

In January 1999 as part of a Site Inspection (SI) investigation, soil samples were collected from the 1918 DSA subarea to assess potential releases of contamination associated with the Penniman shell loading facility and to support hazard ranking system evaluations for CAX. All samples were analyzed for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), pesticides, polychlorinated biphenyls (PCBs), nitramines/nitroaromatics (explosives), and inorganic constituents. Analytical results indicated that arsenic was the only constituent of potential concern (COPC), as it was detected at concentrations exceeding the April 1999 USEPA residential soil risk-based concentrations (RBCs), the screening comparison criteria used at the time. The SI report recommended further evaluation of the 1918 DSA subarea due to the arsenic RBC exceedances being within the first 2 feet of the subsurface and located within 200 feet of occupied buildings (Weston, 1999).

An additional SI was completed in May 2012 with the objective to determine whether a release of hazardous constituents had occurred from past activities regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and if so, to determine whether a suspected release warranted further action. The SI report concluded that no further action for soil and groundwater was warranted and recommended the preparation of a consensus letter to capture the No Further Action recommendation (CH2M HILL, 2012).

## Conceptual Site Model

The conceptual site model (CSM) for soil and groundwater at the 1918 DSA subarea is based in the historical data summarized in this section, and interprets the physical setting, distribution of contamination, potential migration pathways, and potential exposure receptor pathways. A graphical depiction of the CSM for the 1918 DSA subarea of AOC 6 is depicted in **Figure 3**.

### Physical Setting

The 1918 DSA subarea is generally topographically flat and contains no wetlands or water bodies onsite or immediately downgradient of the subarea. The nearest water body is the northwest finger of Penniman Lake (which is being investigated under a separate evaluation), located approximately 400 feet to the southeast. Surface runoff at this site is anticipated to flow over the paved areas to the grassed areas and infiltrate into the subsurface or evaporate.

In general, soil in the 1918 DSA subarea is predominantly olive brown silt and clay, with a pale yellow shell hash present between 8 and 9 feet below ground surface (bgs). The shallow aquifer underlying the site is the Yorktown-Eastover aquifer. Groundwater depths during the recent SI ranged from 10 to 11 feet bgs. Groundwater is expected to flow southeast toward Penniman Lake.

The land use in the 1918 DSA subarea is industrial and the site is composed of grassed areas, a paved parking lot, and two office buildings. Future land use at the 1918 DSA subarea is not expected to change and will likely continue to be industrial use for the foreseeable future.

### Distribution of Contamination

During the May 2012 SI, six co-located surface and subsurface soil samples and three groundwater samples were collected from the 1918 DSA subarea. These samples were analyzed for SVOCs, explosives, and inorganic constituents. Analyses for VOCs, pesticides, and PCBs were not conducted during the recent SI, as analyses for these constituents were included for the samples collected during the 1999 SI and they were found not to be COPCs.

The analytical results were screened against base background soil and groundwater values (95 percent upper tolerance limits [UTLs]) for inorganic constituents (CH2M HILL, 2011) and conservative screening values as follows:

#### Surface and subsurface soil

- USEPA Regional Screening Levels (RSLs) for industrial and residential soil adjusted as appropriate (for noncarcinogenic effects) (May 2012)
- Site-specific ecological screening values (ESVs)

#### Groundwater

- USEPA RSLs for tap water, adjusted as appropriate (for noncarcinogenic effects) (May 2012)
- Federal Safe Drinking Water Act (SDWA) (Title 40 of the Code of Federal Regulations, Part 141) Maximum Contaminant Levels (MCLs)
- Site-specific ESVs<sup>1</sup>

#### Soil

No SVOCs or explosives were detected in surface or subsurface soil samples (see **Appendix A** for the analytical data tables).

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<sup>1</sup> Although both total and dissolved groundwater data are included in the ecological screening tables, only dissolved metals data are considered when selecting COPCs. The dissolved concentrations are likely to be more representative of what would be transported via the groundwater than the total concentrations. (See **Appendix C, Section C.5.3.3** for more information)

Two inorganic constituents (aluminum and lead) were found at concentrations that exceeded the base background 95 percent UTL concentrations and at least one other screening criterion in surface soil (**Figure 4**). Aluminum slightly exceeded the base background 95 percent UTL (12,200 milligrams per kilogram [mg/kg]) and exceeded the adjusted residential RSL (7,000 mg/kg) and the ESV (pH less than 5.5) in one surface soil sample (SS19) at a concentration of 12,800 mg/kg and a pH of 5. Lead exceeded the base background 95 percent UTL (17.4 mg/kg) and slightly exceeded the ESV (120 mg/kg) in one surface soil sample (SS15) at a concentration of 128 mg/kg.

Two inorganic constituents (aluminum and thallium) were found at concentrations that exceeded the base background 95 percent UTL concentrations and their respective adjusted residential RSL in subsurface soil (**Figure 5**). No ESV exceedances were identified. Aluminum slightly exceeded the base background 95 percent UTL (13,000 mg/kg) and exceeded the adjusted residential RSL (7,700 mg/kg) in one subsurface soil sample (SB16) at a concentration of 13,200 mg/kg. Thallium slightly exceeded the adjusted residential RSL (0.078 mg/kg) in one subsurface soil sample (SB16) at a concentration of 0.084 mg/kg (there is no base background 95 percent UTL value for thallium).

### Groundwater

- No SVOCs or explosives were detected in groundwater samples (**Appendix A**).
- Seventeen total inorganic constituents (aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, nickel, selenium, thallium, vanadium, and zinc) and two dissolved inorganic constituents (aluminum and thallium) exceeded their respective base background 95 percent UTL concentrations and at least one screening criterion in one or more groundwater samples (**Figure 6**).

Dissolved inorganic constituent data are likely more representative of inorganic constituent concentrations migrating in groundwater, since the DPT method used for sample collection generally results in higher total inorganic constituent concentrations due to increased sample turbidity. While 17 total inorganic constituents were detected in groundwater samples, only aluminum and thallium were detected above at least one other screening criterion in the dissolved fraction (**Figure 6**) (There are no base background 95 percent UTLs for dissolved aluminum or thallium). Therefore, the higher total inorganic constituent detections are likely the result of the increased turbidity.

Aluminum concentrations exceeded the ESV (87.0 micrograms per liter [ $\mu\text{g/L}$ ]) but not the adjusted residential RSL in all groundwater samples, at a maximum concentration of 385  $\mu\text{g/L}$  (DW09). Thallium concentrations exceeded the adjusted residential RSL (0.037  $\mu\text{g/L}$ ) but not the ESV in one groundwater sample (DW09), at a concentration of 2  $\mu\text{g/L}$ . It should also be noted that while dissolved barium concentrations exceeded the ESV (4  $\mu\text{g/L}$ ) in all groundwater samples (maximum estimated concentration of 50  $\mu\text{g/L}$ ), these concentrations did not exceed the base background 95 percent UTL (127  $\mu\text{g/L}$ ).

### Potential Migration Pathways

The source of potential contamination at the 1918 DSA subarea is anticipated to be the barrels or drums formerly stored onsite, as depicted in the 1918 overhead photograph of the site. However, there is no information as to what was stored in these containers or if any resulted in a release to the environment.

### Receptors

Actual or potential exposures of human and ecological receptors associated with a site are determined by identifying the most likely, and most important, mechanisms and pathways of contaminant release and transport. A complete exposure pathway has three components: (1) a source or sources of contamination that results in a release to the environment; (2) a pathway and mechanism of chemical transport through an environmental medium; and (3) an exposure or contact point for a receptor.

The potential receptors included in the risk assessments of soil and groundwater at the 1918 DSA subarea were current and future recreational users and visitors, trespassers, maintenance workers, and industrial workers,

future residents and construction workers, and lower trophic level terrestrial receptors (plants and soil invertebrates).

## Risk Assessment

Data for the CERCLA-related constituents identified at the 1918 DSA subarea were compared to the previously described screening criteria in **Tables 1, 2, and 3** for surface soil, subsurface soil, and groundwater, respectively. Those constituents that exceed the base background 95 percent UTL and one or more criteria are shown in **Figure 4** for surface soil, **Figure 5** for subsurface soil, and **Figure 6** for groundwater. A human health risk screening for soil, an HHRA for groundwater, and an ERA for soil were completed to determine if any unacceptable risks are present at the 1918 DSA subarea.

### Human Health Risk Assessment Summary

The primary objective of the baseline HHRA is to assess the potential human health risks from contamination associated with groundwater at the 1918 DSA subarea. The May 2012 SI report concluded that the human health risk screening determined that exposure to surface and subsurface soil at the 1918 DSA subarea would not be expected to result in any unacceptable human health risks; therefore, soil was eliminated from further evaluation and was not included in the baseline HHRA (CH2M HILL, 2012). The SI report screening level risk assessment tables, supporting no potential unacceptable human health risks for surface and subsurface soil at the 1918 DSA subarea, are included in **Appendix B, Tables B1, B1.a, B2, and B2.a**. Groundwater data were evaluated in the baseline HHRA to characterize potential current and future risks based on current site conditions.

The baseline HHRA evaluated the carcinogenic risks and noncarcinogenic hazards to a reasonably maximally exposed individual, which is consistent with the National Oil and Hazardous Substances Pollution Contingency Plan and the Risk Assessment Guidance for Superfund HHRA guidance documents (USEPA, 1989, 2001, 2004, and 2009) and Chief of Naval Operations guidance document (CNO, 2001). The reasonable maximum exposure (RME) is the highest exposure that is reasonably expected to occur at a site (USEPA, 1989). When the RME risk exceeded USEPA target risk levels, the central tendency exposure (CTE) risk was evaluated. The CTE risk is the risk to individuals who have average or typical exposure to the environmental media. The baseline HHRA is presented in **Appendix B** of this consensus letter.

### Potential Human Receptors and Exposure Scenarios

The preliminary CSM for human exposures presents an overview of site conditions, potential sources of contamination, potential contaminant-migration pathways, and potential exposure pathways to potential receptors. **Figure 3** presents a graphical depiction of the overall CSM for the 1918 DSA subarea, and **Figure B-1** in **Appendix B** presents the preliminary CSM for human exposures developed for 1918 DSA subarea.

There are no potential current receptors exposed to groundwater at the 1918 DSA subarea. No future use of groundwater is planned at this time; however, the risk assessment conservatively assumed that in the unlikely event future residential development of the site occurs, the residents could use the groundwater as a potable water supply. Therefore, risks associated with groundwater were evaluated assuming future residential potable use as the most conservative case. Additionally, it was assumed that construction workers could be exposed to groundwater during any excavation activities.

### Baseline Human Health Risk Assessment Results

In accordance with the USEPA Region 3 guidance, filtered groundwater samples were used to determine inorganic constituent exposure concentrations for the residential scenarios because a review of the groundwater data determined a significant difference (an order of magnitude or greater) between the filtered (dissolved) and total (unfiltered) results within each sample. Unfiltered groundwater samples were used to determine inorganic constituent exposure concentrations for the construction worker scenario, as a construction worker would directly contact the groundwater in an excavation.

Future residential adult and child exposure to filtered groundwater could potentially pose an unacceptable hazard associated with ingestion of thallium, the only chemical of concern identified for this scenario. However, thallium

was detected in only one of three filtered groundwater samples at a maximum concentration of 2 µg/L, which does not exceed the MCL (2 µg/L).

Future residential lifetime exposure to filtered groundwater would not result in an unacceptable carcinogenic risk. Future construction worker exposure to groundwater would not result in an unacceptable noncarcinogenic hazard or carcinogenic risk.

### Ecological Risk Assessment Summary

A screening-level ecological risk assessment (SERA), constituting Steps 1 and 2 of the ERA process, and the first step (Step 3A) of a Baseline ERA, were completed for the 1918 DSA subarea. This ERA discussion provides detail and documentation of the ecological risk screening performed as part of the final SI (CH2M HILL, 2012), which concluded that there is no unacceptable ecological risk associated with 1918 DSA subarea soil and groundwater.

The SERA was conducted in accordance with the *Navy Policy for Conducting Ecological Risk Assessments* (CNO, 1999) and the Department of the Navy (Navy) guidance for implementing this ERA policy (NAVFAC, 2003). The Navy ERA policy and guidance, which describe a process consisting of eight steps organized into three tiers, are conceptually similar to the eight-step ERA process outlined in USEPA ERA guidance for the Superfund program (USEPA, 1997). For both sets of guidance, Steps 1 and 2 involve conducting a SERA using very conservative assumptions. The complete SERA is presented in **Appendix C** of this consensus letter.

### Potential Ecological Receptors and Exposure Scenarios

A transport pathway describes the mechanisms whereby site-related chemicals, once released, may be transported from a source to ecologically relevant media (such as surface soil) where exposures may occur. The primary release mechanisms and transport pathways at the site include:

- Possible surface runoff from source areas to other areas of the site
- Infiltration, percolation, and leaching of contaminants to groundwater and subsequent discharge of groundwater to the surface water and sediment of downgradient water bodies (Penniman Lake)

Exposure media for ecological receptors are typically limited to surface water, surface sediment, and surface soil. Surface water and sediment are not evaluated in the SERA because the site does not contain wetlands or water bodies. Subsurface soil (6 to 24 inches bgs) is also evaluated because some ecological receptors may be exposed to soil at these depths. Groundwater is generally considered only as a transport medium since there are no ecological exposures to groundwater until it discharges to a water body or surfaces as a seep. In the SERA, groundwater is evaluated as a potential transport medium to downgradient water bodies (Penniman Lake). Air is not addressed in the SERA since this medium is not likely to result in significant contributions to total exposures for the receptors evaluated.

An exposure pathway links a source of contamination with one or more receptors through exposure via one or more media and exposure routes. Exposure, and thus potential risk, can only occur if complete exposure pathways exist. **Figure C-1** in **Appendix C** shows the potentially complete exposure pathways to ecological receptors associated with the 1918 DSA subarea of AOC 6, which include:

- Direct contact with site-related chemicals in surface soil for lower trophic level receptors (such as plants and soil invertebrates)

As previously discussed, there are no complete exposure pathways for aquatic receptors on the site due to the lack of wetland and aquatic habitats. However, groundwater is evaluated as a potential transport medium to downgradient water bodies (Penniman Lake).

Terrestrial plants may be exposed to chemicals present in surface soil through their root surfaces during water and nutrient uptake. Terrestrial invertebrates may be exposed to chemicals in surface soil through dermal contact and ingestion. Due to the small size of the site (less than 1 acre) and its developed nature, exposures to terrestrial upper trophic level receptors (birds and mammals) are not considered significant and were not evaluated (CH2M HILL, 2012).

Specific receptor species or species groups (such as plants) were selected as surrogates to evaluate potential risks to larger components of the ecological community (guilds) used to represent the assessment endpoints. Selection criteria typically include those species that:

- Are known to occur, or are likely to occur, at the site
- Have a particular ecological, economic, or aesthetic value
- Are representative of taxonomic groups, life history traits, and/or trophic levels in the habitats present for which complete exposure pathways are likely to exist
- Can, because of toxicological sensitivity or potential exposure magnitude, be expected to represent potentially sensitive populations

Lower trophic level receptor species were evaluated based upon those taxonomic groupings for which soil screening values have been developed. As such, specific species of plants or soil invertebrates in terrestrial habitats were not chosen as receptors because of the limited information available for specific species and because these receptors were evaluated on a community level via a comparison of chemical concentrations in soil to soil screening values.

### **Ecological Risk Assessment Results**

In Step 3A, no COPCs were identified in 1918 DSA subarea surface soil, subsurface soil, or groundwater. For terrestrial habitats, risks for lower trophic level ecological receptors (plants and invertebrates) are acceptable, particularly given the current and future land use (industrial). Groundwater does not appear to be a significant transport medium for site-related constituents to Penniman Lake from the 1918 DSA subarea, and site-related constituents in groundwater are unlikely to pose a significant risk to aquatic biota.

### **Summary**

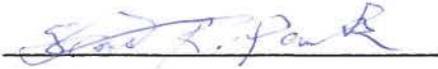
The SI affirmed that soil and groundwater at the 1918 DSA subarea have been sufficiently characterized and the available soil and groundwater data are acceptable to recommend no further action. The no further action recommendation is based on the following:

- Although ingestion of dissolved thallium could potentially pose an unacceptable hazard for the future adult and child resident, dissolved thallium was detected in only one of three groundwater samples at a maximum concentration of 2 µg/L, which does not exceed the MCL (2 µg/L).
- Groundwater is not a source of potable water at the 1918 DSA subarea or CAX, and there is no future or potential planned use for groundwater as a source of potable water in the vicinity.
- It is unlikely that groundwater from the shallow aquifer would ever be used as a potable water supply because of the availability of better water supplies with respect to both natural water quality and quantity.
- No unacceptable human health risk was identified for the construction worker scenario.
- No ecological COPCs were identified in the surface soil, subsurface soil, or groundwater at the 1918 DSA subarea.
- For terrestrial habitats, risks for lower trophic level ecological receptors (plants and invertebrates) are acceptable, particularly given the current and future land use (industrial).
- Groundwater does not appear to be a significant transport medium for site-related constituents to Penniman Lake from the 1918 DSA subarea, and site-related constituents in groundwater are unlikely to pose a significant risk to aquatic biota.
- Future land use at the 1918 DSA subarea is not expected to change and will likely continue to be industrial for the foreseeable future.

## No Further Action Soil and Groundwater Risk Management Consensus

The Navy, in partnership with the USEPA and the Virginia Department of Environmental Quality, has determined that no potential risks for surface and subsurface soil and groundwater exist at the 1918 DSA subarea and that no further action is required for soil and groundwater.

Mr. Scott Park;  
NAVFAC Mid-Atlantic

  
Date 9-15-13

Mr. Gerald Hoover  
USEPA Region 3

  
Date 9-15-13

Mr. Wade Smith;  
VDEQ

  
Date 09/18/2013

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**Tables**

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TABLE 1  
**Surface Soil Sample Exceedances**  
**AOC 6 1918 Drum Storage Area Subarea No Action Consensus Letter**  
**Cheatham Annex**  
**Williamsburg, Virginia**

Station ID	CLEAN CAX 95% UTL for Surface Soil	RSLs Residential Soil Adjusted 0512	ESVs	CAA06-SO14	CAA06-SO15	CAA06-SO16	CAA06-SO17	CAA06-SO18	CAA06-SO19	
Sample ID				CAA06-SS14-1108	CAA06-SS15-1108	CAA06-SS16-1108	CAA06-SS17-1108	CAA06-SS18-1108	CAA06-SS19-1108	CAA06-SS19P-1108
Sample Date				11/11/08	11/11/08	11/11/08	11/11/08	11/11/08	11/11/08	11/11/08
<b>Chemical Name</b>										
<b>Semivolatile Organic Compounds (UG/KG)</b>										
No Detections										
<b>Explosives (UG/KG)</b>										
No Detections										
<b>Total Metals (MG/KG)</b>										
Aluminum	12,200	7,700	pH < 5.5	7,560	8,530	8,710	7,850	5,040	10,300	<b>12,800</b>
Antimony	--	3.1	78	0.11 L	0.5 L	0.07 L	0.05 L	4.5 UL	5.1 UL	5.1 UL
Arsenic	6.36	0.39	18	3.1	3	4.4	2.4	2.6	4.1	4.9
Barium	52.9	1,500	330	31	35.4	32.2	28	45.8	32	37.7
Beryllium	0.587	16	40	0.53	0.35 J	0.42	0.34	0.28 J	0.36 J	0.42 J
Cadmium	--	7	32	0.07 J	0.16 J	0.07 J	0.04 J	0.17 J	0.02 J	0.42 U
Calcium	2,290	--	--	1,230	1,760	8,080	712	560	481	706
Chromium	18.2	0.29	64	9.9	12.3	13.8	10.3	6.3	15	16.7
Cobalt	9.93	2.3	13	1.6 J	1.7 J	2 J	1.4 J	1.1 J	1.5 J	1.9 J
Copper	4.25	310	70	5.4	8.2	4.4	4.2	5.1	7.1	6.5
Iron	19,900	5,500	5 < pH > 8	7,740	6,860	11,000	6,450	5,440	9,450	10,500
Lead	17.4	400	120	57.6	<b>128</b>	27.2	23.3	67.4	34.9	40.2
Magnesium	1,070	--	--	910	1,070	1,060	646	410	812	942
Manganese	324	180	220	95.1	82.9	66.9	58.7	71.2	33.4	55.9
Mercury	0.111	2.3	0.1	0.06 J	0.06 J	0.12 U	0.12 U	0.1 U	0.06 J	0.06 J
Nickel	9.52	150	38	3.9	3.9	5.9	3.6	2.9 J	4.3	4.8
Potassium	708	--	--	646	575	819	492	356 J	790	867
Selenium	0.51	39	0.52	3.1 U	3.4 U	2.7 U	0.31 J	2.6 U	0.35 J	0.37 J
Silver	--	39	560	0.62 J	0.96 U	0.76 U	0.65 U	0.76 U	0.84 U	0.84 U
Sodium	521	--	--	28.5 J	31.4 J	80.5 J	25.5 J	22.6 J	32.4 J	39.7 J
Thallium	--	0.078	1	0.07 J	2.4 U	0.06 J	1.6 U	1.9 U	2.1 U	2.1 U
Vanadium	27.9	39	130	15.5	16.3	16.9	14	8.9	20.2	23.4
Zinc	26.5	2,300	120	51.3	66.2	31.1	22.2	102	23.9	24.1
<b>Wet Chemistry</b>										
% Solids (pct)	--	--	--	79	86	88	84	91	88	89
pH (pH units)	--	--	--	6	6.2	8.4	5.8	6.4	5	NA
Total organic carbon (TOC) (ug/g)	--	--	--	23,000	20,000	8,700	23,000	11,000	22,000	NA

**Notes:**

Shading indicates exceedance of ESV and 95% UTL

**Bold indicates exceedance of Adjusted Residential Soil RSL and 95% UTL**

J - Analyte present, value may or may not be accurate or precise

L - Analyte present, value may be biased low, actual value may be higher

NA - Not analyzed

U - The material was analyzed for, but not detected

UJ - Analyte not detected, quantitation limit may be inaccurate

UL - Analyte not detected, quantitation limit is probably higher

MG/KG - Milligrams per kilogram

PCT - Percent

UG/G - Micrograms per gram

UG/KG - Micrograms per kilogram

TABLE 2  
**Subsurface Soil Sample Exceedances**  
**AOC 6 1918 Drum Storage Area Subarea No Action Consensus Letter**  
**Cheatham Annex**  
**Williamsburg, Virginia**

Station ID	CAX 95% UTL for Subsurface Soil	RSLs Residential Soil Adjusted 0512	ESVs	CAA06-SO14	CAA06-SO15	CAA06-SO16	CAA06-SO17	CAA06-SO18	CAA06-SO19	
Sample ID				CAA06-SB14-1108	CAA06-SB15-1108	CAA06-SB16-1108	CAA06-SB17-1108	CAA06-SB18-1108	CAA06-SB19-1108	CAA06-SB19P-1108
Sample Date				11/11/08	11/11/08	11/11/08	11/11/08	11/11/08	11/11/08	11/11/08
<b>Chemical Name</b>										
<b>Semivolatile Organic Compounds (UG/KG)</b>										
No Detections										
<b>Explosives (UG/KG)</b>										
No Detections										
<b>Total Metals (MG/KG)</b>										
Aluminum	13,000	7,700	pH < 5.5	9,530	12,700	<b>13,200</b>	12,700	5,770	11,200	11,100
Antimony	--	3.1	78	0.1 L	0.16 L	0.16 L	0.16 L	4.9 UL	0.08 L	0.11 L
Arsenic	5.54	0.39	18	4.1	5	4.2	2.6	2.2	3.8	3.4
Barium	84.5	1,500	330	44.5	37.8	27.4	32.7	31.1	42.5	41.9
Beryllium	--	16	40	0.45	0.48	0.35 J	0.31	0.23 J	0.47	0.42
Cadmium	--	7	32	0.03 J	0.04 J	0.44 U	0.28 U	0.08 J	0.04 J	0.02 J
Calcium	2,380	--	--	1,310	1,840	12,600	921	626	3,700	3,530
Chromium	33.7	0.29	64	12.6	20	16.6	14.7	8.4	18.3	19
Cobalt	5.18	2.3	13	1.8 J	2.4 J	1.9 J	1.4 J	0.95 J	2.1 J	1.9 J
Copper	3.17	310	70	4.6	5.2	2.8	3.7	4.2	6.2	5.5
Iron	32,000	5,500	5 < pH > 8	9,960	12,700	11,900	9,900	5,800	12,000	11,100
Lead	8.79	400	120	19.3	60	9.6	7.6	20.1	19.8	22.9
Magnesium	1,120	--	--	840	1,120	1,140	732	432	1,150	1,040
Manganese	176	180	220	104	86.3	29	30.4	44.8	58.8	62.9
Mercury	--	2.3	0.1	0.11 U	0.11 U	0.12 U	0.11 U	0.11 U	0.04 J	0.11 U
Nickel	17.6	150	38	4.2	6.4	5.3	3.9	2.8 J	6.2	6.7
Potassium	901	--	--	621	1,030	960	409	342 J	781	765
Selenium	--	39	0.52	2.7 U	2.9 U	3.1 U	0.33 J	2.9 U	3.2 U	2 U
Sodium	811	--	--	29.9 J	33.4 J	119 J	27.8 J	20.5 J	50.3 J	49.6 J
Thallium	--	0.078	1	1.9 U	2 U	<b>0.08 J</b>	1.4 U	2.1 U	2.2 U	1.4 U
Vanadium	48.3	39	130	18	25.4	23.2	22.2	11.6	21.6	20.4
Zinc	28	2,300	120	21.6	26.9	12.9	9.8	51.1	20.6	19.7
<b>Wet Chemistry</b>										
% Solids (pct)	--	--	--	87	88	87	90	94	92	93
pH (pH units)	--	--	--	8.1	8.5	7.2	6.2	6.1	7.2	NA
Total organic carbon (TOC) (ug/g)	--	--	--	14,000	3,400	1,700	3,700	5,800	20,000	NA

**Notes:**

Shading indicates exceedance of ESV and 95% UTL  
**Bold indicates exceedance of Adjusted Residential Soil RSL and 95% UTL**

- J - Analyte present, value may or may not be accurate or precise
- L - Analyte present, value may be biased low, actual value may be higher
- NA - Not analyzed
- U - The material was analyzed for, but not detected
- UJ - Analyte not detected, quantitation limit may be inaccurate
- UL - Analyte not detected, quantitation limit is probably higher
- MG/KG - Milligrams per kilogram
- PCT - Percent
- UG/G - Micrograms per gram
- UG/KG - Micrograms per kilogram

TABLE 3  
**Groundwater Sample Exceedances**  
**AOC 6 1918 Drum Storage Area Subarea No Action Consensus Letter**  
**Cheatham Annex**  
**Williamsburg, Virginia**

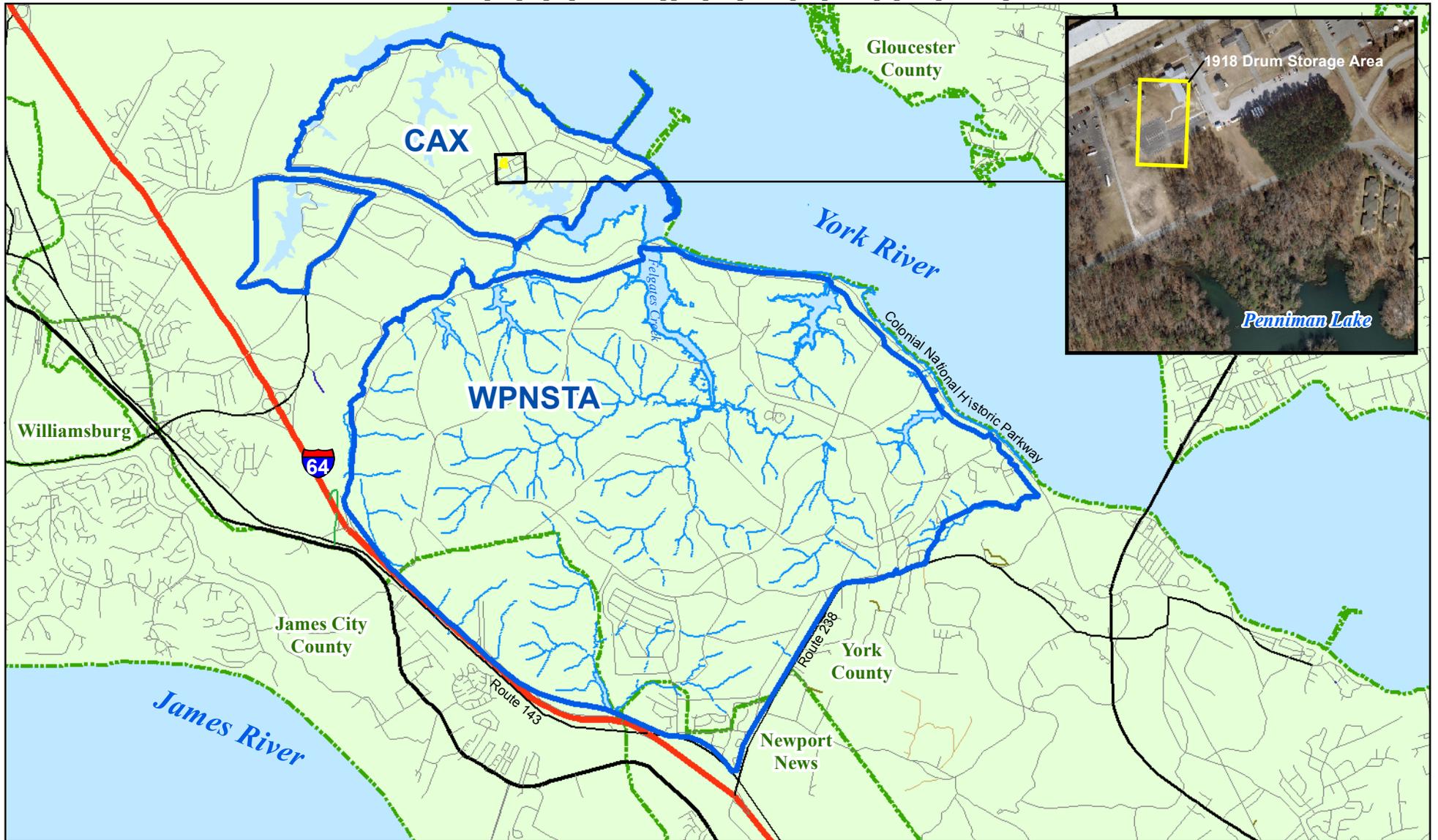
Station ID	CAX 95% UTL for Yorktown-Eastover Aquifer	RSLs Tapwater Adjusted 0512	MCLs	ESVs	CAA06-DW09	CAA06-DW10		CAA06-DW11
Sample ID					CAA06-DW09-1108	CAA06-DW10-1108	CAA06-DW10P1108	CAA06-DW11-1108
Sample Date					11/11/08	11/11/08	11/11/08	11/11/08
<b>Chemical Name</b>								
<b>Semivolatile Organic Compounds (UG/L)</b>								
No Detections								
<b>Explosives (UG/L)</b>								
No Detections								
<b>Total Metals (UG/L)</b>								
Aluminum	2,230	1,600	--	87	<b>57,600</b>	<b>14,600 J</b>	1,810 J	<b>12,100</b>
Antimony	--	0.6	6	30	<b>8.8 J</b>	<b>3.8 J</b>	60 U	<b>3.6 J</b>
Arsenic	2.28	0.045	10	150	<b>134</b>	<b>53.1 J</b>	<b>11.4 J</b>	<b>24.6</b>
Barium	118	290	2,000	4	208	87.1 J	48.7 J	68.5 J
Beryllium	2.45	1.6	4	0.66	<b>4.1 J</b>	1 J	0.18 J	0.8 J
Cadmium	0.605	0.69	5	0.27	<b>5</b>	<b>1.4 J</b>	0.18 J	0.57 J
Calcium	169,000	--	--	--	661,000	278,000	165,000	357,000
Chromium	15.1	0.031	100	11.4	<b>250</b>	<b>59</b>	7.2 J	<b>84.8</b>
Cobalt	20.6	0.47	--	23	<b>23.3 J</b>	7 J	1 J	6 J
Copper	--	62	1,300	9.33	60.2	23.1 J	9.8 J	26
Iron	894	1,100	--	1,000	<b>116,000</b>	<b>32,100 J</b>	<b>5,090 J</b>	<b>27,800</b>
Lead	--	15	15	3.18	<b>50.1</b>	14.6	2.5 J	11.9
Magnesium	11,500	--	--	--	20,700	6,770	2,840 J	5,510
Manganese	57.9	32	--	120	<b>424</b>	<b>109 J</b>	23.5 J	<b>123</b>
Mercury	--	0.43	2	0.91	0.04 L	0.2 UL	0.2 UL	0.2 UL
Nickel	11.4	30	--	52.2	<b>86.7</b>	26.5 J	4.7 J	<b>43.9</b>
Potassium	12,700	--	--	--	23,000	9,220	4,410 J	5,660
Selenium	--	7.8	50	5	<b>5.8 J</b>	<b>5.5 J</b>	35 U	35 U
Sodium	64,500	--	--	--	24,200	14,200	12,400	7,330
Thallium	--	0.016	2	12	<b>2.1 J</b>	25 U	<b>1.7 J</b>	<b>2.2 J</b>
Vanadium	26.2	7.8	--	20	<b>325</b>	<b>85.5</b>	9.6 J	<b>52</b>
Zinc	4.52	470	--	120	227	60.7	10.3 J	60.2
<b>Dissolved Metals (UG/L)</b>								
Aluminum, Dissolved	--	1,600	--	87	385	227	242	250
Barium, Dissolved	127	290	2,000	4	50 J	46.5 J	46.4 J	31.1 J
Calcium, Dissolved	113,000	--	--	--	192,000	166,000	166,000	142,000
Chromium, Dissolved	6.04	0.031	100	11	0.95 J	10 U	10 U	0.58 B
Copper, Dissolved	--	62	1,300	8.96	1.3 J	1.4 J	1.2 J	1.2 J
Iron, Dissolved	275	1,100	--	1,000	336	39.6 B	18.2 B	502
Lead, Dissolved	--	15	15	2.52	2.2 J	2.4 J	1.2 J	1.3 J
Magnesium, Dissolved	11,200	--	--	--	3,010 J	2,460 J	2,430 J	1,580 J
Manganese, Dissolved	49.5	32	--	120	30.5	23.3	24.1	17.7
Nickel, Dissolved	--	30	--	52	7.1 J	5.8 J	6.1 J	6.1 J
Potassium, Dissolved	12,600	--	--	--	2,950 J	3,770 J	3,780 J	912 J
Sodium, Dissolved	62,800	--	--	--	21,600	13,300	13,300	5,860
Thallium, Dissolved	--	0.016	2	12	<b>2 J</b>	25 U	25 U	25 U
Vanadium, Dissolved	--	7.8	--	20	0.9 J	50 U	50 U	50 U
Zinc, Dissolved	--	470	--	118	3.2 J	3 J	2.9 J	4 J

**Notes:**  
Shading indicates exceedance of ESV and 95% UTL  
**Bold indicates exceedance of Adjusted Tapwater RSL and 95% UTL**  
**Bold box indicates exceedance of MCL and 95% UTL**

B - Analyte not detected above the level reported in blanks  
J - Analyte present, value may or may not be accurate or precise  
L - Analyte present, value may be biased low, actual value may be higher  
U - The material was analyzed for, but not detected  
UL - Analyte not detected, quantitation limit is probably higher  
UG/L - Micrograms per liter

**Figures**

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- Legend**
- Activity Boundaries
  - City/County Boundaries
  - Approximate 1918 Drum Storage Study Area

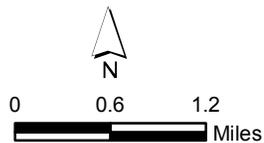
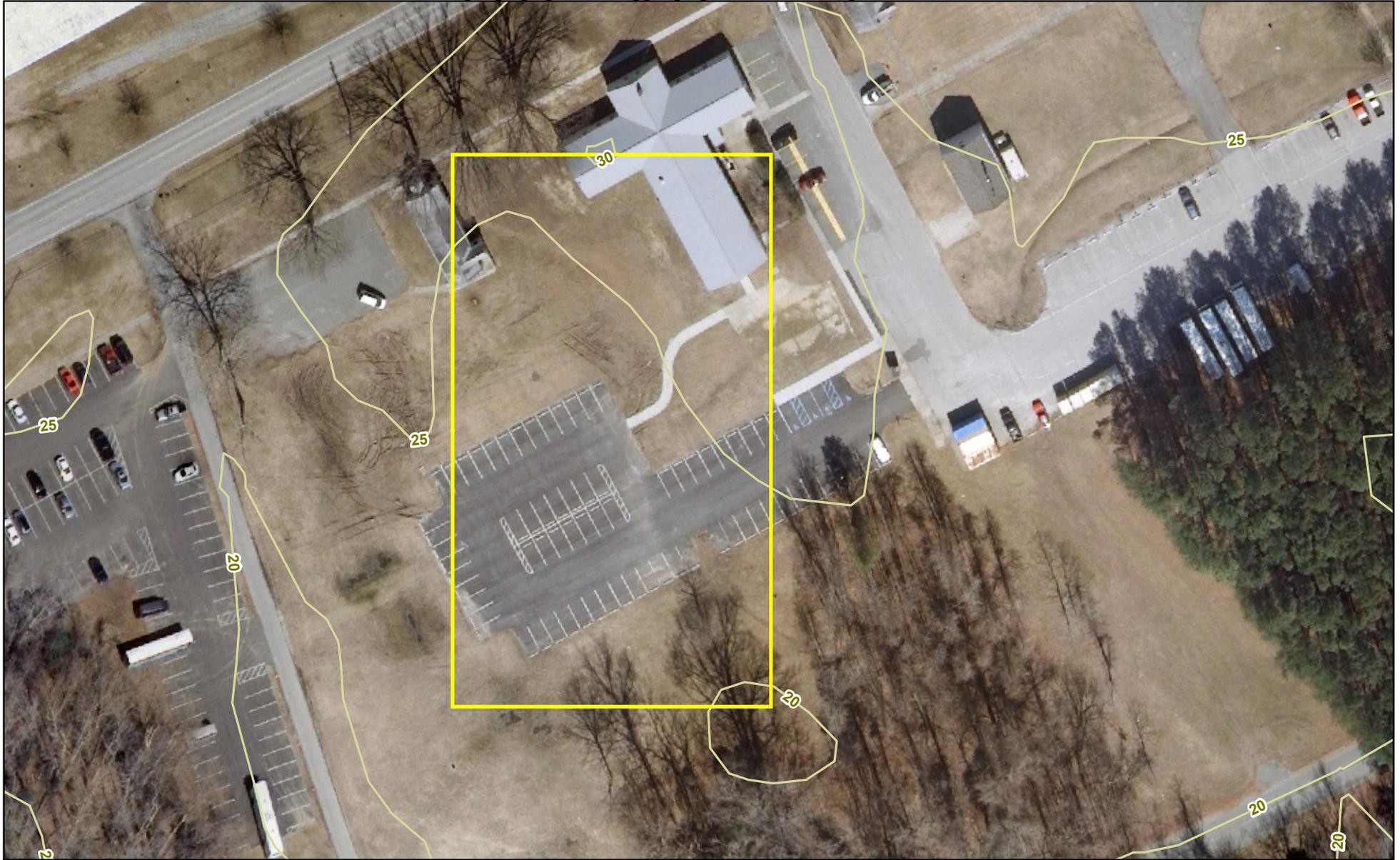


Figure 1  
AOC 6 1918 Drum Storage Area Subarea; Base Map  
AOC 6 1918 Drum Storage Area Subarea  
No Action Consensus Letter  
Cheatham Annex  
Williamsburg, Virginia  
**CH2MHILL**



**Legend**

-  Approximate 1918 Drum Storage Study Area
-  Topographic Surface Contour (feet above mean sea level)

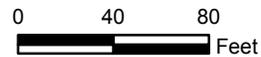


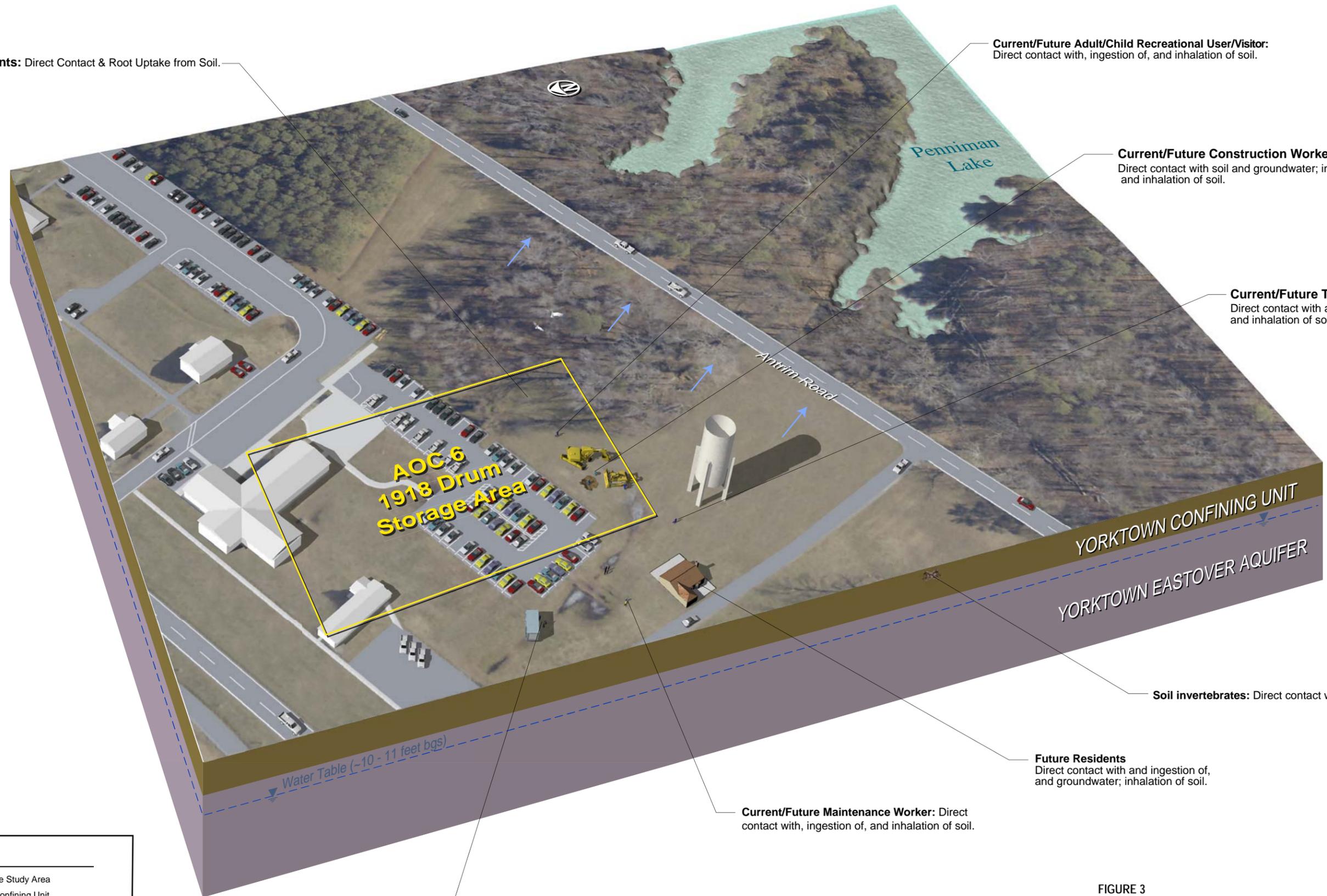
Figure 2  
AOC 6 1918 Drum Storage Area Subarea; Site Map  
AOC 6 1918 Drum Storage Area Subarea  
No Action Consensus Letter  
Cheatham Annex  
Williamsburg, Virginia

**Plants:** Direct Contact & Root Uptake from Soil.

**Current/Future Adult/Child Recreational User/Visitor:** Direct contact with, ingestion of, and inhalation of soil.

**Current/Future Construction Workers**  
Direct contact with soil and groundwater; ingestion and inhalation of soil.

**Current/Future Trespassers**  
Direct contact with and ingestion of, and inhalation of soil.



**Current/Future Industrial Workers:** Direct contact with ingestion of, and inhalation of soil.

**Current/Future Maintenance Worker:** Direct contact with, ingestion of, and inhalation of soil.

**Future Residents**  
Direct contact with and ingestion of, and groundwater; inhalation of soil.

**Soil invertebrates:** Direct contact with soil.

YORKTOWN CONFINING UNIT  
YORKTOWN EASTOVER AQUIFER

Water Table (~10 - 11 feet bgs)

**LEGEND**

- Approximate Study Area
- Yorktown Confining Unit
- Yorktown Eastover Aquifer
- ← Anticipated Surface Water Flow Direction
- ▽ Water Table
- bgs below ground surface

**FIGURE 3**  
AOC 6 1918 Drum Storage Area Subarea; Conceptual Site Model  
AOC 6 1918 Drum Storage Area Subarea  
No Action Consensus Letter  
*Cheatham Annex,*  
*Williamsburg, Virginia*

Station ID	CAA06-SO19
Sample ID	CAA06-SS19-1108*
Sample Date	11/11/08
Total Metals (MG/KG)	
Aluminum	<b>12,800</b> pH = 5

Station ID	CAA06-SO16
Sample ID	CAA06-SS16-1108
Sample Date	11/11/08
No Exceedances	

Station ID	CAA06-SO18
Sample ID	CAA06-SS18-1108
Sample Date	11/11/08
No Exceedances	

Station ID	CAA06-SO15
Sample ID	CAA06-SS15-1108
Sample Date	11/11/08
Total Metals (MG/KG)	
Lead	128

Station ID	CAA06-SO17
Sample ID	CAA06-SS17-1108
Sample Date	11/11/08
No Exceedances	

Station ID	CAA06-SO14
Sample ID	CAA06-SS14-1108
Sample Date	11/11/08
No Exceedances	

	CAX 95% UTL for Surface Soil	RSLs Residential Soil Adjusted 0512	ESVs
Total Metals (µg/l)			
Aluminum	12,200	7,700	pH < 5.5
Lead	17.4	400	120

**Legend**

- Surface Soil Sample Location
- Approximate 1918 Drum Storage Study Area

**Notes:**

Shading indicates exceedance of ESV and 95% UTL  
**Bold indicates exceedance of Adjusted Residential Soil RSL and 95% UTL**  
 MG/KG - Milligrams per kilogram  
 \* Field duplicate was collected at CAA06-SO19; the highest value is shown

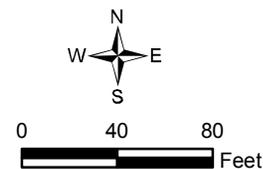


Figure 4  
 AOC 6 1918 Drum Storage Area Subarea;  
 Surface Soil Sample Locations and Exceedances  
 AOC 6 1918 Drum Storage Area Subarea  
 No Action Consensus Letter  
 Cheatham Annex  
 Williamsburg, Virginia  
**CH2MHILL**

Station ID	CAA06-SO19
Sample ID	CAA06-SB19-1108*
Sample Date	11/11/08
No Exceedances	

Station ID	CAA06-SO16
Sample ID	CAA06-SB16-1108
Sample Date	11/11/08
Total Metals (mg/kg)	
Aluminum	<b>13,200</b>
Thallium	<b>0.08 J</b>

Station ID	CAA06-SO18
Sample ID	CAA06-SB18-1108
Sample Date	11/11/08
No Exceedances	

Station ID	CAA06-SO15
Sample ID	CAA06-SB15-1108
Sample Date	11/11/08
No Exceedances	

Station ID	CAA06-SO17
Sample ID	CAA06-SB17-1108
Sample Date	11/11/08
No Exceedances	

Station ID	CAA06-SO14
Sample ID	CAA06-SB14-1108
Sample Date	11/11/08
No Exceedances	

	CAX 95% UTL for Subsurface Soil	RSLs Residential Soil Adjusted 0512	ESVs
Total Metals (µg/l)			
Aluminum	13,000	7,700	pH < 5.5
Thallium	--	0.078	1

- Legend**
- Subsurface Soil Sample Location
  - Approximate 1918 Drum Storage Study Area

**Notes:**  
 Shading indicates exceedance of ESV and 95% UTL  
**Bold indicates exceedance of Adjusted Residential Soil RSL and 95% UTL**  
 J - Analyte present, value may or may not be accurate or precise  
 MG/KG - Milligrams per kilogram  
 \* Field duplicate was collected at CAA06-SO19; the highest value is shown

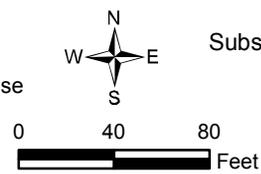
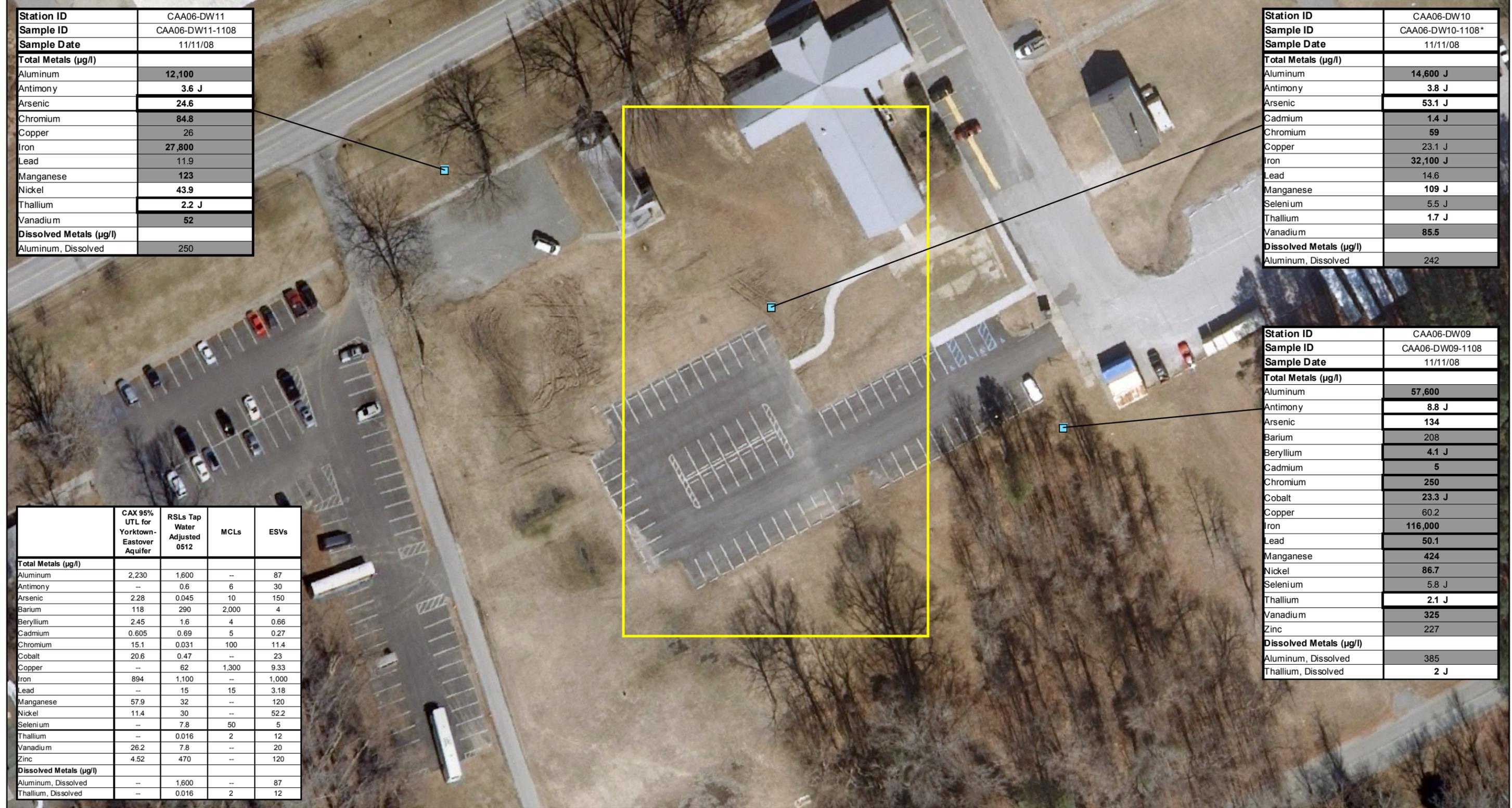


Figure 5  
 AOC 6 1918 Drum Storage Area Subarea;  
 Subsurface Soil Sample Locations and Exceedances  
 AOC 6 1918 Drum Storage Area Subarea  
 No Action Consensus Letter  
 Cheatham Annex  
 Williamsburg, Virginia  
**CH2MHILL**



Station ID	CAA06-DW11
Sample ID	CAA06-DW11-1108
Sample Date	11/11/08
<b>Total Metals (µg/l)</b>	
Aluminum	12,100
Antimony	3.6 J
Arsenic	24.6
Chromium	84.8
Copper	26
Iron	27,800
Lead	11.9
Manganese	123
Nickel	43.9
Thallium	2.2 J
Vanadium	52
<b>Dissolved Metals (µg/l)</b>	
Aluminum, Dissolved	250

Station ID	CAA06-DW10
Sample ID	CAA06-DW10-1108*
Sample Date	11/11/08
<b>Total Metals (µg/l)</b>	
Aluminum	14,600 J
Antimony	3.8 J
Arsenic	53.1 J
Cadmium	1.4 J
Chromium	59
Copper	23.1 J
Iron	32,100 J
Lead	14.6
Manganese	109 J
Selenium	5.5 J
Thallium	1.7 J
Vanadium	85.5
<b>Dissolved Metals (µg/l)</b>	
Aluminum, Dissolved	242

Station ID	CAA06-DW09
Sample ID	CAA06-DW09-1108
Sample Date	11/11/08
<b>Total Metals (µg/l)</b>	
Aluminum	57,600
Antimony	8.8 J
Arsenic	134
Barium	208
Beryllium	4.1 J
Cadmium	5
Chromium	250
Cobalt	23.3 J
Copper	60.2
Iron	116,000
Lead	50.1
Manganese	424
Nickel	86.7
Selenium	5.8 J
Thallium	2.1 J
Vanadium	325
Zinc	227
<b>Dissolved Metals (µg/l)</b>	
Aluminum, Dissolved	385
Thallium, Dissolved	2 J

	CAX 95% UTL for Yorktown-Eastover Aquifer	RSLs Tap Water Adjusted 0512	MCLs	ESVs
<b>Total Metals (µg/l)</b>				
Aluminum	2,230	1,600	--	87
Antimony	--	0.6	6	30
Arsenic	2.28	0.045	10	150
Barium	118	290	2,000	4
Beryllium	2.45	1.6	4	0.66
Cadmium	0.605	0.69	5	0.27
Chromium	15.1	0.031	100	11.4
Cobalt	20.6	0.47	--	23
Copper	--	62	1,300	9.33
Iron	894	1,100	--	1,000
Lead	--	15	15	3.18
Manganese	57.9	32	--	120
Nickel	11.4	30	--	52.2
Selenium	--	7.8	50	5
Thallium	--	0.016	2	12
Vanadium	26.2	7.8	--	20
Zinc	4.52	470	--	120
<b>Dissolved Metals (µg/l)</b>				
Aluminum, Dissolved	--	1,600	--	87
Thallium, Dissolved	--	0.016	2	12

**Legend**  
■ Groundwater/Soil Sample Location  
 Approximate 1918 Drum Storage Study Area

**Notes:**  
 Shading indicates exceedance of ESV and 95% UTL  
**Bold indicates exceedance of Adjusted Residential Soil RSL and 95% UTL**  
 MG/KG - Milligrams per kilogram  
 \* Field duplicate was collected at CAA06-SO19; the highest value is shown

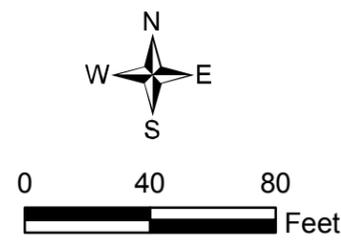
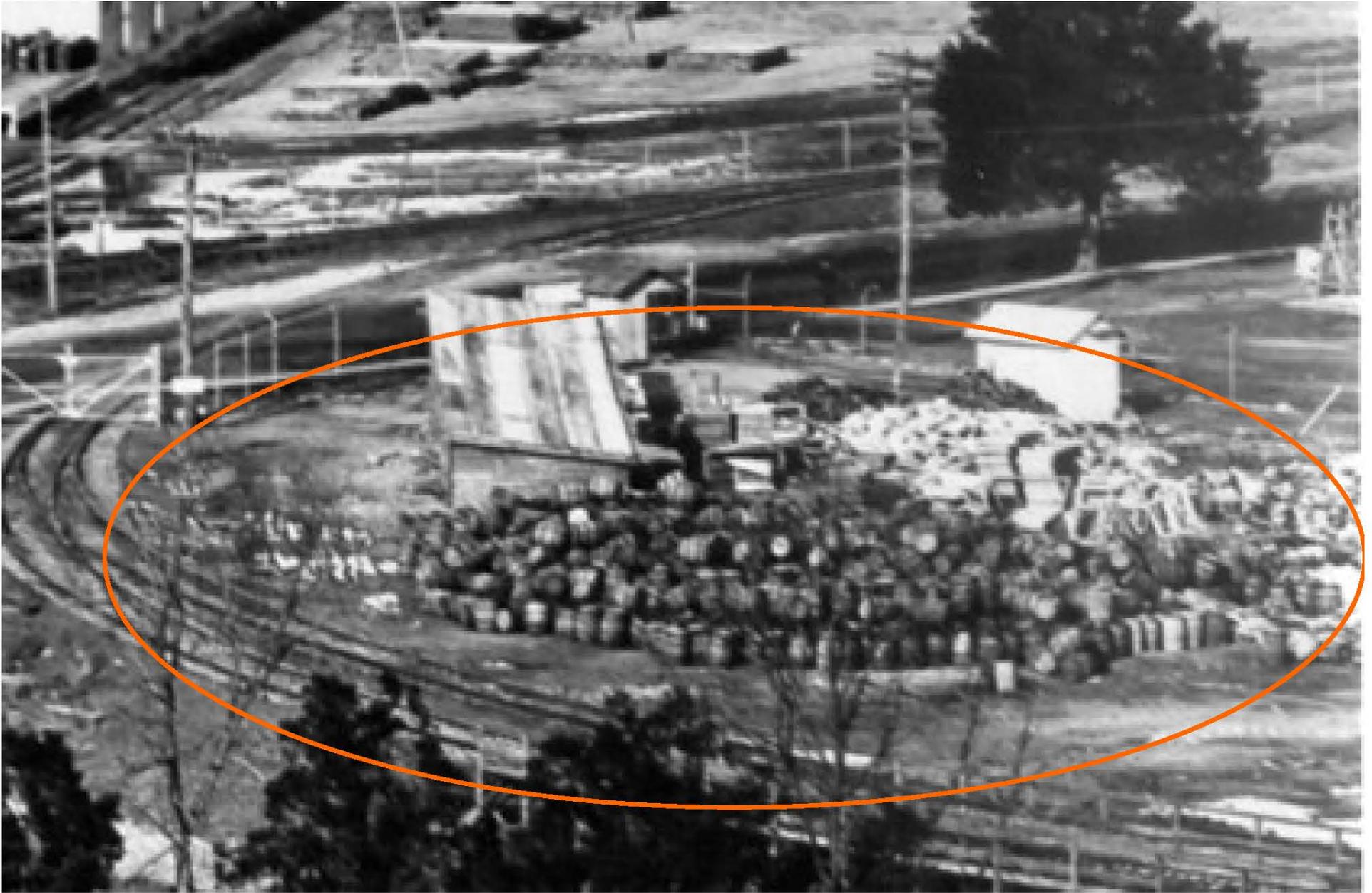


Figure 6  
 AOC 6 1918 Drum Storage Area Subarea; Site Map  
 AOC 6 1918 Drum Storage Area Subarea  
 No Action Consensus Letter  
 Cheatham Annex  
 Williamsburg, Virginia

**Photograph 1**

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Photograph 1 - Drum Storage Area

## Appendix A

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Cheatham Annex  
CAA06  
Loaded Groundwater Raw Analytical Results  
November 2008

Station ID	CAA06-DW09	CAA06-DW10		CAA06-DW11
Sample ID	CAA06-DW09-1108	CAA06-DW10-1108	CAA06-DW10P1108	CAA06-DW11-1108
Sample Date	11/11/08	11/11/08	11/11/08	11/11/08
Chemical Name				
<b>Semivolatile Organic Compounds (UG/L)</b>				
1,1-Biphenyl	9 U	9 U	9 U	9 U
2,2'-Oxybis(1-chloropropane)	9 U	9 U	9 U	9 U
2,4,5-Trichlorophenol	24 U	24 U	24 U	24 U
2,4,6-Trichlorophenol	9 U	9 U	9 U	9 U
2,4-Dichlorophenol	9 U	9 U	9 U	9 U
2,4-Dimethylphenol	9 U	9 U	9 U	9 U
2,4-Dinitrophenol	24 U	24 U	24 U	24 U
2,4-Dinitrotoluene	0.2 U	0.2 U	0.2 U	0.2 U
2,6-Dinitrotoluene	0.2 U	0.2 U	0.2 U	0.2 U
2-Chloronaphthalene	9 U	9 U	9 U	9 U
2-Chlorophenol	9 U	9 U	9 U	9 U
2-Methylnaphthalene	9 U	9 U	9 U	9 U
2-Methylphenol	9 U	9 U	9 U	9 U
2-Nitroaniline	24 U	24 U	24 U	24 U
2-Nitrophenol	9 U	9 U	9 U	9 U
3,3'-Dichlorobenzidine	9 U	9 U	9 U	9 U
3-Nitroaniline	24 U	24 U	24 U	24 U
4,6-Dinitro-2-methylphenol	24 U	24 U	24 U	24 U
4-Bromophenyl-phenylether	9 U	9 U	9 U	9 U
4-Chloro-3-methylphenol	9 U	9 U	9 U	9 U
4-Chloroaniline	9 U	9 U	9 U	9 U
4-Chlorophenyl-phenylether	9 U	9 U	9 U	9 U
4-Methylphenol	9 U	9 U	9 U	9 U
4-Nitroaniline	24 U	24 U	24 U	24 U
4-Nitrophenol	24 R	24 R	24 R	24 R
Acenaphthene	9 U	9 U	9 U	9 U
Acenaphthylene	9 U	9 U	9 U	9 U
Acetophenone	9 U	9 U	9 U	9 U
Anthracene	9 U	9 U	9 U	9 U
Atrazine	9 U	9 U	9 U	9 U
Benzaldehyde	9 U	9 U	9 U	9 U
Benzo(a)anthracene	9 U	9 U	9 U	9 U
Benzo(a)pyrene	9 U	9 U	9 U	9 U
Benzo(b)fluoranthene	9 U	9 U	9 U	9 U
Benzo(g,h,i)perylene	9 U	9 U	9 U	9 U
Benzo(k)fluoranthene	9 U	9 U	9 U	9 U
bis(2-Chloroethoxy)methane	9 U	9 U	9 U	9 U
bis(2-Chloroethyl)ether	9 U	9 U	9 U	9 U
bis(2-Ethylhexyl)phthalate	9 U	9 U	9 U	9 U
Butylbenzylphthalate	9 U	9 U	9 U	9 U
Caprolactam	9 U	9 U	9 U	9 U
Carbazole	9 U	9 U	9 U	9 U
Chrysene	9 U	9 U	9 U	9 U
Dibenz(a,h)anthracene	9 U	9 U	9 U	9 U
Dibenzofuran	9 U	9 U	9 U	9 U
Diethylphthalate	9 U	9 U	9 U	9 U
Dimethyl phthalate	9 U	9 U	9 U	9 U
Di-n-butylphthalate	9 U	9 U	9 U	9 U
Di-n-octylphthalate	9 U	9 U	9 U	9 U
Fluoranthene	9 U	9 U	9 U	9 U
Fluorene	9 U	9 U	9 U	9 U

Cheatham Annex  
CAA06  
Loaded Groundwater Raw Analytical Results  
November 2008

Station ID	CAA06-DW09	CAA06-DW10		CAA06-DW11
Sample ID	CAA06-DW09-1108	CAA06-DW10-1108	CAA06-DW10P1108	CAA06-DW11-1108
Sample Date	11/11/08	11/11/08	11/11/08	11/11/08
Chemical Name				
Hexachlorobenzene	9 U	9 U	9 U	9 U
Hexachlorobutadiene	9 U	9 U	9 U	9 U
Hexachlorocyclopentadiene	9 U	9 U	9 U	9 U
Hexachloroethane	9 U	9 U	9 U	9 U
Indeno(1,2,3-cd)pyrene	9 U	9 U	9 U	9 U
Isophorone	9 U	9 U	9 U	9 U
Naphthalene	9 U	9 U	9 U	9 U
n-Nitroso-di-n-propylamine	9 U	9 U	9 U	9 U
n-Nitrosodiphenylamine	9 U	9 U	9 U	9 U
Nitrobenzene	0.2 U	0.2 U	0.2 U	0.2 U
Pentachlorophenol	24 U	24 U	24 U	24 U
Phenanthrene	9 U	9 U	9 U	9 U
Phenol	9 U	9 U	9 U	9 U
Pyrene	9 U	9 U	9 U	9 U
Explosives (UG/L)				
1,3,5-Trinitrobenzene	0.2 U	0.2 U	0.2 U	0.2 U
1,3-Dinitrobenzene	0.2 U	0.2 U	0.2 U	0.2 U
2,4,6-Trinitrotoluene	0.2 U	0.2 U	0.2 U	0.2 U
2-Amino-4,6-dinitrotoluene	0.2 U	0.2 U	0.2 U	0.2 U
2-Nitrotoluene	0.4 U	0.4 U	0.4 U	0.4 U
3,5-Dinitroaniline	0.2 U	0.2 U	0.2 U	0.2 U
3-Nitrotoluene	0.4 U	0.4 U	0.4 U	0.4 U
4-Amino-2,6-dinitrotoluene	0.2 U	0.2 U	0.2 U	0.2 U
4-Nitrotoluene	0.4 U	0.4 U	0.4 U	0.4 U
HMX	0.4 U	0.4 U	0.4 U	0.4 U
Nitroglycerin	1,000 U	1,000 U	1,000 U	1,000 U
Nitroguanidine	10 U	10 U	10 U	10 U
PETN	1 U	1 U	1 U	1 U
RDX	0.4 U	0.4 U	0.4 U	0.4 U
Tetryl	0.4 U	0.4 U	0.4 U	0.4 U
Total Metals (UG/L)				
Aluminum	57,600	14,600 J	1,810 J	12,100
Antimony	8.8 J	3.8 J	60 U	3.6 J
Arsenic	134	53.1 J	11.4 J	24.6
Barium	208	87.1 J	48.7 J	68.5 J
Beryllium	4.1 J	1 J	0.18 J	0.8 J
Cadmium	5	1.4 J	0.18 J	0.57 J
Calcium	661,000	278,000	165,000	357,000
Chromium	250	59	7.2 J	84.8
Cobalt	23.3 J	7 J	1 J	6 J
Copper	60.2	23.1 J	9.8 J	26
Cyanide	10 U	10 U	10 U	10 U
Iron	116,000	32,100 J	5,090 J	27,800
Lead	50.1	14.6	2.5 J	11.9
Magnesium	20,700	6,770	2,840 J	5,510
Manganese	424	109 J	23.5 J	123
Mercury	0.04 L	0.2 UL	0.2 UL	0.2 UL
Nickel	86.7	26.5 J	4.7 J	43.9
Potassium	23,000	9,220	4,410 J	5,660
Selenium	5.8 J	5.5 J	35 U	35 U
Silver	10 U	10 U	10 U	10 U

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CAA06  
Loaded Groundwater Raw Analytical Results  
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Station ID	CAA06-DW09	CAA06-DW10		CAA06-DW11
Sample ID	CAA06-DW09-1108	CAA06-DW10-1108	CAA06-DW10P1108	CAA06-DW11-1108
Sample Date	11/11/08	11/11/08	11/11/08	11/11/08
Chemical Name				
Sodium	24,200	14,200	12,400	7,330
Thallium	2.1 J	25 U	1.7 J	2.2 J
Vanadium	325	85.5	9.6 J	52
Zinc	227	60.7	10.3 J	60.2
Dissolved Metals (UG/L)				
Aluminum, Dissolved	385	227	242	250
Antimony, Dissolved	60 U	60 U	60 U	60 U
Arsenic, Dissolved	4.6 B	4.5 B	3.6 B	3.3 B
Barium, Dissolved	50 J	46.5 J	46.4 J	31.1 J
Beryllium, Dissolved	5 U	5 U	5 U	5 U
Cadmium, Dissolved	5 U	0.09 B	5 U	0.07 B
Calcium, Dissolved	192,000	166,000	166,000	142,000
Chromium, Dissolved	0.95 J	10 U	10 U	0.58 B
Cobalt, Dissolved	0.92 B	0.66 B	0.7 B	0.56 B
Copper, Dissolved	1.3 J	1.4 J	1.2 J	1.2 J
Iron, Dissolved	336	39.6 B	18.2 B	502
Lead, Dissolved	2.2 J	2.4 J	1.2 J	1.3 J
Magnesium, Dissolved	3,010 J	2,460 J	2,430 J	1,580 J
Manganese, Dissolved	30.5	23.3	24.1	17.7
Mercury, Dissolved	0.2 UL	0.2 UL	0.2 UL	0.2 UL
Nickel, Dissolved	7.1 J	5.8 J	6.1 J	6.1 J
Potassium, Dissolved	2,950 J	3,770 J	3,780 J	912 J
Selenium, Dissolved	35 U	35 U	35 U	35 U
Silver, Dissolved	10 U	10 U	10 U	10 U
Sodium, Dissolved	21,600	13,300	13,300	5,860
Thallium, Dissolved	2 J	25 U	25 U	25 U
Vanadium, Dissolved	0.9 J	50 U	50 U	50 U
Zinc, Dissolved	3.2 J	3 J	2.9 J	4 J

**Notes:**

Shading indicates detections

B - Analyte not detected above the level reported in blanks

J - Analyte present, value may or may not be accurate or precise

L - Analyte present, value may be biased low, actual value may be higher

R - Unreliable Result

U - The material was analyzed for, but not detected

UL - Analyte not detected, quantitation limit is probably higher

UG/L - Micrograms per liter

Cheatham Annex  
CAA06  
Loaded Subsurface Soil Raw Analytical Results  
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Station ID	CAA06-SO14	CAA06-SO15	CAA06-SO16	CAA06-SO17	CAA06-SO18	CAA06-SO19	
Sample ID	CAA06-SB14-1108	CAA06-SB15-1108	CAA06-SB16-1108	CAA06-SB17-1108	CAA06-SB18-1108	CAA06-SB19-1108	CAA06-SB19P-1108
Sample Date	11/11/08	11/11/08	11/11/08	11/11/08	11/11/08	11/11/08	11/11/08
Chemical Name							
<b>Semivolatile Organic Compounds (UG/KG)</b>							
1,1-Biphenyl	380 U	370 U	380 R	360 U	350 U	360 U	350 U
2,2'-Oxybis(1-chloropropane)	380 U	370 U	380 R	360 U	350 U	360 U	350 U
2,4,5-Trichlorophenol	960 U	940 U	950 R	920 U	880 R	900 U	890 U
2,4,6-Trichlorophenol	380 U	370 U	380 R	360 U	350 R	360 U	350 U
2,4-Dichlorophenol	380 U	370 U	380 R	360 U	350 R	360 U	350 U
2,4-Dimethylphenol	380 U	370 U	380 R	360 U	350 R	360 U	350 U
2,4-Dinitrophenol	960 U	940 U	950 R	920 U	880 R	900 U	890 U
2,4-Dinitrotoluene	100 U	100 U	99 U	100 U	100 U	100 U	100 U
2,6-Dinitrotoluene	380 U	370 U	99 UL	360 U	350 U	360 U	350 U
2-Chloronaphthalene	380 U	370 U	380 R	360 U	350 U	360 U	350 U
2-Chlorophenol	380 U	370 U	380 R	360 U	350 R	360 U	350 U
2-Methylnaphthalene	380 U	370 U	380 R	360 U	350 U	360 U	350 U
2-Methylphenol	380 U	370 U	380 R	360 U	350 R	360 U	350 U
2-Nitroaniline	960 U	940 U	950 R	920 U	880 U	900 U	890 U
2-Nitrophenol	380 U	370 U	380 R	360 U	350 R	360 U	350 U
3,3'-Dichlorobenzidine	380 U	370 U	380 R	360 U	350 U	360 U	350 U
3-Nitroaniline	960 U	940 U	950 R	920 U	880 U	900 U	890 U
4,6-Dinitro-2-methylphenol	960 U	940 U	950 R	920 U	880 R	900 U	890 U
4-Bromophenyl-phenylether	380 U	370 U	380 R	360 U	350 U	360 U	350 U
4-Chloro-3-methylphenol	380 U	370 U	380 R	360 U	350 R	360 U	350 U
4-Chloroaniline	380 U	370 U	380 R	360 U	350 U	360 U	350 U
4-Chlorophenyl-phenylether	380 U	370 U	380 R	360 U	350 U	360 U	350 U
4-Methylphenol	380 U	370 U	380 R	360 U	350 R	360 U	350 U
4-Nitroaniline	960 U	940 U	950 R	920 U	880 U	900 U	890 U
4-Nitrophenol	960 U	940 U	950 R	920 U	880 R	900 U	890 U
Acenaphthene	380 U	370 U	380 R	360 U	350 U	360 U	350 U
Acenaphthylene	380 U	370 U	380 R	360 U	350 U	360 U	350 U
Acetophenone	380 U	370 U	380 R	360 U	350 U	360 U	350 U
Anthracene	380 U	370 U	380 R	360 U	350 U	360 U	350 U
Atrazine	380 U	370 U	380 R	360 U	350 U	360 U	350 U
Benzaldehyde	380 U	370 U	380 R	360 U	350 U	360 U	350 U
Benzo(a)anthracene	380 U	370 U	380 R	360 U	350 U	360 U	350 U
Benzo(a)pyrene	380 U	370 U	380 R	360 U	350 U	360 U	350 U
Benzo(b)fluoranthene	380 U	370 U	380 R	360 U	350 U	360 U	350 U
Benzo(g,h,i)perylene	380 U	370 U	380 R	360 U	350 U	360 U	350 U
Benzo(k)fluoranthene	380 U	370 U	380 R	360 U	350 U	360 U	350 U
bis(2-Chloroethoxy)methane	380 U	370 U	380 R	360 U	350 U	360 U	350 U
bis(2-Chloroethyl)ether	380 U	370 U	380 R	360 U	350 U	360 U	350 U
bis(2-Ethylhexyl)phthalate	380 U	370 U	380 R	360 U	350 U	360 U	350 U
Butylbenzylphthalate	380 U	370 U	380 R	360 U	350 U	360 U	350 U
Caprolactam	380 U	370 U	380 R	360 U	350 U	360 U	350 U
Carbazole	380 U	370 U	380 R	360 U	350 U	360 U	350 U

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CAA06  
Loaded Subsurface Soil Raw Analytical Results  
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Station ID	CAA06-SO14	CAA06-SO15	CAA06-SO16	CAA06-SO17	CAA06-SO18	CAA06-SO19	
Sample ID	CAA06-SB14-1108	CAA06-SB15-1108	CAA06-SB16-1108	CAA06-SB17-1108	CAA06-SB18-1108	CAA06-SB19-1108	CAA06-SB19P-1108
Sample Date	11/11/08	11/11/08	11/11/08	11/11/08	11/11/08	11/11/08	11/11/08
<b>Chemical Name</b>							
Chrysene	380 U	370 U	380 R	360 U	350 U	360 U	350 U
Dibenz(a,h)anthracene	380 U	370 U	380 R	360 U	350 U	360 U	350 U
Dibenzofuran	380 U	370 U	380 R	360 U	350 U	360 U	350 U
Diethylphthalate	380 U	370 U	380 R	360 U	350 U	360 U	350 U
Dimethyl phthalate	380 U	370 U	380 R	360 U	350 U	360 U	350 U
Di-n-butylphthalate	380 U	370 U	380 R	360 U	350 U	360 U	350 U
Di-n-octylphthalate	380 UJ	370 U	380 R	360 U	350 U	360 U	350 U
Fluoranthene	380 U	370 U	380 R	360 U	350 U	360 U	350 U
Fluorene	380 U	370 U	380 R	360 U	350 U	360 U	350 U
Hexachlorobenzene	380 U	370 U	380 R	360 U	350 U	360 U	350 U
Hexachlorobutadiene	380 U	370 U	380 R	360 U	350 U	360 U	350 U
Hexachlorocyclopentadiene	380 U	370 U	380 R	360 U	350 U	360 U	350 U
Hexachloroethane	380 U	370 U	380 R	360 U	350 U	360 U	350 U
Indeno(1,2,3-cd)pyrene	380 U	370 U	380 R	360 U	350 U	360 U	350 U
Isophorone	380 U	370 U	380 R	360 U	350 U	360 U	350 U
Naphthalene	380 U	370 U	380 R	360 U	350 U	360 U	350 U
n-Nitroso-di-n-propylamine	380 U	370 U	380 R	360 U	350 U	360 U	350 U
n-Nitrosodiphenylamine	380 U	370 U	380 R	360 U	350 U	360 U	350 U
Nitrobenzene	100 U	100 U	99 U	100 U	100 U	100 U	100 U
Pentachlorophenol	960 U	940 U	950 R	920 U	880 R	900 U	890 U
Phenanthrene	380 U	370 U	380 R	360 U	350 U	360 U	350 U
Phenol	380 U	370 U	380 R	360 U	350 R	360 U	350 U
Pyrene	380 U	370 U	380 R	360 U	350 U	360 U	350 U
<b>Explosives (UG/KG)</b>							
1,3,5-Trinitrobenzene	100 U	100 U	99 U	100 U	100 U	100 U	100 U
1,3-Dinitrobenzene	100 U	100 U	99 U	100 U	100 U	100 U	100 U
2,4,6-Trinitrotoluene	100 U	100 U	99 U	100 U	100 U	100 U	100 U
2-Amino-4,6-dinitrotoluene	100 U	100 U	99 U	100 U	100 U	100 U	100 U
2-Nitrotoluene	200 U						
3,5-Dinitroaniline	100 U	100 U	99 U	100 U	100 U	100 U	100 U
3-Nitrotoluene	200 U						
4-Amino-2,6-dinitrotoluene	100 U	100 U	99 U	100 U	100 U	100 U	100 U
4-Nitrotoluene	200 U						
HMX	200 U						
Nitroglycerin	5,000 U						
Nitroguanidine	130 U	120 U	130 U	120 U	130 U	120 U	130 U
PETN	500 U						
RDX	200 U						
Tetryl	200 U						
<b>Total Metals (MG/KG)</b>							
Aluminum	9,530	12,700	13,200	12,700	5,770	11,200	11,100
Antimony	0.1 L	0.16 L	0.16 L	0.16 L	4.9 UL	0.08 L	0.11 L



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CAA06  
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Station ID	CAA06-SO14	CAA06-SO15	CAA06-SO16	CAA06-SO17	CAA06-SO18	CAA06-SO19	
Sample ID	CAA06-SS14-1108	CAA06-SS15-1108	CAA06-SS16-1108	CAA06-SS17-1108	CAA06-SS18-1108	CAA06-SS19-1108	CAA06-SS19P-1108
Sample Date	11/11/08	11/11/08	11/11/08	11/11/08	11/11/08	11/11/08	11/11/08
Chemical Name							
<b>Semivolatile Organic Compounds (UG/KG)</b>							
1,1-Biphenyl	420 U	380 U	380 U	390 R	360 R	370 U	370 U
2,2'-Oxybis(1-chloropropane)	420 U	380 U	380 U	390 R	360 R	370 U	370 U
2,4,5-Trichlorophenol	1,000 U	960 U	950 U	990 R	910 R	940 U	930 U
2,4,6-Trichlorophenol	420 U	380 U	380 U	390 R	360 R	370 U	370 U
2,4-Dichlorophenol	420 U	380 U	380 U	390 R	360 R	370 U	370 U
2,4-Dimethylphenol	420 U	380 U	380 U	390 R	360 R	370 U	370 U
2,4-Dinitrophenol	1,000 U	960 U	950 U	990 R	910 R	940 U	930 U
2,4-Dinitrotoluene	99 U	100 U	100 U	100 U	100 U	100 U	100 U
2,6-Dinitrotoluene	420 U	380 U	380 U	100 UL	100 UL	370 U	370 U
2-Chloronaphthalene	420 U	380 U	380 U	390 R	360 R	370 U	370 U
2-Chlorophenol	420 U	380 U	380 U	390 R	360 R	370 U	370 U
2-Methylnaphthalene	420 U	380 U	380 U	390 R	360 R	370 U	370 U
2-Methylphenol	420 U	380 U	380 U	390 R	360 R	370 U	370 U
2-Nitroaniline	1,000 U	960 U	950 U	990 R	910 R	940 U	930 U
2-Nitrophenol	420 U	380 U	380 U	390 R	360 R	370 U	370 U
3,3'-Dichlorobenzidine	420 U	380 U	380 U	390 R	360 R	370 U	370 U
3-Nitroaniline	1,000 U	960 U	950 U	990 R	910 R	940 U	930 U
4,6-Dinitro-2-methylphenol	1,000 U	960 U	950 U	990 R	910 R	940 U	930 U
4-Bromophenyl-phenylether	420 U	380 U	380 U	390 R	360 R	370 U	370 U
4-Chloro-3-methylphenol	420 U	380 U	380 U	390 R	360 R	370 U	370 U
4-Chloroaniline	420 U	380 U	380 U	390 R	360 R	370 U	370 U
4-Chlorophenyl-phenylether	420 U	380 U	380 U	390 R	360 R	370 U	370 U
4-Methylphenol	420 U	380 U	380 U	390 R	360 R	370 U	370 U
4-Nitroaniline	1,000 U	960 U	950 U	990 R	910 R	940 U	930 U
4-Nitrophenol	1,000 U	960 U	950 U	990 R	910 R	940 U	930 U
Acenaphthene	420 U	380 U	380 U	390 R	360 R	370 U	370 U
Acenaphthylene	420 U	380 U	380 U	390 R	360 R	370 U	370 U
Acetophenone	420 U	380 U	380 U	390 R	360 R	370 U	370 U
Anthracene	420 U	380 U	380 U	390 R	360 R	370 U	370 U
Atrazine	420 U	380 U	380 U	390 R	360 R	370 U	370 U
Benzaldehyde	420 U	380 U	380 U	390 R	360 R	370 U	370 U
Benzo(a)anthracene	420 U	380 U	380 U	390 R	360 R	370 U	370 U
Benzo(a)pyrene	420 U	380 U	380 U	390 R	360 R	370 U	370 U
Benzo(b)fluoranthene	420 U	380 U	380 U	390 R	360 R	370 U	370 U
Benzo(g,h,i)perylene	420 U	380 U	380 U	390 R	360 R	370 U	370 U
Benzo(k)fluoranthene	420 U	380 U	380 U	390 R	360 R	370 U	370 U
bis(2-Chloroethoxy)methane	420 U	380 U	380 U	390 R	360 R	370 U	370 U
bis(2-Chloroethyl)ether	420 U	380 U	380 U	390 R	360 R	370 U	370 U
bis(2-Ethylhexyl)phthalate	420 U	380 U	380 U	390 R	360 R	370 U	370 U
Butylbenzylphthalate	420 U	380 U	380 U	390 R	360 R	370 U	370 U
Caprolactam	420 U	380 U	380 U	390 R	360 R	370 U	370 U
Carbazole	420 U	380 U	380 U	390 R	360 R	370 U	370 U
Chrysene	420 U	380 U	380 U	390 R	360 R	370 U	370 U

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CAA06  
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Station ID	CAA06-SO14	CAA06-SO15	CAA06-SO16	CAA06-SO17	CAA06-SO18	CAA06-SO19	
Sample ID	CAA06-SS14-1108	CAA06-SS15-1108	CAA06-SS16-1108	CAA06-SS17-1108	CAA06-SS18-1108	CAA06-SS19-1108	CAA06-SS19P-1108
Sample Date	11/11/08	11/11/08	11/11/08	11/11/08	11/11/08	11/11/08	11/11/08
Chemical Name							
Dibenz(a,h)anthracene	420 U	380 U	380 U	390 R	360 R	370 U	370 U
Dibenzofuran	420 U	380 U	380 U	390 R	360 R	370 U	370 U
Diethylphthalate	420 U	380 U	380 U	390 R	360 R	370 U	370 U
Dimethyl phthalate	420 U	380 U	380 U	390 R	360 R	370 U	370 U
Di-n-butylphthalate	420 U	380 U	380 U	390 R	360 R	370 U	370 U
Di-n-octylphthalate	420 UJ	380 U	380 U	390 R	360 R	370 U	370 U
Fluoranthene	420 U	380 U	380 U	390 R	360 R	370 U	370 U
Fluorene	420 U	380 U	380 U	390 R	360 R	370 U	370 U
Hexachlorobenzene	420 U	380 U	380 U	390 R	360 R	370 U	370 U
Hexachlorobutadiene	420 U	380 U	380 U	390 R	360 R	370 U	370 U
Hexachlorocyclopentadiene	420 U	380 U	380 U	390 R	360 R	370 U	370 U
Hexachloroethane	420 U	380 U	380 U	390 R	360 R	370 U	370 U
Indeno(1,2,3-cd)pyrene	420 U	380 U	380 U	390 R	360 R	370 U	370 U
Isophorone	420 U	380 U	380 U	390 R	360 R	370 U	370 U
Naphthalene	420 U	380 U	380 U	390 R	360 R	370 U	370 U
n-Nitroso-di-n-propylamine	420 U	380 U	380 U	390 R	360 R	370 U	370 U
n-Nitrosodiphenylamine	420 U	380 U	380 U	390 R	360 R	370 U	370 U
Nitrobenzene	99 U	100 U	100 U	100 U	100 U	100 U	100 U
Pentachlorophenol	1,000 U	960 U	950 U	990 R	910 R	940 U	930 U
Phenanthrene	420 U	380 U	380 U	390 R	360 R	370 U	370 U
Phenol	420 U	380 U	380 U	390 R	360 R	370 U	370 U
Pyrene	420 U	380 U	380 U	390 R	360 R	370 U	370 U
<b>Explosives (UG/KG)</b>							
1,3,5-Trinitrobenzene	99 U	100 U	100 U	100 U	100 U	100 U	100 U
1,3-Dinitrobenzene	99 U	100 U	100 U	100 U	100 U	100 U	100 U
2,4,6-Trinitrotoluene	99 U	100 U	100 U	100 U	100 U	100 U	100 U
2-Amino-4,6-dinitrotoluene	99 U	100 U	100 U	100 U	100 U	100 U	100 U
2-Nitrotoluene	200 U	200 UL	200 U				
3,5-Dinitroaniline	99 U	100 U	100 U	100 U	100 U	100 U	100 U
3-Nitrotoluene	200 U						
4-Amino-2,6-dinitrotoluene	99 U	100 U	100 U	100 U	100 U	100 U	100 U
4-Nitrotoluene	200 U						
HMX	200 U						
Nitroglycerin	5,000 U						
Nitroguanidine	130 U	120 U	130 U	130 U	130 U	130 U	120 U
PETN	500 U						
RDX	200 U						
Tetryl	200 U						
<b>Total Metals (MG/KG)</b>							
Aluminum	7,560	8,530	8,710	7,850	5,040	10,300	12,800
Antimony	0.11 L	0.5 L	0.07 L	0.05 L	4.5 UL	5.1 UL	5.1 UL
Arsenic	3.1	3	4.4	2.4	2.6	4.1	4.9
Barium	31	35.4	32.2	28	45.8	32	37.7

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Station ID	CAA06-SO14	CAA06-SO15	CAA06-SO16	CAA06-SO17	CAA06-SO18	CAA06-SO19	
Sample ID	CAA06-SS14-1108	CAA06-SS15-1108	CAA06-SS16-1108	CAA06-SS17-1108	CAA06-SS18-1108	CAA06-SS19-1108	CAA06-SS19P-1108
Sample Date	11/11/08	11/11/08	11/11/08	11/11/08	11/11/08	11/11/08	11/11/08
Chemical Name							
Beryllium	0.53	0.35 J	0.42	0.34	0.28 J	0.36 J	0.42 J
Cadmium	0.07 J	0.16 J	0.07 J	0.04 J	0.17 J	0.02 J	0.42 U
Calcium	1,230	1,760	8,080	712	560	481	706
Chromium	9.9	12.3	13.8	10.3	6.3	15	16.7
Cobalt	1.6 J	1.7 J	2 J	1.4 J	1.1 J	1.5 J	1.9 J
Copper	5.4	8.2	4.4	4.2	5.1	7.1	6.5
Cyanide	0.6 U	0.55 U	0.55 U	0.55 U	0.5 U	0.55 U	0.55 U
Iron	7,740	6,860	11,000	6,450	5,440	9,450	10,500
Lead	57.6	128	27.2	23.3	67.4	34.9	40.2
Magnesium	910	1,070	1,060	646	410	812	942
Manganese	95.1	82.9	66.9	58.7	71.2	33.4	55.9
Mercury	0.06 J	0.06 J	0.12 U	0.12 U	0.1 U	0.06 J	0.06 J
Nickel	3.9	3.9	5.9	3.6	2.9 J	4.3	4.8
Potassium	646	575	819	492	356 J	790	867
Selenium	3.1 U	3.4 U	2.7 U	0.31 J	2.6 U	0.35 J	0.37 J
Silver	0.62 J	0.96 U	0.76 U	0.65 U	0.76 U	0.84 U	0.84 U
Sodium	28.5 J	31.4 J	80.5 J	25.5 J	22.6 J	32.4 J	39.7 J
Thallium	0.07 J	2.4 U	0.06 J	1.6 U	1.9 U	2.1 U	2.1 U
Vanadium	15.5	16.3	16.9	14	8.9	20.2	23.4
Zinc	51.3	66.2	31.1	22.2	102	23.9	24.1
Wet Chemistry							
% Solids (pct)	79	86	88	84	91	88	89
pH (pH units)	6	6.2	8.4	5.8	6.4	5	NA
Total organic carbon (TOC) (ug/g)	23,000	20,000	8,700	23,000	11,000	22,000	NA

C:\Users\kmalley\Documents\Work\Graycochea\_Kathleen\05\_MAY\May 15 - Consensus Letter\Appendix A\Raw Surface Soil Analytical Data.xls], jdean6, 04/23/2013

**Notes:**

Shading indicates detections

J - Analyte present, value may or may not be accurate or precise

L - Analyte present, value may be biased low, actual value may be higher

NA - Not analyzed

R - Unreliable Result

U - The material was analyzed for, but not detected

UJ - Analyte not detected, quantitation limit may be inaccurate

UL - Analyte not detected, quantitation limit is probably higher

MG/KG - Milligrams per kilogram

PCT - Percent

PH - pH units

UG/G - Micrograms per gram

UG/KG - Micrograms per kilogram

## Appendix B

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# Baseline Human Health Risk Assessment

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## B.1 Introduction

This attachment presents the baseline human health risk assessment (HHRA) for groundwater at Area of Concern (AOC) 6 1918 Drum Storage Area (DSA) subarea, Naval Weapons Station Yorktown Cheatham Annex (CAX). The HHRA was conducted to assess the nature, magnitude, and probability of potential harm to public health posed by exposure to site-related constituents in groundwater at AOC 6. The analytical data evaluated in the HHRA are presented in **Appendix A**. The Site Inspection report, AOCs 1, 2, 6, 7, and 8 (CH2M HILL, 2012) concluded that exposure to surface and subsurface soil at the 1918 DSA subarea would not be expected to result in any unacceptable human health risks; therefore, soil was eliminated from further evaluation and was not included in this baseline HHRA.

The HHRA incorporates the general methodology described in the following United States Environmental Protection Agency (USEPA) documents:

- Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual, Part A (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 3 Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening (USEPA, 1993)

The HHRA consists of the following components:

- Identification of chemicals of potential concern (COPCs)
- Exposure Assessment
- Toxicity Assessment
- Risk Characterization
- Uncertainty Assessment

These components are described in the following sections. Spreadsheets for the 1918 DSA subarea were prepared in accordance with *Risk Assessment Guidance for Superfund (RAGS), Volume 1, Human Health Evaluation Manual, Part D* (USEPA, 2001) to screen for COPCs and to calculate risks estimates associated with the COPCs. These spreadsheets are presented in **Attachment 1**. **Table 1** in **Attachment 1** presents the selection of exposure pathways for the 1918 DSA subarea.

## B.2 Identification of Chemicals of Potential Concern

The identification of COPCs includes data collection, data evaluation, and data screening steps. The data collection and evaluation steps involve gathering and reviewing the available site data and identifying a set of data 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 reduce the data set to those COPCs.

### Data Evaluation and Selection

Three groundwater samples identified in **Table B-1** were collected via temporary wells using direct-push sampling technology during the 1998 field investigation at AOC 6. The samples were analyzed for semivolatile organic compounds (SVOCs), explosives, unfiltered (total) metals, and filtered (dissolved) metals. No SVOCs or explosives were detected in the groundwater samples. Total and dissolved metals were detected in all of the samples.

All of the data used in the risk assessment have been fully validated and are assumed to represent current conditions. In accordance with the USEPA Region 3 *Draft Guidance on the Selection of Analytical Metal Results from Monitoring Well Samples for Use in the Quantitative Assessment of Risk* (USEPA, 1992), filtered groundwater samples were used to determine inorganic constituent exposure concentrations for the residential scenarios because a review of the groundwater data determined a significant difference (an order of magnitude or greater) between the filtered and total results within each sample. Unfiltered groundwater samples were used to determine inorganic constituent exposure concentrations for the construction worker scenario, as a construction worker would directly contact the groundwater in an excavation.

The groundwater data were evaluated to determine their reliability for use in the quantitative risk assessments. A review of the data and past discussions with USEPA and the Department of the 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.
- Data qualified with an R (rejected) were not used in the risk assessment.
- Data qualified with a B (blank contamination) were used in the risk assessment as if the results were non-detects, with the blank-related concentrations of each constituent used as the sample detection limit.
- For duplicate samples, the maximum concentration between the primary and duplicate sample was used as the sample concentration.

## Selection of Chemicals of Potential Concern

All of the detected constituents were screened following the procedures described in the following paragraphs. The selection of COPCs was based on the criteria presented in the USEPA Region 3 technical guidance manual (USEPA, 1993) and *Risk Assessment Guidance for Superfund (RAGS), Volume 1, Human Health Evaluation Manual, Part D* (USEPA, 2001).

The maximum detected concentration of each constituent in groundwater was compared to the USEPA tap water Regional Screening Level (RSL) (USEPA, 2012). RSLs that are based on noncarcinogenic effects were divided by 10 to account for exposure to multiple constituents that may affect the same target organ. RSLs based on carcinogenic effects were used as presented in the RSL table and are based on a carcinogenic risk of  $10^{-6}$ . Lead concentrations in groundwater were compared to the Safe Drinking Water Act (SDWA) action level of 15 micrograms per liter ( $\mu\text{g/L}$ ) (USEPA, 2009). 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. Groundwater SDWA Maximum Contaminant Levels (MCLs) and CAX basewide background values from the Yorktown-Eastover aquifer are also included on the screening tables (**Attachment 1, Tables 2.1 and 2.2**); however, these values were not used to identify the COPCs.

- Constituents that are considered essential nutrients, are present at low concentrations, and are toxic only at very high doses were eliminated from the quantitative risk analysis. These constituents are calcium, magnesium, potassium, and sodium. Although iron and manganese are also considered essential nutrients and are only toxic at very high doses, iron and manganese were included in the HHRA because toxicity values are available for these two nutrients.

The COPC screening is performed in **Attachment 1, Tables 2.1 and 2.2**. **Table B-2** summarizes the constituents that were selected as COPCs from filtered and total groundwater from the 1918 DSA subarea.

## B.3 Exposure Assessment

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 only quantified for complete exposure pathways.

The components of exposure assessment include the following:

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

## Conceptual Site Model

**Figure B-1** presents the conceptual exposure model showing potential human health exposure scenarios for current and potential future site use.

The 1918 DSA subarea was formerly used for the storage of wooden barrels and 55-gallon drums when the Penniman shell loading facility was active. Currently, the area is developed and consists mostly of open maintained grassy areas, a paved parking lot, and two office buildings. Future land use at the 1918 DSA subarea is not expected to change.

Potable water supplies for CAX are provided by the City of Newport News Water Works. Groundwater is not used as a source of water on the base. However, a potable use scenario was evaluated in this risk assessment. It was conservatively assumed if future residential development of the site occurs the residents could use the groundwater as a potable water supply. The residents would be exposed through ingestion and dermal contact while bathing. Additionally, due to the depth to groundwater (less than 10 feet below ground surface), construction workers could be exposed to the groundwater through dermal contact in an excavation during construction activities.

## Calculation of Exposure Point Concentrations

Exposure is quantified by estimating the EPCs of COPCs and constituent intake by the receptor. EPCs are estimated concentrations that a receptor may contact and are specific to each exposure medium. EPCs may be directly monitored or estimated using environmental models. Constituent concentrations in groundwater were measured for this assessment. Volatile organic compounds are not associated with past site use, and therefore were not analyzed for in the groundwater samples; hence the inhalation pathway for groundwater is not considered a significant contribution to potential risks and was not evaluated.

The maximum detected concentration was used as the EPC for all COPCs because only three samples were available for groundwater.

The EPCs for the COPCs are presented in **Attachment 1, Tables 3.1 and 3.2**.

## Exposure Assumptions and Estimation of Chemical Intakes

Chemical intake is the amount of the chemical constituent entering the receptor's body. The media-specific and exposure-scenario-specific intake equations used in this assessment are provided in **Table 4.1.RME** and **4.1.CTE** in **Attachment 1**. The intake equation requires specific exposure parameters for each exposure pathway. Exposure parameters are often assumed values, and the magnitude influences the estimates of potential exposure (and risk). The reliability of the values chosen can also contribute to the uncertainty of the resulting risk estimates. Many of the exposure parameters have default values suggested by the USEPA and Virginia Department of Environmental Quality (VDEQ), which were used for this assessment. These assumptions, based on estimates of body weights, media intake levels, and exposure frequencies and duration, are provided by USEPA and VDEQ guidance (USEPA, 1989; 1991; 1997a; 2004; VDEQ, 2003). Other assumptions (such as exposure time for the construction worker groundwater exposure scenario) required consideration of location-specific information and were determined using professional judgment. The exposure factors used for different scenarios at the site for reasonable maximum exposure (RME) and central tendency exposure (CTE) scenarios are provided in **Attachment 1, Tables 4.1.RME** and **4.1.CTE**. CTE parameters were only provided for scenarios with RME risks above acceptable risk levels.

The dermal exposure model presented in USEPA's dermal exposure assessment guidance (USEPA, 2004) was used to estimate dermal exposure to groundwater. The values for parameters used in this model (that is, the permeability constant) were obtained from this guidance document and are included in **Tables 7.1.RME Supplement A, 7.2.RME Supplement A, and 7.4.RME Supplement A** in **Attachment 1**.

## B.4 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 determining the potential adverse effects from exposure to the chemical along with 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 (such as 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 noncarcinogenic and carcinogenic risks (USEPA, 2003). The hierarchy of toxicity value sources is the following:

1. Integrated Risk Information System (IRIS) (USEPA, 2013)
2. Provisional Peer-Reviewed Toxicity Values
3. Other USEPA and non-USEPA sources, including the National Center for Environmental Assessment, Agency for Toxic Substances and Disease Registry, Health Effects Assessment Summary Tables (USEPA, 1997b), California Environmental Protection Agency, and USEPA's Office of Water

The use in an HHRA of toxicity values from sources other than IRIS increases the uncertainty of the quantitative risk estimates. Some of the COPCs elicit both systemic (noncarcinogenic) toxic effects and cancer (carcinogenic) effects. Because of this, these constituents are evaluated as both noncarcinogens and carcinogens. The health risks for carcinogenic and noncarcinogenic effects were estimated separately based on different toxicity values.

### Toxicity Information for Noncarcinogenic Effects

Noncarcinogenic 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 (that is, not verified by USEPA), were used for the construction worker scenario.

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, and the dose at which no effect is observed is identified as the no observed adverse effect level. Several uncertainty factors (UFs) may be applied 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 1 to 3,000, and are based on professional judgment. Consequently, there are varying degrees of uncertainty in the toxicity criteria.

USEPA-derived oral RfDs, and associated UF and modifying factor values, available for the groundwater COPCs at the 1918 DSA subarea are presented in **Table 5.1 in Attachment 1**. In accordance with USEPA guidance, 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). This adjustment is shown in **Table 5.1** in **Attachment 1**.

## Toxicity Information for Carcinogenic Effects

Potential carcinogenic effects are quantified using CSFs. 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.

USEPA-derived CSFs are presented in **Table 6.1** in **Attachment 1**. As was done for oral RfDs, oral CSFs were adjusted from administered dose (oral) to absorbed dose (dermal) to evaluate dermal toxicity. When appropriate, the CSFs were adjusted using oral absorption factors (USEPA, 2004). This adjustment is shown in **Table 6.1** in **Attachment 1**.

## Approach for Potential Mutagenic Effects

Consistent with the Cancer Guidelines and Supplemental Guidance (USEPA, 2005a; 2005b), cancer risks were estimated using age-dependent adjustment factors (ADAFs) for COPCs that act via a mutagenic mode of action (MMA). Hexavalent chromium (which was used to estimate risks associated with total chromium, as there are no toxicity values for total chromium, and hexavalent chromium is the more toxic form of chromium) is the only COPC that is categorized as a chemical with an MMA.

The calculation of cancer risk using ADAFs is presented in **Tables 7.3.RME** and **7.3.CTE** in **Attachment 1**. As chemical-specific data are not available for hexavalent chromium, default ADAFs, as included in the USEPA Region 3 Memorandum, *Derivation of RBCs for Carcinogens that Act Via a Mutagenic Mode of Action and Incorporate Default ADAFs* (USEPA, 2006), were used for the MMA evaluation. The default ADAFs used to adjust the CSF are 10 for 0 to 2 year olds, 3 for 2 to 6 year olds, 3 for 6 to 12 year olds, and 1 for 16 to 30 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 residents 6 to 16 years old and 16 to 30 years old, with the exception of the exposure durations, which were 10 years and 14 years, respectively.

## Constituents for Which USEPA Toxicity Values Are Not Available

All of the constituents detected in the 1918 DSA subarea groundwater samples, with the exception of lead, have toxicity factors and USEPA RSLs.

Lead, which does not have an RSL or applicable surrogate, is evaluated by USEPA based on blood-lead uptake using a physiologically based pharmacokinetic model called the Integrated Exposure Uptake Biokinetic Model, which is used to evaluate lead exposures to children. As a screening tool, lead in groundwater is screened against the SDWA action level for lead of 15 µg/L based on potable use of groundwater. Lead was not detected in the filtered groundwater samples; however, it was detected in unfiltered groundwater samples, which were used to evaluate the construction worker exposure to groundwater scenario. There are no models available to quantitatively evaluate nonresidential adult exposure to lead in groundwater.

## B.5 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 used as an integral component in remedial decision making and selection of potential remedies or actions, as necessary.

## Methods for Estimating Risks

Potential human health risks are discussed independently for carcinogenic and noncarcinogenic constituents because of the different toxicological endpoints, relevant exposure duration, and methods used to characterize risk. Exposure to some constituents may result in both noncarcinogenic and carcinogenic effects (for example, arsenic), and therefore, these constituents were evaluated in both groups. The methodology used to estimate noncarcinogenic hazards and carcinogenic risks are described as follows.

### Noncarcinogenic Hazard Estimation

Noncarcinogenic 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):

$$\text{HQ} = \text{Intake} / \text{RfD}$$

The intake and RfD represent the same exposure route (that is, oral intakes are divided by oral RfDs). An HQ that exceeds 1 (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, a hazard index (HI) approach is used (USEPA, 1986). This approach assumes that noncarcinogenic hazards associated with exposure to more than one constituent are additive. Synergistic or antagonistic interactions between constituents are not considered. The HI may exceed 1 even if all of the individual HQs are less than 1. 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.

### Carcinogenic Risk Estimation

The potential for carcinogenic effects due to exposure to site-related constituents is evaluated by estimating the excess lifetime carcinogenic risk (ELCR). ELCR is the incremental increase in the probability of developing cancer during one's lifetime in addition to the background probability of developing cancer.

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

$$\text{ELCR} = \text{Intake} \times \text{CSF}$$

The combined risk from exposure to multiple constituents was evaluated by adding the risks from individual constituents. Risks were also 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, 1994), "[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 10,000 (that is,  $10^{-4}$  ELCR), the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) generally requires remedial action to reduce risks at the site.

## Risk Assessment Results

The results of the risk characterization are presented as follows by receptor. A summary of the RME results is presented in **Table B-3**, and the CTE results are summarized in **Table B-4**. The risk calculations are presented in **Tables 7.1.RME** through **7.4.RME**, **7.1.CTE**, and **7.2.CTE** in **Attachment 1**. CTE risks were calculated only when the RME hazards exceeded the noncarcinogenic target HI of 1, or the RME carcinogenic risks exceeded the acceptable risk range of  $1 \times 10^{-6}$  to  $1 \times 10^{-4}$  (USEPA, 1994). **Tables 9.1.RME** through **9.4.RME**, **9.1.CTE**, and **9.2.CTE** in **Attachment 1** summarize the hazards and risks to each receptor. The constituents of concern (COCs) are identified as follows for

each receptor. 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  $1 \times 10^{-6}$  to a cumulative carcinogenic risk that exceeds  $1 \times 10^{-4}$ .

#### **Future Adult Resident (Noncarcinogenic Hazard, Attachment 1, Tables 9.1.RME and 9.1.CTE)**

The risk assessment assumed that a future adult resident could be exposed to filtered groundwater used as a potable water supply through ingestion and dermal contact while bathing. Carcinogenic risks were not calculated for an adult resident; they were calculated for a lifetime child and adult resident following USEPA guidance.

The cumulative RME noncarcinogenic hazard to the adult resident (HI = 6) exceeds the target HI of 1 due primarily to ingestion of dissolved thallium, the only COC identified for groundwater. Dissolved thallium was detected in one of three groundwater samples at a maximum concentration of 2 µg/L, which does not exceed the SDWA MCL of 2 µg/L.

The CTE noncarcinogenic hazard (HI = 3) also exceeds the target HI.

#### **Future Child Resident (Noncarcinogenic Hazard, Attachment 1, Tables 9.2.RME and 9.2.CTE)**

The risk assessment assumed that a future child resident could be exposed to filtered groundwater used as a potable water supply through ingestion and dermal contact while bathing. Carcinogenic risks were not calculated for a child resident; they were calculated for a lifetime child and adult resident in accordance with USEPA guidance.

The cumulative RME noncarcinogenic hazard to the child resident (HI=13) exceeds the target HI of 1 due primarily to ingestion of dissolved thallium, the only COC identified for groundwater. Dissolved thallium was detected in one of three groundwater samples at a maximum concentration of 2 µg/L, which does not exceed the SDWA MCL of 2 µg/L.

The CTE noncarcinogenic hazard (HI = 9) also exceeds the target HI.

#### **Future Lifetime Resident (Carcinogenic Risk, Attachment 1, Tables 9.3.RME)**

The risk assessment assumed that a future lifetime child and adult resident could be exposed to filtered groundwater used as a potable water supply through ingestion and dermal contact while bathing.

The cumulative RME carcinogenic risk to the resident (ELCR =  $3 \times 10^{-5}$ ) does not exceed the target risk range of  $10^{-6}$  to  $10^{-4}$ .

The CTE carcinogenic risk to the resident (ELCR =  $2 \times 10^{-5}$ ) is within the target risk range.

#### **Future Construction Worker (Attachment 1, Tables 9.4.RME and 9.3.CTE)**

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

The cumulative RME noncarcinogenic hazard (HI = 1) does not exceed the target HI of 1.

Lead was identified as a COPC in groundwater since the maximum and mean (when evaluating potential risks associated with exposure to lead, the mean concentration is used as the exposure concentration) lead concentrations exceeded the screening value of 15 µg/L. Since the construction worker would have much less exposure to groundwater and construction worker exposure is primarily through dermal contact, one would not expect any unacceptable risks associated with lead. Lead is also not a COPC for filtered groundwater.

## **B.6 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.

## Uncertainty Associated with Data Evaluation and COPC Identification

The groundwater data evaluated in the risk assessment include three groundwater samples. Since limited data are available, a 95 percent upper tolerance limit could not be calculated using ProUCL, and therefore, maximum detected concentrations were used as EPCs, potentially overestimating risk.

## 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.

To conservatively evaluate unrestricted land use, it was assumed that the site may be used for residential purposes in the future, although this is not a likely scenario. It is also not likely that groundwater from the shallow aquifer would be used as a potable water supply because of the availability of better water supplies with respect to both water quality and quantity.

## Uncertainty Associated with Toxicity Assessment

Uncertainty associated with the noncarcinogenic toxicity factors is included in the toxicity tables for the 1918 DSA subarea 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 noncarcinogenic toxicity criteria based on the available scientific data for each constituent. The noncarcinogenic 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 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 chromium; this may overestimate or underestimate risks. Additionally, generic ADAFs were used in the MMOA calculations, as no chemical specific ADAFs are available.

Total chromium was identified as a COPC based on comparison to hexavalent chromium screening levels. The toxicity values for hexavalent chromium were conservatively used to estimate potential noncarcinogenic hazards and carcinogenic risks associated with exposures to total chromium. It is highly unlikely all of the chromium detected is in the hexavalent form; therefore, the hazards and risks are likely overestimated for potential exposures to chromium through direct contact with groundwater. It should also be noted that there is some uncertainty associated with the hexavalent chromium oral CSF and RSL, as the value is from the New Jersey Environmental Protection Agency and has not been included in USEPA's IRIS database.

Use of provisional or withdrawn toxicity factors increases the uncertainty of the quantitative hazard and risk estimates. Provisional values were used to provide a quantitative estimate rather than a merely qualitative risk discussion; however, these values should be interpreted cautiously because USEPA has not approved these toxicity values. It should be noted that provisional toxicity values were used to estimate noncarcinogenic hazards associated with thallium, the only COC identified in the HHRA.

A large degree of uncertainty is 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.

## B.7 Human Health Risk Summary

The HHRA was conducted to evaluate the potential human health risks associated with exposure to groundwater at the 1918 DSA subarea based on potential but unlikely and conservative receptor populations and exposure scenarios assuming no additional remedial action is implemented at the site.

**Tables B-3 and B-4 and Attachment 1, Tables 9.1.RME through 9.4.RME and Tables 9.1.CTE and 9.2.CTE,** summarize the RME and CTE potential hazards and risks to each receptor. **Tables 10.1.RME and 10.2.RME and 10.1.CTE and 10.2.CTE in Attachment 1** show the receptor scenarios with total target organ HIs greater than 1, or total carcinogenic risks greater than  $1 \times 10^{-4}$ . The COCs that contribute target organ HIs greater than 0.1 or carcinogenic risks greater than  $1 \times 10^{-6}$  are included in the tables. Risk estimates are summarized as follows.

- Resident (adult and child)
  - Future exposure to groundwater used as potable water supply
  - HIs (RME) for both child and adult exceed 1; associated with ingestion of dissolved thallium, the only COC identified for groundwater
  - HI (CTE) for both child and adult exceed 1; associated with ingestion of dissolved thallium
  - Dissolved thallium was detected in one of three groundwater samples at a maximum concentration of 2 µg/L, which does not exceed the SDWA MCL
  - ELCR (RME) to the lifetime resident within target risk range of  $10^{-6}$  to  $10^{-4}$
  - It is unlikely that groundwater from the shallow aquifer would be used as a potable water supply because of the availability of better water supplies with respect to both water quality and quantity
- Construction worker
  - Future exposure to groundwater in excavation
  - HI and ELCR (RME) associated with exposure to groundwater within acceptable levels

## B.8 References

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## Attachment

1 Human Health Risk Assessment Calculation Tables

### Tables

B-1 Summary of Data Quantitatively Used in HHRA

B-2 Summary of Chemicals of Potential Concern for the Baseline Risk Assessment

B-3 Summary of RME Cancer Risks and Hazard Indices

B-4 Summary of CTE Cancer Risks and Hazard Indices

### Figures

B-1 Conceptual Site Model for HHRA

**Tables**

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Table B1  
 OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - AOC 6  
 Cheatham Annex Areas of Concern, Williamsburg, Virginia  
 Site Investigation Report

Scenario Timeframe: Current
Medium: Surface Soil
Exposure Medium: Surface Soil

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	Screening [3] Background [4] Value	COPC Flag	Screening [3] Toxicity [5] Value	COPC Flag	Screening [3] Toxicity [6] Value	COPC Flag	Rationale for Contaminant Deletion or Selection [7]		
Surface Soil	<b>7429-90-5</b>	<b>Aluminum</b>	<b>5.0E+03</b>	<b>1.3E+04</b>	<b>MG/KG</b>	<b>CAA06-SS19P-1108</b>	<b>6/6</b>	<b>13 - 19</b>	<b>1.3E+04</b>	<b>1.2E+04</b>	<b>YES</b>	<b>7.7E+03</b>	<b>N</b>	<b>YES</b>	<b>9.9E+04</b>	<b>NM</b>	<b>NO</b>	<b>ASL-Res</b>
AOC 6	7440-36-0	Antimony	5.0E-02 L	5.0E-01 L	MG/KG	CAA06-SS15-1108	4/6	3.9 - 5.8	5.0E-01	1.1E+01	NO	3.1E+00	N	N/A	4.1E+01	N	N/A	BBK
DSA	7440-38-2	Arsenic	2.4E+00	4.9E+00	MG/KG	CAA06-SS19P-1108	6/6	0.65 - 0.96	4.9E+00	6.4E+00	NO	3.9E-01	C*	N/A	1.6E+00	C	N/A	BBK
	7440-39-3	Barium	2.8E+01	4.6E+01	MG/KG	CAA06-SS18-1108	6/6	13 - 19	4.6E+01	5.3E+01	NO	1.5E+03	N	N/A	1.9E+04	NM	N/A	BBK
	7440-41-7	Beryllium	2.8E-01 J	5.3E-01	MG/KG	CAA06-SS14-1108	6/6	0.32 - 0.48	5.3E-01	5.9E-01	NO	1.6E+01	N	N/A	2.0E+02	N	N/A	BBK
	7440-43-9	Cadmium	2.0E-02 J	1.7E-01 J	MG/KG	CAA06-SS18-1108	6/6	0.32 - 0.48	1.7E-01	1.5E+00	NO	7.0E+00	N	N/A	8.0E+01	N	N/A	BBK
	7440-70-2	Calcium	5.6E+02	8.1E+03	MG/KG	CAA06-SS16-1108	6/6	320 - 480	8.1E+03	2.3E+03	YES	NA	NUT	N/A	NUT	NUT	NUT	NUT
	7440-47-3	Chromium	6.3E+00	1.7E+01	MG/KG	CAA06-SS19P-1108	6/6	0.65 - 0.96	1.7E+01	1.8E+01	NO	2.9E-01	C	N/A	5.6E+00	C	N/A	BBK
	7440-48-4	Cobalt	1.1E+00 J	2.0E+00 J	MG/KG	CAA06-SS16-1108	6/6	3.2 - 4.8	2.0E+00	9.9E+00	NO	2.3E+00	N	N/A	3.0E+01	N	N/A	BBK
	7440-50-8	Copper	4.2E+00	8.2E+00	MG/KG	CAA06-SS15-1108	6/6	1.6 - 2.4	8.2E+00	4.3E+00	YES	3.1E+02	N	NO	4.1E+03	N	NO	BSL
	7439-89-6	Iron	5.4E+03	1.1E+04	MG/KG	CAA06-SS16-1108	6/6	6.5 - 9.6	1.1E+04	2.0E+04	NO	5.5E+03	N	N/A	7.2E+04	NM	N/A	BBK
	7439-92-1	Lead	2.3E+01	1.3E+02	MG/KG	CAA06-SS15-1108	6/6	0.65 - 0.96	1.3E+02	1.7E+01	YES	4.0E+02	NL	NO	8.0E+02	N	NO	BSL
	7439-95-4	Magnesium	4.1E+02	1.1E+03	MG/KG	CAA06-SS15-1108	6/6	320 - 480	1.1E+03	1.1E+03	YES	N/A	NUT	N/A	NUT	NUT	NUT	
	7439-96-5	Manganese	5.6E+01	9.5E+01	MG/KG	CAA06-SS14-1108	6/6	0.97 - 1.4	9.5E+01	3.2E+02	NO	1.8E+02	N	N/A	2.3E+03	N	N/A	BBK
	7439-97-6	Mercury	6.0E-02 J	6.0E-02 J	MG/KG	CAA06-SS14-1108; CAA06-SS15-1108; CAA06-SS19-1108; CAA06-SS19P-1108	3/6	0.1 - 0.13	6.0E-02	1.1E-01	NO	2.3E+00	N	NO	3.1E+01	N	N/A	BBK
	7440-02-0	Nickel	2.9E+00 J	5.9E+00	MG/KG	CAA06-SS16-1108	6/6	2.6 - 3.8	5.9E+00	9.5E+00	NO	1.5E+02	N	N/A	2.0E+03	N	N/A	BBK
	7440-09-7	Potassium	3.6E+02 J	8.7E+02	MG/KG	CAA06-SS19P-1108	6/6	320 - 480	8.7E+02	7.1E+02	YES	N/A	NUT	N/A	NUT	NUT	NUT	
	7782-49-2	Selenium	3.1E-01 J	3.7E-01 J	MG/KG	CAA06-SS19P-1108	2/6	2.3 - 3.4	3.7E-01	5.1E-01	NO	3.9E+01	N	N/A	5.1E+02	N	N/A	BBK
	7440-22-4	Silver	6.2E-01 J	6.2E-01 J	MG/KG	CAA06-SS14-1108	1/6	0.65 - 0.96	6.2E-01	2.1E+00	NO	3.9E+01	N	N/A	5.1E+02	N	N/A	BBK
	7440-23-5	Sodium	2.3E+01 J	8.1E+01 J	MG/KG	CAA06-SS16-1108	6/6	320 - 480	8.1E+01	5.2E+02	NO	N/A	N/A	N/A	N/A	N/A	N/A	BBK
	7440-28-0	Thallium	6.0E-02 J	7.0E-02 J	MG/KG	CAA06-SS14-1108	2/6	1.6 - 2.4	7.0E-02	ND	YES	7.8E-02	N	NO	1.0E+00	N	NO	BSL
	7440-62-2	Vanadium	8.9E+00	2.3E+01	MG/KG	CAA06-SS19P-1108	6/6	3.2 - 4.8	2.3E+01	2.8E+01	NO	3.9E+01	N	N/A	5.2E+02	N	N/A	BBK
	7440-66-6	Zinc	2.2E+01	1.0E+02	MG/KG	CAA06-SS18-1108	6/6	3.9 - 5.8	1.0E+02	2.7E+01	YES	2.3E+03	N	NO	3.1E+04	NM	NO	BSL

[1] Minimum/Maximum detected concentrations.

[2] Maximum concentration is used for screening.

[3] Screening Steps: The maximum concentrations were compared to background concentrations. If exceedances, the maximum concentrations were then compared to RSLs.

[4] Background values from Cheatham Annex/Yorktown background surface soil samples; values represent the 95% UTL.

[5] Oak Ridge National Laboratory (ORNL). June, 2011. Regional Screening Levels for Chemical Contaminants at Superfund Sites. Residential Soil RSLs (based on 10<sup>-6</sup> for carcinogens and HQ of 0.1 for noncarcinogens). Available Online: <http://epa-prgs.ornl.gov/chemicals/index.shtml>

[6] Oak Ridge National Laboratory (ORNL). June, 2011. Regional Screening Levels for Chemical Contaminants at Superfund Sites. Industrial Soil RSLs (based on 10<sup>-6</sup> for carcinogens and HQ of 0.1 for noncarcinogens). Available Online: <http://epa-prgs.ornl.gov/chemicals/index.shtml>  
 RSL value for Chromium(VI) used as surrogate for chromium.

The soil value of 400 mg/kg for lead is from the Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities, USEPA, July 14, 1994.

[7] Rationale Codes

Selection Reason:	Above Residential Soil Screening Levels (ASL-Res)
	Above Industrial Soil Screening Levels (ASL-Ind)
Deletion Reason:	Below Background (BBK)
	Below Screening Level (BSL)
	No Toxicity Information (NTX)
	Essential Nutrient (NUT)

COPC = Chemical of Potential Concern

ARAR/TBC = Applicable or Relevant and Appropriate Requirement/

To Be Considered

J = Estimated Value

K = Biased High

L = Biased Low

C = Carcinogenic

C\* = where: N RSL < 100X C RSL

C\*\* = where N RSL < 10X C RSL, therefore, N RSL used

N = Noncarcinogenic

N/A = Not available or Not applicable

M = Concentration may exceed ceiling limit

ND = Not detected

**TABLE B1.a**

Step 2 Surface Soil Screening - Risk Ratio, Maximum Detected Concentration

Cheatham Annex Areas of Concern, Williamsburg, Virginia

AOC 6 1918 Drum Storage Area - Surface Soil

Analyte	Detection Frequency	Maximum Detected Concentration (Qualifier)	Sample Location of Maximum Detected Concentration	Residential Soil RSL	Acceptable Risk Level	Corresponding Hazard Index <sup>a</sup>	Corresponding Cancer Risk <sup>b</sup>	Target Organ
<b>Metals (mg/kg)</b>								
Aluminum	6 / 6	1.3E+04	CAA06-SS19P-1108	7.7E+04	1	0.2	NA	Developmental, Neurological
<b>Cumulative Corresponding Hazard Index<sup>c</sup></b>						<b>0.2</b>		
<b>Cumulative Corresponding Cancer Risk<sup>d</sup></b>							<b>0E+00</b>	
Total Developmental HI =							0.2	
Total Neurological HI =							0.2	

**Notes:**

<sup>a</sup> Corresponding Hazard Index equals maximum detected concentration divided by the RSL divided by the acceptable risk level.

<sup>b</sup> Corresponding Cancer Risk equals maximum detected concentration divided by the RSL divided by the acceptable risk level.

<sup>c</sup> Cumulative Corresponding Hazard Index equals sum of Corresponding Hazard Indices for each constituent.

<sup>d</sup> Cumulative Corresponding Cancer Risk equals sum of Corresponding Cancer Risks for each constituent.

Constituent selected as COPC if it contributes to an overall Hazard Index by target organ greater than 0.5 or Cumulative Corresponding Cancer Risk greater than 5E-05,

otherwise, constituent not selected as COPC.

Constituents selected as COPCs are indicated by shading.

COPC = Constituent of Potential Concern

HI = Hazard Index

mg/kg = milligrams per kilogram

NA = Not available/not applicable

Table B2  
 OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - AOC 6  
 Cheatham Annex Areas of Concern, Williamsburg, Virginia  
 Site Investigation Report

Scenario Timeframe: Future  
 Medium: Subsurface Soil  
 Exposure Medium: Subsurface Soil

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	Screening [3] Background [4] Value	COPC Flag	Screening [3] Toxicity [5] Value	COPC Flag	Screening [3] Toxicity [6] Value	COPC Flag	Rationale for Contaminant Deletion or Selection [7]
<b>DSA</b>	<b>7429-90-5</b>	<b>Aluminum</b>	<b>5.8E+03</b>	<b>1.3E+04</b>	<b>MG/KG</b>	<b>CAA06-SB16-1108</b>	<b>6/6</b>	<b>11 - 18</b>	<b>1.3E+04</b>	<b>1.3E+04</b>	<b>YES</b>	<b>7.7E+03 N</b>	<b>YES</b>	<b>9.9E+04 NM</b>	<b>NO</b>	<b>ASL-Res</b>
Subsurface Soil	7440-36-0	Antimony	1.0E-01 L	1.6E-01 L	MG/KG	CAA06-SB15-1108;CAA06-SB16-1108;	5/6	3.3 - 5.4	1.6E-01	ND	YES	3.1E+00 N	NO	4.1E+01 N	NO	BSL
	7440-38-2	Arsenic	2.2E+00	5.0E+00	MG/KG	CAA06-SB15-1108	6/6	0.56 - 0.9	5.0E+00	5.5E+00	NO	3.9E-01 C*	N/A	1.6E+00 C	N/A	BBK
	7440-39-3	Barium	2.7E+01	4.5E+01	MG/KG	CAA06-SB14-1108	6/6	11 - 18	4.5E+01	8.5E+01	NO	1.5E+03 N	N/A	1.9E+04 NM	N/A	BBK
	7440-41-7	Beryllium	2.3E-01 J	4.8E-01	MG/KG	CAA06-SB15-1108	6/6	0.28 - 0.45	4.8E-01	5.2E-01	NO	1.6E+01 N	N/A	2.0E+02 N	N/A	BBK
	7440-43-9	Cadmium	3.0E-02 J	8.0E-02 J	MG/KG	CAA06-SB18-1108	4/6	0.28 - 0.45	8.0E-02	ND	YES	7.0E+00 N	NO	8.0E+01 N	NO	BSL
	7440-70-2	Calcium	6.3E+02	1.3E+04	MG/KG	CAA06-SB16-1108	6/6	280 - 450	1.3E+04	2.4E+03	YES	N/A	NUT	N/A	NUT	NUT
	7440-47-3	Chromium	8.4E+00	2.0E+01	MG/KG	CAA06-SB15-1108	6/6	0.56 - 0.9	2.0E+01	3.4E+01	NO	2.9E-01 C	N/A	5.6E+00 C	N/A	BBK
	7440-48-4	Cobalt	9.5E-01 J	2.4E+00 J	MG/KG	CAA06-SB15-1108	6/6	2.8 - 4.5	2.4E+00	5.2E+00	NO	2.3E+00 N	N/A	3.0E+01 N	N/A	BBK
	7440-50-8	Copper	2.8E+00	6.2E+00	MG/KG	CAA06-SB19-1108	6/6	1.4 - 2.2	6.2E+00	3.2E+00	YES	3.1E+02 N	NO	4.1E+03 N	NO	BSL
	7439-89-6	Iron	5.8E+03	1.3E+04	MG/KG	CAA06-SB15-1108	6/6	5.6 - 9	1.3E+04	3.2E+04	NO	5.5E+03 N	N/A	7.2E+04 NM	N/A	BBK
	7439-92-1	Lead	7.6E+00	6.0E+01	MG/KG	CAA06-SB15-1108	6/6	0.56 - 0.9	6.0E+01	8.8E+00	YES	4.0E+02 NL	NO	8.0E+02 NL	NO	BSL
	7439-95-4	Magnesium	4.3E+02	1.2E+03	MG/KG	CAA06-SB19-1108	6/6	280 - 450	1.2E+03	1.1E+03	YES	N/A	NUT	N/A	NUT	NUT
	7439-96-5	Manganese	2.9E+01	1.0E+02	MG/KG	CAA06-SB14-1108	6/6	0.84 - 1.4	1.0E+02	1.8E+02	NO	1.8E+02 N	N/A	2.3E+03 N	N/A	BBK
	7439-97-6	Mercury	4.0E-02 J	4.0E-02 J	MG/KG	CAA06-SB19-1108	1/6	0.1 - 0.12	4.0E-02	1.4E-01	NO	2.3E+00 N	N/A	3.1E+01 N	N/A	BBK
	7440-02-0	Nickel	2.8E+00 J	6.7E+00	MG/KG	CAA06-SB19P-1108	6/6	2.2 - 3.6	6.7E+00	1.8E+01	NO	1.5E+02 N	N/A	2.0E+03 N	N/A	BBK
	7440-09-7	Potassium	3.4E+02 J	1.0E+03	MG/KG	CAA06-SB15-1108	6/6	280 - 450	1.0E+03	9.0E+02	YES	N/A	NUT	N/A	NUT	NUT
	7782-49-2	Selenium	3.3E-01 J	3.3E-01 J	MG/KG	CAA06-SB17-1108	1/6	2 - 3.2	3.3E-01	6.4E-01	NO	3.9E+01 N	N/A	5.1E+02 N	N/A	BBK
	7440-23-5	Sodium	2.1E+01 J	1.2E+02 J	MG/KG	CAA06-SB16-1108	6/6	280 - 450	1.2E+02	8.1E+02	NO	N/A	N/A	N/A	N/A	BBK
	<b>7440-28-0</b>	<b>Thallium</b>	<b>8.0E-02 J</b>	<b>8.0E-02 J</b>	<b>MG/KG</b>	<b>CAA06-SB16-1108</b>	<b>1/6</b>	<b>1.4 - 2.2</b>	<b>8.0E-02</b>	<b>ND</b>	<b>YES</b>	<b>7.8E-02 N</b>	<b>YES</b>	<b>1.0E+00 N</b>	<b>NO</b>	<b>ASL-Res</b>
	7440-62-2	Vanadium	1.2E+01	2.5E+01	MG/KG	CAA06-SB15-1108	6/6	2.8 - 4.5	2.5E+01	4.8E+01	NO	3.9E+01 N	N/A	5.2E+02 N	N/A	BBK
	7440-66-6	Zinc	9.8E+00	5.1E+01	MG/KG	CAA06-SB18-1108	6/6	3.3 - 5.4	5.1E+01	2.8E+01	YES	2.3E+03 N	NO	3.1E+04 NM	NO	BSL

[1] Minimum/Maximum detected concentrations.

[2] Maximum concentration is used for screening.

[3] Screening Steps: The maximum concentrations were compared to background concentrations. If exceedances, the maximum concentrations were then compared to RSLs.

[4] Background values from Cheatham Annex/Yorktown background surface soil samples; values represent the 95% UTL.

[5] Oak Ridge National Laboratory (ORNL), June, 2011. Regional Screening Levels for Chemical Contaminants at Superfund Sites.

Residential Soil RSLs (based on 10<sup>6</sup> for carcinogens and HQ of 0.1 for noncarcinogens). Available Online: <http://epa-prgs.ornl.gov/chemicals/index.shtml>

[6] Oak Ridge National Laboratory (ORNL), June, 2011. Regional Screening Levels for Chemical Contaminants at Superfund Sites.

Industrial Soil RSLs (based on 10<sup>6</sup> for carcinogens and HQ of 0.1 for noncarcinogens). Available Online: <http://epa-prgs.ornl.gov/chemicals/index.shtml>

The soil value of 400 mg/kg for lead is from the Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action

Facilities, USEPA, July 14, 1994.

RSL value for Chromium(VI) used as surrogate for chromium.

RSL value for Manganese (water) used as surrogate for manganese.

RSL value for Mercury (inorganic salts) used as surrogate for mercury.

[7] Rationale Codes

Selection Reason: Above Residential Soil Screening Levels (ASL-Res)  
 Above Industrial Soil Screening Levels (ASL-Ind)  
 Deletion Reason: Below Background (BBK)  
 Below Screening Level (BSL)  
 No Toxicity Information (NTX)  
 Essential Nutrient (NUT)

COPC = Chemical of Potential Concern

J = Estimated Value

L = Biased Low

C = Carcinogenic

C\* = where: N RSL < 100X C RSL

N = Noncarcinogenic

RSL = Regional Screening Levels

N/A = Not available or Not applicable

M = Concentration may exceed ceiling limit

ND = Not detected

**TABLE B2a**

Step 2 Soil Screening - Risk Ratio, Maximum Detected Concentration

Cheatham Annex Areas of Concern, Williamsburg, Virginia

DSA - Subsurface Soil

Analyte	Detection Frequency	Maximum Detected Concentration (Qualifier)	Sample Location of Maximum Detected Concentration	Residential Soil RSL	Acceptable Risk Level	Corresponding Hazard Index <sup>a</sup>	Corresponding Cancer Risk <sup>b</sup>	Target Organ
<b>Metals (mg/kg)</b>								
Aluminum	6 / 6	1.3E+04	CAA06-SB16-1108	7.7E+04	1E+00	0.2	NA	Developmental, Neurological
Thallium	1 / 6	8.0E-02 J	CAA06-SB16-1108	7.8E-01	1E+00	0.1	NA	Hair, Skin
<b>Cumulative Corresponding Hazard Index<sup>c</sup></b>						<b>0.2</b>		
<b>Cumulative Corresponding Cancer Risk<sup>d</sup></b>							<b>NA</b>	
							Total Developmental HI =	0.2
							Total Neurological HI =	0.2
							Total Hair HI =	0.1
							Total Skin HI =	0.1

**Notes:**

<sup>a</sup> Corresponding Hazard Index equals maximum detected concentration divided by the RSL divided by the acceptable risk level.

<sup>b</sup> Corresponding Cancer Risk equals maximum detected concentration divided by the RSL divided by the acceptable risk level.

<sup>c</sup> Cumulative Corresponding Hazard Index equals sum of Corresponding Hazard Indices for each constituent.

<sup>d</sup> Cumulative Corresponding Cancer Risk equals sum of Corresponding Cancer Risks for each constituent.

Constituent selected as COPC if it contributes to an overall Hazard Index by target organ greater than 0.5 or Cumulative Corresponding Cancer Risk greater than 5E-05, otherwise, constituent not selected as COPC.

Constituents selected as COPCs are indicated by shading.

COPC = Constituent of Potential Concern

HI = Hazard Index

J = Estimated Value

mg/kg = milligrams per kilogram

NA = Not available/not applicable

**Table B-1**  
 Summary of Data Quantitatively Used in HHRA  
 AOC 6  
 NWS Yorktown Cheatham Annex, Williamsburg, Virginia

Medium	Date of Sampling	Sample Location	Sample	Parameters
<b>Shallow Aquifer Groundwater</b>				
Groundwater	11/11/2008	CAA06-DW09	CAA06-DW09-1108	Total Metals, Dissolved Metals
	11/11/2008	CAA06-DW10	CAA06-DW10-1108	Total Metals, Dissolved Metals
	11/11/2008	CAA06-DW10	CAA06-DW10P1108 <sup>1</sup>	Total Metals, Dissolved Metals
	11/11/2008	CAA06-DW11	CAA06-DW11-1108	Total Metals, Dissolved Metals

Notes:

<sup>1</sup> Duplicate of sample listed above.

**Table B-2**

Summary of Chemicals of Potential Concern for the Baseline Risk Assessment

AOC 6

NWS Yorktown Cheatham Annex, Williamsburg, Virginia

<b><i>Groundwater - Shallow Aquifer - Filtered</i></b>	
Chromium, Dissolved	Thallium, Dissolved

<b><i>Groundwater - Shallow Aquifer - Unfiltered</i></b>	
Aluminum	Cobalt
Antimony	Iron
Arsenic	Lead
Beryllium	Manganese
Cadmium	Nickel
Chromium	Thallium
	Vanadium

TABLE B-3  
 Summary of RME Cancer Risks and Hazard Indices  
 AOC 6  
 NWS Yorktown Cheatham Annex, Williamsburg, Virginia

Receptor	Media	Exposure Route	Cancer Risk	Chemicals with Cancer Risks >10 <sup>-4</sup>	Chemicals with Cancer Risks >10 <sup>-5</sup> and <10 <sup>-4</sup>	Chemicals with Cancer Risks >10 <sup>-6</sup> and <10 <sup>-5</sup>	Hazard Index	Chemicals with HI>1
Future Adult Resident	Groundwater Shallow Aquifer	Ingestion	N/A				5	Thallium, Dissolved
		Dermal Contact	N/A				0.03	
		Inhalation	N/A				N/A	
		Total	N/A				6	Thallium, Dissolved
	All Media	Total	N/A				6	
Future Child Resident	Groundwater Shallow Aquifer	Ingestion	N/A				13	Thallium, Dissolved
		Dermal Contact	N/A				0.1	
		Inhalation	N/A				N/A	
		Total	N/A				13	Thallium, Dissolved
	All Media	Total	N/A				13	
Future Child/Adult Resident	Groundwater Shallow Aquifer	Ingestion	2E-05		Chromium, Dissolved		N/A	
		Dermal Contact	1E-05			Chromium, Dissolved	N/A	
		Inhalation	N/A				N/A	
		Total	3E-05		Chromium, Dissolved		N/A	
	All Media	Total	3E-05				N/A	
Future Construction Worker Adult	Groundwater Shallow Aquifer	Ingestion	N/A				N/A	
		Dermal Contact	3E-05		Chromium		1	
		Inhalation	N/A				N/A	
		Total	3E-05		Chromium		1	
	All Media	Total	3E-05				1	

N/A = not applicable; not available

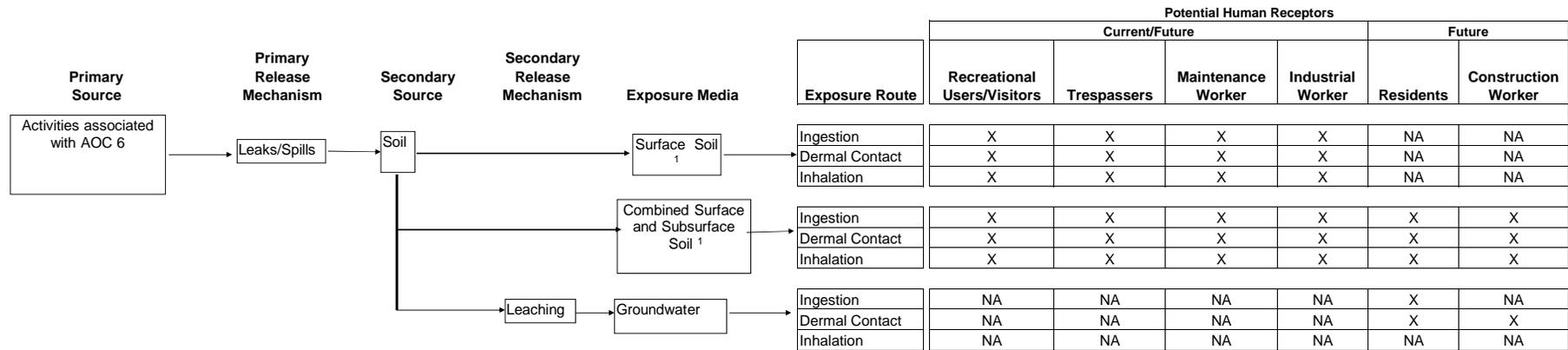
TABLE B-4  
 Summary of CTE Cancer Risks and Hazard Indices  
 AOC 6  
 NWS Yorktown Cheatham Annex, Williamsburg, Virginia

Receptor	Media	Exposure Route	Cancer Risk	Chemicals with Cancer Risks >10 <sup>-4</sup>	Chemicals with Cancer Risks >10 <sup>-5</sup> and <10 <sup>-4</sup>	Chemicals with Cancer Risks >10 <sup>-6</sup> and <10 <sup>-5</sup>	Hazard Index	Chemicals with HI>1
Future Adult Resident	Groundwater	Ingestion	N/A				3	Thallium, Dissolved
		Shallow Aquifer	Dermal Contact	N/A			0.009	
		Inhalation	N/A				N/A	
		Total	N/A				3	Thallium, Dissolved
	All Media	Total	N/A				3	
Future Child Resident	Groundwater	Ingestion	N/A				9	Thallium, Dissolved
		Shallow Aquifer	Dermal Contact	N/A			0.02	
		Inhalation	N/A				N/A	
		Total	N/A				9	Thallium, Dissolved
	All Media	Total	N/A				9	

N/A = not applicable; not available

**Figure**

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**FIGURE B-1**  
 Conceptual Site Model for HHRA  
 AOC 6  
 NWS Yorktown Cheatham Annex, Williamsburg, Virginia

<sup>1</sup> Previously evaluated. No potential unacceptable risks identified, therefore, not included in this evaluation.  
 NA - Not Applicable or pathway is incomplete  
 X - Potentially complete exposure pathways

**Attachment 1**  
**Human Health Risk Assessment Calculation Tables**

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TABLE 1  
SELECTION OF EXPOSURE PATHWAYS  
AOC 6  
NWS Yorktown Cheatham Annex, Williamsburg, 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	Groundwater	Shallow Aquifer - Tap Water	Resident*	Adult	Dermal Absorption	On-site	Quant	Groundwater is not currently used on-site as a water supply and the site is not expected to be developed for residential use; however, residential potable use of groundwater is included for a conservative evaluation of unrestricted land use.
						Ingestion	On-site	Quant	
					Child	Dermal Absorption	On-site	Quant	
						Ingestion	On-site	Quant	
					Child/Adult	Dermal Absorption	On-site	Quant	
						Ingestion	On-site	Quant	
		Shallow Aquifer - Water in Excavation Trench	Construction Worker	Adult	Dermal	On-site	Quant	Construction workers could be exposed to shallow groundwater during construction and excavation activities.	
					Ingestion	On-site	None	Incidental ingestion of groundwater by construction workers would be minimal during construction or excavation activities.	
		Air	Shallow Aquifer - Water Vapors at Showerhead	Resident*	Adult	Inhalation	On-site	None	No VOCs were detected in groundwater, therefore the inhalation pathway is not evaluated.
						Child	Inhalation	On-site	None
Child/Adult	Inhalation						On-site	None	No VOCs were detected in groundwater, therefore the inhalation pathway is not evaluated.
Shallow Aquifer - Water Vapors in Excavation Trench	Construction Worker			Adult	Inhalation	On-site	None	No VOCs were detected in groundwater, therefore the inhalation pathway is not evaluated.	

\* Noncarcinogenic hazard evaluated separately for adult and child residential receptors, combined lifetime carcinogenic risk evaluated on an age-adjusted basis for residential scenario.

Table 2.1  
 OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN  
 AOC 6  
 NWS Yorktown Cheatham Annex, Williamsburg, Virginia

Scenario Timeframe: Future Medium: Groundwater Exposure Medium: Groundwater
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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
Shallow Aquifer - Tap Water	7429-90-5	Aluminum, Dissolved	2.4E+02	3.9E+02	UG/L	CAA06-DW09-1108	3/3	200 - 200	3.9E+02	N/A	1.6E+03 N	50 - 200	SMCL	NO	BSL
	7440-39-3	Barium, Dissolved	3.1E+01 J	5.0E+01 J	UG/L	CAA06-DW09-1108	3/3	200 - 200	5.0E+01	1.3E+02	2.9E+02 N	2.0E+03	MCL	NO	BSL
	7440-70-2	Calcium, Dissolved	1.4E+05	1.9E+05	UG/L	CAA06-DW09-1108	3/3	5000 - 5000	1.9E+05	1.1E+05	N/A	N/A		NO	NUT
	<b>7440-47-3</b>	<b>Chromium, Dissolved</b>	<b>9.5E-01 J</b>	<b>9.5E-01 J</b>	<b>UG/L</b>	<b>CAA06-DW09-1108</b>	<b>1/3</b>	<b>10 - 10</b>	<b>9.5E-01</b>	<b>6.0E+00</b>	<b>3.1E-02 C</b>	<b>1.0E+02</b>	<b>MCL</b>	<b>YES</b>	<b>ASL</b>
	7440-50-8	Copper, Dissolved	1.2E+00 J	1.4E+00 J	UG/L	CAA06-DW10-1108	3/3	25 - 25	1.4E+00	N/A	6.2E+01 N	1.3E+03	MCL	NO	BSL
	7439-89-6	Iron, Dissolved	3.4E+02	5.0E+02	UG/L	CAA06-DW11-1108	2/3	100 - 100	5.0E+02	2.8E+02	1.1E+03 N	3.0E+02	SMCL	NO	BSL
	7439-92-1	Lead, Dissolved	1.3E+00 J	2.4E+00 J	UG/L	CAA06-DW10-1108	3/3	10 - 10	2.4E+00	N/A	1.5E+01 N	1.5E+01	MCL	NO	BSL
	7439-95-4	Magnesium, Dissolved	1.6E+03 J	3.0E+03 J	UG/L	CAA06-DW09-1108	3/3	5000 - 5000	3.0E+03	1.1E+04	N/A	N/A		NO	NUT
	7439-96-5	Manganese, Dissolved	1.8E+01	3.1E+01	UG/L	CAA06-DW09-1108	3/3	15 - 15	3.1E+01	5.0E+01	3.2E+01 N	5.0E+01	SMCL	NO	BSL
	7440-02-0	Nickel, Dissolved	6.1E+00 J	7.1E+00 J	UG/L	CAA06-DW09-1108	3/3	40 - 40	7.1E+00	N/A	3.0E+01 N	N/A		NO	BSL
	7440-09-7	Potassium, Dissolved	9.1E+02 J	3.8E+03 J	UG/L	CAA06-DW10P1108	3/3	5000 - 5000	3.8E+03	1.3E+04	N/A	N/A		NO	NUT
	7440-23-5	Sodium, Dissolved	5.9E+03	2.2E+04	UG/L	CAA06-DW09-1108	3/3	5000 - 5000	2.2E+04	6.3E+04	N/A	N/A		NO	NUT
	<b>7440-28-0</b>	<b>Thallium, Dissolved</b>	<b>2.0E+00 J</b>	<b>2.0E+00 J</b>	<b>UG/L</b>	<b>CAA06-DW09-1108</b>	<b>1/3</b>	<b>25 - 25</b>	<b>2.0E+00</b>	<b>N/A</b>	<b>1.6E-02 N</b>	<b>2.0E+00</b>	<b>MCL</b>	<b>YES</b>	<b>ASL</b>
	7440-62-2	Vanadium, Dissolved	9.0E-01 J	9.0E-01 J	UG/L	CAA06-DW09-1108	1/3	50 - 50	9.0E-01	N/A	7.8E+00 N	N/A		NO	BSL
	7440-66-6	Zinc, Dissolved	3.0E+00 J	4.0E+00 J	UG/L	CAA06-DW11-1108	3/3	60 - 60	4.0E+00	N/A	4.7E+02 N	5.0E+03	SMCL	NO	BSL

[1] Minimum/Maximum detected concentration. Filtered results were used for metals since in general significant difference between filtered and unfiltered.  
 [2] Maximum concentration is used for screening.  
 [3] Background values from June 2012, CAX Yorktown Eastover groundwater background; values represent the 95% UTL.  
 [4] Oak Ridge National Laboratory (ORNL), May 2012. 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](http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm)  
 Concentrations based on non-carcinogenic health effects are adjusted to an HI=0.1 (divided by 10).  
 RSL value for Chromium(VI) used as surrogate for chromium.  
 The tap water value of 15 ug/L for lead is the action level provided in the Drinking Water Regulations and Health Advisories.  
 [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  
 MCL = Maximum Contaminant Level  
 N = Noncarcinogenic  
 N/A = Not available  
 SMCL = Maximum Contaminant Level, Secondary Drinking Water Standards  
 UG/L = micrograms per liter  
 C = Carcinogenic

Table 2.2  
 OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN  
 AOC 6  
 NWS Yorktown Cheatham Annex, Williamsburg, Virginia

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: 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
Shallow Aquifer - Water in Excavation Trench	7429-90-5	Aluminum	1.2E+04	5.8E+04	UG/L	CAA06-DW09-1108	3/3	200 - 200	5.8E+04	2.2E+03	1.6E+03 N	50 to 200	SMCL	YES	ASL
	7440-36-0	Antimony	3.6E+00 J	8.8E+00 J	UG/L	CAA06-DW09-1108	3/3	60 - 60	8.8E+00	N/A	6.0E-01 N	6.0E+00	MCL	YES	ASL
	7440-38-2	Arsenic	2.5E+01	1.3E+02	UG/L	CAA06-DW09-1108	3/3	10 - 10	1.3E+02	2.3E+00	4.5E-02 C	1.0E+01	MCL	YES	ASL
	7440-39-3	Barium	6.9E+01 J	2.1E+02	UG/L	CAA06-DW09-1108	3/3	200 - 200	2.1E+02	1.2E+02	2.9E+02 N	2.0E+03	MCL	NO	BSL
	7440-41-7	Beryllium	8.0E-01 J	4.1E+00 J	UG/L	CAA06-DW09-1108	3/3	5 - 5	4.1E+00	2.5E+00	1.6E+00 N	4.0E+00	MCL	YES	ASL
	7440-43-9	Cadmium	5.7E-01 J	5.0E+00	UG/L	CAA06-DW09-1108	3/3	5 - 5	5.0E+00	6.1E-01	6.9E-01 N	5.0E+00	MCL	YES	ASL
	7440-70-2	Calcium	2.8E+05	6.6E+05	UG/L	CAA06-DW09-1108	3/3	5000 - 5000	6.6E+05	1.7E+05	N/A	N/A		NO	NUT
	7440-47-3	Chromium	5.9E+01	2.5E+02	UG/L	CAA06-DW09-1108	3/3	10 - 10	2.5E+02	1.5E+01	3.1E-02 C	1.0E+02	MCL	YES	ASL
	7440-48-4	Cobalt	6.0E+00 J	2.3E+01 J	UG/L	CAA06-DW09-1108	3/3	50 - 50	2.3E+01	2.1E+01	4.7E-01 N	N/A		YES	ASL
	7440-50-8	Copper	2.3E+01 J	6.0E+01	UG/L	CAA06-DW09-1108	3/3	25 - 25	6.0E+01	N/A	6.2E+01 N	1.3E+03	MCL	NO	BSL
	7439-89-6	Iron	2.8E+04	1.2E+05	UG/L	CAA06-DW09-1108	3/3	100 - 100	1.2E+05	8.9E+02	1.1E+03 N	3.0E+02	SMCL	YES	ASL
	7439-92-1	Lead	1.2E+01	5.0E+01	UG/L	CAA06-DW09-1108	3/3	10 - 10	5.0E+01	N/A	1.5E+01 NL	1.5E+01	MCL	YES	ASL
	7439-95-4	Magnesium	5.5E+03	2.1E+04	UG/L	CAA06-DW09-1108	3/3	5000 - 5000	2.1E+04	1.2E+04	N/A	N/A		NO	NUT
	7439-96-5	Manganese	1.1E+02 J	4.2E+02	UG/L	CAA06-DW09-1108	3/3	15 - 15	4.2E+02	5.8E+01	3.2E+01 N	5.0E+01	SMCL	YES	ASL
	7439-97-6	Mercury	4.0E-02 L	4.0E-02 L	UG/L	CAA06-DW09-1108	1/3	0.2 - 0.2	4.0E-02	N/A	4.3E-01 N	2.0E+00	MCL	NO	BSL
	7440-02-0	Nickel	2.7E+01 J	8.7E+01	UG/L	CAA06-DW09-1108	3/3	40 - 40	8.7E+01	1.1E+01	3.0E+01 N	N/A		YES	ASL
	7440-09-7	Potassium	5.7E+03	2.3E+04	UG/L	CAA06-DW09-1108	3/3	5000 - 5000	2.3E+04	1.3E+04	N/A	N/A		NO	NUT
	7782-49-2	Selenium	5.5E+00 J	5.8E+00 J	UG/L	CAA06-DW09-1108	2/3	35 - 35	5.8E+00	N/A	7.8E+00 N	5.0E+01	MCL	NO	BSL
	7440-23-5	Sodium	7.3E+03	2.4E+04	UG/L	CAA06-DW09-1108	3/3	5000 - 5000	2.4E+04	6.5E+04	N/A	N/A		NO	NUT
	7440-28-0	Thallium	1.7E+00 J	2.2E+00 J	UG/L	CAA06-DW11-1108	3/3	25 - 25	2.2E+00	N/A	1.6E-02 N	2.0E+00	MCL	YES	ASL
7440-62-2	Vanadium	5.2E+01	3.3E+02	UG/L	CAA06-DW09-1108	3/3	50 - 50	3.3E+02	2.6E+01	7.8E+00 N	N/A		YES	ASL	
7440-66-6	Zinc	6.0E+01	2.3E+02	UG/L	CAA06-DW09-1108	3/3	60 - 60	2.3E+02	4.5E+00	4.7E+02 N	5.0E+03	SMCL	NO	BSL	

[1] Minimum/Maximum detected concentration. Unfiltered results were used for metals since in construction worker would be not exposed to filtered groundwater COPC = Chemical of Potential Concern

[2] Maximum concentration is used for screening. ARAR/TBC = Applicable or Relevant and Appropriate Requirement/ To Be Considered

[3] Background values from June 2012, CAX Yorktown Eastover groundwater background; values represent the 95% UTL. J = Estimated Value

[4] Oak Ridge National Laboratory (ORNL). May 2012. 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](http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm) L = Biased Low  
 RSL value for Chromium(VI) used as surrogate for chromium. MCL = Maximum Contaminant Level  
 The tap water value of 15 ug/L for lead is the action level provided in the Drinking Water Regulations and Health Advisories. N = Noncarcinogenic  
 RSL value for mercuric chloride and other mercury salts used as surrogate for mercury. N/A = Not available

[5] Rationale Codes NL = Noncarcinogenic lead tap water RSL not adjusted by dividing by 10.  
 SMCL = Maximum Contaminant Level, Secondary Drinking Water Standards  
 UG/L = micrograms per liter  
 C = Carcinogenic

Selection Reason: Above Screening Levels (ASL)  
 Deletion Reason: No Toxicity Information (NTX)  
 Essential Nutrient (NUT)

Table 3.1.RME  
MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATION SUMMARY  
AOC 6  
NWS Yorktown Cheatham Annex, Willimasburg, Virginia

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)	Maximum Concentration (Qualifier)	Exposure Point Concentration			
						Value	Units	Statistic	Rationale
Shallow Aquifer - Tap Water	Chromium, Dissolved	UG/L	N/A	N/A	9.5E-01 J	9.5E-01	UG/L	Max	1
	Thallium, Dissolved	UG/L	N/A	N/A	2.0E+00 J	2.0E+00	UG/L	Max	1

Options: Maximum Detected Concentration (Max)

(1) Maximum detected concentration used because only three samples in data set.

J = Estimated Value  
UG/L = micrograms per liter  
N/A = Not Applicable

Table 3.2.RME  
MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATION SUMMARY  
AOC 6  
NWS Yorktown Cheatham Annex, Willimasburg, Virginia

Scenario Timeframe: Future  
Medium: Groundwater  
Exposure Medium: Groundwater

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)	Maximum Concentration (Qualifier)	Exposure Point Concentration			
						Value	Units	Statistic	Rationale
Shallow Aquifer - Water in Excavation Trench	Aluminum	UG/L	2.8E+04	N/A	5.8E+04	5.8E+04	UG/L	Max	1
	Antimony	UG/L	5.4E+00	N/A	8.8E+00 J	8.8E+00	UG/L	Max	1
	Arsenic	UG/L	7.1E+01	N/A	1.3E+02	1.3E+02	UG/L	Max	1
	Beryllium	UG/L	2.0E+00	N/A	4.1E+00 J	4.1E+00	UG/L	Max	1
	Cadmium	UG/L	2.3E+00	N/A	5.0E+00	5.0E+00	UG/L	Max	1
	Chromium	UG/L	1.3E+02	N/A	2.5E+02	2.5E+02	UG/L	Max	1
	Cobalt	UG/L	1.2E+01	N/A	2.3E+01 J	2.3E+01	UG/L	Max	1
	Iron	UG/L	5.9E+04	N/A	1.2E+05	1.2E+05	UG/L	Max	1
	Lead	UG/L	2.6E+01	N/A	5.0E+01	2.6E+01	UG/L	Mean	2
	Manganese	UG/L	2.2E+02	N/A	4.2E+02	4.2E+02	UG/L	Max	1
	Nickel	UG/L	5.2E+01	N/A	8.7E+01	8.7E+01	UG/L	Max	1
	Thallium	UG/L	2.0E+00	N/A	2.2E+00 J	2.2E+00	UG/L	Max	1
Vanadium	UG/L	1.5E+02	N/A	3.3E+02	3.3E+02	UG/L	Max	1	

Options: Maximum Detected Concentration (Max); Mean Detected Concentration (Mean)

- (1) Maximum detected concentration used because only three samples in data set.
- (2) Mean lead concentration used for the lead model.

J = Estimated Value  
UG/L = micrograms per liter  
N/A = Not Applicable

TABLE 4.1.RME  
VALUES USED FOR DAILY INTAKE CALCULATIONS  
REASONABLE MAXIMUM EXPOSURE  
AOC 6  
NWS Yorktown Cheatham Annex, Williamsburg, Virginia

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/Reference	Intake Equation/Model Name
Ingestion	Resident	Adult	Shallow Aquifer - Tap Water	CW	Chemical Concentration in Water	See Table 3.1	µg/l	See Table 3.1	Chronic Daily Intake (CDI) (mg/kg-day) = CW x IR-W x EF x ED x CF2 x 1/BW x 1/AT
				IR-W	Ingestion Rate of Water	2	liters/day	EPA, 1997	
				EF	Exposure Frequency	350	days/year	EPA, 1991	
				ED	Exposure Duration	24	years	EPA, 1991	
				CF2	Conversion Factor 2	0.001	mg/µg	--	
				BW	Body Weight	70	kg	EPA, 1991	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	8,760	days	EPA, 1989	
				Child	Shallow Aquifer - Tap Water	Child	CW	Chemical Concentration in Water	
	IR-W	Ingestion Rate of Water	1				liters/day	EPA, 1997	
	EF	Exposure Frequency	350				days/year	EPA, 1991	
	ED	Exposure Duration	6				years	EPA, 1991	
	CF2	Conversion Factor 2	0.001				mg/µg	--	
	BW	Body Weight	15				kg	EPA, 1991	
	AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989				
AT-N	Averaging Time (Non-Cancer)	2,190	days	EPA, 1989					
Child/Adult	Shallow Aquifer - Tap Water	Child/Adult	CW	Chemical Concentration in Water	See Table 3.1	µg/l	See Table 3.1	CDI (mg/kg-day) = CW x IR-W-Adj x EF x CF2 x 1/AT  IR-W-Adj (liter-year/kg-day) = (ED-C x IR-W-C / BW-C) + (ED-A x IR-W-A / BW-A)	
			IR-W-A	Ingestion Rate of Water, Adult	2	liters/day	EPA, 1997		
			IR-W-C	Ingestion Rate of Water, Child	1	liters/day	EPA, 1997		
			IR-W-Adj	Ingestion Rate of Water, Age-adjusted	1.09	liter-year/kg-day	calculated		
			EF	Exposure Frequency	350	days/year	EPA, 1991		
			ED-A	Exposure Duration, Adult	24	years	EPA, 1991		
			ED-C	Exposure Duration, Child	6	years	EPA, 1991		
			CF2	Conversion Factor 2	0.001	mg/µg	--		
			BW-A	Body Weight, Adult	70	kg	EPA, 1991		
			BW-C	Body Weight, Child	15	kg	EPA, 1991		
AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989					

TABLE 4.1.RME  
VALUES USED FOR DAILY INTAKE CALCULATIONS  
REASONABLE MAXIMUM EXPOSURE  
AOC 6  
NWS Yorktown Cheatham Annex, Williamsburg, Virginia

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/Reference	Intake Equation/Model Name
Dermal	Resident	Adult	Shallow Aquifer - Tap Water	CW	Chemical Concentration in Water	See Table 3.1	µg/l	See Table 3.1	CDI (mg/kg-day) = DAevent x SA x EV x EF x ED x 1/BW x 1/AT
		DAevent		Dermally Absorbed Dose per Event	calculated	mg/cm <sup>2</sup> -event	calculated		
				FA	Fraction absorbed water	chemical specific	dimensionless	EPA, 2004	Inorganics: DAevent (mg/cm <sup>2</sup> -event) = Kp x CW x t <sub>event</sub> x CF2 x CF3
				K <sub>p</sub>	Permeability Coefficient	chemical specific	cm/hr	EPA, 2004	
				τ	Lag Time	chemical specific	hr/event	EPA, 2004	Organics : t <sub>event</sub> <t*: DAevent (mg/cm <sup>2</sup> -event) = 2 x FA x Kp x CW x (sqrt((6 x τ x t <sub>event</sub> )/π)) 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	t <sub>event</sub> >t*: DAevent (mg/cm <sup>2</sup> -event) = FA x Kp x CW x ( t <sub>event</sub> /(1+B) + 2 x τ x ((1 + 3B + 3B <sup>2</sup> )/(1+B) <sup>2</sup> )) x CF2 x CF3
				t <sub>event</sub>	Event Time	0.58	hr/event	EPA, 2004	
				SA	Skin Surface Area Available for Contact	18,000	cm <sup>2</sup>	EPA, 2004	x CF2 x CF3
				EV	Event Frequency	1	events/day	EPA, 2004	
				EF	Exposure Frequency	350	days/year	EPA, 2004	t <sub>event</sub> >t*: DAevent (mg/cm <sup>2</sup> -event) = FA x Kp x CW x ( t <sub>event</sub> /(1+B) + 2 x τ x ((1 + 3B + 3B <sup>2</sup> )/(1+B) <sup>2</sup> )) x CF2 x CF3
				ED	Exposure Duration	24	years	EPA, 2004	
				BW	Body Weight	70	kg	EPA, 1991	--
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	8,760	days	EPA, 1989	--
				CF2	Conversion Factor 2	0.001	mg/µg	--	
				CF3	Conversion Factor 3	0.001	l/cm <sup>3</sup>	--	
		Child	Shallow Aquifer - Tap Water	CW	Chemical Concentration in Water	See Table 3.1	µg/l	See Table 3.1	CDI (mg/kg-day) = DAevent x SA x EV x EF x ED x 1/BW x 1/AT
				DAevent	Dermally Absorbed Dose per Event	calculated	mg/cm <sup>2</sup> -event		
				FA	Fraction absorbed water	chemical specific	dimensionless	EPA, 2004	Inorganics: DAevent (mg/cm <sup>2</sup> -event) = Kp x CW x t <sub>event</sub> x CF2 x CF3
				K <sub>p</sub>	Permeability Coefficient	chemical specific	cm/hr	EPA, 2004	
				τ	Lag Time	chemical specific	hr/event	EPA, 2004	Organics : t <sub>event</sub> <t*: DAevent (mg/cm <sup>2</sup> -event) = 2 x FA x Kp x CW x (sqrt((6 x τ x t <sub>event</sub> )/π)) 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	t <sub>event</sub> >t*: DAevent (mg/cm <sup>2</sup> -event) = FA x Kp x CW x ( t <sub>event</sub> /(1+B) + 2 x τ x ((1 + 3B + 3B <sup>2</sup> )/(1+B) <sup>2</sup> )) x CF2 x CF3
				t <sub>event</sub>	Event Time	1.0	hr/event	EPA, 2004	
				SA	Skin Surface Area Available for Contact	6,600	cm <sup>2</sup>	EPA, 2004	x CF2 x CF3
				EV	Event Frequency	1	events/day	EPA, 2004	
				EF	Exposure Frequency	350	days/year	EPA, 2004	t <sub>event</sub> >t*: DAevent (mg/cm <sup>2</sup> -event) = FA x Kp x CW x ( t <sub>event</sub> /(1+B) + 2 x τ x ((1 + 3B + 3B <sup>2</sup> )/(1+B) <sup>2</sup> )) x CF2 x CF3
				ED	Exposure Duration	6	years	EPA, 2004	
				BW	Body Weight	15	kg	EPA, 1991	--
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	2,190	days	EPA, 1989	--
				CF2	Conversion Factor 2	0.001	mg/µg	--	
				CF3	Conversion Factor 3	0.001	l/cm <sup>3</sup>	--	

TABLE 4.1.RME  
VALUES USED FOR DAILY INTAKE CALCULATIONS  
REASONABLE MAXIMUM EXPOSURE  
AOC 6  
NWS Yorktown Cheatham Annex, Williamsburg, Virginia

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: 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	Shallow Aquifer - Tap Water	CW	Chemical Concentration in Water	See Table 3.1	µg/l	See Table 3.1	$CDI \text{ (mg/kg-day)} = DA\text{-Adj} \times EF \times 1/AT$  $DA\text{-Adj} = (DA\text{event-A} \times SA\text{-A} \times ED\text{-A} \times 1/BW\text{-A}) + (DA\text{event-C} \times SA\text{-C} \times ED\text{-C} \times 1/BW\text{-C})$  Inorganics: $DA\text{event} \text{ (mg/cm}^2\text{-event)} = Kp \times CW \times t_{\text{event}} \times CF2 \times CF3$  Organics : $t_{\text{event}} < t^*$ : $DA\text{event} \text{ (mg/cm}^2\text{-event)} = 2 \times FA \times Kp \times CW \times (\text{sqrt}((6 \times \tau \times t_{\text{event}})/\pi)) \times CF2 \times CF3$  $t_{\text{event}} > t^*$ : $DA\text{event} \text{ (mg/cm}^2\text{-event)} = FA \times Kp \times CW \times (t_{\text{event}}/(1+B) + 2 \times \tau \times ((1 + 3B + 3B^2)/(1+B)^2)) \times CF2 \times CF3$
				DAevent-A	Dermally Absorbed Dose per Event, Adult	calculated	mg/cm <sup>2</sup> -event	calculated	
				DAevent-C	Dermally Absorbed Dose per Event, Child	calculated	mg/cm <sup>2</sup> -event	calculated	
				DA-Adj	Dermally Absorbed Dose, Age-adjusted	calculated	mg-year/event-kg	calculated	
				FA	Fraction absorbed water	chemical specific	dimensionless	EPA, 2004	
				K <sub>p</sub>	Permeability Coefficient	chemical specific	cm/hr	EPA, 2004	
				τ	Lag Time	chemical specific	hr/event	EPA, 2004	
				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	
				t <sub>event</sub> -A	Event Time, Adult	0.58	hr/event	EPA, 2004	
				t <sub>event</sub> -C	Event Time, Child	1.0	hr/event	EPA, 2004	
				SA-A	Skin Surface Area, Adult	18,000	cm <sup>2</sup>	EPA, 2004	
				SA-C	Skin Surface Area, Child	6,600	cm <sup>2</sup>	EPA, 2004	
				EV	Event Frequency	1	events/day	EPA, 2004	
				EF	Exposure Frequency	350	days/year	EPA, 2004	
				ED-A	Exposure Duration, Adult	24	years	EPA, 2004	
				ED-C	Exposure Duration, Child	6	years	EPA, 2004	
				BW-A	Body Weight, Adult	70	kg	EPA, 1991	
				BW-C	Body Weight, Child	15	kg	EPA, 1991	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
CF2	Conversion Factor 2	0.001	mg/µg	--					
CF3	Conversion Factor 3	0.001	l/cm <sup>3</sup>	--					

TABLE 4.1.RME  
VALUES USED FOR DAILY INTAKE CALCULATIONS  
REASONABLE MAXIMUM EXPOSURE  
AOC 6  
NWS Yorktown Cheatham Annex, Williamsburg, Virginia

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/Reference	Intake Equation/Model Name
Dermal	Construction Worker	Adult	Shallow Aquifer - Water in Excavation Trench	CW	Chemical Concentration in Water	See Table 3.2	µg/l	See Table 3.2	$CDI \text{ (mg/kg-day)} = DA_{event} \times SA \times EV \times EF \times ED \times 1/BW \times 1/AT$  $Inorganics: DA_{event} \text{ (mg/cm}^2\text{-event)} = K_p \times CW \times t_{event} \times CF2 \times CF3$  $Organics:$ $t_{event} < t^*: DA_{event} \text{ (mg/cm}^2\text{-event)} = 2 \times FA \times K_p \times CW \times (\sqrt{6 \times \tau \times t_{event}}/\pi) \times CF2 \times CF3$  $t_{event} > t^*: DA_{event} \text{ (mg/cm}^2\text{-event)} = FA \times K_p \times CW \times (t_{event}/(1+B) + 2 \times \tau \times ((1 + 3B + 3B^2)/(1+B)^2)) \times CF2 \times CF3$
				DAevent	Dermally Absorbed Dose per Event	calculated	mg/cm <sup>2</sup> -event	calculated	
				FA	Fraction absorbed water	chemical specific	dimensionless	EPA, 2004	
				K <sub>p</sub>	Permeability Coefficient	chemical specific	cm/hr	EPA, 2004	
				τ	Lag Time	chemical specific	hr/event	EPA, 2004	
				t*	Time to Reach Steady-state Ratio of Permeability of Stratum Corneum to Epidermis	chemical specific	hours	EPA, 2004	
				B		chemical specific	dimensionless	EPA, 2004	
				t <sub>event</sub>	Event Time	8	hr/day	(1)	
				SA	Skin Surface Area Available for Contact	5,700	cm <sup>2</sup>	EPA, 2004, (2)	
				EV	Event Frequency	1	events/day	EPA, 2004	
				EF	Exposure Frequency	125	days/year	VDEQ, 2003	
				ED	Exposure Duration	1	years	EPA, 1991	
				BW	Body Weight	70	kg	EPA, 1991	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
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 <sup>3</sup>	--					

- (1) Professional judgment based on construction activities that would occur 8 hrs per day for the RME.  
(2) Skin surface area in contact with groundwater assumed to be head, hands, forearms, lower legs, and feet.

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EPA, 1989: Risk Assessment Guidance for Superfund. Vol.1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.  
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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  
AOC 6  
NWS Yorktown Cheatham Annex, Williamsburg, Virginia

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/Reference	Intake Equation/Model Name
Ingestion	Resident	Adult	Shallow Aquifer Tap Water	CW	Chemical Concentration in Water	See Table 3.1	µg/l	See Table 3.1	Chronic Daily Intake (CDI) (mg/kg-day) = CW x IR-W x EF x ED x CF2 x 1/BW x 1/AT
				IR-W	Ingestion Rate of Water	1.4	liters/day	EPA, 1993	
				EF	Exposure Frequency	234	days/year	EPA, 1993	
				ED	Exposure Duration	9	years	EPA, 1993	
				CF2	Conversion Factor 2	0.001	mg/µg	--	
				BW	Body Weight	70	kg	EPA, 1991	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	3,285	days	EPA, 1989	
				Child	Shallow Aquifer Tap Water	CW	Chemical Concentration in Water	See Table 3.1	
		IR-W	Ingestion Rate of Water			1	liters/day	EPA, 1997	
		EF	Exposure Frequency			234	days/year	EPA, 1993	
		ED	Exposure Duration			6	years	EPA, 1991	
		CF2	Conversion Factor 2			0.001	mg/µg	--	
		BW	Body Weight			15	kg	EPA, 1991	
		AT-C	Averaging Time (Cancer)			25,550	days	EPA, 1989	
		AT-N	Averaging Time (Non-Cancer)			2,190	days	EPA, 1989	
		Child/Adult	Shallow Aquifer Tap Water			CW	Chemical Concentration in Water	See Table 3.1	µg/l
				IR-W-A	Ingestion Rate of Water, Adult	1.4	liters/day	EPA, 1993	
				IR-W-C	Ingestion Rate of Water, Child	1	liters/day	EPA, 1997	
				IR-W-Adj	Ingestion Rate of Water, Age-adjusted	0.58	liter-year/kg-day	calculated	
				EF	Exposure Frequency	234	days/year	EPA, 1993	
				ED-A	Exposure Duration, Adult	9	years	EPA, 1993	
				ED-C	Exposure Duration, Child	6	years	EPA, 1991	
				CF2	Conversion Factor 2	0.001	mg/µg	--	
BW-A	Body Weight, Adult			70	kg	EPA, 1991			
BW-C	Body Weight, Child			15	kg	EPA, 1991			
AT-C	Averaging Time (Cancer)			25,550	days	EPA, 1989			

TABLE 4.1.CTE  
VALUES USED FOR DAILY INTAKE CALCULATIONS  
CENTRAL TENDENCY EXPOSURE  
AOC 6  
NWS Yorktown Cheatham Annex, Williamsburg, Virginia

Scenario Timeframe: Future  
Medium: Groundwater  
Exposure Medium: Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/Reference	Intake Equation/Model Name
Dermal	Resident	Adult	Shallow Aquifer Tap Water	CW	Chemical Concentration in Water	See Table 3.1	µg/l	See Table 3.1	$CDI \text{ (mg/kg-day)} =$ $DA_{event} \times SA \times EV \times EF \times ED \times 1/BW \times 1/AT$  Inorganics: $DA_{event} \text{ (mg/cm}^2\text{-event)} =$ $K_p \times CW \times t_{event} \times CF2 \times CF3$  Organics : $t_{event} < t^*$ : $DA_{event} \text{ (mg/cm}^2\text{-event)} =$ $2 \times FA \times K_p \times CW \times (\text{sqrt}((6 \times \tau \times t_{event})/\pi))$ $\times CF2 \times CF3$  $t_{event} > t^*$ : $DA_{event} \text{ (mg/cm}^2\text{-event)} =$ $FA \times K_p \times CW \times (t_{event}/(1+B) + 2 \times \tau \times ((1 + 3B + 3B^2)/(1+B^2))) \times CF2 \times CF3$
		DAevent		Dermally Absorbed Dose per Event	Calculated	mg/cm <sup>2</sup> -event	calculated		
FA	Fraction absorbed water	Chemical specific		dimensionless	EPA, 2004				
K <sub>p</sub>	Permeability Coefficient	Chemical specific		cm/hr	EPA, 2004				
τ	Lag Time	Chemical specific		hr/event	EPA, 2004				
t*	Time to Reach Steady-state Ratio of Permeability of stratum Corneum to Epidermis	Chemical specific		hours	EPA, 2004				
B	Epidermis	Chemical specific		dimensionless	EPA, 2004				
t <sub>event</sub>	Event Time	0.25		hr/event	EPA, 2004				
SA	Skin Surface Area Available for Contact	18,000		cm <sup>2</sup>	EPA, 2004				
EV	Event Frequency	1		events/day	EPA, 2004				
EF	Exposure Frequency	234		days/year	EPA, 1993				
ED	Exposure Duration	9		years	EPA, 2004				
BW	Body Weight	70		kg	EPA, 1991				
AT-C	Averaging Time (Cancer)	25,550		days	EPA, 1989				
AT-N	Averaging Time (Non-Cancer)	3,285		days	EPA, 1989				
CF2	Conversion Factor 2	0.001		mg/µg	--				
CF3	Conversion Factor 3	0.001		l/cm <sup>3</sup>	--				
		Child	Shallow Aquifer Tap Water	CW	Chemical Concentration in Water	See Table 3.1	µg/l	See Table 3.1	$CDI \text{ (mg/kg-day)} =$ $DA_{event} \times SA \times EV \times EF \times ED \times 1/BW \times 1/AT$  Inorganics: $DA_{event} \text{ (mg/cm}^2\text{-event)} =$ $K_p \times CW \times t_{event} \times CF2 \times CF3$  Organics : $t_{event} < t^*$ : $DA_{event} \text{ (mg/cm}^2\text{-event)} =$ $2 \times FA \times K_p \times CW \times (\text{sqrt}((6 \times \tau \times t_{event})/\pi))$ $\times CF2 \times CF3$  $t_{event} > t^*$ : $DA_{event} \text{ (mg/cm}^2\text{-event)} =$ $FA \times K_p \times CW \times (t_{event}/(1+B) + 2 \times \tau \times ((1 + 3B + 3B^2)/(1+B^2))) \times CF2 \times CF3$
		DAevent		Dermally Absorbed Dose per Event	Calculated	mg/cm <sup>2</sup> -event	calculated		
		FA		Fraction absorbed water	Chemical specific	dimensionless	EPA, 2004		
		K <sub>p</sub>		Permeability Coefficient	Chemical specific	cm/hr	EPA, 2004		
		τ		Lag Time	Chemical specific	hr/event	EPA, 2004		
		t*		Time to Reach Steady-state Ratio of Permeability of Stratum Corneum to Epidermis	Chemical specific	hours	EPA, 2004		
		B		Epidermis	Chemical specific	dimensionless	EPA, 2004		
		t <sub>event</sub>		Event Time	0.33	hr/event	EPA, 2004		
		SA		Skin Surface Area Available for Contact	6,600	cm <sup>2</sup>	EPA, 2004		
		EV		Event Frequency	1	events/day	EPA, 2004		
		EF		Exposure Frequency	234	days/year	EPA, 1993		
		ED		Exposure Duration	6	years	EPA, 2001		
		BW		Body Weight	15	kg	EPA, 1991		
		AT-C		Averaging Time (Cancer)	25,550	days	EPA, 1989		
		AT-N		Averaging Time (Non-Cancer)	2,190	days	EPA, 1989		
		CF2		Conversion Factor 2	0.001	mg/µg	--		
		CF3		Conversion Factor 3	0.001	l/cm <sup>3</sup>	--		

TABLE 4.1.CTE  
VALUES USED FOR DAILY INTAKE CALCULATIONS  
CENTRAL TENDENCY EXPOSURE  
AOC 6  
NWS Yorktown Cheatham Annex, Williamsburg, Virginia

Scenario Timeframe: Future  
Medium: Groundwater  
Exposure Medium: 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	Shallow Aquifer Tap Water	CW	Chemical Concentration in Water	See Table 3.1	µg/l	See Table 3.1	$CDI (mg/kg\text{-}day) = DA\text{-}Adj \times EF \times 1/AT$  $DA\text{-}Adj = (DAevent\text{-}A \times SA\text{-}A \times ED\text{-}A \times 1/BW\text{-}A) + (DAevent\text{-}C \times SA\text{-}C \times ED\text{-}C \times 1/BW\text{-}C)$  Inorganics: $DAevent (mg/cm^2\text{-}event) = Kp \times CW \times t_{event} \times CF2 \times CF3$  Organics : $t_{event} < t^*$ : $DAevent (mg/cm^2\text{-}event) = 2 \times FA \times Kp \times CW \times (\sqrt{(6 \times \tau \times t_{event})/\pi}) \times CF2 \times CF3$  $t_{event} > t^*$ : $DAevent (mg/cm^2\text{-}event) = FA \times Kp \times CW \times (t_{event}/(1+B) + 2 \times \tau \times ((1 + 3B + 3B^2)/(1+B^2))) \times CF2 \times CF3$
				DAevent-A	Dermally Absorbed Dose per Event, Adult	Calculated	mg/cm <sup>2</sup> -event	calculated	
DAevent-C				Dermally Absorbed Dose per Event, Child	Calculated	mg/cm <sup>2</sup> -event	calculated		
DA-Adj				Dermally Absorbed Dose, Age-adjusted	Calculated	mg-year/event-kg	calculated		
FA				Fraction absorbed water	Chemical specific	dimensionless	EPA, 2004		
K <sub>p</sub>				Permeability Coefficient	Chemical specific	cm/hr	EPA, 2004		
τ				Lag Time	Chemical specific	hr/event	EPA, 2004		
t*				Time to Reach Steady-state Ratio of Permeability of Stratum Corneum to Epidermis	Chemical specific	hours	EPA, 2004		
B					Chemical specific	dimensionless	EPA, 2004		
t <sub>event</sub> -A				Event Time, Adult	0.25	hr/event	EPA, 2004		
t <sub>event</sub> -C				Event Time, Child	0.33	hr/event	EPA, 2004		
SA-A				Skin Surface Area, Adult	18,000	cm <sup>2</sup>	EPA, 2004		
SA-C				Skin Surface Area, Child	6,600	cm <sup>2</sup>	EPA, 2004		
EV				Event Frequency	1	events/day	EPA, 2004		
EF				Exposure Frequency	234	days/year	EPA, 1993		
ED-A				Exposure Duration, Adult	9	years	EPA, 2001		
ED-C				Exposure Duration, Child	6	years	EPA, 2001		
BW-A				Body Weight, Adult	70	kg	EPA, 1991		
BW-C				Body Weight, Child	15	kg	EPA, 1991		
AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989					
CF2	Conversion Factor 2	0.001	mg/µg	--					
CF3	Conversion Factor 3	0.001	l/cm <sup>3</sup>	--					
	Construction Worker	Adult	Shallow Aquifer - Water in Excavation Trench	CW	Chemical Concentration in Water	See Table 3.2	µg/l	See Table 3.2	$CDI (mg/kg\text{-}day) = DAevent \times SA \times EV \times EF \times ED \times 1/BW \times 1/AT$  Inorganics: $DAevent (mg/cm^2\text{-}event) = Kp \times CW \times t_{event} \times CF2 \times CF3$  Organics : $t_{event} < t^*$ : $DAevent (mg/cm^2\text{-}event) = 2 \times FA \times Kp \times CW \times (\sqrt{(6 \times \tau \times t_{event})/\pi}) \times CF2 \times CF3$  $t_{event} > t^*$ : $DAevent (mg/cm^2\text{-}event) = FA \times Kp \times CW \times (t_{event}/(1+B) + 2 \times \tau \times ((1 + 3B + 3B^2)/(1+B^2))) \times CF2 \times CF3$
DAevent				Dermally Absorbed Dose per Event	Calculated	mg/cm <sup>2</sup> -event	calculated		
FA				Fraction absorbed water	Chemical specific	dimensionless	EPA, 2004		
K <sub>p</sub>				Permeability Coefficient	Chemical specific	cm/hr	EPA, 2004		
τ				Lag Time	Chemical specific	hr/event	EPA, 2004		
t*				Time to Reach Steady-state Ratio of Permeability of Stratum Corneum to Epidermis	Chemical specific	hours	EPA, 2004		
B					Chemical specific	dimensionless	EPA, 2004		
t <sub>event</sub>				Event Time	4	hr/day	(1)		
SA				Skin Surface Area Available for Contact	5,700	cm <sup>2</sup>	EPA, 2004, (2)		
EV				Event Frequency	1	events/day	EPA, 2004		
EF				Exposure Frequency	125	days/year	VDEQ, 2003		
ED				Exposure Duration	1	years	EPA, 1991		
BW				Body Weight	70	kg	EPA, 1991		
AT-C				Averaging Time (Cancer)	25,550	days	EPA, 1989		
AT-N	Averaging Time (Non-Cancer)	365	days	EPA, 1989					
CF2	Conversion Factor 2	0.001	mg/µg	--					

TABLE 4.1.CTE  
VALUES USED FOR DAILY INTAKE CALCULATIONS  
CENTRAL TENDENCY EXPOSURE  
AOC 6  
NWS Yorktown Cheatham Annex, Williamsburg, Virginia

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
				CF3	Conversion Factor 3	0.001	l/cm <sup>3</sup>	--	

- (1) Assumed construction workers could spend 4 hours/day near the excavation trench.
- (2) Skin surface area in contact with groundwater assumed to be head, hands, forearms, lower legs, and feet.

Sources:

EPA, 1989: Risk Assessment Guidance for Superfund. Vol.1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.  
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VDEQ, 2003: Virginia Department of Environmental Quality, Voluntary Remediation Program Risk Assessment Guidance. Dec. 2003

TABLE 5.1.RME  
 Non-Cancer Toxicity Data -- Oral/Dermal  
 AOC 6  
 NWS Yorktown Cheatham Annex, Williamsburg, 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 (3) (MM/DD/YY)
Aluminum	Chronic	1.0E+00	mg/kg-day	100%	1.0E+00	mg/kg-day	Neurological	100	PPRTV	10/23/2006
	Subchronic	1.0E+00	mg/kg-day	100%	1.0E+00	mg/kg-day	Neurological	30	ATSDR	9/2008
Antimony	Chronic	4.0E-04	mg/kg-day	15%	6.0E-05	mg/kg-day	Longevity, Blood	1000	IRIS	8/21/2012
	Subchronic	4.0E-04	mg/kg-day	15%	6.0E-05	mg/kg-day	Whole Body, Blood	1000	PPRTV	7/29/2008
Arsenic	Chronic	3.0E-04	mg/kg-day	95%	3.0E-04	mg/kg-day	Skin, Vascular	3/1	IRIS	8/21/2012
	Subchronic	3.0E-04	mg/kg-day	95%	3.0E-04	mg/kg-day	Skin	3	HEAST	7/01/1997
Beryllium	Chronic	2.0E-03	mg/kg-day	0.7%	1.4E-05	mg/kg-day	Gastrointestinal	300	IRIS	8/21/2012
	Subchronic	5.0E-03	mg/kg-day	0.7%	3.5E-05	mg/kg-day	None Observed	100	HEAST	7/1997
Cadmium (water)	Chronic	5.0E-04	mg/kg-day	5%	2.5E-05	mg/kg-day	Kidney	10	IRIS	8/21/2012
	Subchronic	N/A		N/A	N/A					
Chromium (hexavalent)	Chronic	3.0E-03	mg/kg-day	2.5%	7.5E-05	mg/kg-day	Not identified	300	IRIS	8/21/2012
	Subchronic	5.0E-03	mg/kg-day	2.5%	1.3E-04	mg/kg-day	Blood	100	ATSDR	9/2008
Cobalt	Chronic	3.0E-04	mg/kg-day	100%	3.0E-04	mg/kg-day	Thyroid	3000	PPRTV	8/25/2008
	Subchronic	3.0E-03	mg/kg-day	100%	3.0E-03	mg/kg-day	Thyroid	300	PPRTV	8/25/2008
Iron	Chronic	7.0E-01	mg/kg-day	100%	7.0E-01	mg/kg-day	GI System	1.5	PPRTV	9/11/2006
	Subchronic	7.0E-01	mg/kg-day	100%	7.0E-01	mg/kg-day	GI System	1.5	PPRTV	9/11/2006
Lead	Chronic	N/A		N/A	N/A					
	Subchronic	N/A		N/A	N/A					
Manganese	Chronic	1.4E-01	mg/kg-day	100%	1.4E-01	mg/kg-day	CNS	1	IRIS	8/21/2012
	Subchronic	1.4E-01	mg/kg-day	100%	1.4E-01	mg/kg-day	CNS	1	HEAST	7/1997
Nickel	Chronic	2.0E-02	mg/kg-day	4%	8.0E-04	mg/kg-day	Decreased body and organ weights	300	IRIS	8/21/2012
	Subchronic	2.0E-02	mg/kg-day	4%	8.0E-04	mg/kg-day	Decreased body and organ weights	300	HEAST	7/1997
Thallium	Chronic	1.0E-05	mg/kg-day	100%	1.0E-05	mg/kg-day	Hair	3000	PPRTV	10/8/2010
	Subchronic	4.0E-05	mg/kg-day	100%	4.0E-05	mg/kg-day	Hair	1000	PPRTV	10/8/2010
Vanadium	Chronic	5.0E-03	mg/kg-day	100%	5.0E-03	mg/kg-day	Hair	1000	IRIS/RSL	8/21/2012
	Subchronic	7.0E-03	mg/kg-day	100%	7.0E-03	mg/kg-day	Lifetime	100	HEAST	7/01/1997

(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 Dermal RfD = RfD (oral) x Oral to Dermal Adjustment Factor

(3) For ATSDR, date of ATSDR toxicity profile  
 For IRIS values, date IRIS was searched.  
 For HEAST values, date of HEAST.  
 For PPRTV values, date of the PPRTV toxicity profile.  
 For RSL values, the date of the RSL Table.

(4) As provided in the RSL Table.

Definitions: ATSDR = Agency for Toxic Substances and Disease Registry  
 HEAST = Health Effects Assessment Summary Tables  
 IRIS = Integrated Risk Information System  
 N/A = Not available/not applicable  
 PPRTV = Provisional Peer-Reviewed Toxicity Values  
 RSL = Regional Screening Level Table

TABLE 6.1.RME  
 Cancer Toxicity Data -- Oral/Dermal  
 AOC 6  
 NWS Yorktown Cheatham Annex, Williamsburg, 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	N/A	N/A	N/A				
Antimony	N/A	N/A	N/A				
Arsenic	1.5E+00	95%	1.5E+00	(mg/kg-day) <sup>-1</sup>	A	IRIS	8/21/2012
Beryllium	N/A	N/A	N/A				
Cadmium (water)	N/A	N/A	N/A				
Chromium (hexavalent) (3)	5.0E-01	2.5%	2.0E+01	(mg/kg-day) <sup>-1</sup>	D	New Jersey	8/21/2012
Cobalt	N/A	N/A	N/A				
Iron	N/A	N/A	N/A				
Lead	N/A	N/A	N/A				
Manganese	N/A	N/A	N/A		D	IRIS	8/21/2012
Nickel	N/A	N/A	N/A				
Thallium	N/A	N/A	N/A				
Vanadium	N/A	N/A	N/A				

(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%.

Definitions: N/A = Not Available, Not Applicable  
 IRIS = Integrated Risk Information System  
 New Jersey = New Jersey EPA

(2) Adjusted based on RAGS Part E. Adjusted Dermal CSF = CSF (oral) / Oral to Dermal Adjustment Factor

(3) This chemical operates with a mutagenic mode of action.

Chemical-specific data are not available; therefore, default age-dependant adjustment factors (ADAF) will be applied to the slope factor as follows:

AGE	AGE ADAF
0-<2	10
2-<16	3
16-<30	1

Weight of Evidence definitions:

Group A - Human Carcinogen

Group D - Not Classifiable as to Human Carcinogenicity.

TABLE 7.1.RME  
 CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS  
 REASONABLE MAXIMUM EXPOSURE  
 AOC 6  
 NWS Yorktown Cheatham Annex, Williamsburg, 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			
					Value	Units	Value	Units	Value	Units	Value	Units	Value	Units	Value	Units		
Groundwater	Groundwater	Shallow Aquifer - Tap Water	Ingestion	Chromium, Dissolved	9.5E-01	ug/L	N/A		N/A		N/A	2.6E-05	mg/kg/day	3.0E-03	mg/kg/day	8.7E-03		
				Thallium, Dissolved	2.0E+00	ug/L	N/A		N/A		N/A	5.5E-05	mg/kg/day	1.0E-05	mg/kg/day	5.5E+00		
				Exp. Route Total					N/A							5.5E+00		
			Dermal Absorption	Chromium, Dissolved	9.5E-01	ug/L	N/A		N/A		N/A		2.7E-07	mg/kg/day	7.5E-05	mg/kg/day	3.6E-03	
				Thallium, Dissolved	2.0E+00	ug/L	N/A		N/A		N/A		2.9E-07	mg/kg/day	1.0E-05	mg/kg/day	2.9E-02	
				Exp. Route Total					N/A								3.2E-02	
				Exposure Point Total					N/A								5.5E+00	
				Exposure Medium Total					N/A								5.5E+00	
			Shallow Aquifer Groundwater Total							N/A								5.5E+00
			Total of Receptor Risks Across All Media										N/A	Total of Receptor Hazards Across All Media				5.5E+00

Notes-  
 N/A =Not available; Not applicable.  
 DA<sub>event</sub> for dermal exposure to groundwater calculated on Tables 7.1.RME Supplement A.

Table 7.1.RME Supplement A  
 Calculation of DAevent  
 Resident Adult Shallow Groundwater  
 AOC 6  
 NWS Yorktown Cheatham Annex, Williamsburg, Virginia

Chemical of Potential Concern	Water Concentration (CW) (µg/L)	Permeability Coefficient (Kp) (cm/hr)	B (dimensionless)	Lag Time (τ <sub>event</sub> ) (hr)	t* (hr)	Fraction Absorbed Water (FA) (dimensionless)	Duration of Event (tevent) (hr)	DAevent (mg/cm <sup>2</sup> -event)	Eq
Chromium, Dissolved	9.5E-01	2.0E-03	N/A	N/A	N/A	N/A	0.58	1.1E-09	1
Thallium, Dissolved	2.0E+00	1.0E-03	N/A	N/A	N/A	N/A	0.58	1.2E-09	1

**Inorganics: DAevent (mg/cm<sup>2</sup>-event) =**

$$DA_{event} = Kp \times CW \times tevent \times 0.001 \text{ mg/ug} \times 0.001 \text{ l/cm}^3 \quad (\text{Eq 1})$$

Notes:

N/A - Not applicable

Permeability constants and other input parameter values 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.

B - Dimensionless ratio of the permeability coefficient of a compound through the stratum corneum relative to its permeability coefficient across the viable epidermis (dimensionless).

t\* - Time to reach steady-state

TABLE 7.2.RME  
 CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS  
 REASONABLE MAXIMUM EXPOSURE  
 AOC 6  
 NWS Yorktown Cheatham Annex, Williamsburg, 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			
					Value	Units	Value	Units	Value	Units	Value	Units	Value	Units	Value	Units		
Groundwater	Groundwater	Shallow Aquifer - Tap Water	Ingestion	Chromium, Dissolved	9.5E-01	ug/L	N/A		N/A		N/A	6.1E-05	mg/kg/day	3.0E-03	mg/kg/day	2.0E-02		
				Thallium, Dissolved	2.0E+00	ug/L	N/A		N/A		N/A	1.3E-04	mg/kg/day	1.0E-05	mg/kg/day	1.3E+01		
				Exp. Route Total					N/A							1.3E+01		
			Dermal Absorption	Chromium, Dissolved	9.5E-01	ug/L	N/A		N/A		N/A		8.0E-07	mg/kg/day	7.5E-05	mg/kg/day	1.1E-02	
				Thallium, Dissolved	2.0E+00	ug/L	N/A		N/A		N/A		8.4E-07	mg/kg/day	1.0E-05	mg/kg/day	8.4E-02	
				Exp. Route Total					N/A								9.5E-02	
				Exposure Point Total					N/A								1.3E+01	
				Exposure Medium Total					N/A								1.3E+01	
			Shallow Aquifer Groundwater Total							N/A								1.3E+01
			Total of Receptor Risks Across All Media										N/A	Total of Receptor Hazards Across All Media				1.3E+01

Notes-  
 N/A =Not available; Not applicable.

DA<sub>event</sub> for dermal exposure to groundwater calculated on Tables 7.2.RME Supplement A.

Table 7.2.RME Supplement A  
 Calculation of DAevent  
 Resident Child Shallow Groundwater  
 AOC 6  
 NWS Yorktown Cheatham Annex, Williamsburg, Virginia

Chemical of Potential Concern	Water Concentration (CW) (µg/L)	Permeability Coefficient (Kp) (cm/hr)	B (dimensionless)	Lag Time (τ <sub>event</sub> ) (hr)	t* (hr)	Fraction Absorbed Water (FA) (dimensionless)	Duration of Event (tevent) (hr)	DAevent (mg/cm <sup>2</sup> -event)	Eq
Chromium, Dissolved	9.5E-01	2.0E-03	N/A	N/A	N/A	N/A	1	1.9E-09	1
Thallium, Dissolved	2.0E+00	1.0E-03	N/A	N/A	N/A	N/A	1	2.0E-09	1

**Inorganics: DAevent (mg/cm<sup>2</sup>-event) =**

$$DA_{event} = Kp \times CW \times tevent \times 0.001 \text{ mg/ug} \times 0.001 \text{ l/cm}^3 \quad (\text{Eq 1})$$

Notes:

N/A - Not applicable

Permeability constants and other input parameter values 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.

B - Dimensionless ratio of the permeability coefficient of a compound through the stratum corneum relative to its permeability coefficient across the viable epidermis (dimensionless).

t\* - Time to reach steady-state

TABLE 7.3.RME  
 CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS  
 REASONABLE MAXIMUM EXPOSURE

AOC 6  
 NWS Yorktown Cheatham Annex, Williamsburg, Virginia

Scenario Timeframe: Future  
 Receptor Population: Resident  
 Receptor Age: Child/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	Groundwater	Shallow Aquifer - Tap Water	Ingestion	Chromium, Dissolved <sup>1</sup>	9.5E-01	ug/L	3.0E-05	mg/kg/day	5.0E-01	mg/kg-day	2.2E-05	N/A		N/A		N/A		
				Thallium, Dissolved	2.0E+00	ug/L			N/A			N/A		N/A		N/A		
				Exp. Route Total							2.2E-05						N/A	
			Dermal Absorption	Chromium, Dissolved <sup>1</sup>	9.5E-01	ug/L	1.6E-07	mg/kg/day	2.0E+01	mg/kg/day	1.1E-05	N/A	N/A	N/A		N/A		N/A
				Thallium, Dissolved	2.0E+00	ug/L			N/A		N/A	N/A		N/A				
				Exp. Route Total							1.1E-05							N/A
				Exposure Point Total							3.3E-05							N/A
				Exposure Medium Total							3.3E-05							N/A
			Shallow Aquifer Groundwater Total									3.3E-05						N/A
			Total of Receptor Risks Across All Media										3.3E-05	Total of Receptor Hazards Across All Media				N/A

Notes-

N/A =Not available; Not applicable.

DA<sub>event</sub> for dermal exposure to groundwater calculated on Tables 7.1.RME Supplement A and 7.2.RME Supplement A.

<sup>1</sup> See Table 7.3.RME Supplement A for calculation of intake and cancer risk following MMOA method.

TABLE 7.3.RME Supplement A  
 CALCULATION OF CHEMICAL CANCER RISKS FOR COPC WITH MUTAGENIC MODE OF ACTION  
 REASONABLE MAXIMUM EXPOSURE  
 AOC 6  
 NWS Yorktown Cheatham Annex, Williamsburg, 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										
					Value	Units	Intake				Units	CSF/Unit Risk				Cancer Risk	
							Value					Units	Value				
							0-2 yrs	2-6 yrs	6-16 years	16-30 yrs			0-2 yrs (ADAF=10)	2-6 yrs (ADAF=3)	6-16 yrs (ADAF=3)		16-30 yrs (ADAF=1)
Groundwater	Groundwater	Shallow Aquifer - Tap Water	Ingestion	Chromium, dissolved	9.5E-01	ug/L	1.7E-06	3.5E-06	3.7E-06	5.2E-06	mg/kg/day	5.0E+00	1.5E+00	1.5E+00	5.0E-01	1/(mg/kg-day)	2.2E-05
			Dermal	Chromium, dissolved	9.5E-01	ug/L	2.3E-08	4.6E-08	3.9E-08	5.4E-08	mg/kg/day	2.0E+02	6.0E+01	6.0E+01	2.0E+01	1/(mg/kg-day)	1.1E-05

$$\text{Cancer risk} = (\text{Intake}_{0-2} \times \text{CSF}_{0-2}) + (\text{Intake}_{2-6} \times \text{CSF}_{2-6}) + (\text{Intake}_{6-16} \times \text{CSF}_{6-16}) + (\text{Intake}_{16-30} \times \text{CSF}_{16-30})$$

TABLE 7.4.RME  
 CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS  
 REASONABLE MAXIMUM EXPOSURE

AOC 6

NWS Yorktown Cheatham Annex, Williamsburg, 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	Groundwater	Shallow Aquifer - Water in Excavation Trench	Dermal Absorption	Aluminum	5.8E+04	ug/L	1.8E-04	mg/kg/day	N/A		N/A	1.3E-02	mg/kg/day	1.0E+00	mg/kg/day	1.3E-02
				Antimony	8.8E+00	ug/L	2.8E-08	mg/kg/day	N/A		N/A	2.0E-06	mg/kg/day	6.0E-05	mg/kg/day	3.3E-02
				Arsenic	1.3E+02	ug/L	4.3E-07	mg/kg/day	1.5E+00	mg/kg/day	6.4E-07	3.0E-05	mg/kg/day	3.0E-04	mg/kg/day	1.0E-01
				Beryllium	4.1E+00	ug/L	1.3E-08	mg/kg/day	N/A		N/A	9.1E-07	mg/kg/day	3.5E-05	mg/kg/day	2.6E-02
				Cadmium	5.0E+00	ug/L	1.6E-08	mg/kg/day	N/A		N/A	1.1E-06	mg/kg/day	2.5E-05	mg/kg/day	4.5E-02
				Chromium	2.5E+02	ug/L	1.6E-06	mg/kg/day	2.0E+01	mg/kg/day	3.2E-05	1.1E-04	mg/kg/day	1.3E-04	mg/kg/day	8.9E-01
				Cobalt	2.3E+01	ug/L	3.0E-08	mg/kg/day	N/A		N/A	2.1E-06	mg/kg/day	3.0E-03	mg/kg/day	6.9E-04
				Iron	1.2E+05	ug/L	3.7E-04	mg/kg/day	N/A		N/A	2.6E-02	mg/kg/day	7.0E-01	mg/kg/day	3.7E-02
				Manganese	4.2E+02	ug/L	1.4E-06	mg/kg/day	N/A		N/A	9.5E-05	mg/kg/day	1.4E-01	mg/kg/day	6.8E-04
				Nickel	8.7E+01	ug/L	5.5E-08	mg/kg/day	N/A		N/A	3.9E-06	mg/kg/day	8.0E-04	mg/kg/day	4.8E-03
				Thallium	2.2E+00	ug/L	7.0E-09	mg/kg/day	N/A		N/A	4.9E-07	mg/kg/day	4.0E-05	mg/kg/day	1.2E-02
				Vanadium	3.3E+02	ug/L	1.0E-06	mg/kg/day	N/A		N/A	7.3E-05	mg/kg/day	5.0E-03	mg/kg/day	1.5E-02
							Exp. Route Total							3.3E-05		
			Exposure Point Total							3.3E-05					1.2E+00	
			Exposure Medium Total							3.3E-05					1.2E+00	
			Shallow Aquifer Groundwater Total							3.3E-05					1.2E+00	
Total of Receptor Risks Across All Media										3.3E-05	Total of Receptor Hazards Across All Media					1.2E+00

Notes-

Table 7.4.RME Supplement A  
 Calculation of DAevent  
 Construction Worker Shallow Ground Water  
 AOC 6  
 NWS Yorktown Cheatham Annex, Williamsburg, Virginia

Chemical of Potential Concern	Water Concentration (CW) (µg/L)	Permeability Coefficient (Kp) (cm/hr)	B (dimensionless)	Lag Time ( $\tau_{event}$ ) (hr)	t* (hr)	Fraction Absorbed Water (FA) (dimensionless)	Duration of Event (tevent) (hr)	DAevent (mg/cm <sup>2</sup> -event)	Eq
Aluminum	5.8E+04	1.0E-03	N/A	N/A	N/A	N/A	8	4.6E-04	1
Antimony	8.8E+00	1.0E-03	N/A	N/A	N/A	N/A	8	7.0E-08	1
Arsenic	1.3E+02	1.0E-03	N/A	N/A	N/A	N/A	8	1.1E-06	1
Beryllium	4.1E+00	1.0E-03	N/A	N/A	N/A	N/A	8	3.3E-08	1
Cadmium	5.0E+00	1.0E-03	N/A	N/A	N/A	N/A	8	4.0E-08	1
Chromium	2.5E+02	2.0E-03	N/A	N/A	N/A	N/A	8	4.0E-06	1
Cobalt	2.3E+01	4.0E-04	N/A	N/A	N/A	N/A	8	7.5E-08	1
Iron	1.2E+05	1.0E-03	N/A	N/A	N/A	N/A	8	9.3E-04	1
Manganese	4.2E+02	1.0E-03	N/A	N/A	N/A	N/A	8	3.4E-06	1
Nickel	8.7E+01	2.0E-04	N/A	N/A	N/A	N/A	8	1.4E-07	1
Thallium	2.2E+00	1.0E-03	N/A	N/A	N/A	N/A	8	1.8E-08	1
Vanadium	3.3E+02	1.0E-03	N/A	N/A	N/A	N/A	8	2.6E-06	1

**Inorganics: DAevent (mg/cm<sup>2</sup>-event) =**

$$DA_{event} = Kp \times CW \times tevent \times 0.001 \text{ mg/ug} \times 0.001 \text{ l/cm}^3 \quad (\text{Eq 1})$$

Notes:

N/A - Not applicable

Permeability constants and other input parameter values 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.

B - Dimensionless ratio of the permeability coefficient of a compound through the stratum corneum relative to its permeability coefficient across the viable epidermis (dimensionless).

t\* - Time to reach steady-state

TABLE 7.1.CTE  
 CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS  
 CENTRAL TENDENCY EXPOSURE  
 AOC 6  
 NWS Yorktown Cheatham Annex, Williamsburg, 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	Groundwater	Shallow Aquifer - Tap Water	Ingestion	Chromium, Dissolved	9.5E-01	ug/L	N/A		N/A		N/A	1.2E-05	mg/kg/day	3.0E-03	mg/kg/day	4.1E-03	
				Thallium, Dissolved	2.0E+00	ug/L	N/A		N/A		N/A	2.6E-05	mg/kg/day	1.0E-05	mg/kg/day	2.6E+00	
				Exp. Route Total					N/A							2.6E+00	
			Dermal Absorption	Chromium, Dissolved	9.5E-01	ug/L	N/A		N/A		N/A		7.8E-08	mg/kg/day	7.5E-05	mg/kg/day	1.0E-03
				Thallium, Dissolved	2.0E+00	ug/L	N/A		N/A		N/A		8.2E-08	mg/kg/day	1.0E-05	mg/kg/day	8.2E-03
				Exp. Route Total					N/A							9.3E-03	
				Exposure Point Total					N/A							2.6E+00	
				Exposure Medium Total					N/A							2.6E+00	
			Shallow Aquifer Groundwater Total								N/A						2.6E+00
			Total of Receptor Risks Across All Media										N/A	Total of Receptor Hazards Across All Media			

Notes-  
 N/A =Not available; Not applicable.  
 DA<sub>event</sub> for dermal exposure to groundwater calculated on Tables 7.1.CTE Supplement A.

Table 7.1.CTE Supplement A  
 Calculation of DAevent  
 Resident Adult Shallow Groundwater  
 AOC 6  
 NWS Yorktown Cheatham Annex, Williamsburg, Virginia

Chemical of Potential Concern	Water Concentration (CW) (µg/L)	Permeability Coefficient (Kp) (cm/hr)	B (dimensionless)	Lag Time (τ <sub>event</sub> ) (hr)	t* (hr)	Fraction Absorbed Water (FA) (dimensionless)	Duration of Event (tevent) (hr)	DAevent (mg/cm <sup>2</sup> -event)	Eq
Chromium, Dissolved	9.5E-01	2.0E-03	N/A	N/A	N/A	N/A	0.25	4.8E-10	1
Thallium, Dissolved	2.0E+00	1.0E-03	N/A	N/A	N/A	N/A	0.25	5.0E-10	1

**Inorganics: DAevent (mg/cm<sup>2</sup>-event) =**

$$DA_{event} = Kp \times CW \times tevent \times 0.001 \text{ mg/ug} \times 0.001 \text{ l/cm}^3 \quad (\text{Eq 1})$$

Notes:

N/A - Not applicable

Permeability constants and other input parameter values 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.

B - Dimensionless ratio of the permeability coefficient of a compound through the stratum corneum relative to its permeability coefficient across the viable epidermis (dimensionless).

t\* - Time to reach steady-state

TABLE 7.2.CTE  
 CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS  
 CENTRAL TENDENCY EXPOSURE  
 AOC 6  
 NWS Yorktown Cheatham Annex, Williamsburg, 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		
					Value	Units	Value	Units	Value	Units	Value	Units	Value	Units	Value	Units	
Groundwater	Groundwater	Shallow Aquifer - Tap Water	Ingestion	Chromium, Dissolved	9.5E-01	ug/L	N/A		N/A		N/A	4.1E-05	mg/kg/day	3.0E-03	mg/kg/day	1.4E-02	
				Thallium, Dissolved	2.0E+00	ug/L	N/A		N/A		N/A	8.5E-05	mg/kg/day	1.0E-05	mg/kg/day	8.5E+00	
				Exp. Route Total					N/A							8.6E+00	
			Dermal Absorption	Chromium, Dissolved	9.5E-01	ug/L	N/A		N/A		N/A		1.8E-07	mg/kg/day	7.5E-05	mg/kg/day	2.4E-03
				Thallium, Dissolved	2.0E+00	ug/L	N/A		N/A		N/A		1.9E-07	mg/kg/day	1.0E-05	mg/kg/day	1.9E-02
				Exp. Route Total					N/A							2.1E-02	
				Exposure Point Total					N/A							8.6E+00	
				Exposure Medium Total					N/A							8.6E+00	
			Shallow Aquifer Groundwater Total							N/A							8.6E+00
			Total of Receptor Risks Across All Media										N/A	Total of Receptor Hazards Across All Media			

Notes-  
 N/A =Not available; Not applicable.  
 DA<sub>event</sub> for dermal exposure to groundwater calculated on Tables 7.2.CTE Supplement A.

Table 7.2.CTE Supplement A  
 Calculation of DAevent  
 Resident Child Shallow Groundwater  
 AOC 6  
 NWS Yorktown Cheatham Annex, Williamsburg, Virginia

Chemical of Potential Concern	Water Concentration (CW) (µg/L)	Permeability Coefficient (Kp) (cm/hr)	B (dimensionless)	Lag Time (τ <sub>event</sub> ) (hr)	t* (hr)	Fraction Absorbed Water (FA) (dimensionless)	Duration of Event (tevent) (hr)	DAevent (mg/cm <sup>2</sup> -event)	Eq
Chromium, Dissolved	9.5E-01	2.0E-03	N/A	N/A	N/A	N/A	0.33	6.3E-10	1
Thallium, Dissolved	2.0E+00	1.0E-03	N/A	N/A	N/A	N/A	0.33	6.6E-10	1

**Inorganics: DAevent (mg/cm<sup>2</sup>-event) =**

$$DA_{event} = Kp \times CW \times tevent \times 0.001 \text{ mg/ug} \times 0.001 \text{ l/cm}^3 \quad (\text{Eq 1})$$

Notes:

N/A - Not applicable

Permeability constants and other input parameter values 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.

B - Dimensionless ratio of the permeability coefficient of a compound through the stratum corneum relative to its permeability coefficient across the viable epidermis (dimensionless).

t\* - Time to reach steady-state

TABLE 9.1.RME  
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs  
REASONABLE MAXIMUM EXPOSURE  
AOC 6  
NWS Yorktown Cheatham Annex, Williamsburg, 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	Chromium, Dissolved	N/A	N/A	N/A	N/A	Not identified	Hair	9E-03	N/A	4E-03	1E-02	
			Thallium, Dissolved	N/A	N/A	N/A	N/A			5E+00	N/A	3E-02	6E+00	
		Chemical Total			N/A	N/A	N/A	N/A			5E+00	N/A	3E-02	6E+00
		Exposure Point Total							N/A					6E+00
		Exposure Medium Total							N/A					6E+00
Shallow Aquifer Groundwater Total							N/A					6E+00		
Receptor Total							N/A	Receptor HI Total				6E+00		

Notes:

N/A = Not applicable

HI = Hazard Index

Total Hair HI Across All Media = 6E+00

TABLE 9.2.RME  
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs  
REASONABLE MAXIMUM EXPOSURE  
AOC 6  
NWS Yorktown Cheatham Annex, Williamsburg, 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	Chromium, Dissolved	N/A	N/A	N/A	N/A	Not identified	Hair	2E-02	N/A	1E-02	3E-02
			Thallium, Dissolved	N/A	N/A	N/A	N/A			1E+01	N/A	8E-02	1E+01
		Chemical Total		N/A	N/A	N/A	N/A		1E+01	N/A	1E-01	1E+01	
		Exposure Point Total					N/A					1E+01	
		Exposure Medium Total					N/A					1E+01	
Shallow Aquifer Groundwater Total							N/A					1E+01	
Receptor Total							N/A				Receptor HI Total	1E+01	

Notes:

N/A = Not applicable

HI = Hazard Index

Total Hair HI Across All Media = 1E+01

TABLE 9.3.RME  
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs  
REASONABLE MAXIMUM EXPOSURE  
AOC 6  
NWS Yorktown Cheatham Annex, Williamsburg, 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	Chromium, Dissolved	2E-05	N/A	1E-05	3E-05	Not identified	Hair	N/A	N/A	N/A	N/A
			Thallium, Dissolved	N/A	N/A	N/A	N/A			N/A	N/A	N/A	
		Chemical Total	2E-05	N/A	1E-05	3E-05		N/A	N/A	N/A	N/A		
		Exposure Point Total				3E-05					N/A		
		Exposure Medium Total				3E-05					N/A		
Shallow Aquifer Groundwater Total							3E-05					N/A	
Receptor Total							3E-05				Receptor HI Total	N/A	

Notes:  
N/A = Not applicable  
HI = Hazard Index

TABLE 9.4.RME  
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs  
REASONABLE MAXIMUM EXPOSURE  
AOC 6  
NWS Yorktown Cheatham Annex, Williamsburg, 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	N/A	N/A	N/A	N/A	Neurological	N/A	N/A	1E-02	1E-02			
			Antimony	N/A	N/A	N/A	N/A	Whole Body, Blood	N/A	N/A	3E-02	3E-02			
			Arsenic	N/A	N/A	6E-07	6E-07	Skin	N/A	N/A	1E-01	1E-01			
			Beryllium	N/A	N/A	N/A	N/A	None Observed	N/A	N/A	3E-02	3E-02			
			Cadmium	N/A	N/A	N/A	N/A	Kidney	N/A	N/A	4E-02	4E-02			
			Chromium	N/A	N/A	3E-05	3E-05	Blood	N/A	N/A	9E-01	9E-01			
			Cobalt	N/A	N/A	N/A	N/A	Thyroid	N/A	N/A	7E-04	7E-04			
			Iron	N/A	N/A	N/A	N/A	Gastrointestinal	N/A	N/A	4E-02	4E-02			
			Manganese	N/A	N/A	N/A	N/A	CNS	N/A	N/A	7E-04	7E-04			
			Nickel	N/A	N/A	N/A	N/A	Decreased body and organ weights	N/A	N/A	5E-03	5E-03			
			Thallium	N/A	N/A	N/A	N/A	Hair	N/A	N/A	1E-02	1E-02			
			Vanadium	N/A	N/A	N/A	N/A	Lifetime	N/A	N/A	1E-02	1E-02			
			Chemical Total				N/A	N/A	3E-05	3E-05		N/A	N/A	1E+00	1E+00
			Exposure Point Total								3E-05				
Exposure Medium Total								3E-05					1E+00		
Shallow Aquifer Groundwater Total								3E-05					1E+00		
Receptor Total								3E-05	Receptor HI Total				1E+00		

Notes:

N/A = Not applicable

HI = Hazard Index

CNS = Central Nervous System

Total Neurological/CNS HI Across All Media =	1E-02
Total Whole Body HI Across All Media =	3E-02
Total Blood HI Across All Media =	9E-01
Total Skin HI Across All Media =	1E-01
Total Kidney HI Across All Media =	4E-02
Total Thyroid HI Across All Media =	7E-04
Total Gastrointestinal HI Across All Media =	4E-02
Total Decreased body and organ weights Across All Media =	5E-03
Total Hair HI Across All Media =	1E-02
Total Lifetime HI Across All Media =	1E-02

TABLE 9.1.CTE  
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs  
CENTRAL TENDENCY EXPOSURE  
AOC 6  
NWS Yorktown Cheatham Annex, Williamsburg, 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	Chromium, Dissolved	N/A	N/A	N/A	N/A	Not identified	4E-03	N/A	1E-03	5E-03
			Thallium, Dissolved	N/A	N/A	N/A	N/A					
		Chemical Total	N/A	N/A	N/A	N/A	3E+00	N/A	9E-03	3E+00		
		Exposure Point Total					N/A					3E+00
		Exposure Medium Total					N/A					3E+00
Shallow Aquifer Groundwater Total							N/A					3E+00
Receptor Total							N/A	Receptor HI Total				3E+00

Notes:

N/A = Not applicable

HI = Hazard Index

Total Hair HI Across All Media = 3E+00

TABLE 9.2.CTE  
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs  
CENTRAL TENDENCY EXPOSURE  
AOC 6  
NWS Yorktown Cheatham Annex, Williamsburg, 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	Chromium, Dissolved	N/A	N/A	N/A	N/A	Not identified	Hair	1E-02	N/A	2E-03	2E-02	
			Thallium, Dissolved	N/A	N/A	N/A	N/A			9E+00	N/A	2E-02	9E+00	
		Chemical Total			N/A	N/A	N/A	N/A		9E+00	N/A	2E-02	9E+00	
		Exposure Point Total							N/A					9E+00
		Exposure Medium Total							N/A					9E+00
Shallow Aquifer Groundwater Total							N/A					9E+00		
Receptor Total							N/A	Receptor HI Total				9E+00		

Notes:

N/A = Not applicable

HI = Hazard Index

Total Hair HI Across All Media = 9E+00

TABLE 10.1.RME  
 RISK SUMMARY  
 REASONABLE MAXIMUM EXPOSURE  
 AOC 6  
 NWS Yorktown Cheatham Annex, Williamsburg, 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	Thallium, Dissolved	N/A	N/A	N/A	N/A	Hair	5E+00	N/A	3E-02	6E+00
			Chemical Total	N/A	N/A	N/A	N/A		5E+00	N/A	3E-02	6E+00
		Exposure Point Total					N/A					6E+00
		Exposure Medium Total					N/A					6E+00
Shallow Aquifer Groundwater Total							N/A					6E+00
Receptor Total							N/A	Receptor HI Total				6E+00

Notes:

N/A = Not applicable

HI = Hazard Index

Total Hair HI Across All Media = 6E+00

TABLE 10.2.RME  
RISK SUMMARY  
REASONABLE MAXIMUM EXPOSURE  
AOC 6  
NWS Yorktown Cheatham Annex, Williamsburg, 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	Thallium, Dissolved	N/A	N/A	N/A	N/A	Hair	1E+01	N/A	8E-02	1E+01
			Chemical Total	N/A	N/A	N/A	N/A		1E+01	N/A	8E-02	1E+01
		Exposure Point Total					N/A					1E+01
		Exposure Medium Total					N/A					1E+01
Shallow Aquifer Groundwater Total							N/A					1E+01
Receptor Total							N/A	Receptor HI Total				1E+01

Notes:

N/A = Not applicable

HI = Hazard Index

Total Hair HI Across All Media = 1E+01

TABLE 10.1.CTE  
RISK SUMMARY  
CENTRAL TENDENCY EXPOSURE  
AOC 6  
NWS Yorktown Cheatham Annex, Williamsburg, 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	Thallium, Dissolved	N/A	N/A	N/A	N/A	Hair	3E+00	N/A	8E-03	3E+00
			Chemical Total	N/A	N/A	N/A	N/A		3E+00	N/A	8E-03	3E+00
		Exposure Point Total					N/A					3E+00
		Exposure Medium Total					N/A					3E+00
Shallow Aquifer Groundwater Total							N/A					3E+00
Receptor Total							N/A	Receptor HI Total				3E+00

Notes:

N/A = Not applicable

HI = Hazard Index

Total Hair HI Across All Media = 3E+00

TABLE 10.2.CTE  
RISK SUMMARY  
CENTRAL TENDENCY EXPOSURE  
AOC 6  
NWS Yorktown Cheatham Annex, Williamsburg, 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	Thallium, Dissolved	N/A	N/A	N/A	N/A	Hair	9E+00	N/A	2E-02	9E+00
			Chemical Total	N/A	N/A	N/A	N/A		9E+00	N/A	2E-02	9E+00
		Exposure Point Total					N/A					9E+00
		Exposure Medium Total					N/A					9E+00
Shallow Aquifer Groundwater Total							N/A					9E+00
Receptor Total							N/A	Receptor HI Total				9E+00

Notes:

N/A = Not applicable

HI = Hazard Index

Total Hair HI Across All Media = 9E+00

## Appendix C

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# Ecological Risk Assessment

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## C.1 Introduction

This appendix contains a screening-level ecological risk assessment (SERA), constituting Steps 1 and 2 of the ecological risk assessment (ERA) process and the first step (Step 3A) of a baseline ecological risk assessment (BERA) for the Area of Concern (AOC) 6 1918 Drum Storage Area (DSA) subarea. This ERA provides detail and documentation of the ecological risk screening performed as part of the final Site Inspection (SI) (CH2M HILL, 2012), which concluded no unacceptable ecological risk associated with 1918 DSA subarea soil and groundwater.

### C.1.1 Ecological Risk Assessment Process

This ERA was conducted in accordance with the *Navy Policy for Conducting Ecological Risk Assessments* (CNO, 1999) and the Department of the Navy (Navy) guidance for implementing this ERA policy (NAVFAC, 2003). The Navy ERA policy and guidance, which describe a process consisting of eight steps organized into three tiers, are conceptually similar to the eight-step ERA process outlined in United States Environmental Protection Agency (USEPA) ERA guidance for the Superfund program (USEPA, 1997). For both sets of guidance, Steps 1 and 2 involve conducting a SERA using very conservative assumptions. The BERA represents Steps 3 through 7. The BERA uses less conservative (but more realistic) assumptions and site-specific data to refine the risk estimates from the SERA for components that fail the initial screening. Step 8 addresses risk management issues. The major differences between the Navy ERA policy and guidance and the USEPA ERA guidance are:

- Navy policy and guidance provide clearly defined criteria for exiting the ERA process at specific points
- Navy policy and guidance divide Step 3 (the first step of the BERA) into two distinct sub-steps (Steps 3A and 3B), with a potential exit point after Step 3A
- Navy policy and guidance incorporate risk management considerations throughout all tiers of the ERA process

ERAs are conducted using a tiered, step-wise approach and are punctuated with Scientific Management Decision Points (SMDPs). SMDPs represent points in the ERA process where agreement on conclusions, actions, or methodologies is needed so that the ERA process can continue (or terminate) in a technically defensible manner. The results of the ERA at a particular SMDP are used to determine how the ERA process should proceed, for example, to the next step in the process or directly to a later step. The process continues until a final decision has been reached (remedial action if unacceptable risks are identified or no further action if risks are acceptable). The process can also be iterative if data needs are identified at any step; the needed data are collected and the process starts again at the point appropriate to the type of data collected.

The screening (preliminary) problem formulation is the first step of an ERA and establishes the goals, scope, and focus of the SERA. Step 1 of the ERA process is intended to answer two main questions:

- Do complete exposure pathways exist?
- Are sufficient data available to conduct the SERA?

If no complete exposure pathways exist, the ERA process terminates at Step 1 with a conclusion of negligible (acceptable) risk because exposure, and thus potential risk, can only occur if complete exposure pathways exist. If one or more complete exposure pathways are known to exist, or are likely to exist, the ERA process continues to Step 2 but only evaluates those pathways that have been determined to be “critical” (ecologically important), that is, represent exposures to sensitive receptors that are associated with the predominant fate and transport mechanisms at the site (USEPA, 1997). An evaluation of the available data is then conducted to determine if they are adequate to support the SERA. If not, additional data are collected before the ERA process continues. The second step of the ERA process involves conducting a screening exposure assessment, a screening effects assessment, and a screening risk calculation (risk characterization).

The results of the SERA are used to evaluate the potential for unacceptable ecological risks based upon very conservative assumptions. If the results of the SERA suggest that further ecological risk evaluation is warranted, the ERA process proceeds to the BERA (Steps 3 through 7), which is a more detailed phase of the ERA process, for the pathways, chemicals, receptors, and areas identified in the SERA. As previously indicated, the first step of the BERA (Step 3) is divided into two distinct sub-steps (3A and 3B) in Navy ERA guidance.

Step 3 of the USEPA ERA guidance consists of the following activities (USEPA, 1997):

1. Refinement of the chemicals of potential concern (COPCs) from the SERA
2. Further characterizing the potential ecological effects of contaminants
3. Refining information on contaminant fate and transport, complete exposure pathways, and receptors potentially at risk
4. Selecting assessment endpoints
5. Refining the conceptual model and risk hypotheses from the SERA

Step 3A of the Navy policy and guidance (refinement of conservative exposure assumptions) corresponds to the first activity, previously listed, for the USEPA ERA guidance. In Step 3A, a refined evaluation of exposure estimates is conducted using less conservative (but more realistic) assumptions and additional methodologies relative to those used in the SERA, which is intended to be a very conservative assessment (NAVFAC, 2003). Examples of less conservative (but more realistic) exposure assumptions include using central tendency (mean) estimates (rather than maximums) for media concentrations, bioaccumulation factors, and exposure parameters. Examples of additional methodologies include the consideration of background concentrations, bioavailability, and detection frequency (CNO, 1999; NAVFAC, 2003).

If risk estimates (and their associated uncertainty) are acceptable following Step 3A (**Section C.5**), the site will meet the conditions of the exit criterion specified in the Navy policy and guidance. If the Step 3A evaluation does not support a determination of acceptable risk within acceptable uncertainty, the site continues to Step 3B.

Step 3B of the Navy policy and guidance (problem formulation) corresponds conceptually to the last four activities, previously listed, for Step 3 of the USEPA ERA guidance. In Step 3B, the preliminary conceptual model from the SERA is refined based upon the results of the Step 3A evaluation to develop a revised list of key receptors, critical exposure pathways, key COPCs, assessment endpoints, measurement endpoints, and risk hypotheses. Based upon the refined conceptual model, the lines of evidence to be used in characterizing risk are determined. Agreement on the refined conceptual model, COPCs, exposure pathways, endpoints, and risk hypotheses constitutes the SMDP at the end of Step 3 in both Navy and USEPA ERA guidance.

Following the completion of Step 3, a decision point is reached with two potential outcomes. If the refined risk estimates are acceptable for each selected assessment endpoint, the investigation proceeds to risk characterization (Step 7) to document this conclusion and the ERA process terminates. If the uncertainties associated with the refined risk estimates are unacceptable and/or the risk estimates indicate that unacceptable risks may exist, site-specific studies might be required and the ERA process continues (Steps 4 through 6). Step 4 is a work-planning step where additional site-specific studies are scoped and designed. Step 5 consists of the verification of the field sampling design developed in Step 4, while Step 6 constitutes the site investigation and data analysis phase of the process. The scope (the spatial extent of sampling) and components (the collection of biological data such as tissue samples, toxicity testing, and so forth) of any site-specific studies are determined by the conclusions of Step 3 and the pathways and endpoints associated with the potential unacceptable risks.

Step 7 consists of the documentation and synthesis of the information and data identified in Steps 1 through 3 (no additional study) or Steps 1 through 6 (additional study). In this step, risk is evaluated and characterized using both quantitative and qualitative methods. Conclusions are made as to whether or not there is a reasonable potential for unacceptable ecological risk, and if there is a potential for unacceptable ecological risk, the

magnitude of that risk. The results of the completed BERA (Step 7) are used to make any necessary risk management decisions (Step 8) related to current or future risks. Possible decisions include:

- Adequate information is available to conclude that no unacceptable ecological risks exist. The assessment should stop at Step 7.
- Adequate information is available to conclude that unacceptable ecological risks exist for which remedial actions or controls are warranted. Whether remedial actions or controls are taken, and which specific actions or controls are taken, will depend upon a number of risk management factors such as the results of any human health risk assessments (if applicable) and the potential impact of the remedial action or control itself on the habitats and biota present. This analysis would occur as part of Step 8.
- Adequate information is not available to estimate risk or the risk estimate is believed to be too conservative or uncertain to recommend remediation. The assessment should be refined.

## C.2 Problem Formulation

Problem formulation establishes the goals, scope, and focus of the ERA. As part of problem formulation, the ecological setting of the 1918 DSA subarea is characterized in terms of the habitats and biota known or likely to be present. The types and concentrations of chemicals that are present in ecologically relevant media are also described based upon available analytical data. Surface soil (0 to 6 inches below ground surface [bgs]) is the primary ecologically relevant medium at the site. Subsurface soils (6 to 24 inches bgs) are also evaluated, in accordance with Region 3 Biological Technical Assistance Group (BTAG) guidance, because some ecological receptors may be exposed to soils at these depths. Groundwater is also evaluated as a potential transport medium to downgradient water bodies (Penniman Lake).

A conceptual model is developed that describes source areas, transport pathways and exposure media, exposure pathways and routes, and receptors. Assessment endpoints, measurement endpoints, and risk hypotheses are developed to evaluate those receptors for which critical exposure pathways exist. The fate, transport, and toxicological properties of the chemicals present at the 1918 DSA subarea are also considered during this process.

### C.2.1 Environmental Setting

AOC 6 is composed of five non-contiguous subareas, each less than 1 acre, related to the former Penniman Shell Loading Plant (PSLP). The PSLP was an explosives manufacturing facility operated by DuPont during World War I on what is now Naval Weapons Station Yorktown Cheatham Annex (CAX) and adjacent areas. This facility operated as a trinitrotoluene manufacturing plant beginning in approximately 1916, and subsequently began loading artillery shells for the war effort in 1918. Between 1918 and 1925, this facility was demolished and the site reverted to farmland. The 1918 DSA subarea, one of the AOC 6 subareas and the subject of this ERA, was identified by the USEPA from a 1918 overhead photograph. This subarea was used for the storage of wooden barrels and/or 55-gallon drums when the shell loading facility was active.

The 1918 DSA subarea is generally topographically flat and contains no wetlands or water bodies. The northwest finger of Penniman Lake is located approximately 400 feet southeast (downgradient) of the 1918 DSA subarea (**Figure 1**). The shallow aquifer underlying the 1918 DSA subarea is the Yorktown-Eastover aquifer. Groundwater was encountered from approximately 10 to 11 feet bgs at the DSA during the SI and is expected to flow southeast toward Penniman Lake, which is the nearest water body to this site.

Public access to the area containing the 1918 DSA subarea is restricted, although Navy and Department of Defense personnel do have access to this area. The 1918 DSA subarea, which encompasses approximately 0.75 acre (**Figure 2**), is mostly developed, containing a paved parking lot and two office buildings. The remainder of the site consists of open maintained grassy areas. Future land use at the 1918 DSA subarea is not expected to change and will likely continue as industrial for the foreseeable future.

## C.2.2 Data Used in the Ecological Risk Assessment

Soil samples collected as part of the SI were quantitatively evaluated in this ERA. Since ecological exposures are generally confined to the top 2 feet of the soil column, the soil data used in this ERA were confined to this depth range but were evaluated separately as surface samples (0 to 6 inches bgs) and subsurface samples (6 to 24 inches bgs). Six surface soil and six subsurface soil samples (SS/SB-14 through SS/SB-19) were collected from the 1918 DSA subarea as part of the 2008 SI field activities. The soil sample locations were positioned to determine whether a release from historical activities had occurred and to characterize potential migration pathways. Additionally, one of the soil samples (SS/SB-19) was collected from a location expected to be upgradient of the 1918 DSA subarea, in an area assumed to be unaffected by site conditions.

Although ecological receptors do not typically have direct exposure to groundwater, groundwater data collected as part of the SI were also evaluated in this ERA. This was done to provide a conservative evaluation of the potential for significant contaminant transport via groundwater to downgradient receiving water bodies and the subsequent potential exposure of ecological receptors in these water bodies. Direct-push groundwater samples were collected from three locations (DW-09 through DW-11) during the 2008 SI field activities. The groundwater samples were collected from within the 1918 DSA subarea (DW-10) and in the upgradient (in an area assumed to be unaffected by site conditions) and downgradient directions (DW-11 and DW-09, respectively). The groundwater samples were positioned to determine if a release had occurred and to characterize potential migration pathways.

The samples used in this ERA are listed in **Table C-1** and are shown on **Figures 4, 5, and 6**. The analytical results for these samples can be found in **Appendix A**.

## C.2.3 Conceptual Model

The conceptual model relates potentially exposed receptor populations with potential source areas based upon physical site characteristics and complete exposure pathways. Important components of the conceptual model are the identification of potential source areas, transport pathways, exposure media, exposure pathways and routes, and receptors. Actual or potential exposures of ecological receptors associated with a site are determined by identifying the most likely, and most important, mechanisms and pathways of contaminant release and transport. A complete exposure pathway has three components: (1) a source or sources of contamination that results in a release to the environment; (2) a pathway and mechanism of chemical transport through an environmental medium; and (3) an exposure or contact point for an ecological receptor. **Figure C-1** illustrates a diagrammatic conceptual model for the 1918 DSA subarea. Key components of this conceptual model are discussed in the following subsections.

### Source Areas

The source of potential contamination at the 1918 DSA subarea is the historical drum storage activities that have occurred at this site.

### Transport Pathways and Exposure Media

A transport pathway describes the mechanisms whereby site-related chemicals, once released, may be transported from a source to ecologically relevant media (such as surface soil) where exposures may occur. These transport pathways are shown on **Figure C-1**.

The primary release mechanisms and transport pathways at the site include:

- Possible surface runoff from source areas to other areas of the site
- Infiltration, percolation, and leaching of contaminants to groundwater and subsequent discharge to the surface water and sediment of downgradient water bodies (Penniman Lake)

Exposure media for ecological receptors are typically limited to surface water, surface sediment, and surface soil. Surface water and sediment are not evaluated in this ERA because the site does not contain wetlands or water bodies. Subsurface soils (6 to 24 inches bgs) are also evaluated because some ecological receptors may be

exposed to soils at these depths. Groundwater is generally considered only as a transport medium since there are no ecological exposures to groundwater until it discharges to a water body or surfaces as a seep. In this ERA, groundwater is evaluated as a potential transport medium to downgradient water bodies (Penniman Lake). Air is not addressed in this ERA since this medium is not likely to result in significant contributions to total exposures for the receptors evaluated.

### Exposure Pathways and Routes

An exposure pathway links a source of contamination with one or more receptors through exposure via one or more media and exposure routes. Exposure, and thus potential risk, can only occur if complete exposure pathways exist. **Figure C-1** shows the potentially complete exposure pathways to ecological receptors associated with the 1918 DSA subarea, which include:

- Direct contact with site-related chemicals in surface soil for lower trophic level receptors (such as plants and soil invertebrates)

As previously discussed, there are no complete exposure pathways for aquatic receptors on the site due to the lack of wetland and aquatic habitats. However, groundwater is evaluated as a potential transport medium to downgradient water bodies (Penniman Lake).

An exposure route describes the specific mechanism(s) by which a receptor is exposed to a chemical present in an environmental medium. The most common exposure routes are dermal contact, direct uptake, ingestion, and inhalation. Terrestrial plants may be exposed to chemicals present in surface soils through their root surfaces during water and nutrient uptake. Terrestrial invertebrates may be exposed to chemicals in surface soil through dermal contact and ingestion. Due to the small size of the site (less than 1 acre) and its developed nature, exposures to terrestrial upper trophic level receptors (birds and mammals) are not considered significant and are not evaluated (CH2M HILL, 2012).

### Receptors

Because of the complexity of natural systems, it is generally not practical to directly assess the potential impacts to all ecological receptors present at a site. Therefore, specific receptor species or species groups (such as plants) are selected as surrogates to evaluate potential risks to larger components of the ecological community (guilds) used to represent the assessment endpoints. Selection criteria typically include those species that:

- Are known to occur, or are likely to occur, at the site
- Have a particular ecological, economic, or aesthetic value
- Are representative of taxonomic groups, life history traits, and/or trophic levels in the habitats present for which complete exposure pathways are likely to exist
- Can, because of toxicological sensitivity or potential exposure magnitude, be expected to represent potentially sensitive populations

Lower trophic level receptor species were evaluated based upon those taxonomic groupings for which soil screening values have been developed. As such, specific species of plants or soil invertebrates in terrestrial habitats were not chosen as receptors because of the limited information available for specific species and because these receptors were evaluated on a community level via a comparison of chemical concentrations in soil to soil screening values.

Amphibians are typically selected as a receptor group only when freshwater aquatic or wetland habitats are present on, or in the contaminant transport pathways (as defined in the conceptual model) of, a site. This is not the case at the 1918 DSA subarea based on the lack of these habitats.

Reptiles are an applicable receptor group. Individual species of reptiles are not, however, selected for evaluation because of the general lack of available toxicological information for this taxonomic group for direct effects.

Potential risks to reptiles from direct exposures to surface soil are evaluated using soil screening values developed for other taxonomic groups (previously described). This is discussed further in **Section C.6**.

### Endpoints and Risk Hypotheses

The conclusion of the problem formulation includes the selection of ecological endpoints and risk hypotheses, which are based upon the conceptual model. Two types of endpoints, assessment endpoints and measurement endpoints, are defined as part of the ERA process (USEPA, 1997). An assessment endpoint is an explicit expression of the environmental component or value that is to be protected. A measurement endpoint is a measurable ecological characteristic that is related to the component or value chosen as the assessment endpoint. The considerations for selecting assessment and measurement endpoints are summarized in USEPA (1997) and discussed in detail in Suter (1989; 1990; 1993). Risk hypotheses are testable hypotheses about the relationship among the assessment endpoints and their predicted responses when exposed to contaminants.

Endpoints define ecological attributes that are to be protected (assessment endpoints) and measurable characteristics of those attributes (measurement endpoints) that can be used to gauge the degree of impact that has or may occur. Assessment endpoints most often relate to attributes of biological populations or communities, and are intended to focus the risk assessment on particular components of the ecosystem that could be adversely affected by chemicals attributable to a site (USEPA, 1997). Assessment endpoints contain an entity (such as a plant population) and an attribute of that entity (such as survival rate). Individual assessment endpoints usually encompass a group of species or populations (the receptor) with some common characteristic, such as specific exposure route or contaminant sensitivity, with the receptor then used to represent the assessment endpoint in the risk evaluation.

Assessment and measurement endpoints may involve ecological components from any level of biological organization, from individual organisms to the ecosystem itself. Effects on individual organisms are important for some receptors, such as rare and endangered species; population- and community-level effects are typically more relevant to ecosystems. Population- and community-level effects are usually difficult to evaluate directly without long-term and extensive study. However, measurement endpoint evaluations at the individual level, such as an evaluation of the effects of chemical exposure on reproduction, can be used to predict effects on an assessment endpoint at the population or community level. In addition, use of criteria values designed to protect the majority of the components of a community (such as the Ambient Water Quality Criteria [AWQC] for the Protection of Aquatic Life) can be useful in evaluating potential community- and/or population-level effects.

**Table C-2** shows the assessment endpoints, risk hypotheses, and measurement endpoints used in the ERA. **Table C-2** also shows the receptors associated with each endpoint.

## C.3 Exposure Assessment

The principal activity associated with the exposure assessment is the estimation of chemical concentrations in applicable media, termed exposure point concentrations (EPCs), to which the receptors may be exposed. This is accomplished through the selection of appropriate sets of the available analytical data using a set of criteria (such as validation status and sampling date). Once the analytical data sets are selected, EPCs are calculated as a particular point on the distribution of concentrations. At the screening level (SERA, Step 2), the EPC is the maximum detected concentration. At the baseline level (BERA, Step 3A), EPCs are central tendency estimates (that is, arithmetic mean).

For conservatism, the maximum (SERA) and mean (BERA) reporting limits for chemicals analyzed for but not detected were also compared to medium-specific ecological screening values (ESVs). This was done to determine whether reporting limits were less than chemical concentrations at which potential adverse effects to ecological receptors may occur.

### C.3.1 Selection Criteria for Analytical Data

Available analytical data (**Section C.2.2**) were selected for use in the ERA based upon the following:

- Data must have been validated by a qualified data validator using acceptable data validation methods. Rejected (R) values were not used in the ERA. Unqualified data and data qualified as J (estimated), L (biased low), or K (biased high) were treated as detected. Data qualified as U (undetected) or B (blank contamination) were treated as non-detected.
- For samples with duplicate analyses, the higher of the two concentrations was used, for conservatism, when both values were detects or when both values were non-detects. In cases where one result was a detection and the other a non-detect, the detected value was used in the assessment.
- For non-detected results, the sample quantitation (reporting) limit (SQL) was used to represent the concentration. When calculating statistics (such as arithmetic mean), one-half of the SQL was used for non-detected results.

### C.3.2 Exposure Point Concentrations

EPCs are calculated as a particular point on the distribution of concentrations. At the screening level, the EPC is the maximum detected concentration. At the baseline level, EPCs are typically central tendency estimates (arithmetic mean), which provide a more representative estimate of potential exposures and risks to receptor populations (the focus of the selected assessment endpoints). In this ERA, the maximum, arithmetic mean, and 95 percent upper confidence limit (UCL) of the arithmetic mean concentrations were evaluated for direct exposures.

## C.4 Effects Assessment

The effects assessment defines the methods and data used to define an adverse ecological effect. For this ERA, effects data are available from multiple lines of evidence, as follows:

- **ESVs for Soil** - Analytical surface and shallow subsurface soil data are compared to the soil ESVs developed in **Section C.4.1**.
- **ESVs for Surface Water** - Analytical groundwater data are compared to literature-based surface water ESVs developed in **Section C.4.1**.
- **Bioavailability Measures** - Additional data were collected to help evaluate chemical-specific bioavailability in abiotic media.

In addition, a comparison of site soil and groundwater concentrations to facility background concentrations was conducted as an additional line of evidence (**Section C.5**).

### C.4.1 Medium-specific Ecological Screening Values

Medium-specific ESVs were established for each ecologically relevant medium. Based upon the conceptual model (**Figure C-1**), exposure to surface (and shallow subsurface) soils, and possible indirect exposure to groundwater, are the potentially complete pathways.

#### Soil ESVs

The soil ESVs used in the ERA are summarized in **Table C-3**. When more than one ESV was available (such as fauna and flora) from a particular source for a chemical, the lowest of these values was selected. **Table C-4** lists the uncertainty factors used to derive some of the ESVs.

#### Surface Water ESVs

The surface water ESVs used to screen groundwater considered the salinity of the receiving water body to determine whether to apply freshwater or marine values. Because the salinity of Penniman Lake is less than 1 part

per thousand (based upon the 2000 Pond Study), freshwater ESVs were used. The water ESVs used in the ERA are summarized in **Table C-5**. **Table C-4** lists the uncertainty factors used to derive some of the ESVs.

The surface water ESVs used in the ERA considered Region 3 BTAG screening values (USEPA, 2006b), as well as additional ESVs available from the literature. When more than one ESV was available (such as fauna and flora) from a particular source for a chemical, the lowest of these values was selected. The ESVs for chemicals known to bioaccumulate in aquatic food webs were based upon the final chronic value (rather than the final residue value) in accordance with USEPA (1996; 2009) and Suter and Tsao (1996). The use of final chronic values is intended to protect aquatic receptors from direct exposures to chemicals in surface water, rather than from exposure via food webs.

## C.4.2 Bioavailability Measures

Data collected to evaluate the potential chemical-specific bioavailability in abiotic media included:

- **Soil** – Total Organic Carbon and pH
- **Groundwater** – Dissolved metals

## C.5 Risk Characterization

The risk characterization portion of the ERA uses the information generated during the three previous parts of the ERA (problem formulation, exposure assessment, and effects assessment) to estimate potential risks to ecological receptors at the level of conservatism applied (screening or baseline).

### C.5.1 Screening-level Ecological Risk Assessment Approach

The main objective of risk characterization at the screening level (termed risk calculation) is to derive a list of COPCs. As part of this risk calculation, the maximum exposure concentrations (abiotic media) are compared with the corresponding ESVs to derive risk estimates using the hazard quotient (HQ) method. HQs are calculated by dividing the chemical concentration in the medium being evaluated by the corresponding medium-specific ESV. HQs equaling or exceeding 1 indicate the potential for unacceptable risk since the chemical concentration (exposure) equals or exceeds the ESV (effect); these chemicals are identified as COPCs at Step 2. However, ESVs and exposure estimates are derived using intentionally conservative assumptions at the screening level such that HQs greater than or equal to 1 do not necessarily indicate that unacceptable risks are present. Rather, it identifies chemical-pathway-receptor combinations requiring further evaluation using less conservative (but more realistic) exposure scenarios and assumptions. HQs less than 1 indicate that unacceptable risks are unlikely, enabling a conclusion of negligible (acceptable) risk to be reached with high confidence.

In addition to chemicals that exceed medium-specific ESVs based upon maximum detected concentrations, the following also applies to COPC selection at Step 2:

- Non-detected chemicals were retained as COPCs if the maximum detection limit exceeded the ESV for that medium
- All detected chemicals lacking an ESV were retained as COPCs
- The essential nutrients calcium, magnesium, potassium, and sodium were excluded as potential COPCs since they are essential macronutrients that are needed in relatively high concentrations for normal metabolism, growth, and reproduction

### C.5.2 Baseline Ecological Risk Assessment Approach

COPCs from the SERA are reevaluated in the first step of the BERA (Step 3A). As previously discussed, this reevaluation involves using less conservative (but more realistic) assumptions about exposures and a comparison of these revised exposure estimates (based upon central tendency estimates of media concentrations) with ESVs.

In addition to chemicals that exceed medium-specific ESVs based upon mean detected concentrations, the following also applies to COPC selection at Step 3A:

- All detected chemicals lacking an ESV were retained as COPCs for risk evaluation

For Step 3A, the following additional factors were also considered, as appropriate:

- **Background Concentrations.** Facility-specific background concentrations were also considered in the reevaluation for soil and groundwater. The background evaluation consisted of a direct comparison of site concentrations to the upper tolerance limits (UTLs) developed for inorganic constituents in the background study in a manner analogous to the comparison to ESVs. Soil background 95 percent UTL values have been developed separately for surface and subsurface soils. The background 95 percent UTL values for groundwater have been derived for both the Yorktown-Eastover aquifer (deep) and the Cornwallis Cave aquifer (shallow). Yorktown-Eastover aquifer UTLs are applicable to the 1918 DSA subarea.

### C.5.3 Comparison with Ecological Screening Values

As discussed in **Section C.3.2**, the maximum, arithmetic mean, and 95 percent UCL of the arithmetic mean concentrations were compared with ESVs. Chemicals were excluded from further consideration in the SERA if the HQ based upon the maximum concentration was less than 1. Chemicals were excluded from further consideration in the BERA if the HQ based upon the 95 percent UCL was less than 1.

#### Surface Soil

Maximum, mean, and 95 percent UCL surface soil concentrations are compared to soil ESVs for plants and soil invertebrates in **Table C-6**. **Table C-6** also contains a comparison against background UTLs for metals that exceeded soil ESVs based upon 95 percent UCL concentrations.

Three inorganic constituents (aluminum, iron, and lead) exceeded ESVs based upon maximum detected concentrations (**Table C-6**), although the exceedance for aluminum was in the upgradient sample (SS-19). The ESVs for aluminum and iron are based upon soil pH. Thus, aluminum, iron, and lead were identified as Step 2 COPCs. Three semivolatile organic compounds (SVOCs) (4,6-dinitro-2-methylphenol, 4-nitrophenol, and atrazine) were not detected but maximum detection limits exceeded ESVs. These three chemicals were also identified as Step 2 COPCs.

Mean and 95 percent UCL concentrations in surface soil are also compared with ESVs in **Table C-6**. No chemical had a HQ that equaled or exceeded 1 based upon the 95 percent UCL or mean concentrations. Thus, no Step 3A COPCs were identified. Two chemicals (4-nitrophenol and atrazine) were not detected but 95 percent UCL and mean concentrations based upon detection limits exceeded ESVs. These two chemicals were not identified as Step 3A COPCs but are discussed in **Section C.6**.

- No Step 3A COPCs were identified. Thus, there are no unacceptable ecological risks associated with this medium.

#### Subsurface Soil

Maximum, mean, and 95 percent UCL subsurface soil concentrations are compared to soil ESVs for plants and soil invertebrates in **Table C-7**. **Table C-7** also contains a comparison against background UTLs for metals that exceeded soil ESVs based upon 95 percent UCL concentrations.

One inorganic constituent (iron) exceeded ESVs based upon maximum detected concentrations (**Table C-7**). The ESV for iron is based upon soil pH. Thus, iron was identified as a Step 2 COPC. Two SVOCs (4-nitrophenol and atrazine) were not detected but maximum detection limits exceeded ESVs. These two chemicals were also identified as Step 2 COPCs.

Mean and 95 percent UCL concentrations in surface soil are also compared with ESVs in **Table C-7**. The HQ for iron did not equal or exceed 1 based upon the 95 percent UCL or mean concentrations, and maximum concentrations did not exceed background UTLs. Thus, no Step 3A COPCs were identified. Two chemicals (4-nitrophenol and

atrazine) were not detected but 95 percent UCL and mean concentrations based upon detection limits exceeded ESVs. These two chemicals were not identified as Step 3A COPCs but are discussed in **Section C.6**.

- No Step 3A COPCs were identified. Thus, there are no unacceptable ecological risks associated with this medium.

## Groundwater

Although ecological receptors do not typically have direct exposure to groundwater, surface water ESVs were compared to site groundwater data (with and without dilution factors) in order to provide a conservative evaluation of the potential for significant contaminant transport via groundwater to downgradient receiving water bodies (Penniman Lake). In the absence of site-specific dilution factors for groundwater, Buchman (1999) recommends using a dilution factor of 10 to account for the dilution expected during migration and upon discharge of groundwater to surface water. The groundwater evaluation provided in the ERA was a modified version of the initial (screening) groundwater evaluation method provided in the decision tree of USEPA (2008a). Modifications included the use of mean concentrations and dilution factors in Step 3A, consistent with the less conservative (but more realistic) assumptions applied as part of the Step 3A evaluation.

Although both total and dissolved groundwater data were included in the screening tables, only dissolved metals data were considered when selecting COPCs because groundwater samples were collected via direct-push, not from monitoring wells, and chemicals in groundwater are most likely to travel dissolved in water rather than adhered to particles since they must travel through soil pores. Similarly, when groundwater discharges to a water body (at which time ecological exposures become possible), the bulk of the discharged chemicals are likely to be dissolved in water since the discharge must pass through the pores in the underlying sediments. Thus, the dissolved concentrations are likely to be more representative of what would be transported via the groundwater than the total concentrations. Once discharged, the dissolved metal fraction in water (filtered samples) is more representative of the bioavailable fraction to aquatic receptors than the total metal fraction (unfiltered samples) (USEPA, 1996). This is reflected in how the most recent AWQC have been developed for many metals, that is, they are based upon the dissolved fraction (USEPA, 2009).

Maximum, mean, and 95 percent UCL groundwater concentrations are compared to ESVs in **Table C-8**. **Table C-8** also contains a comparison against background UTLs for metals that exceeded ESVs based upon 95 percent UCL concentrations.

Two inorganics (aluminum and barium) exceeded ESVs based upon maximum detected concentrations in filtered samples (**Table C-8**). Thus, aluminum and barium were identified as Step 2 COPCs. Five dissolved metals, 22 SVOCs, and one explosive were not detected but maximum detection limits exceeded ESVs. All of these chemicals were also identified as Step 2 COPCs.

The comparison of maximum undiluted groundwater concentrations with surface water ESVs is very conservative and likely significantly overestimates potential ecological exposures to sediment pore water in the biologically active zone and, especially, in the water column. The mean concentration is likely to provide a more realistic estimate of potential transport and exposure because groundwater discharge to the water bodies is expected to be diffuse rather than concentrated at particular points. Groundwater is also unlikely to be discharged undiluted. In the absence of site-specific dilution factors, Buchman (1999) recommends using a dilution factor of 10 to account for the dilution expected during migration to surface water bodies. Site-specific factors were not available so the “default” value of 10 was applied.

Mean and 95 percent UCL chemical concentrations in groundwater are also compared with ESVs in **Table C-8**. This comparison was done assuming no dilution as well as using a dilution factor of 10. The HQs for aluminum and barium (dissolved) exceeded 1 based upon the undiluted 95 percent UCL and mean concentrations. Aluminum also exceeded the background UTL, although barium did not. The HQ for aluminum was less than 1 assuming a dilution factor of 10 (**Table C-8**). Thus, no Step 3A COPCs were identified. Five dissolved metals, 16 SVOCs, and one explosive were not detected but 95 percent UCL and mean concentrations based upon detection limits exceeded ESVs. These chemicals were not identified as Step 3A COPCs but are discussed in **Section C.6**.

- No Step 3A COPCs were identified. Thus, there are no unacceptable ecological risks associated with this medium.

### C.5.4 Risk Evaluation

In this section, the various lines of evidence discussed in the previous section are integrated in order to evaluate the potential for unacceptable risks.

#### Terrestrial Habitats

Three assessment endpoints were developed for terrestrial habitats at the 1918 DSA subarea (**Table C-2**). Lines of evidence for terrestrial habitats included:

- Comparison of surface soil and shallow subsurface soil concentrations with ESVs
- Comparison of site soil concentrations with background concentrations

In surface and subsurface soils, no chemical had a 95 percent UCL-based HQ that equaled or exceeded 1 and also equaled or exceeded background UTLs. Thus, no Step 3A COPCs were identified and there are no unacceptable ecological risks associated with site soil.

#### Aquatic Habitats

In groundwater, only aluminum had a 95 percent UCL-based HQ that equaled or exceeded 1 assuming no dilution and also equaled or exceeded the background UTL. With a dilution factor of 10, the HQ for aluminum was less than 1. Thus, no Step 3A COPCs were identified and there are no unacceptable ecological risks associated with site groundwater. Based upon the results of this evaluation, groundwater does not appear to be a significant transport medium for site-related constituents to Penniman Lake, and site-related constituents that might reach this water body via groundwater would not pose an unacceptable risk to aquatic biota.

### C.5.5 Risk Summary and Conclusions

In Step 3A, no COPCs were identified in 1918 DSA subarea surface soil, subsurface soil, or groundwater. For terrestrial habitats, risks for lower trophic level ecological receptors (plants and invertebrates) are acceptable, particularly given the current and future land use (industrial). Groundwater does not appear to be a significant transport medium for site-related constituents to Penniman Lake, and site-related constituents in groundwater are unlikely to pose a significant risk to aquatic biota.

## C.6 Uncertainties

Uncertainties are present in all ERAs because of the limitations of the available data and the need to make certain assumptions and extrapolations based upon incomplete information. Since conservative assumptions were generally used in the exposure and effects assessments, these uncertainties are more likely to result in an overestimation rather than an underestimation of the likelihood and magnitude of risks to ecological receptors.

The ERA uses “standard” methods and typical ranges of values for EPCs (maximum, mean, and 95 percent UCL) and other parameters. This results in risk estimates that adequately span the risk range from extremely conservative (screening estimates) to central tendency (mean baseline estimates). The uncertainties associated with many of the particular inputs to the risk estimates are discussed as follows. What constitutes an unacceptable risk within this risk range is ultimately a risk management decision.

The uncertainties in this ERA are mainly attributable to the following factors:

- Reporting Limits - Reporting limits for some undetected analytes exceeded applicable ESVs in some media. **Table C-9** summarizes these constituents, by medium, and reports both the ratio of the minimum and maximum reporting limits to the ESV, as well as the ratio of the mean value (calculated using one-half of the reporting limit for each sample) to the ESV. Because these constituents were not detected, they are not known to be present on the site but the potential for unacceptable risks cannot be totally discounted because the reporting limits are higher than the ESVs. The magnitude of the ratios can be used to qualitatively

evaluate the magnitude of the associated uncertainty (that is, higher ratios are indicative of a greater likelihood that chemicals are present at concentrations that exceed the screening value relative to lower ratios). In surface soil, three undetected chemicals equaled or exceeded reporting limits but the mean ratio was less than 1 for one of the three, less than 2 for the second, and approximately 16 for the third. In subsurface soil, two undetected chemicals exceeded reporting limits but the mean ratio was less than 2 for one and approximately 15 for the other. In groundwater, mean reporting limits were generally less than 10 times ESVs.

In summary, there were few chemicals with very high mean ratios, suggesting that the associated uncertainties are relatively low. Because standard analytical methods were used and the sample reporting limits were not elevated relative to the method reporting limits for the vast majority of samples and analytes, these uncertainties are considered acceptable and are unlikely to impact the conclusions of the ERA.

- Duplicate Analyses - When evaluating samples with field duplicates, the value used in the ERA was always the detect when one result was a detect and the duplicate was a non-detect, regardless of whether or not the non-detected value was higher. In these cases, the use of the detect has less uncertainty since it represents an actual measured value (versus an upper limit bound) and the two samples will have identical or similar reporting limits.
- Selection of COPCs - Chemicals without available ESVs for a medium were not retained as COPCs for risk evaluation unless they were detected. These uncertainties are unlikely to impact the conclusions of the ERA since these chemicals are not known to be present on the site.
- Chemical Mixtures - Information on the toxicological effects of chemical interactions is generally lacking for ecological receptors, which required (as is standard for ERAs) that the chemicals be evaluated on a compound-by-compound basis during the comparison to ESVs. This could result in an underestimation of risk (if there are additive or synergistic effects among chemicals) or an overestimation of risks (if there are antagonistic effects among chemicals).
- Receptor Species Selection - Reptiles were selected as receptors in the ERA, but were not evaluated quantitatively even when exposure pathways were likely to be complete. This represents an uncertainty in the ERA. It was also assumed that any reptiles present on the site were not exposed to significantly higher concentrations of chemicals and were not more sensitive to chemicals than other receptor species evaluated in the ERA. This assumption was a source of uncertainty in the ERA. In addition, there is some uncertainty associated with the use of specific receptor species to represent larger groups of organisms (such as guilds).
- Mean Versus Maximum Media Concentrations - As is typical in an ERA, a finite number of samples of environmental media are used to develop the exposure estimates. The maximum measured concentration provides a conservative estimate for immobile biota or those with a limited home range. The most realistic exposure estimates for mobile species with relatively large home ranges and for species populations (even those that are immobile or have limited home ranges) are those based upon the mean chemical concentrations in each medium to which these receptors are exposed. The arithmetic mean and 95 percent UCL of the arithmetic mean were used quantitatively in the BERA portion of this ERA to represent the average exposure scenarios per Navy ERA guidance.
- Evaluation of the Groundwater Transport Pathway - Potential ecological risks from groundwater discharge to downgradient surface water bodies (Penniman Lake) were indirectly evaluated through a comparison of groundwater concentrations from site samples with surface water ESVs. Surface water, pore water, and/or sediment samples were not collected from this water body during the SI as related to the 1918 DSA subarea. The direct screening of groundwater data is normally the first step in such an evaluation (USEPA, 2008a), with surface water, pore water, and/or sediment samples only collected from the receiving water body or bodies if the initial screening indicates the potential for significant transport and exposure from this pathway. Based upon the results of the groundwater screening, potential ecological risks were not high enough to warrant further evaluation or sample collection in the receiving water body, although Penniman Lake is currently the subject of a Remedial Investigation unrelated to the 1918 DSA subarea.

- Comparisons to Background Concentrations - Background concentrations were used to judge the site-relatedness of individual chemicals. If site concentrations were consistent with background levels, it was assumed that the concentrations were not related to known site-related source areas. There exists the possibility that concentrations below background were indeed site-related, rendering the assumption false. However, the potential impact of this possibility is minimal since chemicals at concentrations consistent with background should exhibit no different ecological effects than commonly occurring in areas not affected by releases, regardless of their source.

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## **Ecological Risk Assessment Tables**

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TABLE C-1

**Samples Used in the Ecological Risk Assessment****AOC 6 - 1918 Drum Storage Area*****WPNSTA Cheatham Annex, Williamsburg, Virginia***

Station ID	Sample ID	Sample Date	Depth (inches)
<b>Surface Soil</b>			
CAA06-SO14	CAA06-SS14-1108	11/11/2008	0-6
CAA06-SO15	CAA06-SS15-1108	11/11/2008	0-6
CAA06-SO16	CAA06-SS16-1108	11/11/2008	0-6
CAA06-SO17	CAA06-SS17-1108	11/11/2008	0-6
CAA06-SO18	CAA06-SS18-1108	11/11/2008	0-6
CAA06-SO19	CAA06-SS19-1108	11/11/2008	0-6
CAA06-SO19	CAA06-SS19P-1108	11/11/2008	0-6
<b>Subsurface Soil</b>			
CAA06-SO14	CAA06-SB14-1108	11/11/2008	6-24
CAA06-SO15	CAA06-SB15-1108	11/11/2008	6-24
CAA06-SO16	CAA06-SB16-1108	11/11/2008	6-24
CAA06-SO17	CAA06-SB17-1108	11/11/2008	6-24
CAA06-SO18	CAA06-SB18-1108	11/11/2008	6-24
CAA06-SO19	CAA06-SB19-1108	11/11/2008	6-24
CAA06-SO19	CAA06-SB19P-1108	11/11/2008	6-24
<b>Groundwater</b>			
CAA06-DW09	CAA06-DW09-1108	11/11/2008	--
CAA06-DW10	CAA06-DW10-1108	11/11/2008	--
CAA06-DW10	CAA06-DW10P-1108	11/11/2008	--
CAA06-DW11	CAA06-DW11-1108	11/11/2008	

Shaded cells indicate field duplicates

TABLE C-2

**Assessment Endpoints, Risk Hypotheses, and Measurement Endpoints****AOC 6 - 1918 Drum Storage Area*****WPNSTA Cheatham Annex, Williamsburg, Virginia***

<b>Assessment Endpoint</b>	<b>Risk Hypothesis</b>	<b>Measurement Endpoint</b>	<b>Receptor</b>
Survival, growth, and reproduction of terrestrial soil invertebrate communities	Are site-related chemical concentrations in surface soil sufficient to adversely effect soil invertebrate communities?	Comparison of maximum (SERA) and mean (BERA) chemical concentrations in surface soil with soil screening values	Soil invertebrates
Survival, growth, and reproduction of terrestrial plant communities	Are site-related chemical concentrations in surface soil sufficient to adversely effect terrestrial plant communities?	Comparison of maximum (SERA) and mean (BERA) chemical concentrations in surface soil with soil screening values	Terrestrial plants
Survival, growth, and reproduction of terrestrial reptile populations	Are site-related chemical concentrations in surface soil sufficient to cause adverse effects (on growth, survival, or reproduction) to terrestrial reptile populations?	Comparison of maximum (SERA) and mean (BERA) chemical concentrations in surface soil with soil screening values	Reptiles

TABLE C-3

## Ecological Screening Values (ESVs) for Soil - Plants and Soil Invertebrates

## AOC 6 - 1918 Drum Storage Area

## WPNSTA Cheatham Annex, Williamsburg, Virginia

Chemical	ESV	Units	Reference	Type/Receptor	Comments
<b>Inorganics</b>					
Aluminum	pH < 5.5	--	USEPA 2003a	--	Eco-SSL
Antimony	78.0	mg/kg	USEPA 2005a	Invertebrate	Eco-SSL
Arsenic	18.0	mg/kg	USEPA 2005b	Plant	Eco-SSL
Barium	330	mg/kg	USEPA 2005c	Invertebrate	Eco-SSL
Beryllium	40.0	mg/kg	USEPA 2005d	Invertebrate	Eco-SSL
Cadmium	32.0	mg/kg	USEPA 2005e	Plant	Eco-SSL
Chromium	64.0	mg/kg	CCME 2007	--	Soil Quality Guideline
Cobalt	13.0	mg/kg	USEPA 2005f	Plant	Eco-SSL
Copper	70.0	mg/kg	USEPA 2007a	Plant	Eco-SSL
Cyanide	15.8	mg/kg	MHSPE 2000	--	Geometric mean of target and intervention values (complex)
Iron	5 < pH > 8	--	USEPA 2003b	--	Eco-SSL
Lead	120	mg/kg	USEPA 2005g	Plant	Eco-SSL
Manganese	220	mg/kg	USEPA 2007b	Plant	Eco-SSL
Mercury	0.10	mg/kg	Efroymsen et al. 1997b	Invertebrate	
Nickel	38.0	mg/kg	USEPA 2007c	Plant	Eco-SSL
Selenium	0.52	mg/kg	USEPA 2007d	Plant	Eco-SSL
Silver	560	mg/kg	USEPA 2006c	Plant	Eco-SSL
Thallium	1.00	mg/kg	Efroymsen et al. 1997a	Plant	
Vanadium	130	mg/kg	CCME 2007	--	Soil Quality Guideline
Zinc	120	mg/kg	USEPA 2007e	Invertebrate	Eco-SSL
<b>Semivolatile Organic Compounds</b>					
1,1-Biphenyl	13,600	ug/kg	Efroymsen et al. 1997a	Plant	EC50 (68,000); UF of 5
2,2'-Oxybis(1-chloropropane)	NSV	--	--	--	
2,4,5-Trichlorophenol	1,350	ug/kg	Efroymsen et al. 1997a	Plant	NOEC
2,4,6-Trichlorophenol	580	ug/kg	Efroymsen et al. 1997b	Invertebrate	LC50 of 58,000; UF of 100
2,4-Dichlorophenol	500	ug/kg	CCME 2007; Beyer 1990	--	Interim Remediation Criteria (IRC) for residential/parkland; B value
2,4-Dimethylphenol	1,000	ug/kg	CCME 2007; Beyer 1990	--	Interim Remediation Criteria (IRC) for residential/parkland; B value
2,4-Dinitrophenol	20,000	ug/kg	Efroymsen et al. 1997a	Plant	NOEC
2,4-Dinitrotoluene	11,000	ug/kg	NRCC 2006	Plant/Invertebrate	
2,6-Dinitrotoluene	8,500	ug/kg	NRCC 2006	Plant/Invertebrate	
2-Chloronaphthalene	LMW PAHs	--	--	--	
2-Chlorophenol	500	ug/kg	CCME 2007; Beyer 1990	--	Interim Remediation Criteria (IRC) for residential/parkland; B value
2-Methylnaphthalene	LMW PAHs	--	--	--	
2-Methylphenol	1,000	ug/kg	CCME 2007; Beyer 1990	--	Interim Remediation Criteria (IRC) for residential/parkland; B value
2-Nitroaniline	NSV	--	--	--	
2-Nitrophenol	1,000	ug/kg	CCME 2007; Beyer 1990	--	Interim Remediation Criteria (IRC) for residential/parkland; B value
3,3'-Dichlorobenzidine	NSV	--	--	--	
3-Nitroaniline	NSV	--	--	--	
4,6-Dinitro-2-methylphenol	1,000	ug/kg	CCME 2007; Beyer 1990	--	Interim Remediation Criteria (IRC) for residential/parkland; B value
4-Bromophenyl-phenylether	NSV	--	--	--	
4-Chloro-3-methylphenol	500	ug/kg	CCME 2007; Beyer 1990	--	Interim Remediation Criteria (IRC) for residential/parkland; B value
4-Chloroaniline	500	ug/kg	MHSPE 2000	--	Geometric mean of target and intervention values
4-Chlorophenyl-phenylether	NSV	--	--	--	
4-Methylphenol	1,000	ug/kg	CCME 2007; Beyer 1990	--	Interim Remediation Criteria (IRC) for residential/parkland; B value
4-Nitroaniline	NSV	--	--	--	
4-Nitrophenol	380	ug/kg	Efroymsen et al. 1997b	Invertebrate	LC50 of 38,000; UF of 100
Acenaphthene	LMW PAHs	--	--	--	
Acenaphthylene	LMW PAHs	--	--	--	
Acetophenone	NSV	--	--	--	
Anthracene	LMW PAHs	--	--	--	

TABLE C-3

## Ecological Screening Values (ESVs) for Soil - Plants and Soil Invertebrates

## AOC 6 - 1918 Drum Storage Area

## WPNSTA Cheatham Annex, Williamsburg, Virginia

Chemical	ESV	Units	Reference	Type/Receptor	Comments
Atrazine	11.9	ug/kg	MHSPE 2000; 2001	--	Geometric mean of target and SRC values
Benzaldehyde	NSV	--	--	--	
Benzo(a)anthracene	HMW PAHs	--	--	--	
Benzo(a)pyrene	HMW PAHs	--	--	--	
Benzo(b)fluoranthene	HMW PAHs	--	--	--	
Benzo(g,h,i)perylene	HMW PAHs	--	--	--	
Benzo(k)fluoranthene	HMW PAHs	--	--	--	
bis(2-Chloroethoxy)methane	NSV	--	--	--	
bis(2-Chloroethyl)ether	NSV	--	--	--	
bis(2-Ethylhexyl)phthalate	30,000	ug/kg	CCME 2007	Plant	Interim Remediation Criteria (IRC) for residential/parkland
Butylbenzylphthalate	30,000	ug/kg	CCME 2007	Plant	Interim Remediation Criteria (IRC) for residential/parkland
Caprolactam	NSV	--	--	--	
Carbazole	NSV	--	--	--	
Chrysene	HMW PAHs	--	--	--	
Dibenz(a,h)anthracene	HMW PAHs	--	--	--	
Dibenzofuran	NSV	--	--	--	
Diethylphthalate	26,800	ug/kg	Efroymsen et al. 1997a	Plant	EC50 (134,000); UF of 5
Dimethyl phthalate	10,640	ug/kg	Efroymsen et al. 1997b	Invertebrate	LC50 of 1,064,000; UF of 100
Di-n-butylphthalate	40,000	ug/kg	Efroymsen et al. 1997a	Plant	LOEC (200,000); UF of 5
Di-n-octylphthalate	30,000	ug/kg	CCME 2007	Plant	Interim Remediation Criteria (IRC) for residential/parkland
Fluoranthene	LMW PAHs	--	--	--	
Fluorene	LMW PAHs	--	--	--	
Hexachlorobenzene	1,000	ug/kg	Beyer 1990	--	B value
Hexachlorobutadiene	NSV	--	--	--	
Hexachlorocyclopentadiene	2,000	ug/kg	Efroymsen et al. 1997a	Plant	LOEC (10,000); UF of 5
Hexachloroethane	NSV	--	--	--	
Indeno(1,2,3-cd)pyrene	HMW PAHs	--	--	--	
Isophorone	NSV	--	--	--	
Naphthalene	LMW PAHs	--	--	--	
Nitrobenzene	2,260	ug/kg	Efroymsen et al. 1997b	Invertebrate	LC50 of 226,000; UF of 100
n-Nitroso-di-n-propylamine	NSV	--	--	--	
n-Nitrosodiphenylamine	1,090	ug/kg	Efroymsen et al. 1997b	Invertebrate	LC50 of 109,000; UF of 100
PAH (HMW)	18,000	ug/kg	USEPA 2007f	Invertebrate	Eco-SSL
PAH (LMW)	29,000	ug/kg	USEPA 2007f	Invertebrate	Eco-SSL
Pentachlorophenol	5,000	ug/kg	USEPA 2007g	Plant	Eco-SSL
Phenanthrene	LMW PAHs	--	--	--	
Phenol	1,880	ug/kg	Efroymsen et al. 1997b	Invertebrate	LC50 of 188,000; UF of 100
Pyrene	HMW PAHs	--	--	--	
<b>Explosives</b>					
1,3,5-Trinitrobenzene	NSV	--	--	--	
1,3-Dinitrobenzene	NSV	--	--	--	
2,4,6-Trinitrotoluene	10,000	ug/kg	Talmage et al. 1999	Plant	
2,4-Dinitrotoluene	11,000	ug/kg	NRCC 2006	Plant/Invertebrate	
2,6-Dinitrotoluene	8,500	ug/kg	NRCC 2006	Plant/Invertebrate	
2-Amino-4,6-dinitrotoluene	80,000	ug/kg	Talmage et al. 1999	Plant	
2-Nitrotoluene	NSV	--	--	--	
3,5-Dinitroaniline	NSV	--	--	--	
3-Nitrotoluene	NSV	--	--	--	
4-Amino-2,6-dinitrotoluene	80,000	ug/kg	2-Amino-4,6-dinitrotoluene	Plant	
4-Nitrotoluene	NSV	--	--	--	
HMX	10,000	ug/kg	Talmage et al. 1999	Invertebrate	
Nitrobenzene	2,260	ug/kg	Efroymsen et al. 1997b	Invertebrate	LC50 of 226,000; UF of 100
Nitroglycerine	NSV	--	--	--	
Nitroguanidine	NSV	--	--	--	
PETN	NSV	--	--	--	
RDX	10,000	ug/kg	Talmage et al. 1999	Invertebrate	
Tetryl	10,000	ug/kg	Talmage et al. 1999	Plant	

NSV - No Screening Value

TABLE C-4

**Uncertainty Factors**

**AOC 6 - 1918 Drum Storage Area**

***WPNSTA Cheatham Annex, Williamsburg, Virginia***

<b>Convert From</b>	<b>Convert To</b>	<b>Uncertainty Factor</b>
Chronic NOAEL or NOEC	Chronic NOAEL or NOEC	1
Chronic LOAEL or LOEC	Chronic NOAEL or NOEC	5
Subchronic NOAEL or NOEC	Chronic NOAEL or NOEC	10
Subchronic LOAEL or LOEC	Chronic NOAEL or NOEC	20
Acute NOAEL or NOEC	Chronic NOAEL or NOEC	30
Acute LOAEL or LOEC	Chronic NOAEL or NOEC	50
LD50 or LC50	Chronic NOAEL or NOEC	100

Uncertainty factors from Wentsel et al. (1996)

Durations are defined as follows (USEPA 1999; Sample et al. 1996):

- Acute: <3 days (plants, invertebrates)
- Subchronic: 3 - 6 days (plants, invertebrates)
- Chronic: >7 days (plants, invertebrates)

TABLE C-5

**Ecological Screening Values (ESVs) for Water  
AOC 6 - 1918 Drum Storage Area**

*WPNSTA Cheatham Annex, Williamsburg, Virginia*

Chemical	Type	ESV	Units	Hardness (mg/L)	pH	Reference	Comments
<b>Inorganics (Total)</b>							
Aluminum	Fresh	87.0	ug/L			USEPA 2009	AWQC
Antimony	Fresh	30.0	ug/L			Suter and Tsao 1996	Final Chronic Value
Arsenic	Fresh	150	ug/L			USEPA 2009	AWQC
Barium	Fresh	4.00	ug/L			Suter and Tsao 1996	Secondary Chronic Value
Beryllium	Fresh	0.66	ug/L			Suter and Tsao 1996	Secondary Chronic Value
Cadmium	Fresh	0.27	ug/L	100		USEPA 2009	AWQC
Chromium	Fresh	11.4	ug/L			USEPA 2009	AWQC
Cobalt	Fresh	23.0	ug/L			Suter and Tsao 1996	Secondary Chronic Value
Copper	Fresh	9.33	ug/L	100		USEPA 2006a	AWQC
Cyanide	Fresh	5.20	ug/L			USEPA 2009	AWQC
Iron	Fresh	1,000	ug/L			USEPA 2009	AWQC
Lead	Fresh	3.18	ug/L	100		USEPA 2009	AWQC
Manganese	Fresh	120	ug/L			Suter and Tsao 1996	Secondary Chronic Value
Mercury	Fresh	0.91	ug/L			USEPA 2009	AWQC
Nickel	Fresh	52.2	ug/L	100		USEPA 2009	AWQC
Selenium	Fresh	5.00	ug/L			USEPA 2009	AWQC
Silver	Fresh	0.36	ug/L			Suter and Tsao 1996	Secondary Chronic Value
Thallium	Fresh	12.0	ug/L			Suter and Tsao 1996	Secondary Chronic Value
Vanadium	Fresh	20.0	ug/L			Suter and Tsao 1996	Secondary Chronic Value
Zinc	Fresh	120	ug/L	100		USEPA 2009	AWQC
<b>Dissolved Metals</b>							
Aluminum	Fresh	87.0	ug/L			USEPA 2009	AWQC
Antimony	Fresh	30.0	ug/L			Suter and Tsao 1996	Final Chronic Value
Arsenic	Fresh	150	ug/L			USEPA 2009	AWQC
Barium	Fresh	4.00	ug/L			Suter and Tsao 1996	Secondary Chronic Value
Beryllium	Fresh	0.66	ug/L			Suter and Tsao 1996	Secondary Chronic Value
Cadmium	Fresh	0.25	ug/L	100		USEPA 2009	AWQC
Chromium	Fresh	11.0	ug/L			USEPA 2009	AWQC
Cobalt	Fresh	23.0	ug/L			Suter and Tsao 1996	Secondary Chronic Value
Copper	Fresh	8.96	ug/L	100		USEPA 2006a	AWQC
Iron	Fresh	1,000	ug/L			USEPA 2009	AWQC
Lead	Fresh	2.52	ug/L	100		USEPA 2009	AWQC
Manganese	Fresh	120	ug/L			Suter and Tsao 1996	Secondary Chronic Value

TABLE C-5

## Ecological Screening Values (ESVs) for Water

AOC 6 - 1918 Drum Storage Area

WPNSTA Cheatham Annex, Williamsburg, Virginia

Chemical	Type	ESV	Units	Hardness (mg/L)	pH	Reference	Comments
Mercury	Fresh	0.77	ug/L			USEPA 2009	AWQC
Nickel	Fresh	52.0	ug/L	100		USEPA 2009	AWQC
Selenium	Fresh	4.61	ug/L			USEPA 2009	AWQC
Silver	Fresh	0.36	ug/L			Suter and Tsao 1996	Secondary Chronic Value
Thallium	Fresh	12.0	ug/L			Suter and Tsao 1996	Secondary Chronic Value
Vanadium	Fresh	20.0	ug/L			Suter and Tsao 1996	Secondary Chronic Value
Zinc	Fresh	118	ug/L	100		USEPA 2009	AWQC
<b>Semivolatile Organic Compounds</b>							
1,1-Biphenyl	Fresh	14.0	ug/L			USEPA 1996	Secondary Chronic Value
2,2'-Oxybis(1-chloropropane)	--	NSV	--			--	
2,4,5-Trichlorophenol	Fresh	63.0	ug/L			Buchman 2008	
2,4,6-Trichlorophenol	Fresh	4.90	ug/L			Buchman 2008	
2,4-Dichlorophenol	Fresh	11.0	ug/L			USEPA 2006b	Secondary Chronic Value
2,4-Dimethylphenol	Fresh	100	ug/L			Buchman 2008	
2,4-Dinitrophenol	Fresh	19.0	ug/L			Buchman 2008	
2,4-Dinitrotoluene	Fresh	44.0	ug/L			USEPA 2006b	Secondary Chronic Value
2,6-Dinitrotoluene	Fresh	81.0	ug/L			USEPA 2006b	Secondary Chronic Value
2-Chloronaphthalene	Fresh	0.40	ug/L			Buchman 2008	
2-Chlorophenol	Fresh	24.0	ug/L			USEPA 2006b	Final Chronic Value
2-Methylnaphthalene	Fresh	330	ug/L			Buchman 2008	
2-Methylphenol	Fresh	13.0	ug/L			Suter and Tsao 1996	Secondary Chronic Value
2-Nitroaniline	--	NSV	--			--	
2-Nitrophenol	Fresh	1,920	ug/L			USEPA 2006b	
3,3'-Dichlorobenzidine	Fresh	4.50	ug/L			USEPA 2006b	Final Chronic Value
3-Nitroaniline	--	NSV	--			--	
4,6-Dinitro-2-methylphenol	Fresh	2.30	ug/L			USEPA 2001	
4-Bromophenyl-phenylether	Fresh	1.50	ug/L			USEPA 1996	Secondary Chronic Value
4-Chloro-3-methylphenol	Fresh	0.30	ug/L			USEPA 2001	
4-Chloroaniline	Fresh	232	ug/L			USEPA 2006b	
4-Chlorophenyl-phenylether	--	NSV	--			--	
4-Methylphenol	Fresh	543	ug/L			USEPA 2006b	
4-Nitroaniline	--	NSV	--			--	
4-Nitrophenol	Fresh	300	ug/L			Suter and Tsao 1996	Secondary Chronic Value
Acenaphthene	Fresh	23.0	ug/L			USEPA 1996	Final Chronic Value

TABLE C-5

**Ecological Screening Values (ESVs) for Water  
AOC 6 - 1918 Drum Storage Area**

**WPNSTA Cheatham Annex, Williamsburg, Virginia**

Chemical	Type	ESV	Units	Hardness (mg/L)	pH	Reference	Comments
Acenaphthylene	Fresh	4,840	ug/L			Buchman 2008	
Acetophenone	--	NSV	--			--	
Anthracene	Fresh	0.73	ug/L			Suter and Tsao 1996	Secondary Chronic Value
Atrazine	Fresh	1.80	ug/L			USEPA 2006b	
Benzaldehyde	--	NSV	--			--	
Benzo(a)anthracene	Fresh	0.027	ug/L			Suter and Tsao 1996	Secondary Chronic Value
Benzo(a)pyrene	Fresh	0.014	ug/L			Suter and Tsao 1996	Secondary Chronic Value
Benzo(b)fluoranthene	Fresh	9.07	ug/L			Buchman 2008	
Benzo(g,h,i)perylene	Fresh	7.64	ug/L			Buchman 2008	
Benzo(k)fluoranthene	Fresh	9.07	ug/L			Benzo(b)fluoranthene value	
bis(2-Chloroethoxy)methane	--	NSV	--			--	
bis(2-Chloroethyl)ether	Fresh	1,900	ug/L			Buchman 2008	
bis(2-Ethylhexyl)phthalate	Fresh	32.0	ug/L			USEPA 1996	Secondary Chronic Value
Butylbenzylphthalate	Fresh	19.0	ug/L			USEPA 1996	Secondary Chronic Value
Caprolactam	--	NSV	--			--	
Carbazole	--	NSV	--			--	
Chrysene	--	NSV	--			--	
Dibenz(a,h)anthracene	--	NSV	--			--	
Dibenzofuran	Fresh	3.70	ug/L			Suter and Tsao 1996	Secondary Chronic Value
Diethylphthalate	Fresh	270	ug/L			USEPA 2008b	Secondary Chronic Value
Dimethyl phthalate	Fresh	330	ug/L			USEPA 2001	
Di-n-butylphthalate	Fresh	35.0	ug/L			Suter and Tsao 1996	Secondary Chronic Value
Di-n-octylphthalate	Fresh	22.0	ug/L			USEPA 2006b	
Fluoranthene	Fresh	8.10	ug/L			USEPA 1996	Final Chronic Value
Fluorene	Fresh	3.90	ug/L			USEPA 1996	Secondary Chronic Value
Hexachlorobenzene	Fresh	3.68	ug/L			Buchman 2008	
Hexachlorobutadiene	Fresh	1.30	ug/L			USEPA 2006b	
Hexachlorocyclopentadiene	Fresh	1.04	ug/L			Buchman 2008	LOEL/5
Hexachloroethane	Fresh	12.0	ug/L			USEPA 1996	Secondary Chronic Value
Indeno(1,2,3-cd)pyrene	Fresh	4.31	ug/L			Buchman 2008	
Isophorone	Fresh	1,170	ug/L			USEPA 2001	
Naphthalene	Fresh	12.0	ug/L			Suter and Tsao 1996	Secondary Chronic Value
Nitrobenzene	Fresh	270	ug/L			USEPA 2001	Acute/10
n-Nitroso-di-n-propylamine	--	NSV	--			--	

TABLE C-5

**Ecological Screening Values (ESVs) for Water****AOC 6 - 1918 Drum Storage Area****WPNSTA Cheatham Annex, Williamsburg, Virginia**

Chemical	Type	ESV	Units	Hardness (mg/L)	pH	Reference	Comments
n-Nitrosodiphenylamine	Fresh	210	ug/L			Suter and Tsao 1996	Secondary Chronic Value
Pentachlorophenol	Fresh	15.0	ug/L		7.8	USEPA 2009	AWQC
Phenanthrene	Fresh	6.30	ug/L			USEPA 1996	Final Chronic Value
Phenol	Fresh	110	ug/L			Suter and Tsao 1996	Secondary Chronic Value
Pyrene	Fresh	0.025	ug/L			USEPA 2006b	
<b>Explosives</b>							
1,3,5-Trinitrobenzene	Fresh	11.0	ug/L			Talmage et al. 1999	Secondary Chronic Value
1,3-Dinitrobenzene	Fresh	17.0	ug/L			Talmage et al. 1999	Secondary Chronic Value
2,4,6-Trinitrotoluene	Fresh	93.0	ug/L			Talmage et al. 1999	Secondary Chronic Value
2,4-Dinitrotoluene	Fresh	44.0	ug/L			USEPA 2006b	Secondary Chronic Value
2,6-Dinitrotoluene	Fresh	81.0	ug/L			USEPA 2006b	Secondary Chronic Value
2-Amino-4,6-dinitrotoluene	Fresh	19.0	ug/L			Talmage et al. 1999	Secondary Chronic Value
2-Nitrotoluene	Fresh	3,400	ug/L			NAVFAC 2007	
3,5-Dinitroaniline	Fresh	59.0	ug/L			Talmage et al. 1999	Secondary Chronic Value
3-Nitrotoluene	Fresh	750	ug/L			USEPA 2006b	
4-Amino-2,6-dinitrotoluene	Fresh	19.0	ug/L			2-Amino-4,6-dinitrotoluene value	
4-Nitrotoluene	Fresh	1,900	ug/L			USEPA 2006b	
HMX	Fresh	330	ug/L			Talmage et al. 1999	Secondary Chronic Value
Nitrobenzene	Fresh	270	ug/L			USEPA 2001	Acute/10
Nitroglycerine	Fresh	138	ug/L			USEPA 2006b	
Nitroguanidine	Fresh	220	ug/L			NAVFAC 2007	NOEC
PETN	Fresh	85,000	ug/L			USEPA 2006b	
RDX	Fresh	186	ug/L			Talmage et al. 1999	Secondary Chronic Value
Tetryl	--	NSV	--			--	

NSV - No Screening Value

TABLE C-6  
 Ecological Screening Statistics - AOC 6 1918 Drum Storage Area Surface Soil  
 AOC 6 - 1918 Drum Storage Area  
 WPNSTA Cheatham Annex, Williamsburg, Virginia

Chemical	Range of Non-Detect Values	Frequency of Detection	Minimum Concentration Detected	Maximum Concentration Detected	Sample ID of Maximum Detected Concentration	Arithmetic Mean	Standard Deviation of Mean	95% UCL (Norm)	Geometric Mean	Screening Value	Frequency of Exceedance <sup>1</sup>	Maximum Hazard Quotient <sup>2</sup>	Step 2 COPC?	95% UCL Hazard Quotient	Mean Hazard Quotient	Step 3A COPC?	95% UTL	Frequency of UTL Exceedance	Maximum Ratio to UTL	COPC for Risk Evaluation?
<b>Inorganics (MG/KG)</b>																				
Aluminum	-- --	6 / 6	5,040	12,800	CAA06-SS19-1108	8,415	2,521	10,489	8,110	pH < 5.5	1 / 6	--	YES	mean pH > 5.5	--	NO	12,200	1 / 6	1.05	NO
Antimony	4.50 - 5.10	4 / 6	0.050	0.50	CAA06-SS15-1108	0.92	1.16	1.88	0.32	78.0	0 / 6	0.01	NO	--	--	NO	--	-- / --	--	NO
Arsenic	-- --	6 / 6	2.40	4.90	CAA06-SS19-1108	3.40	1.01	4.23	3.28	18.0	0 / 6	0.27	NO	--	--	NO	--	-- / --	--	NO
Barium	-- --	6 / 6	28.0	45.8	CAA06-SS18-1108	35.0	6.28	40.2	34.6	330	0 / 6	0.14	NO	--	--	NO	--	-- / --	--	NO
Beryllium	-- --	6 / 6	0.28	0.53	CAA06-SS14-1108	0.39	0.087	0.46	0.38	40.0	0 / 6	0.01	NO	--	--	NO	--	-- / --	--	NO
Cadmium	-- --	6 / 6	0.020	0.17	CAA06-SS18-1108	0.088	0.062	0.14	0.069	32.0	0 / 6	0.01	NO	--	--	NO	--	-- / --	--	NO
Calcium <sup>3</sup>	-- --	6 / 6	560	8,080	CAA06-SS16-1108	2,175	2,927	4,583	1,304	NSV	-- / --	--	NO	--	--	NO	--	-- / --	--	NO
Chromium	-- --	6 / 6	6.30	16.7	CAA06-SS19-1108	11.6	3.58	14.5	11.1	64.0	0 / 6	0.26	NO	--	--	NO	--	-- / --	--	NO
Cobalt	-- --	6 / 6	1.10	2.00	CAA06-SS16-1108	1.62	0.33	1.89	1.59	13.0	0 / 6	0.15	NO	--	--	NO	--	-- / --	--	NO
Copper	-- --	6 / 6	4.20	8.20	CAA06-SS15-1108	5.73	1.59	7.04	5.56	70.0	0 / 6	0.12	NO	--	--	NO	--	-- / --	--	NO
Cyanide	0.50 - 0.60	0 / 6	--	--	--	0.28	0.016	0.29	0.27	15.8	-- / --	0.04	NO	--	--	NO	--	-- / --	--	NO
Iron	-- --	6 / 6	5,440	11,000	CAA06-SS16-1108	7,998	2,262	9,859	7,741	5 < pH > 8	1 / 6	--	YES	mean pH in range	--	NO	19,900	0 / 6	0.55	NO
Lead	-- --	6 / 6	23.3	128	CAA06-SS15-1108	57.3	38.6	89.0	48.3	120	1 / 6	1.07	YES	0.74	0.48	NO	--	-- / --	--	NO
Magnesium <sup>3</sup>	-- --	6 / 6	410	1,070	CAA06-SS15-1108	840	260	1,054	798	NSV	-- / --	--	NO	--	--	NO	--	-- / --	--	NO
Manganese	-- --	6 / 6	55.9	95.1	CAA06-SS14-1108	71.8	14.9	84.1	70.5	220	0 / 6	0.43	NO	--	--	NO	--	-- / --	--	NO
Mercury	0.10 - 0.12	3 / 6	0.060	0.060	CAA06-SS14-1108	0.058	0.0041	0.062	0.058	0.10	0 / 6	0.60	NO	--	--	NO	--	-- / --	--	NO
Nickel	-- --	6 / 6	2.90	5.90	CAA06-SS16-1108	4.17	1.05	5.03	4.06	38.0	0 / 6	0.16	NO	--	--	NO	--	-- / --	--	NO
Potassium <sup>3</sup>	-- --	6 / 6	356	867	CAA06-SS19-1108	626	195	786	599	NSV	-- / --	--	NO	--	--	NO	--	-- / --	--	NO
Selenium	2.60 - 3.40	2 / 6	0.31	0.37	CAA06-SS19-1108	1.10	0.60	1.59	0.90	0.52	0 / 6	0.71	NO	--	--	NO	--	-- / --	--	NO
Silver	0.65 - 0.96	1 / 6	0.62	0.62	CAA06-SS14-1108	0.43	0.10	0.52	0.42	560	0 / 6	0.001	NO	--	--	NO	--	-- / --	--	NO
Sodium <sup>3</sup>	-- --	6 / 6	22.6	80.5	CAA06-SS16-1108	38.0	21.6	55.8	34.4	NSV	-- / --	--	NO	--	--	NO	--	-- / --	--	NO
Thallium	1.60 - 2.40	2 / 6	0.060	0.070	CAA06-SS14-1108	0.69	0.50	1.10	0.40	1.00	0 / 6	0.07	NO	--	--	NO	--	-- / --	--	NO
Vanadium	-- --	6 / 6	8.90	23.4	CAA06-SS19-1108	15.8	4.69	19.7	15.2	130	0 / 6	0.18	NO	--	--	NO	--	-- / --	--	NO
Zinc	-- --	6 / 6	22.2	102	CAA06-SS18-1108	49.5	30.9	74.9	42.3	120	0 / 6	0.85	NO	--	--	NO	--	-- / --	--	NO
<b>Semivolatile Organic Compounds (UG/KG)</b>																				
1,1-Biphenyl	370 - 420	0 / 4	--	--	--	194	11.1	207	194	13,600	-- / --	0.03	NO	--	--	NO	--	-- / --	--	NO
2,2'-Oxybis(1-chloropropane)	370 - 420	0 / 4	--	--	--	194	11.1	207	194	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
2,4,5-Trichlorophenol	940 - 1,000	0 / 4	--	--	--	481	13.1	497	481	1,350	-- / --	0.74	NO	--	--	NO	--	-- / --	--	NO
2,4,6-Trichlorophenol	370 - 420	0 / 4	--	--	--	194	11.1	207	194	580	-- / --	0.72	NO	--	--	NO	--	-- / --	--	NO
2,4-Dichlorophenol	370 - 420	0 / 4	--	--	--	194	11.1	207	194	500	-- / --	0.84	NO	--	--	NO	--	-- / --	--	NO
2,4-Dimethylphenol	370 - 420	0 / 4	--	--	--	194	11.1	207	194	1,000	-- / --	0.42	NO	--	--	NO	--	-- / --	--	NO
2,4-Dinitrophenol	940 - 1,000	0 / 4	--	--	--	481	13.1	497	481	20,000	-- / --	0.05	NO	--	--	NO	--	-- / --	--	NO
2,4-Dinitrotoluene	370 - 420	0 / 4	--	--	--	194	11.1	207	194	11,000	-- / --	0.04	NO	--	--	NO	--	-- / --	--	NO
2,6-Dinitrotoluene	370 - 420	0 / 4	--	--	--	194	11.1	207	194	8,500	-- / --	0.05	NO	--	--	NO	--	-- / --	--	NO
2-Chloronaphthalene	370 - 420	0 / 4	--	--	--	194	11.1	207	194	LMW PAH	-- / --	--	--	--	--	NO	--	-- / --	--	NO
2-Chlorophenol	370 - 420	0 / 4	--	--	--	194	11.1	207	194	500	-- / --	0.84	NO	--	--	NO	--	-- / --	--	NO
2-Methylnaphthalene	370 - 420	0 / 4	--	--	--	194	11.1	207	194	LMW PAH	-- / --	--	--	--	--	NO	--	-- / --	--	NO
2-Methylphenol	370 - 420	0 / 4	--	--	--	194	11.1	207	194	1,000	-- / --	0.42	NO	--	--	NO	--	-- / --	--	NO
2-Nitroaniline	940 - 1,000	0 / 4	--	--	--	481	13.1	497	481	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
2-Nitrophenol	370 - 420	0 / 4	--	--	--	194	11.1	207	194	1,000	-- / --	0.42	NO	--	--	NO	--	-- / --	--	NO
3,3'-Dichlorobenzidine	370 - 420	0 / 4	--	--	--	194	11.1	207	194	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
3-Nitroaniline	940 - 1,000	0 / 4	--	--	--	481	13.1	497	481	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
4,6-Dinitro-2-methylphenol	940 - 1,000	0 / 4	--	--	--	481	13.1	497	481	1,000	-- / --	1.00	YES	0.50	0.48	NO	--	-- / --	--	NO
4-Bromophenyl-phenylether	370 - 420	0 / 4	--	--	--	194	11.1	207	194	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
4-Chloro-3-methylphenol	370 - 420	0 / 4	--	--	--	194	11.1	207	194	500	-- / --	0.84	NO	--	--	NO	--	-- / --	--	NO
4-Chloroaniline	370 - 420	0 / 4	--	--	--	194	11.1	207	194	500	-- / --	0.84	NO	--	--	NO	--	-- / --	--	NO
4-Chlorophenyl-phenylether	370 - 420	0 / 4	--	--	--	194	11.1	207	194	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
4-Methylphenol	370 - 420	0 / 4	--	--	--	194	11.1	207	194	1,000	-- / --	0.42	NO	--	--	NO	--	-- / --	--	NO

TABLE C-6  
 Ecological Screening Statistics - AOC 6 1918 Drum Storage Area Surface Soil  
 AOC 6 - 1918 Drum Storage Area  
 WPNSTA Cheatham Annex, Williamsburg, Virginia

Chemical	Range of Non-Detect Values	Frequency of Detection	Minimum Concentration Detected	Maximum Concentration Detected	Sample ID of Maximum Detected Concentration	Arithmetic Mean	Standard Deviation of Mean	95% UCL (Norm)	Geometric Mean	Screening Value	Frequency of Exceedance <sup>1</sup>	Maximum Hazard Quotient <sup>2</sup>	Step 2 COPC?	95% UCL Hazard Quotient	Mean Hazard Quotient	Step 3A COPC?	95% UTL	Frequency of UTL Exceedance	Maximum Ratio to UTL	COPC for Risk Evaluation?
4-Nitroaniline	940 - 1,000	0 / 4	--	--	--	481	13.1	497	481	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
4-Nitrophenol	940 - 1,000	0 / 4	--	--	--	481	13.1	497	481	380	-- / --	2.63	YES	1.31	1.27	NO <sup>4</sup>	--	-- / --	--	NO <sup>4</sup>
Acenaphthene	370 - 420	0 / 4	--	--	--	194	11.1	207	194	LMW PAH	-- / --	--	--	--	--	NO	--	-- / --	--	NO
Acenaphthylene	370 - 420	0 / 4	--	--	--	194	11.1	207	194	LMW PAH	-- / --	--	--	--	--	NO	--	-- / --	--	NO
Acetophenone	370 - 420	0 / 4	--	--	--	194	11.1	207	194	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
Anthracene	370 - 420	0 / 4	--	--	--	194	11.1	207	194	LMW PAH	-- / --	--	--	--	--	NO	--	-- / --	--	NO
Atrazine	370 - 420	0 / 4	--	--	--	194	11.1	207	194	11.9	-- / --	35.3	YES	17.4	16.3	NO <sup>4</sup>	--	-- / --	--	NO <sup>4</sup>
Benzaldehyde	370 - 420	0 / 4	--	--	--	194	11.1	207	194	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
Benzo(a)anthracene	370 - 420	0 / 4	--	--	--	194	11.1	207	194	HMW PAH	-- / --	--	NO	--	--	NO	--	-- / --	--	NO
Benzo(a)pyrene	370 - 420	0 / 4	--	--	--	194	11.1	207	194	HMW PAH	-- / --	--	NO	--	--	NO	--	-- / --	--	NO
Benzo(b)fluoranthene	370 - 420	0 / 4	--	--	--	194	11.1	207	194	HMW PAH	-- / --	--	NO	--	--	NO	--	-- / --	--	NO
Benzo(g,h,i)perylene	370 - 420	0 / 4	--	--	--	194	11.1	207	194	HMW PAH	-- / --	--	NO	--	--	NO	--	-- / --	--	NO
Benzo(k)fluoranthene	370 - 420	0 / 4	--	--	--	194	11.1	207	194	HMW PAH	-- / --	--	NO	--	--	NO	--	-- / --	--	NO
Butylbenzylphthalate	370 - 420	0 / 4	--	--	--	194	11.1	207	194	30,000	-- / --	0.01	NO	--	--	NO	--	-- / --	--	NO
Caprolactam	370 - 420	0 / 4	--	--	--	194	11.1	207	194	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
Carbazole	370 - 420	0 / 4	--	--	--	194	11.1	207	194	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
Chrysene	370 - 420	0 / 4	--	--	--	194	11.1	207	194	HMW PAH	-- / --	--	NO	--	--	NO	--	-- / --	--	NO
Di-n-butylphthalate	370 - 420	0 / 4	--	--	--	194	11.1	207	194	40,000	-- / --	0.01	NO	--	--	NO	--	-- / --	--	NO
Di-n-octylphthalate	370 - 420	0 / 4	--	--	--	194	11.1	207	194	30,000	-- / --	0.01	NO	--	--	NO	--	-- / --	--	NO
Dibenz(a,h)anthracene	370 - 420	0 / 4	--	--	--	194	11.1	207	194	HMW PAH	-- / --	--	NO	--	--	NO	--	-- / --	--	NO
Dibenzofuran	370 - 420	0 / 4	--	--	--	194	11.1	207	194	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
Diethylphthalate	370 - 420	0 / 4	--	--	--	194	11.1	207	194	26,800	-- / --	0.02	NO	--	--	NO	--	-- / --	--	NO
Dimethyl phthalate	370 - 420	0 / 4	--	--	--	194	11.1	207	194	10,640	-- / --	0.04	NO	--	--	NO	--	-- / --	--	NO
Fluoranthene	370 - 420	0 / 4	--	--	--	194	11.1	207	194	LMW PAH	-- / --	--	--	--	--	NO	--	-- / --	--	NO
Fluorene	370 - 420	0 / 4	--	--	--	194	11.1	207	194	LMW PAH	-- / --	--	--	--	--	NO	--	-- / --	--	NO
Hexachlorobenzene	370 - 420	0 / 4	--	--	--	194	11.1	207	194	1,000	-- / --	0.42	NO	--	--	NO	--	-- / --	--	NO
Hexachlorobutadiene	370 - 420	0 / 4	--	--	--	194	11.1	207	194	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
Hexachlorocyclopentadiene	370 - 420	0 / 4	--	--	--	194	11.1	207	194	2,000	-- / --	0.21	NO	--	--	NO	--	-- / --	--	NO
Hexachloroethane	370 - 420	0 / 4	--	--	--	194	11.1	207	194	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
Indeno(1,2,3-cd)pyrene	370 - 420	0 / 4	--	--	--	194	11.1	207	194	HMW PAH	-- / --	--	NO	--	--	NO	--	-- / --	--	NO
Isophorone	370 - 420	0 / 4	--	--	--	194	11.1	207	194	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
Naphthalene	370 - 420	0 / 4	--	--	--	194	11.1	207	194	LMW PAH	-- / --	--	--	--	--	NO	--	-- / --	--	NO
Nitrobenzene	370 - 420	0 / 4	--	--	--	194	11.1	207	194	2,260	-- / --	0.19	NO	--	--	NO	--	-- / --	--	NO
PAH (HMW)	1,665 - 1,890	0 / 4	--	--	--	872	49.9	931	871	18,000	-- / --	0.11	NO	--	--	NO	--	-- / --	--	NO
PAH (LMW)	1,665 - 1,890	0 / 4	--	--	--	872	49.9	931	871	29,000	-- / --	0.07	NO	--	--	NO	--	-- / --	--	NO
Pentachlorophenol	940 - 1,000	0 / 4	--	--	--	481	13.1	497	481	5,000	-- / --	0.20	NO	--	--	NO	--	-- / --	--	NO
Phenanthrene	370 - 420	0 / 4	--	--	--	194	11.1	207	194	LMW PAH	-- / --	--	--	--	--	NO	--	-- / --	--	NO
Phenol	370 - 420	0 / 4	--	--	--	194	11.1	207	194	1,880	-- / --	0.22	NO	--	--	NO	--	-- / --	--	NO
Pyrene	370 - 420	0 / 4	--	--	--	194	11.1	207	194	HMW PAH	-- / --	--	NO	--	--	NO	--	-- / --	--	NO
bis(2-Chloroethoxy)methane	370 - 420	0 / 4	--	--	--	194	11.1	207	194	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
bis(2-Chloroethyl)ether	370 - 420	0 / 4	--	--	--	194	11.1	207	194	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
bis(2-Ethylhexyl)phthalate	370 - 420	0 / 4	--	--	--	194	11.1	207	194	30,000	-- / --	0.01	NO	--	--	NO	--	-- / --	--	NO
n-Nitroso-di-n-propylamine	370 - 420	0 / 4	--	--	--	194	11.1	207	194	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
n-Nitrosodiphenylamine	370 - 420	0 / 4	--	--	--	194	11.1	207	194	1,090	-- / --	0.39	NO	--	--	NO	--	-- / --	--	NO
<b>Explosives (UG/KG)</b>																				
1,3,5-Trinitrobenzene	99.0 - 100	0 / 6	--	--	--	49.9	0.20	50.1	49.9	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
1,3-Dinitrobenzene	99.0 - 100	0 / 6	--	--	--	49.9	0.20	50.1	49.9	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
2,4,6-Trinitrotoluene	99.0 - 100	0 / 6	--	--	--	49.9	0.20	50.1	49.9	10,000	-- / --	0.01	NO	--	--	NO	--	-- / --	--	NO
2,4-Dinitrotoluene	99.0 - 100	0 / 6	--	--	--	49.9	0.20	50.1	49.9	11,000	-- / --	0.01	NO	--	--	NO	--	-- / --	--	NO
2,6-Dinitrotoluene	99.0 - 100	0 / 6	--	--	--	49.9	0.20	50.1	49.9	8,500	-- / --	0.01	NO	--	--	NO	--	-- / --	--	NO

TABLE C-6  
 Ecological Screening Statistics - AOC 6 1918 Drum Storage Area Surface Soil  
 AOC 6 - 1918 Drum Storage Area  
 WPNSTA Cheatham Annex, Williamsburg, Virginia

Chemical	Range of Non-Detect Values	Frequency of Detection	Minimum Concentration Detected	Maximum Concentration Detected	Sample ID of Maximum Detected Concentration	Arithmetic Mean	Standard Deviation of Mean	95% UCL (Norm)	Geometric Mean	Screening Value	Frequency of Exceedance <sup>1</sup>	Maximum Hazard Quotient <sup>2</sup>	Step 2 COPC?	95% UCL Hazard Quotient	Mean Hazard Quotient	Step 3A COPC?	95% UTL	Frequency of UTL Exceedance	Maximum Ratio to UTL	COPC for Risk Evaluation?
2-Amino-4,6-dinitrotoluene	99.0 - 100	0 / 6	--	--	--	49.9	0.20	50.1	49.9	80,000	-- / --	0.001	NO	--	--	NO	--	-- / --	--	NO
2-Nitrotoluene	200 - 200	0 / 6	--	--	--	100	0.0	100	100	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
3,5-Dinitroaniline	99.0 - 100	0 / 6	--	--	--	49.9	0.20	50.1	49.9	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
3-Nitrotoluene	200 - 200	0 / 6	--	--	--	100	0.0	100	100	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
4-Amino-2,6-dinitrotoluene	99.0 - 100	0 / 6	--	--	--	49.9	0.20	50.1	49.9	80,000	-- / --	0.001	NO	--	--	NO	--	-- / --	--	NO
4-Nitrotoluene	200 - 200	0 / 6	--	--	--	100	0.0	100	100	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
HMX	200 - 200	0 / 6	--	--	--	100	0.0	100	100	10,000	-- / --	0.02	NO	--	--	NO	--	-- / --	--	NO
Nitrobenzene	99.0 - 100	0 / 6	--	--	--	49.9	0.20	50.1	49.9	2,260	-- / --	0.04	NO	--	--	NO	--	-- / --	--	NO
Nitroglycerin	5,000 - 5,000	0 / 6	--	--	--	2,500	0.0	2,500	2,500	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
Nitroguanidine	120 - 130	0 / 6	--	--	--	64.2	2.04	65.8	64.1	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
PETN	500 - 500	0 / 6	--	--	--	250	0.0	250	250	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
RDX	200 - 200	0 / 6	--	--	--	100	0.0	100	100	10,000	-- / --	0.02	NO	--	--	NO	--	-- / --	--	NO
Tetryl	200 - 200	0 / 6	--	--	--	100	0.0	100	100	10,000	-- / --	0.02	NO	--	--	NO	--	-- / --	--	NO
<b>Other Parameters</b>																				
Total organic carbon (MG/KG)	-- - --	6 / 6	8,700	23,000	CAA06-SS14-1108	17,950	6,411	23,224	16,774	--	-- / --	--	--	--	--	--	--	-- / --	--	--
pH	-- - --	6 / 6	5.00	8.40	CAA06-SS16-1108	6.30	1.14	7.24	6.22	--	-- / --	--	--	--	--	--	--	-- / --	--	--

NSV - No Screening Value

1 - Count of detected samples exceeding or equaling Screening Value

2 - Shaded cells indicate hazard quotient based on reporting limits

3 - Macronutrient - Not considered to be a COPC

4 - See uncertainty section

TABLE C-7  
 Ecological Screening Statistics - AOC 6 1918 Drum Storage Area Subsurface Soil  
 AOC 6 - 1918 Drum Storage Area  
 WPNSTA Cheatham Annex, Williamsburg, Virginia

Chemical	Range of Non-Detect Values	Frequency of Detection	Minimum Concentration Detected	Maximum Concentration Detected	Sample ID of Maximum Detected Concentration	Arithmetic Mean	Standard Deviation of Mean	95% UCL (Norm)	Geometric Mean	Screening Value	Frequency of Exceedance <sup>1</sup>	Maximum Hazard Quotient <sup>2</sup>	Step 2 COPC?	95% UCL Hazard Quotient	Mean Hazard Quotient	Step 3A COPC?	95% UTL	Frequency of UTL Exceedance	Maximum Ratio to UTL	COPC for Risk Evaluation?
<b>Inorganics (MG/KG)</b>																				
Aluminum	-- --	6 / 6	5,770	13,200	CAA06-SB16-1108	10,850	2,830	13,178	10,462	pH < 5.5	0 / 6	--	NO	--	--	NO	--	-- / --	--	NO
Antimony	4.90 - 4.90	5 / 6	0.10	0.16	CAA06-SB15-1108	0.52	0.94	1.30	0.22	78.0	0 / 6	0.002	NO	--	--	NO	--	-- / --	--	NO
Arsenic	-- --	6 / 6	2.20	5.00	CAA06-SB15-1108	3.65	1.05	4.52	3.51	18.0	0 / 6	0.28	NO	--	--	NO	--	-- / --	--	NO
Barium	-- --	6 / 6	27.4	44.5	CAA06-SB14-1108	36.0	6.73	41.5	35.5	330	0 / 6	0.13	NO	--	--	NO	--	-- / --	--	NO
Beryllium	-- --	6 / 6	0.23	0.48	CAA06-SB15-1108	0.38	0.10	0.46	0.37	40.0	0 / 6	0.01	NO	--	--	NO	--	-- / --	--	NO
Cadmium	0.28 - 0.44	4 / 6	0.030	0.080	CAA06-SB18-1108	0.092	0.075	0.15	0.070	32.0	0 / 6	0.003	NO	--	--	NO	--	-- / --	--	NO
Calcium <sup>3</sup>	-- --	6 / 6	626	12,600	CAA06-SB16-1108	3,500	4,589	7,275	2,004	NSV	-- / --	--	NO	--	--	NO	--	-- / --	--	NO
Chromium	-- --	6 / 6	8.40	20.0	CAA06-SB15-1108	15.2	4.31	18.8	14.6	64.0	0 / 6	0.31	NO	--	--	NO	--	-- / --	--	NO
Cobalt	-- --	6 / 6	0.95	2.40	CAA06-SB15-1108	1.76	0.52	2.18	1.69	13.0	0 / 6	0.18	NO	--	--	NO	--	-- / --	--	NO
Copper	-- --	6 / 6	2.80	6.20	CAA06-SB19-1108	4.45	1.18	5.42	4.31	70.0	0 / 6	0.09	NO	--	--	NO	--	-- / --	--	NO
Cyanide	0.50 - 0.55	0 / 6	--	--	--	0.26	0.014	0.27	0.26	15.8	-- / --	0.03	NO	--	--	NO	--	-- / --	--	NO
Iron	-- --	6 / 6	5,800	12,700	CAA06-SB15-1108	10,377	2,518	12,448	10,061	5 < pH > 8	2 / 6	--	YES	mean pH in range	--	NO	32,000	0 / 6	0.40	NO
Lead	-- --	6 / 6	7.60	60.0	CAA06-SB15-1108	23.3	19.0	38.9	18.4	120	0 / 6	0.50	NO	--	--	NO	--	-- / --	--	NO
Magnesium <sup>3</sup>	-- --	6 / 6	432	1,150	CAA06-SB19-1108	902	290	1,141	855	NSV	-- / --	--	NO	--	--	NO	--	-- / --	--	NO
Manganese	-- --	6 / 6	29.0	104	CAA06-SB14-1108	59.6	30.7	84.8	53.1	220	0 / 6	0.47	NO	--	--	NO	--	-- / --	--	NO
Mercury	0.11 - 0.12	1 / 6	0.040	0.040	CAA06-SB19-1108	0.053	0.0068	0.059	0.053	0.10	0 / 6	0.40	NO	--	--	NO	--	-- / --	--	NO
Nickel	-- --	6 / 6	2.80	6.70	CAA06-SB19-1108	4.88	1.52	6.13	4.67	38.0	0 / 6	0.18	NO	--	--	NO	--	-- / --	--	NO
Potassium <sup>3</sup>	-- --	6 / 6	342	1,030	CAA06-SB15-1108	691	283	924	637	NSV	-- / --	--	NO	--	--	NO	--	-- / --	--	NO
Selenium	2.70 - 3.20	1 / 6	0.33	0.33	CAA06-SB17-1108	1.29	0.48	1.68	1.15	0.52	0 / 6	0.63	NO	--	--	NO	--	-- / --	--	NO
Silver	0.56 - 0.90	0 / 6	--	--	--	0.40	0.062	0.45	0.39	560	-- / --	0.002	NO	--	--	NO	--	-- / --	--	NO
Sodium <sup>3</sup>	-- --	6 / 6	20.5	119	CAA06-SB16-1108	46.8	36.7	77.0	38.8	NSV	-- / --	--	NO	--	--	NO	--	-- / --	--	NO
Thallium	1.40 - 2.20	1 / 6	0.080	0.080	CAA06-SB16-1108	0.81	0.39	1.13	0.63	1.00	0 / 6	0.08	NO	--	--	NO	--	-- / --	--	NO
Vanadium	-- --	6 / 6	11.6	25.4	CAA06-SB15-1108	20.3	4.91	24.4	19.7	130	0 / 6	0.20	NO	--	--	NO	--	-- / --	--	NO
Zinc	-- --	6 / 6	9.80	51.1	CAA06-SB18-1108	23.8	14.7	35.9	20.6	120	0 / 6	0.43	NO	--	--	NO	--	-- / --	--	NO
<b>Semivolatile Organic Compounds (UG/KG)</b>																				
1,1-Biphenyl	350 - 380	0 / 5	--	--	--	182	5.70	187	182	13,600	-- / --	0.03	NO	--	--	NO	--	-- / --	--	NO
2,2'-Oxybis(1-chloropropane)	350 - 380	0 / 5	--	--	--	182	5.70	187	182	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
2,4,5-Trichlorophenol	900 - 960	0 / 4	--	--	--	465	12.9	480	465	1,350	-- / --	0.71	NO	--	--	NO	--	-- / --	--	NO
2,4,6-Trichlorophenol	360 - 380	0 / 4	--	--	--	184	4.79	189	184	580	-- / --	0.66	NO	--	--	NO	--	-- / --	--	NO
2,4-Dichlorophenol	360 - 380	0 / 4	--	--	--	184	4.79	189	184	500	-- / --	0.76	NO	--	--	NO	--	-- / --	--	NO
2,4-Dimethylphenol	360 - 380	0 / 4	--	--	--	184	4.79	189	184	1,000	-- / --	0.38	NO	--	--	NO	--	-- / --	--	NO
2,4-Dinitrophenol	900 - 960	0 / 4	--	--	--	465	12.9	480	465	20,000	-- / --	0.05	NO	--	--	NO	--	-- / --	--	NO
2,4-Dinitrotoluene	350 - 380	0 / 5	--	--	--	182	5.70	187	182	11,000	-- / --	0.03	NO	--	--	NO	--	-- / --	--	NO
2,6-Dinitrotoluene	350 - 380	0 / 5	--	--	--	182	5.70	187	182	8,500	-- / --	0.04	NO	--	--	NO	--	-- / --	--	NO
2-Chloronaphthalene	350 - 380	0 / 5	--	--	--	182	5.70	187	182	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
2-Chlorophenol	360 - 380	0 / 4	--	--	--	184	4.79	189	184	500	-- / --	0.76	NO	--	--	NO	--	-- / --	--	NO
2-Methylnaphthalene	350 - 380	0 / 5	--	--	--	182	5.70	187	182	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
2-Methylphenol	360 - 380	0 / 4	--	--	--	184	4.79	189	184	1,000	-- / --	0.38	NO	--	--	NO	--	-- / --	--	NO
2-Nitroaniline	880 - 960	0 / 5	--	--	--	460	15.8	475	460	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
2-Nitrophenol	360 - 380	0 / 4	--	--	--	184	4.79	189	184	1,000	-- / --	0.38	NO	--	--	NO	--	-- / --	--	NO
3,3'-Dichlorobenzidine	350 - 380	0 / 5	--	--	--	182	5.70	187	182	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
3-Nitroaniline	880 - 960	0 / 5	--	--	--	460	15.8	475	460	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
4,6-Dinitro-2-methylphenol	900 - 960	0 / 4	--	--	--	465	12.9	480	465	1,000	-- / --	0.96	NO	--	--	NO	--	-- / --	--	NO
4-Bromophenyl-phenylether	350 - 380	0 / 5	--	--	--	182	5.70	187	182	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
4-Chloro-3-methylphenol	360 - 380	0 / 4	--	--	--	184	4.79	189	184	500	-- / --	0.76	NO	--	--	NO	--	-- / --	--	NO
4-Chloroaniline	350 - 380	0 / 5	--	--	--	182	5.70	187	182	500	-- / --	0.76	NO	--	--	NO	--	-- / --	--	NO
4-Chlorophenyl-phenylether	350 - 380	0 / 5	--	--	--	182	5.70	187	182	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
4-Methylphenol	360 - 380	0 / 4	--	--	--	184	4.79	189	184	1,000	-- / --	0.38	NO	--	--	NO	--	-- / --	--	NO
4-Nitroaniline	880 - 960	0 / 5	--	--	--	460	15.8	475	460	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
4-Nitrophenol	900 - 960	0 / 4	--	--	--	465	12.9	480	465	380	-- / --	2.53	YES	1.26	1.22	NO <sup>4</sup>	--	-- / --	--	NO <sup>4</sup>

TABLE C-7  
 Ecological Screening Statistics - AOC 6 1918 Drum Storage Area Subsurface Soil  
 AOC 6 - 1918 Drum Storage Area  
 WPNSTA Cheatham Annex, Williamsburg, Virginia

Chemical	Range of Non-Detect Values	Frequency of Detection	Minimum Concentration Detected	Maximum Concentration Detected	Sample ID of Maximum Detected Concentration	Arithmetic Mean	Standard Deviation of Mean	95% UCL (Norm)	Geometric Mean	Screening Value	Frequency of Exceedance <sup>1</sup>	Maximum Hazard Quotient <sup>2</sup>	Step 2 COPC?	95% UCL Hazard Quotient	Mean Hazard Quotient	Step 3A COPC?	95% UTL	Frequency of UTL Exceedance	Maximum Ratio to UTL	COPC for Risk Evaluation?
Acenaphthene	350 - 380	0 / 5	--	--	--	182	5.70	187	182	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
Acenaphthylene	350 - 380	0 / 5	--	--	--	182	5.70	187	182	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
Acetophenone	350 - 380	0 / 5	--	--	--	182	5.70	187	182	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
Anthracene	350 - 380	0 / 5	--	--	--	182	5.70	187	182	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
Atrazine	350 - 380	0 / 5	--	--	--	182	5.70	187	182	11.9	-- / --	31.9	YES	15.8	15.3	NO <sup>4</sup>	--	-- / --	--	NO <sup>4</sup>
Benzaldehyde	350 - 380	0 / 5	--	--	--	182	5.70	187	182	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
Benzo(a)anthracene	350 - 380	0 / 5	--	--	--	182	5.70	187	182	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
Benzo(a)pyrene	350 - 380	0 / 5	--	--	--	182	5.70	187	182	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
Benzo(b)fluoranthene	350 - 380	0 / 5	--	--	--	182	5.70	187	182	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
Benzo(g,h,i)perylene	350 - 380	0 / 5	--	--	--	182	5.70	187	182	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
Benzo(k)fluoranthene	350 - 380	0 / 5	--	--	--	182	5.70	187	182	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
Butylbenzylphthalate	350 - 380	0 / 5	--	--	--	182	5.70	187	182	30,000	-- / --	0.01	NO	--	--	NO	--	-- / --	--	NO
Caprolactam	350 - 380	0 / 5	--	--	--	182	5.70	187	182	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
Carbazole	350 - 380	0 / 5	--	--	--	182	5.70	187	182	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
Chrysene	350 - 380	0 / 5	--	--	--	182	5.70	187	182	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
Di-n-butylphthalate	350 - 380	0 / 5	--	--	--	182	5.70	187	182	40,000	-- / --	0.01	NO	--	--	NO	--	-- / --	--	NO
Di-n-octylphthalate	350 - 380	0 / 5	--	--	--	182	5.70	187	182	30,000	-- / --	0.01	NO	--	--	NO	--	-- / --	--	NO
Dibenz(a,h)anthracene	350 - 380	0 / 5	--	--	--	182	5.70	187	182	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
Dibenzofuran	350 - 380	0 / 5	--	--	--	182	5.70	187	182	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
Diethylphthalate	350 - 380	0 / 5	--	--	--	182	5.70	187	182	26,800	-- / --	0.01	NO	--	--	NO	--	-- / --	--	NO
Dimethyl phthalate	350 - 380	0 / 5	--	--	--	182	5.70	187	182	10,640	-- / --	0.04	NO	--	--	NO	--	-- / --	--	NO
Fluoranthene	350 - 380	0 / 5	--	--	--	182	5.70	187	182	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
Fluorene	350 - 380	0 / 5	--	--	--	182	5.70	187	182	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
Hexachlorobenzene	350 - 380	0 / 5	--	--	--	182	5.70	187	182	1,000	-- / --	0.38	NO	--	--	NO	--	-- / --	--	NO
Hexachlorobutadiene	350 - 380	0 / 5	--	--	--	182	5.70	187	182	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
Hexachlorocyclopentadiene	350 - 380	0 / 5	--	--	--	182	5.70	187	182	2,000	-- / --	0.19	NO	--	--	NO	--	-- / --	--	NO
Hexachloroethane	350 - 380	0 / 5	--	--	--	182	5.70	187	182	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
Indeno(1,2,3-cd)pyrene	350 - 380	0 / 5	--	--	--	182	5.70	187	182	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
Isophorone	350 - 380	0 / 5	--	--	--	182	5.70	187	182	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
Naphthalene	350 - 380	0 / 5	--	--	--	182	5.70	187	182	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
Nitrobenzene	350 - 380	0 / 5	--	--	--	182	5.70	187	182	2,260	-- / --	0.17	NO	--	--	NO	--	-- / --	--	NO
PAH (total)	3,150 - 3,420	0 / 5	--	--	--	1,638	51.3	1,687	1,637	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
PAH (HMW)	1,575 - 1,710	0 / 5	--	--	--	819	25.7	843	819	18,000	-- / --	0.10	NO	--	--	NO	--	-- / --	--	NO
PAH (LMW)	1,575 - 1,710	0 / 5	--	--	--	819	25.7	843	819	29,000	-- / --	0.06	NO	--	--	NO	--	-- / --	--	NO
Pentachlorophenol	900 - 960	0 / 4	--	--	--	465	12.9	480	465	5,000	-- / --	0.19	NO	--	--	NO	--	-- / --	--	NO
Phenanthrene	350 - 380	0 / 5	--	--	--	182	5.70	187	182	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
Phenol	360 - 380	0 / 4	--	--	--	184	4.79	189	184	1,880	-- / --	0.20	NO	--	--	NO	--	-- / --	--	NO
Pyrene	350 - 380	0 / 5	--	--	--	182	5.70	187	182	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
bis(2-Chloroethoxy)methane	350 - 380	0 / 5	--	--	--	182	5.70	187	182	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
bis(2-Chloroethyl)ether	350 - 380	0 / 5	--	--	--	182	5.70	187	182	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
bis(2-Ethylhexyl)phthalate	350 - 380	0 / 5	--	--	--	182	5.70	187	182	30,000	-- / --	0.01	NO	--	--	NO	--	-- / --	--	NO
n-Nitroso-di-n-propylamine	350 - 380	0 / 5	--	--	--	182	5.70	187	182	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
n-Nitrosodiphenylamine	350 - 380	0 / 5	--	--	--	182	5.70	187	182	1,090	-- / --	0.35	NO	--	--	NO	--	-- / --	--	NO
<b>Explosives (UG/KG)</b>																				
1,3,5-Trinitrobenzene	99.0 - 100	0 / 6	--	--	--	49.9	0.20	50.1	49.9	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
1,3-Dinitrobenzene	99.0 - 100	0 / 6	--	--	--	49.9	0.20	50.1	49.9	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
2,4,6-Trinitrotoluene	99.0 - 100	0 / 6	--	--	--	49.9	0.20	50.1	49.9	10,000	-- / --	0.01	NO	--	--	NO	--	-- / --	--	NO
2,4-Dinitrotoluene	99.0 - 100	0 / 6	--	--	--	49.9	0.20	50.1	49.9	11,000	-- / --	0.01	NO	--	--	NO	--	-- / --	--	NO
2,6-Dinitrotoluene	99.0 - 100	0 / 6	--	--	--	49.9	0.20	50.1	49.9	8,500	-- / --	0.01	NO	--	--	NO	--	-- / --	--	NO
2-Amino-4,6-dinitrotoluene	99.0 - 100	0 / 6	--	--	--	49.9	0.20	50.1	49.9	80,000	-- / --	0.001	NO	--	--	NO	--	-- / --	--	NO
2-Nitrotoluene	200 - 200	0 / 6	--	--	--	100	0.0	100	100	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
3,5-Dinitroaniline	99.0 - 100	0 / 6	--	--	--	49.9	0.20	50.1	49.9	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO

TABLE C-7  
 Ecological Screening Statistics - AOC 6 1918 Drum Storage Area Subsurface Soil  
 AOC 6 - 1918 Drum Storage Area  
 WPNSTA Cheatham Annex, Williamsburg, Virginia

Chemical	Range of Non-Detect Values	Frequency of Detection	Minimum Concentration Detected	Maximum Concentration Detected	Sample ID of Maximum Detected Concentration	Arithmetic Mean	Standard Deviation of Mean	95% UCL (Norm)	Geometric Mean	Screening Value	Frequency of Exceedance <sup>1</sup>	Maximum Hazard Quotient <sup>2</sup>	Step 2 COPC?	95% UCL Hazard Quotient	Mean Hazard Quotient	Step 3A COPC?	95% UTL	Frequency of UTL Exceedance	Maximum Ratio to UTL	COPC for Risk Evaluation?
3-Nitrotoluene	200 - 200	0 / 6	--	--	--	100	0.0	100	100	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
4-Amino-2,6-dinitrotoluene	99.0 - 100	0 / 6	--	--	--	49.9	0.20	50.1	49.9	80,000	-- / --	0.001	NO	--	--	NO	--	-- / --	--	NO
4-Nitrotoluene	200 - 200	0 / 6	--	--	--	100	0.0	100	100	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
HMX	200 - 200	0 / 6	--	--	--	100	0.0	100	100	10,000	-- / --	0.02	NO	--	--	NO	--	-- / --	--	NO
Nitrobenzene	99.0 - 100	0 / 6	--	--	--	49.9	0.20	50.1	49.9	2,260	-- / --	0.04	NO	--	--	NO	--	-- / --	--	NO
Nitroglycerin	5,000 - 5,000	0 / 6	--	--	--	2,500	0.0	2,500	2,500	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
Nitroguanidine	120 - 130	0 / 6	--	--	--	63.3	2.58	65.5	63.3	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
PETN	500 - 500	0 / 6	--	--	--	250	0.0	250	250	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO
RDX	200 - 200	0 / 6	--	--	--	100	0.0	100	100	10,000	-- / --	0.02	NO	--	--	NO	--	-- / --	--	NO
Tetryl	200 - 200	0 / 6	--	--	--	100	0.0	100	100	10,000	-- / --	0.02	NO	--	--	NO	--	-- / --	--	NO
<b>Other Parameters</b>																				
Total organic carbon (MG/KG)	-- - --	6 / 6	1,700	20,000	CAA06-SB19-1108	8,100	7,268	14,079	5,712	--	-- / --	--	--	--	--	--	--	-- / --	--	--
pH	-- - --	6 / 6	6.10	8.50	CAA06-SB15-1108	7.22	0.97	8.01	7.16	--	-- / --	--	--	--	--	--	--	-- / --	--	--

NSV - No Screening Value

1 - Count of detected samples exceeding or equaling Screening Value

2 - Shaded cells indicate hazard quotient based on reporting limits

3 - Macronutrient - Not considered to be a COPC

4 - See uncertainty section

TABLE C-8  
 Ecological Screening Statistics - AOC 6 1918 Drum Storage Area Groundwater  
 AOC 6 - 1918 Drum Storage Area  
 WPNSTA Cheatham Annex, Williamsburg, Virginia

Chemical	Range of Non-Detect Values	Frequency of Detection	Minimum Concentration Detected	Maximum Concentration Detected	Sample ID of Maximum Detected Concentration	Arithmetic Mean	Standard Deviation of Mean	95% UCL (Norm)	Geometric Mean	Screening Value	Frequency of Exceedance <sup>1</sup>	Maximum Hazard Quotient <sup>2</sup>	Step 2 COPC?	95% UCL Hazard Quotient	Mean Hazard Quotient	Step 3A COPC?	95% UTL	Frequency of UTL Exceedance	Maximum Ratio to UTL	COPC for Risk Evaluation?	COPC with DF of 10?
<b>Inorganics (UG/L)</b>																					
Aluminum	-- --	3 / 3	12,100	57,600	CAA06-DW09-1108	28,100	25,578	71,221	21,670	87.0	3 / 3	662	--	819	323	--	2,230	3 / 3	25.8	--	--
Antimony	-- --	3 / 3	3.60	8.80	CAA06-DW09-1108	5.40	2.95	10.4	4.94	30.0	0 / 3	0.29	--	--	--	--	--	-- / --	--	--	--
Arsenic	-- --	3 / 3	24.6	134	CAA06-DW09-1108	70.6	56.8	166	55.9	150	0 / 3	0.89	--	--	--	--	--	-- / --	--	--	--
Barium	-- --	3 / 3	68.5	208	CAA06-DW09-1108	121	75.7	249	107	4.00	3 / 3	52.0	--	62.2	30.3	--	118	1 / 3	1.76	--	--
Beryllium	-- --	3 / 3	0.80	4.10	CAA06-DW09-1108	1.97	1.85	5.09	1.49	0.66	3 / 3	6.21	--	7.71	2.98	--	2.45	1 / 3	1.67	--	--
Cadmium	-- --	3 / 3	0.57	5.00	CAA06-DW09-1108	2.32	2.35	6.29	1.59	0.27	3 / 3	18.5	--	23.3	8.59	--	0.605	2 / 3	8.26	--	--
Calcium <sup>3</sup>	-- --	3 / 3	278,000	661,000	CAA06-DW09-1108	432,000	202,215	772,905	403,309	NSV	-- / --	--	--	--	--	--	--	-- / --	--	--	--
Chromium	-- --	3 / 3	59.0	250	CAA06-DW09-1108	131	104	306	108	11.4	3 / 3	21.9	--	26.8	11.5	--	15.1	3 / 3	16.6	--	--
Cobalt	-- --	3 / 3	6.00	23.3	CAA06-DW09-1108	12.1	9.71	28.5	9.93	23.0	1 / 3	1.01	--	1.24	0.53	--	--	-- / --	--	--	--
Copper	-- --	3 / 3	23.1	60.2	CAA06-DW09-1108	36.4	20.6	71.2	33.1	9.33	3 / 3	6.45	--	7.63	3.91	--	12.2	3 / 3	4.93	--	--
Cyanide	10.0 - 10.0	0 / 3	--	--	--	5.00	0.0	5.00	5.00	5.20	-- / --	1.92	--	0.96	0.96	--	--	-- / --	--	--	--
Iron	-- --	3 / 3	27,800	116,000	CAA06-DW09-1108	58,633	49,727	142,467	46,954	1,000	3 / 3	116	--	142	58.6	--	894	3 / 3	130	--	--
Lead	-- --	3 / 3	11.9	50.1	CAA06-DW09-1108	25.5	21.3	61.5	20.6	3.18	3 / 3	15.7	--	19.3	8.03	--	21.3	1 / 3	2.35	--	--
Magnesium <sup>3</sup>	-- --	3 / 3	5,510	20,700	CAA06-DW09-1108	10,993	8,430	25,205	9,174	NSV	-- / --	--	--	--	--	--	--	-- / --	--	--	--
Manganese	-- --	3 / 3	109	424	CAA06-DW09-1108	219	178	519	178	120	2 / 3	3.53	--	4.32	1.82	--	57.9	3 / 3	7.32	--	--
Mercury	0.20 - 0.20	1 / 3	0.040	0.040	CAA06-DW09-1108	0.080	0.035	0.14	0.074	0.91	0 / 3	0.04	--	--	--	--	--	-- / --	--	--	--
Nickel	-- --	3 / 3	26.5	86.7	CAA06-DW09-1108	52.4	31.0	105	46.5	52.2	1 / 3	1.66	--	2.01	1.00	--	11.4	3 / 3	7.61	--	--
Potassium <sup>3</sup>	-- --	3 / 3	5,660	23,000	CAA06-DW09-1108	12,627	9,158	28,066	10,627	NSV	-- / --	--	--	--	--	--	--	-- / --	--	--	--
Selenium	35.0 - 35.0	2 / 3	5.50	5.80	CAA06-DW09-1108	9.60	6.84	21.1	8.23	5.00	2 / 3	1.16	--	4.23	1.92	--	--	-- / --	--	--	--
Silver	10.0 - 10.0	0 / 3	--	--	--	5.00	0.0	5.00	5.00	0.36	-- / --	27.8	--	13.9	13.9	--	--	-- / --	--	--	--
Sodium <sup>3</sup>	-- --	3 / 3	7,330	24,200	CAA06-DW09-1108	15,243	8,483	29,545	13,606	NSV	-- / --	--	--	--	--	--	--	-- / --	--	--	--
Thallium	-- --	3 / 3	1.70	2.20	CAA06-DW11-1108	2.00	0.26	2.45	1.99	12.0	0 / 3	0.18	--	--	--	--	--	-- / --	--	--	--
Vanadium	-- --	3 / 3	52.0	325	CAA06-DW09-1108	154	149	405	113	20.0	3 / 3	16.3	--	20.3	7.71	--	26.2	3 / 3	12.4	--	--
Zinc	-- --	3 / 3	60.2	227	CAA06-DW09-1108	116	96.2	278	94.0	120	1 / 3	1.89	--	2.32	0.97	--	--	-- / --	--	--	--
<b>Dissolved Metals (UG/L)</b>																					
Aluminum	-- --	3 / 3	242	385	CAA06-DW09-1108	292	80.4	428	286	87.0	3 / 3	4.43	YES	4.92	3.36	YES	100	3 / 3	3.85	YES	NO
Antimony	60.0 - 60.0	0 / 3	--	--	--	30.0	0.0	30.0	30.0	30.0	-- / --	2.00	YES	1.00	1.00	NO <sup>4</sup>	--	-- / --	--	NO <sup>4</sup>	NO
Arsenic	3.30 - 4.60	0 / 3	--	--	--	2.07	0.36	2.68	2.04	150	-- / --	0.03	NO	--	--	NO	--	-- / --	--	NO	NO
Barium	-- --	3 / 3	31.1	50.0	CAA06-DW09-1108	42.5	10.1	59.5	41.7	4.00	3 / 3	12.5	YES	14.9	10.6	YES	127	0 / 3	0.39	NO	NO
Beryllium	5.00 - 5.00	0 / 3	--	--	--	2.50	0.0	2.50	2.50	0.66	-- / --	7.58	YES	3.79	3.79	NO <sup>4</sup>	--	-- / --	--	NO <sup>4</sup>	NO
Cadmium	0.070 - 5.00	0 / 3	--	--	--	1.68	1.42	4.08	0.60	0.25	-- / --	20.3	YES	16.6	6.82	NO <sup>4</sup>	--	-- / --	--	NO <sup>4</sup>	NO <sup>4</sup>
Calcium <sup>3</sup>	-- --	3 / 3	142,000	192,000	CAA06-DW09-1108	166,667	25,007	208,824	165,412	NSV	-- / --	--	NO	--	--	NO	--	-- / --	--	NO	NO
Chromium	0.58 - 10.0	1 / 3	0.95	0.95	CAA06-DW09-1108	2.08	2.55	6.38	1.11	11.0	0 / 3	0.09	NO	--	--	NO	--	-- / --	--	NO	NO
Cobalt	0.56 - 0.92	0 / 3	--	--	--	0.36	0.091	0.52	0.36	23.0	-- / --	0.04	NO	--	--	NO	--	-- / --	--	NO	NO
Copper	-- --	3 / 3	1.20	1.40	CAA06-DW10-1108	1.30	0.100	1.47	1.30	8.96	0 / 3	0.16	NO	--	--	NO	--	-- / --	--	NO	NO
Iron	39.6 - 39.6	2 / 3	336	502	CAA06-DW11-1108	286	245	699	149	1,000	0 / 3	0.50	NO	--	--	NO	--	-- / --	--	NO	NO
Lead	-- --	3 / 3	1.30	2.40	CAA06-DW10-1108	1.97	0.59	2.95	1.90	2.52	0 / 3	0.95	NO	--	--	NO	--	-- / --	--	NO	NO
Magnesium <sup>3</sup>	-- --	3 / 3	1,580	3,010	CAA06-DW09-1108	2,350	721	3,566	2,270	NSV	-- / --	--	NO	--	--	NO	--	-- / --	--	NO	NO
Manganese	-- --	3 / 3	17.7	30.5	CAA06-DW09-1108	24.1	6.40	34.9	23.5	120	0 / 3	0.25	NO	--	--	NO	--	-- / --	--	NO	NO
Mercury	0.20 - 0.20	0 / 3	--	--	--	0.10	1.70E-17	0.10	0.10	0.77	-- / --	0.26	NO	--	--	NO	--	-- / --	--	NO	NO
Nickel	-- --	3 / 3	6.10	7.10	CAA06-DW09-1108	6.43	0.58	7.41	6.42	52.0	0 / 3	0.14	NO	--	--	NO	--	-- / --	--	NO	NO
Potassium <sup>3</sup>	-- --	3 / 3	912	3,780	CAA06-DW10-1108	2,547	1,476	5,035	2,167	NSV	-- / --	--	NO	--	--	NO	--	-- / --	--	NO	NO
Selenium	35.0 - 35.0	0 / 3	--	--	--	17.5	0.0	17.5	17.5	4.61	-- / --	7.59	YES	3.80	3.80	NO <sup>4</sup>	--	-- / --	--	NO <sup>4</sup>	NO
Silver	10.0 - 10.0	0 / 3	--	--	--	5.00	0.0	5.00	5.00	0.36	-- / --	27.8	YES	13.9	13.9	NO <sup>4</sup>	--	-- / --	--	NO <sup>4</sup>	NO <sup>4</sup>
Sodium <sup>3</sup>	-- --	3 / 3	5,860	21,600	CAA06-DW09-1108	13,587	7,874	26,861	11,896	NSV	-- / --	--	NO	--	--	NO	--	-- / --	--	NO	NO
Thallium	25.0 - 25.0	1 / 3	2.00	2.00	CAA06-DW09-1108	9.00	6.06	19.2	6.79	12.0	0 / 3	0.17	NO	--	--	NO	--	-- / --	--	NO	NO
Vanadium	50.0 - 50.0	1 / 3	0.90	0.90	CAA06-DW09-1108	17.0	13.9	40.4	8.25	20.0	0 / 3	0.05	NO	--	--	NO	--	-- / --	--	NO	NO
Zinc	-- --	3 / 3	3.00	4.00	CAA06-DW11-1108	3.40	0.53	4.29	3.37	118	0 / 3	0.03	NO	--	--	NO	--	-- / --	--	NO	NO
<b>Semivolatile Organic Compounds (UG/L)</b>																					

TABLE C-8  
 Ecological Screening Statistics - AOC 6 1918 Drum Storage Area Groundwater  
 AOC 6 - 1918 Drum Storage Area  
 WPNSTA Cheatham Annex, Williamsburg, Virginia

Chemical	Range of Non-Detect Values	Frequency of Detection	Minimum Concentration Detected	Maximum Concentration Detected	Sample ID of Maximum Detected Concentration	Arithmetic Mean	Standard Deviation of Mean	95% UCL (Norm)	Geometric Mean	Screening Value	Frequency of Exceedance <sup>1</sup>	Maximum Hazard Quotient <sup>2</sup>	Step 2 COPC?	95% UCL Hazard Quotient	Mean Hazard Quotient	Step 3A COPC?	95% UTL	Frequency of UTL Exceedance	Maximum Ratio to UTL	COPC for Risk Evaluation?	COPC with DF of 10?
1,1-Biphenyl	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	14.0	-- / --	0.64	NO	--	--	NO	--	-- / --	--	NO	NO
2,2'-Oxybis(1-chloropropane)	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO	NO
2,4,5-Trichlorophenol	24.0 - 24.0	0 / 3	--	--	--	12.0	0.0	12.0	12.0	63.0	-- / --	0.38	NO	--	--	NO	--	-- / --	--	NO	NO
2,4,6-Trichlorophenol	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	4.90	-- / --	1.84	YES	0.92	0.92	NO	--	-- / --	--	NO	NO
2,4-Dichlorophenol	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	11.0	-- / --	0.82	NO	--	--	NO	--	-- / --	--	NO	NO
2,4-Dimethylphenol	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	100	-- / --	0.09	NO	--	--	NO	--	-- / --	--	NO	NO
2,4-Dinitrophenol	24.0 - 24.0	0 / 3	--	--	--	12.0	0.0	12.0	12.0	19.0	-- / --	1.26	YES	0.63	0.63	NO	--	-- / --	--	NO	NO
2,4-Dinitrotoluene	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	44.0	-- / --	0.20	NO	--	--	NO	--	-- / --	--	NO	NO
2,6-Dinitrotoluene	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	81.0	-- / --	0.11	NO	--	--	NO	--	-- / --	--	NO	NO
2-Chloronaphthalene	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	0.40	-- / --	22.5	YES	11.3	11.3	NO <sup>4</sup>	--	-- / --	--	NO <sup>4</sup>	NO <sup>4</sup>
2-Chlorophenol	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	24.0	-- / --	0.38	NO	--	--	NO	--	-- / --	--	NO	NO
2-Methylnaphthalene	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	330	-- / --	0.03	NO	--	--	NO	--	-- / --	--	NO	NO
2-Methylphenol	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	13.0	-- / --	0.69	NO	--	--	NO	--	-- / --	--	NO	NO
2-Nitroaniline	24.0 - 24.0	0 / 3	--	--	--	12.0	0.0	12.0	12.0	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO	NO
2-Nitrophenol	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	1,920	-- / --	0.00	NO	--	--	NO	--	-- / --	--	NO	NO
3,3'-Dichlorobenzidine	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	4.50	-- / --	2.00	YES	1.00	1.00	NO <sup>4</sup>	--	-- / --	--	NO <sup>4</sup>	NO
3-Nitroaniline	24.0 - 24.0	0 / 3	--	--	--	12.0	0.0	12.0	12.0	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO	NO
4,6-Dinitro-2-methylphenol	24.0 - 24.0	0 / 3	--	--	--	12.0	0.0	12.0	12.0	2.30	-- / --	10.4	YES	5.22	5.22	NO <sup>4</sup>	--	-- / --	--	NO <sup>4</sup>	NO
4-Bromophenyl-phenylether	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	1.50	-- / --	6.00	YES	3.00	3.00	NO <sup>4</sup>	--	-- / --	--	NO <sup>4</sup>	NO
4-Chloro-3-methylphenol	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	0.30	-- / --	30.0	YES	15.0	15.0	NO <sup>4</sup>	--	-- / --	--	NO <sup>4</sup>	NO <sup>4</sup>
4-Chloroaniline	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	232	-- / --	0.04	NO	--	--	NO	--	-- / --	--	NO	NO
4-Chlorophenyl-phenylether	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO	NO
4-Methylphenol	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	543	-- / --	0.02	NO	--	--	NO	--	-- / --	--	NO	NO
4-Nitroaniline	24.0 - 24.0	0 / 3	--	--	--	12.0	0.0	12.0	12.0	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO	NO
4-Nitrophenol	-- --	0 / 0	--	--	--	--	--	--	--	300	-- / --	--	NO	--	--	NO	--	-- / --	--	NO	NO
Acenaphthene	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	23.0	-- / --	0.39	NO	--	--	NO	--	-- / --	--	NO	NO
Acenaphthylene	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	4,840	-- / --	0.002	NO	--	--	NO	--	-- / --	--	NO	NO
Acetophenone	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO	NO
Anthracene	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	0.73	-- / --	12.3	YES	6.16	6.16	NO <sup>4</sup>	--	-- / --	--	NO <sup>4</sup>	NO
Atrazine	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	1.80	-- / --	5.00	YES	2.50	2.50	NO <sup>4</sup>	--	-- / --	--	NO <sup>4</sup>	NO
Benzaldehyde	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO	NO
Benzo(a)anthracene	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	0.027	-- / --	333	YES	167	167	NO <sup>4</sup>	--	-- / --	--	NO <sup>4</sup>	NO <sup>4</sup>
Benzo(a)pyrene	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	0.014	-- / --	643	YES	321	321	NO <sup>4</sup>	--	-- / --	--	NO <sup>4</sup>	NO <sup>4</sup>
Benzo(b)fluoranthene	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	9.07	-- / --	0.99	NO	--	--	NO	--	-- / --	--	NO	NO
Benzo(g,h,i)perylene	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	7.64	-- / --	1.18	YES	0.59	0.59	NO	--	-- / --	--	NO	NO
Benzo(k)fluoranthene	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	9.07	-- / --	0.99	NO	--	--	NO	--	-- / --	--	NO	NO
Butylbenzylphthalate	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	19.0	-- / --	0.47	NO	--	--	NO	--	-- / --	--	NO	NO
Caprolactam	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO	NO
Carbazole	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO	NO
Chrysene	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO	NO
Di-n-butylphthalate	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	35.0	-- / --	0.26	NO	--	--	NO	--	-- / --	--	NO	NO
Di-n-octylphthalate	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	22.0	-- / --	0.41	NO	--	--	NO	--	-- / --	--	NO	NO
Dibenz(a,h)anthracene	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO	NO
Dibenzofuran	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	3.70	-- / --	2.43	YES	1.22	1.22	NO <sup>4</sup>	--	-- / --	--	NO <sup>4</sup>	NO
Diethylphthalate	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	270	-- / --	0.03	NO	--	--	NO	--	-- / --	--	NO	NO
Dimethyl phthalate	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	330	-- / --	0.03	NO	--	--	NO	--	-- / --	--	NO	NO
Fluoranthene	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	8.10	-- / --	1.11	YES	0.56	0.56	NO	--	-- / --	--	NO	NO
Fluorene	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	3.90	-- / --	2.31	YES	1.15	1.15	NO <sup>4</sup>	--	-- / --	--	NO <sup>4</sup>	NO
Hexachlorobenzene	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	3.68	-- / --	2.45	YES	1.22	1.22	NO <sup>4</sup>	--	-- / --	--	NO <sup>4</sup>	NO
Hexachlorobutadiene	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	1.30	-- / --	6.92	YES	3.46	3.46	NO <sup>4</sup>	--	-- / --	--	NO <sup>4</sup>	NO

TABLE C-8  
 Ecological Screening Statistics - AOC 6 1918 Drum Storage Area Groundwater  
 AOC 6 - 1918 Drum Storage Area  
 WPNSTA Cheatham Annex, Williamsburg, Virginia

Chemical	Range of Non-Detect Values	Frequency of Detection	Minimum Concentration Detected	Maximum Concentration Detected	Sample ID of Maximum Detected Concentration	Arithmetic Mean	Standard Deviation of Mean	95% UCL (Norm)	Geometric Mean	Screening Value	Frequency of Exceedance <sup>1</sup>	Maximum Hazard Quotient <sup>2</sup>	Step 2 COPC?	95% UCL Hazard Quotient	Mean Hazard Quotient	Step 3A COPC?	95% UTL	Frequency of UTL Exceedance	Maximum Ratio to UTL	COPC for Risk Evaluation?	COPC with DF of 10?
Hexachlorocyclopentadiene	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	1.04	-- / --	8.65	YES	4.33	4.33	NO <sup>4</sup>	--	-- / --	--	NO <sup>4</sup>	NO
Hexachloroethane	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	12.0	-- / --	0.75	NO	--	--	NO	--	-- / --	--	NO	NO
Indeno(1,2,3-cd)pyrene	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	4.31	-- / --	2.09	YES	1.04	1.04	NO <sup>4</sup>	--	-- / --	--	NO <sup>4</sup>	NO
Isophorone	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	1,170	-- / --	0.01	NO	--	--	NO	--	-- / --	--	NO	NO
Naphthalene	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	12.0	-- / --	0.75	NO	--	--	NO	--	-- / --	--	NO	NO
Nitrobenzene	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	270	-- / --	0.03	NO	--	--	NO	--	-- / --	--	NO	NO
Pentachlorophenol	24.0 - 24.0	0 / 3	--	--	--	12.0	0.0	12.0	12.0	15.0	-- / --	1.60	YES	0.80	0.80	NO	--	-- / --	--	NO	NO
Phenanthrene	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	6.30	-- / --	1.43	YES	0.71	0.71	NO	--	-- / --	--	NO	NO
Phenol	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	110	-- / --	0.08	NO	--	--	NO	--	-- / --	--	NO	NO
Pyrene	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	0.025	-- / --	360	YES	180	180	NO <sup>4</sup>	--	-- / --	--	NO <sup>4</sup>	NO <sup>4</sup>
bis(2-Chloroethoxy)methane	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	NSV	-- / --	NSV	NO	--	--	NO	--	-- / --	--	NO	NO
bis(2-Chloroethyl)ether	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	1,900	-- / --	0.005	NO	--	--	NO	--	-- / --	--	NO	NO
bis(2-Ethylhexyl)phthalate	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	32.0	-- / --	0.28	NO	--	--	NO	--	-- / --	--	NO	NO
n-Nitroso-di-n-propylamine	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	120	-- / --	0.08	NO	--	--	NO	--	-- / --	--	NO	NO
n-Nitrosodiphenylamine	9.00 - 9.00	0 / 3	--	--	--	4.50	0.0	4.50	4.50	210	-- / --	0.04	NO	--	--	NO	--	-- / --	--	NO	NO
<b>Explosives (UG/L)</b>																					
1,3,5-Trinitrobenzene	0.20 - 0.20	0 / 3	--	--	--	0.10	1.70E-17	0.10	0.10	11.0	-- / --	0.02	NO	--	--	NO	--	-- / --	--	NO	NO
1,3-Dinitrobenzene	0.20 - 0.20	0 / 3	--	--	--	0.10	1.70E-17	0.10	0.10	17.0	-- / --	0.01	NO	--	--	NO	--	-- / --	--	NO	NO
2,4,6-Trinitrotoluene	0.20 - 0.20	0 / 3	--	--	--	0.10	1.70E-17	0.10	0.10	93.0	-- / --	0.002	NO	--	--	NO	--	-- / --	--	NO	NO
2,4-Dinitrotoluene	0.20 - 0.20	0 / 3	--	--	--	0.10	1.70E-17	0.10	0.10	44.0	-- / --	0.005	NO	--	--	NO	--	-- / --	--	NO	NO
2,6-Dinitrotoluene	0.20 - 0.20	0 / 3	--	--	--	0.10	1.70E-17	0.10	0.10	81.0	-- / --	0.002	NO	--	--	NO	--	-- / --	--	NO	NO
2-Amino-4,6-dinitrotoluene	0.20 - 0.20	0 / 3	--	--	--	0.10	1.70E-17	0.10	0.10	19.0	-- / --	0.011	NO	--	--	NO	--	-- / --	--	NO	NO
2-Nitrotoluene	0.40 - 0.40	0 / 3	--	--	--	0.20	3.40E-17	0.20	0.20	3,400	-- / --	0.0001	NO	--	--	NO	--	-- / --	--	NO	NO
3,5-Dinitroaniline	0.20 - 0.20	0 / 3	--	--	--	0.10	1.70E-17	0.10	0.10	59.0	-- / --	0.003	NO	--	--	NO	--	-- / --	--	NO	NO
3-Nitrotoluene	0.40 - 0.40	0 / 3	--	--	--	0.20	3.40E-17	0.20	0.20	750	-- / --	0.001	NO	--	--	NO	--	-- / --	--	NO	NO
4-Amino-2,6-dinitrotoluene	0.20 - 0.20	0 / 3	--	--	--	0.10	1.70E-17	0.10	0.10	19.0	-- / --	0.01	NO	--	--	NO	--	-- / --	--	NO	NO
4-Nitrotoluene	0.40 - 0.40	0 / 3	--	--	--	0.20	3.40E-17	0.20	0.20	1,900	-- / --	0.0002	NO	--	--	NO	--	-- / --	--	NO	NO
HMX	0.40 - 0.40	0 / 3	--	--	--	0.20	3.40E-17	0.20	0.20	330	-- / --	0.001	NO	--	--	NO	--	-- / --	--	NO	NO
Nitrobenzene	0.20 - 0.20	0 / 3	--	--	--	0.10	1.70E-17	0.10	0.10	270	-- / --	0.001	NO	--	--	NO	--	-- / --	--	NO	NO
Nitroglycerin	1,000 - 1,000	0 / 3	--	--	--	500	0.0	500	500	138	-- / --	7.25	YES	3.62	3.62	NO <sup>4</sup>	--	-- / --	--	NO <sup>4</sup>	NO
Nitroguanidine	10.0 - 10.0	0 / 3	--	--	--	5.00	0.0	5.00	5.00	220	-- / --	0.05	NO	--	--	NO	--	-- / --	--	NO	NO
PETN	1.00 - 1.00	0 / 3	--	--	--	0.50	0.0	0.50	0.50	85,000	-- / --	0.00001	NO	--	--	NO	--	-- / --	--	NO	NO
RDX	0.40 - 0.40	0 / 3	--	--	--	0.20	3.40E-17	0.20	0.20	186	-- / --	0.002	NO	--	--	NO	--	-- / --	--	NO	NO
Tetryl	0.40 - 0.40	0 / 3	--	--	--	0.20	3.40E-17	0.20	0.20	8.00	-- / --	0.05	NO	--	--	NO	--	-- / --	--	NO	NO

NSV - No Screening Value  
 1 - Count of detected samples exceeding or equaling Screening Value  
 2 - Shaded cells indicate hazard quotient based on reporting limits  
 3 - Macronutrient - Not considered to be a COPC  
 4 - See uncertainty section

TABLE C-9

## Reporting Limit to Screening Value Comparison

## AOC 6 - 1918 Drum Storage Area

## WPNSTA Cheatham Annex, Williamsburg, Virginia

Chemical	Units	Frequency of Detection	Minimum Reporting Limit	Maximum Reporting Limit	Mean Concentration	ESV	Minimum Ratio	Maximum Ratio	Mean Ratio
<b>Surface Soil</b>									
4,6-Dinitro-2-methylphenol	UG/KG	0 / 4	940	1,000	481	1,000	0.94	1.00	0.48
4-Nitrophenol	UG/KG	0 / 4	940	1,000	481	380	2.47	2.63	1.27
Atrazine	UG/KG	0 / 4	370	420	194	11.9	31.1	35.3	16.3
<b>Subsurface Soil</b>									
4-Nitrophenol	UG/KG	0 / 4	900	960	465	380	2.37	2.53	1.22
Atrazine	UG/KG	0 / 5	350	380	182	11.9	29.4	31.9	15.3
<b>Groundwater</b>									
Antimony (dissolved)	UG/L	0 / 3	60.0	60.0	30.0	30.0	2.00	2.00	1.00
Beryllium (dissolved)	UG/L	0 / 3	5.00	5.00	2.50	0.66	7.58	7.58	3.79
Cadmium (dissolved)	UG/L	0 / 3	0.070	5.00	1.68	0.25	0.28	20.3	6.82
Selenium (dissolved)	UG/L	0 / 3	35.0	35.0	17.5	4.61	7.59	7.59	3.80
Silver (dissolved)	UG/L	0 / 3	10.0	10.0	5.00	0.36	27.8	27.8	13.9
2,4,6-Trichlorophenol	UG/L	0 / 3	9.00	9.00	4.50	4.90	1.84	1.84	0.92
2,4-Dinitrophenol	UG/L	0 / 3	24.0	24.0	12.0	19.0	1.26	1.26	0.63
2-Chloronaphthalene	UG/L	0 / 3	9.00	9.00	4.50	0.40	22.5	22.5	11.3
3,3'-Dichlorobenzidine	UG/L	0 / 3	9.00	9.00	4.50	4.50	2.00	2.00	1.00
4,6-Dinitro-2-methylphenol	UG/L	0 / 3	24.0	24.0	12.0	2.30	10.4	10.4	5.22
4-Bromophenyl-phenylether	UG/L	0 / 3	9.00	9.00	4.50	1.50	6.00	6.00	3.00
4-Chloro-3-methylphenol	UG/L	0 / 3	9.00	9.00	4.50	0.30	30.0	30.0	15.0
Anthracene	UG/L	0 / 3	9.00	9.00	4.50	0.73	12.3	12.3	6.16
Atrazine	UG/L	0 / 3	9.00	9.00	4.50	1.80	5.00	5.00	2.50
Benzo(a)anthracene	UG/L	0 / 3	9.00	9.00	4.50	0.027	333	333	167
Benzo(a)pyrene	UG/L	0 / 3	9.00	9.00	4.50	0.014	643	643	321
Benzo(g,h,i)perylene	UG/L	0 / 3	9.00	9.00	4.50	7.64	1.18	1.18	0.59
Dibenzofuran	UG/L	0 / 3	9.00	9.00	4.50	3.70	2.43	2.43	1.22
Fluoranthene	UG/L	0 / 3	9.00	9.00	4.50	8.10	1.11	1.11	0.56
Fluorene	UG/L	0 / 3	9.00	9.00	4.50	3.90	2.31	2.31	1.15
Hexachlorobenzene	UG/L	0 / 3	9.00	9.00	4.50	3.68	2.45	2.45	1.22
Hexachlorobutadiene	UG/L	0 / 3	9.00	9.00	4.50	1.30	6.92	6.92	3.46

TABLE C-9

**Reporting Limit to Screening Value Comparison****AOC 6 - 1918 Drum Storage Area*****WPNSTA Cheatham Annex, Williamsburg, Virginia***

<b>Chemical</b>	<b>Units</b>	<b>Frequency of Detection</b>	<b>Minimum Reporting Limit</b>	<b>Maximum Reporting Limit</b>	<b>Mean Concentration</b>	<b>ESV</b>	<b>Minimum Ratio</b>	<b>Maximum Ratio</b>	<b>Mean Ratio</b>
Hexachlorocyclopentadiene	UG/L	0 / 3	9.00	9.00	4.50	1.04	8.65	8.65	4.33
Indeno(1,2,3-cd)pyrene	UG/L	0 / 3	9.00	9.00	4.50	4.31	2.09	2.09	1.04
Pentachlorophenol	UG/L	0 / 3	24.0	24.0	12.0	15.0	1.60	1.60	0.80
Phenanthrene	UG/L	0 / 3	9.00	9.00	4.50	6.30	1.43	1.43	0.71
Pyrene	UG/L	0 / 3	9.00	9.00	4.50	0.025	360	360	180
Nitroglycerin	UG/L	0 / 3	1,000	1,000	500	138	7.25	7.25	3.62

Shaded cells indicate ratio &gt; 1

## **Ecological Risk Assessment Figures**

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**RTCs**

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**From:** Smith, Wade (DEQ) [Wade.Smith@deq.virginia.gov]  
**Sent:** Thursday, July 11, 2013 9:23 AM  
**To:** scott.park@navy.mil  
**Cc:** Ivester, Marlene/VBO; Sawyer, Stephanie/VBO; Haug.Susanne@epa.gov;  
hoover.gerald@epa.gov  
**Subject:** CAX: AOC 6 Consensus Letter  
**Attachments:** Draft\_AOC6\_NFA\_ConsensusLetter(DEQ).docx

**Follow Up Flag:** Follow up  
**Flag Status:** Completed

Thank you for giving the DEQ the opportunity to comment on the June 6, 2013 *Draft Consensus Letter* for CAX AOC 6.

The Draft Consensus Letter was received by the DEQ on June 7, 2013.

The DEQ's comments are attached (track changes via Word).

Upon receipt of the requested revisions, the DEQ will issue an official letter for your files.

Please let me know if you have any questions.

Sincerely,

Wade M. Smith  
Remediation Project Manager  
Virginia Department of Environmental Quality  
Office of Remediation Programs  
Phone: (804) 698-4125  
[wade.smith@deq.virginia.gov](mailto:wade.smith@deq.virginia.gov)

## Draft Consensus Letter for Soil and Groundwater at the Area of Concern 6 1918 Drum Storage Area Subarea, Naval Weapons Station Yorktown Cheatham Annex, Williamsburg, Virginia

PREPARED FOR: CAX Partnering Team:  
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Susanne Haug – USEPA  
Wade Smith – VDEQ

COPY TO: Marlene Ivester – CH2M HILL  
Stephanie Sawyer – CH2M HILL

PREPARED BY: CH2M HILL

DATE: June 6, 2013

This consensus letter summarizes soil and groundwater data and human health and ecological risks and provides the rationale for the CAX Partnering Team consensus for no further action for soil and groundwater at the 1918 Drum Storage Area (DSA) subarea within Area of Concern (AOC) 6 at Naval Weapons Station Yorktown Cheatham Annex (CAX) (**Figure 1**). The results of a baseline human health risk assessment (HHRA) and an ecological risk assessment (ERA) are presented in this consensus letter, and provide support for the rationale for soil and groundwater risk management considerations to support no further action at the 1918 DSA subarea. The 1918 DSA subarea is the only subarea being evaluated in this consensus letter; the other four subareas of AOC 6 will be evaluated separately.

### Background

The 1918 DSA subarea is one of five subareas that comprise AOC 6 (Penniman AOC). It is a developed area, located south of Antrim Road, consisting mostly of open and maintained grassy areas and a parking lot (**Figure 2**). The 1918 DSA subarea was identified by the United States Environmental Protection Agency (USEPA) from a 1918 overhead photograph. This subarea was once used for the storage of wooden barrels and/or drums of unknown content when the shell loading facility was active (ATSDR, 2004).

### Previous Investigations

In January 1999 as part of a Site Inspection (SI) investigation, soil samples were collected from the 1918 DSA subarea to assess potential releases of contamination associated with the Penniman shell loading facility and to support hazard ranking system evaluations for CAX. All samples were analyzed for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), pesticides, polychlorinated biphenyls (PCBs), nitramines/nitroaromatics (explosives), and inorganic constituents. Analytical results indicated that arsenic was the only constituent of potential concern (COPC), as it was detected at concentrations exceeding the April 1999 USEPA residential soil risk-based concentrations (RBCs), the screening comparison criteria used at the time. The SI report recommended further evaluation of the 1918 DSA subarea due to the arsenic RBC exceedances being within the first 2 feet of the subsurface and located within 200 feet of occupied buildings (Weston, 1999).

An additional SI was completed in May 2012 with the objective to determine whether a release of hazardous constituents had occurred from past activities regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and if so, to determine whether a suspected release warranted further action. The SI report concluded that no further action for soil and groundwater was warranted and recommended the preparation of a consensus letter to capture the No Further Action recommendation (CH2M HILL, 2012).

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Comment [WS1]: Please consider including this photograph as a reference.

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## Conceptual Site Model

The conceptual site model (CSM) for soil and groundwater at the 1918 DSA subarea is based in the historical data summarized in this section, and interprets the physical setting, distribution of contamination, potential migration pathways, and potential exposure receptor pathways. A graphical depiction of the CSM for the 1918 DSA subarea of AOC 6 is depicted in **Figure 3**.

### Physical Setting

The 1918 DSA subarea is generally topographically flat and contains no wetlands or water bodies onsite or immediately downgradient of the subarea. The nearest water body is the northwest finger of Penniman Lake (which ~~is~~ being investigated under a separate evaluation), located approximately 400 feet to the southeast. Surface runoff at this site is anticipated to flow over the paved areas to the grassed areas and infiltrate into the subsurface or evaporate.

In general, soil in the 1918 DSA subarea is predominantly olive brown silt and clay, with a pale yellow shell hash present between 8 and 9 feet below ground surface (bgs). The shallow aquifer underlying the site is the Yorktown-Eastover aquifer. Groundwater depths during the recent SI ranged from 10 to 11 feet bgs. Groundwater is expected to flow southeast toward Penniman Lake.

The land use in the 1918 DSA subarea is industrial and the site is composed of grassed areas, a paved parking lot, and two office buildings. Future land use at the 1918 DSA subarea is not expected to change and will likely continue to be industrial use for the foreseeable future.

### Distribution of Contamination

During the May 2012 SI, six co-located surface and subsurface soil samples and three groundwater samples were collected from the 1918 DSA subarea. These samples were analyzed for SVOCs, explosives, and inorganic constituents. Analyses for VOCs, pesticides, and PCBs were not conducted during the recent SI, as analyses for these constituents were included for the samples collected during the 1999 SI and they were found not to be COPCs.

The analytical results were screened against base background soil and groundwater values (95 percent upper tolerance limits [UTLs]) for inorganic constituents (CH2M HILL, 2011) and conservative screening values as follows:

#### Surface and subsurface soil

- USEPA Regional Screening Levels (RSLs) for industrial and residential soil adjusted as appropriate (for noncarcinogenic effects) (May 2012)
- Site-specific ecological screening values (ESVs)

#### Groundwater

- USEPA RSLs for tap water, adjusted as appropriate (for noncarcinogenic effects) (May 2012)
- Federal Safe Drinking Water Act (SDWA) (Title 40 of the Code of Federal Regulations, Part 141) Maximum Contaminant Levels (MCLs)
- Site-specific ESVs<sup>1</sup>

#### Soil

No SVOCs or explosives were detected in surface or subsurface soil samples (see **Appendix A** for the analytical data tables).

<sup>1</sup> Although both total and dissolved groundwater data are included in the ecological screening tables, only dissolved metals data are considered when selecting COPCs. The dissolved concentrations are likely to be more representative of what would be transported via the groundwater than the total concentrations. (See **Appendix C, Section C.5.3.3** for more information)

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Two inorganic constituents (aluminum and lead) were found at concentrations that exceeded the base background 95 percent UTL concentrations and at least one other screening criterion in surface soil (**Figure 4**). Aluminum slightly exceeded the base background 95 percent UTL (12,200 milligrams per kilogram [mg/kg]) and exceeded the adjusted residential RSL (7,000 mg/kg) and the ESV (pH less than 5.5) in one surface soil sample (SS19) at a concentration of 12,800 mg/kg and a pH of 5. Lead exceeded the base background 95 percent UTL (17.4 mg/kg) and slightly exceeded the ESV (120 mg/kg) in one surface soil sample (SS15) at a concentration of 128 mg/kg.

Two inorganic constituents (aluminum and thallium) were found at concentrations that exceeded the base background 95 percent UTL concentrations and their respective adjusted residential RSL in subsurface soil (**Figure 5**). No ESV exceedances were identified. Aluminum slightly exceeded the base background 95 percent UTL (13,000 mg/kg) and exceeded the adjusted residential RSL (7,700 mg/kg) in one subsurface soil sample (SB16) at a concentration of 13,200 mg/kg. Thallium slightly exceeded the adjusted residential RSL (0.078 mg/kg) in one subsurface soil sample (SB16) at a concentration of 0.084 mg/kg (there is no base background 95 percent UTL value for thallium).

#### Groundwater

- No SVOCs or explosives were detected in groundwater samples (**Appendix A**).
- Seventeen total inorganic constituents (aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, nickel, selenium, thallium, vanadium, and zinc) and two dissolved inorganic constituents (aluminum and thallium) exceeded their respective base background 95 percent UTL concentrations and at least one screening criterion in one or more groundwater samples (**Figure 6**).

Dissolved inorganic constituent data are likely more representative of inorganic constituent concentrations migrating in groundwater, since the DPT method used for sample collection generally results in higher total inorganic constituent concentrations due to increased sample turbidity. While 17 total inorganic constituents were detected in groundwater samples, only aluminum and thallium were detected above at least one other screening criterion in the dissolved fraction (**Figure 6**) (There are no base background 95 percent UTLs for dissolved aluminum or thallium). Therefore, the higher total inorganic constituent detections are likely the result of the increased turbidity.

Aluminum concentrations exceeded the ESV (87.0 micrograms per liter [ $\mu\text{g/L}$ ]) but not the adjusted residential RSL in all groundwater samples, at a maximum concentration of 385  $\mu\text{g/L}$  (DW09). Thallium concentrations exceeded the adjusted residential RSL (0.037  $\mu\text{g/L}$ ) but not the ESV in one groundwater sample (DW09), at a concentration of 2  $\mu\text{g/L}$ . It should also be noted that while dissolved barium concentrations exceeded the ESV (4  $\mu\text{g/L}$ ) in all groundwater samples (maximum estimated concentration of 50  $\mu\text{g/L}$ ), these concentrations did not exceed the base background 95 percent UTL (127  $\mu\text{g/L}$ ).

#### Potential Migration Pathways

The source of potential contamination at the 1918 DSA subarea is anticipated to be the barrels or drums formerly stored onsite, as depicted in the 1918 overhead photograph of the site. However, there is no information as to what was stored in these containers or if any resulted in a release to the environment.

#### Receptors

Actual or potential exposures of human and ecological receptors associated with a site are determined by identifying the most likely, and most important, mechanisms and pathways of contaminant release and transport. A complete exposure pathway has three components: (1) a source or sources of contamination that results in a release to the environment; (2) a pathway and mechanism of chemical transport through an environmental medium; and (3) an exposure or contact point for a receptor.

The potential receptors included in the risk assessments of soil and groundwater at the 1918 DSA subarea were current and future recreational users and visitors, trespassers, maintenance workers, and industrial workers,

future residents and construction workers, and lower trophic level terrestrial receptors (plants and soil invertebrates).

## Risk Assessment

Data for the CERCLA-related constituents identified at the 1918 DSA subarea were compared to the previously described screening criteria in **Tables 1, 2, and 3** for surface soil, subsurface soil, and groundwater, respectively. Those constituents that exceed the base background 95 percent UTL and one or more criteria are shown in **Figure 4** for surface soil, **Figure 5** for subsurface soil, and **Figure 6** for groundwater. A human health risk screening for soil, an HHRA for groundwater, and an ERA for soil were completed to determine if any unacceptable risks are present at the 1918 DSA subarea.

### Human Health Risk Assessment Summary

The primary objective of the baseline HHRA is to assess the potential human health risks from contamination associated with groundwater at the 1918 DSA subarea. The May 2012 SI report concluded that the human health risk screening determined that exposure to surface and subsurface soil at the 1918 DSA subarea would not be expected to result in any unacceptable human health risks; therefore, soil was eliminated from further evaluation and was not included in the baseline HHRA (CH2M HILL, 2012). The SI report screening level risk assessment tables, supporting no potential unacceptable human health risks for surface and subsurface soil at the 1918 DSA subarea, are included in **Appendix B, Tables B1, B1.a, B2, and B2.a**. Groundwater data were evaluated in the baseline HHRA to characterize potential current and future risks based on current site conditions.

The baseline HHRA evaluated the carcinogenic risks and noncarcinogenic hazards to a reasonably maximally exposed individual, which is consistent with the National Oil and Hazardous Substances Pollution Contingency Plan and the Risk Assessment Guidance for Superfund HHRA guidance documents (USEPA, 1989, 2001, 2004, and 2009) and Chief of Naval Operations guidance document (CNO, 2001). The reasonable maximum exposure (RME) is the highest exposure that is reasonably expected to occur at a site (USEPA, 1989). When the RME risk exceeded USEPA target risk levels, the central tendency exposure (CTE) risk was evaluated. The CTE risk is the risk to individuals who have average or typical exposure to the environmental media. The baseline HHRA is presented in **Appendix B** of this consensus letter.

### Potential Human Receptors and Exposure Scenarios

The preliminary CSM for human exposures presents an overview of site conditions, potential sources of contamination, potential contaminant-migration pathways, and potential exposure pathways to potential receptors. **Figure 3** presents a graphical depiction of the overall CSM for the 1918 DSA subarea, and **Figure B-1** in **Appendix B** presents the preliminary CSM for human exposures developed for 1918 DSA subarea.

There are no potential current receptors exposed to groundwater at the 1918 DSA subarea. No future use of groundwater is planned at this time; however, the risk assessment conservatively assumed that in the unlikely event future residential development of the site occurs, the residents could use the groundwater as a potable water supply. Therefore, risks associated with groundwater were evaluated assuming future residential potable use as the most conservative case. Additionally, it was assumed that construction workers could be exposed to groundwater during any excavation activities.

### Baseline Human Health Risk Assessment Results

In accordance with the USEPA Region 3 guidance, filtered groundwater samples were used to determine inorganic constituent exposure concentrations for the residential scenarios because a review of the groundwater data determined a significant difference (an order of magnitude or greater) between the filtered (dissolved) and total (unfiltered) results within each sample. Unfiltered groundwater samples were used to determine inorganic constituent exposure concentrations for the construction worker scenario, as a construction worker would directly contact the groundwater in an excavation.

Future residential adult and child exposure to filtered groundwater could potentially pose an unacceptable hazard associated with ingestion of thallium, the only chemical of concern identified for this scenario. However, thallium

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was detected in only one of three filtered groundwater samples at a maximum concentration of 2 µg/L, which does not exceed the MCL (2 µg/L).

Future residential lifetime exposure to filtered groundwater would not result in an unacceptable carcinogenic risk. Future construction worker exposure to groundwater would not result in an unacceptable noncarcinogenic hazard or carcinogenic risk.

### Ecological Risk Assessment Summary

A screening-level ecological risk assessment (SERA), constituting Steps 1 and 2 of the ERA process, and the first step (Step 3A) of a Baseline ERA, were completed for the 1918 DSA subarea. This ERA discussion provides detail and documentation of the ecological risk screening performed as part of the final SI (CH2M HILL, 2012), which concluded that there is no unacceptable ecological risk associated with 1918 DSA subarea soil and groundwater.

The SERA was conducted in accordance with the *Navy Policy for Conducting Ecological Risk Assessments* (CNO, 1999) and the Department of the Navy (Navy) guidance for implementing this ERA policy (NAVFAC, 2003). The Navy ERA policy and guidance, which describe a process consisting of eight steps organized into three tiers, are conceptually similar to the eight-step ERA process outlined in USEPA ERA guidance for the Superfund program (USEPA, 1997). For both sets of guidance, Steps 1 and 2 involve conducting a SERA using very conservative assumptions. The complete SERA is presented in **Appendix C** of this consensus letter.

### Potential Ecological Receptors and Exposure Scenarios

A transport pathway describes the mechanisms whereby site-related chemicals, once released, may be transported from a source to ecologically relevant media (such as surface soil) where exposures may occur. The primary release mechanisms and transport pathways at the site include:

- Possible surface runoff from source areas to other areas of the site
- Infiltration, percolation, and leaching of contaminants to groundwater and subsequent discharge of groundwater to the surface water and sediment of downgradient water bodies (Penniman Lake)

Exposure media for ecological receptors are typically limited to surface water, surface sediment, and surface soil. Surface water and sediment are not evaluated in the SERA because the site does not contain wetlands or water bodies. Subsurface soil (6 to 24 inches bgs) is also evaluated because some ecological receptors may be exposed to soil at these depths. Groundwater is generally considered only as a transport medium since there are no ecological exposures to groundwater until it discharges to a water body or surfaces as a seep. In the SERA, groundwater is evaluated as a potential transport medium to downgradient water bodies (Penniman Lake). Air is not addressed in the SERA since this medium is not likely to result in significant contributions to total exposures for the receptors evaluated.

An exposure pathway links a source of contamination with one or more receptors through exposure via one or more media and exposure routes. Exposure, and thus potential risk, can only occur if complete exposure pathways exist. **Figure C-1** in **Appendix C** shows the potentially complete exposure pathways to ecological receptors associated with the 1918 DSA subarea of AOC 6, which include:

- Direct contact with site-related chemicals in surface soil for lower trophic level receptors (such as plants and soil invertebrates)

As previously discussed, there are no complete exposure pathways for aquatic receptors on the site due to the lack of wetland and aquatic habitats. However, groundwater is evaluated as a potential transport medium to downgradient water bodies (Penniman Lake).

Terrestrial plants may be exposed to chemicals present in surface soil through their root surfaces during water and nutrient uptake. Terrestrial invertebrates may be exposed to chemicals in surface soil through dermal contact and ingestion. Due to the small size of the site (less than 1 acre) and its developed nature, exposures to terrestrial upper trophic level receptors (birds and mammals) are not considered significant and were not evaluated (CH2M HILL, 2012).

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Specific receptor species or species groups (such as plants) were selected as surrogates to evaluate potential risks to larger components of the ecological community (guilds) used to represent the assessment endpoints. Selection criteria typically include those species that:

- Are known to occur, or are likely to occur, at the site
- Have a particular ecological, economic, or aesthetic value
- Are representative of taxonomic groups, life history traits, and/or trophic levels in the habitats present for which complete exposure pathways are likely to exist
- Can, because of toxicological sensitivity or potential exposure magnitude, be expected to represent potentially sensitive populations

Lower trophic level receptor species were evaluated based upon those taxonomic groupings for which soil screening values have been developed. As such, specific species of plants or soil invertebrates in terrestrial habitats were not chosen as receptors because of the limited information available for specific species and because these receptors were evaluated on a community level via a comparison of chemical concentrations in soil to soil screening values.

#### Ecological Risk Assessment Results

In Step 3A, no COPCs were identified in 1918 DSA subarea surface soil, subsurface soil, or groundwater. For terrestrial habitats, risks for lower trophic level ecological receptors (plants and invertebrates) are acceptable, particularly given the current and future land use (industrial). Groundwater does not appear to be a significant transport medium for site-related constituents to Penniman Lake from the 1918 DSA subarea, and site-related constituents in groundwater are unlikely to pose a significant risk to aquatic biota.

#### Summary

The SI affirmed that soil and groundwater at the 1918 DSA subarea have been sufficiently characterized and the available soil and groundwater data are acceptable to recommend no further action. The no further action recommendation is based on the following:

- Although ingestion of dissolved thallium could potentially pose an unacceptable hazard for the future adult and child resident, dissolved thallium was detected in only one of three groundwater samples at a maximum concentration of 2 µg/L, which does not exceed the MCL (2 µg/L).
- Groundwater is not a source of potable water at the 1918 DSA subarea or CAX, and there is no future or potential planned use for groundwater as a source of potable water in the vicinity.
- It is unlikely that groundwater from the shallow aquifer would ever be used as a potable water supply because of the availability of better water supplies with respect to both natural water quality and quantity.
- No unacceptable human health risk was identified for the construction worker scenario.
- No ecological COPCs were identified in the surface soil, subsurface soil, or groundwater at the 1918 DSA subarea.
- For terrestrial habitats, risks for lower trophic level ecological receptors (plants and invertebrates) are acceptable, particularly given the current and future land use (industrial).
- Groundwater does not appear to be a significant transport medium for site-related constituents to Penniman Lake from the 1918 DSA subarea, and site-related constituents in groundwater are unlikely to pose a significant risk to aquatic biota.
- Future land use at the 1918 DSA subarea is not expected to change and will likely continue to be industrial for the foreseeable future.

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## No Further Action Soil and Groundwater Risk Management Consensus

The Navy, in partnership with the USEPA and the Virginia Department of Environmental Quality, has determined that no potential risks for surface and subsurface soil ~~and~~ groundwater exist at the 1918 DSA subarea and that no further action is required for soil ~~and~~ groundwater.

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Mr. Scott Park;  
NAVFAC Mid-Atlantic

\_\_\_\_\_ Date \_\_\_\_\_

Ms. Susanne Haug;  
USEPA Region 3

\_\_\_\_\_ Date \_\_\_\_\_

Mr. Wade Smith;  
VDEQ

\_\_\_\_\_ Date \_\_\_\_\_

## References

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**Response to Comments**  
**Draft Consensus Letter for Soil and Groundwater at the Area**  
**of Concern 6 1918 Drum Storage Area Subarea**

**Naval Weapons Station Yorktown Cheatham Annex**  
**Williamsburg, VA**  
**August 28, 2013**

Comments received by email on July 11, 2013 from Wade Smith, Virginia Department of Environmental Quality (VADEQ).

*VADEQ Comment #1 ("Background" section, third sentence): Please consider including this [1918 overhead] photograph as a reference.*

Navy Response: As requested, the referenced 1918 overhead photograph was added to the Consensus Letter as Photograph 1.

**Regulatory Acceptance**

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY  
REGION III  
1650 Arch Street  
Philadelphia, Pennsylvania 19103-2029

August 28, 2013

Mr. Scott Park  
NAVFAC MIDLANT, Building N-26, Room 3208  
Attention: Code OPHE3, Mr. Scott Park  
9742 Maryland Avenue  
Norfolk, VA 23511-3095

Subject: Draft Technical Memorandum, Consensus Letter for Groundwater and Soil at the Area of Concern 6, 1918 Drum Storage Area Subarea, Naval Weapons Station Yorktown Cheatham Annex, Williamsburg, Virginia, June 2013

Mr. Park:

Thank you for the opportunity to review the subject document. EPA has no comments on this document. Please submit a final copy of the subject document for our records.

If you have any questions, please contact me at 215-814-2077.

Sincerely,

A handwritten signature in blue ink that reads "Gerald F. Hoover".

Gerald F. Hoover, RPM  
NPL/BRAC Federal Facilities Branch

cc: Wade Smith, VDEQ



# COMMONWEALTH of VIRGINIA

## DEPARTMENT OF ENVIRONMENTAL QUALITY

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Douglas W. Domenech  
Secretary of Natural Resources

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Director

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August 30, 2013

Mr. Scott Park  
NAVFAC MIDLANT, Building N-26  
Hampton Roads Restoration Product Line, Code OPHREV4  
9742 Maryland Avenue  
Norfolk, VA 23511-3095

Consensus Letter  
AOC 6 – 1918 Drum Storage Area Subarea  
Naval Weapons Station Yorktown  
Cheatham Annex  
Williamsburg, Virginia

Dear Mr. Park:

The Virginia Department of Environmental Quality (DEQ) has received the *Response to Comments* (RTCs) associated with the Consensus Letter for AOC 6 – 1918 Drum Storage Area Subarea at Naval Weapons Station Yorktown, Cheatham Annex (CAX), Williamsburg, Virginia. The RTCs, prepared by CH2M HILL, were received by the DEQ (electronically) on August 28, 2013.

Thank you for providing the DEQ's Office of Remediation Programs the opportunity to review the above-referenced RTCs. Subsequent to DEQ's internal review, this office concurs with the proposed text revisions and recommends submittal of the *Final Consensus Letter* for signature.

Please contact me at (804) 698-4125 or [wade.smith@deq.virginia.gov](mailto:wade.smith@deq.virginia.gov) with any additional questions.

Sincerely,

A handwritten signature in blue ink, appearing to read "Wade M. Smith".

Wade M. Smith  
Remediation Project Manager  
Office of Remediation Programs

cc: Jerry Hoover, EPA