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Final

Remedial Investigation/Human Health Risk Assessment for Site 7
Naval Amphibious Base Little Creek
Virginia Beach, Virginia

Prepared for

Department of the Navy
Atlantic Division
Naval Facilities Engineering Command
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Remedial Investigation/Human Health Risk Assessment for Site 7
Naval Amphibious Base, Little Creek
Virginia Beach, Virginia

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Executive Summary

This report presents the revised Remedial Investigation (RI) and revised Human Health Risk Assessment (HHRA) for Site 7 at the Naval Amphibious Base (NAB) Little Creek in Virginia Beach, Virginia. Site 7 is the Amphibious Base Landfill, located in the south-central portion of the installation. This RI/HHRA report was prepared by CH2M HILL under the Naval Facilities Engineering Command, Atlantic Division (LANTDIV), Comprehensive Long-Term Environmental Action Navy II (CLEAN II) Contract N62470-95-D-6007, Contract Task Order (CTO) 159, for submittal to LANTDIV, the U.S. Environmental Protection Agency (USEPA), and the Virginia Department of Environmental Quality (VDEQ).

Site 7, the Amphibious Base Landfill, is bounded on the north by the southeast shoreline of Little Creek Cove, on the east by Helicopter Road, on the south by Amphibious Drive and the Hampton Roads Sanitation District (HRSD) treatment plant, and on the west by a relatively undeveloped area recently used for the construction of an ammunition magazine. The landfill covers approximately 38 acres and contains approximately 500,000 cubic yards (cy) of waste. The Amphibious Base Landfill operated from 1962 through 1979. Landfill contents probably include non-hazardous solid waste from base housing and other residential activities at the installation; however, specific records concerning the types and quantities of waste placed at the landfill are not available. Because the landfill was the recipient of all the wastes produced at NAB Little Creek, it may have also received potentially hazardous materials.

An initial RI and HHRA were performed for this site (along with five other sites) at NAB Little Creek by Foster Wheeler Environmental Services (FWES) in November 1994. The report for this effort was not reviewed by the USEPA. When the base was placed on the National Priorities List (NPL) in 1999, USEPA required that the HHRA for Site 7 be rewritten in accordance with current USEPA guidelines and that Site 7 be included in the Ecological Risk Assessment (ERA) being conducted for NAB Little Creek. This revised RI/HHRA has been developed to meet the current regulatory requirements and to incorporate additional long-term monitoring data for Site 7.

Information collected during the RI conducted by FWES in 1994 and the long-term monitoring program currently in place at Site 7 indicated that the different media contain several contaminants that exceed corresponding screening criteria. Contaminants include various volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), pesticides/polychlorinated biphenyls (PCBs), and inorganics in groundwater; VOCs and inorganics in surface water; SVOCs, pesticides/PCBs, and inorganics in sediment; and SVOCs, pesticides/PCBs, and inorganics in surface and subsurface soils.

The revised HHRA, conducted using data from the RI/FS performed by FWES in 1994 and the long-term monitoring data at Site 7 (Rounds 5 through 7), indicate that no unacceptable risks or hazards exist based on current site use. However, the combined surface and subsurface soil at the weigh station area, the site perimeter, and the covered area, where iron and thallium contribute to the hazard, suggest that an exposure to these areas by a future child resident may result in a non-carcinogenic hazard slightly above USEPA's target

hazard level. Additionally, exposure to vanadium in the combined surface and subsurface soil at the site perimeter may result in a non-carcinogenic hazard slightly above USEPA's target hazard level to future adult residents, industrial workers, and construction workers. Also, future potable use of Columbia Aquifer groundwater would result in an unacceptable risk and hazard to child residents from arsenic, iron, and manganese and to adult residents from arsenic. However, arsenic, iron, and manganese were all detected in Site 7 groundwater at concentrations similar to background conditions. Future construction work involving contact with the groundwater and future potable use of the groundwater by industrial workers would result in risks within USEPA target levels.

The ERA for Site 7, entitled *Draft Final Ecological Risk Assessment Site 7-Amphibious Base Landfill*, April 2004, was submitted as a separate document. The ERA includes a screening ecological risk assessment (SERA), constituting Steps 1 and 2 of the process, and the first step (Step 3) of a baseline ecological risk assessment (BERA). The available data (collected from 1986 through 2003) suggest that potential exposures and risks to lower trophic level receptors are possible in the central portion of the drainage canal. Cyanide and carbon disulfide each exceeded their respective screening values in surface water samples collected in the central portion of the drainage canal. In sediments collected from the central portion of the drainage canal, copper, lead, aroclor-1260, and five pesticides were identified as Chemicals of Concern (COCs).

Based upon the results of this ERA, the Tier 1 Partnering Team has reached consensus to conduct an Interim Removal Action (IRA), on a non time critical basis, in the drainage canal rather than proceed to Step 4 of the ERA process. The action, which will be documented in an Engineering Evaluation/Cost Analysis (EE/CA), will consist of removing the top foot of sediment from the area between sample location 218 and the northern abutment of Amphibious Drive. The existing access road culvert will also be permanently removed. Following the sediment removal, one foot of clean fill will be placed in the excavated area of the drainage canal. No confirmation sampling will be required. The Tier 1 Partnering Team also agreed that the remainder of Site 7 does not present an unacceptable risk to ecological receptors.

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B Round 5 Long-Term Monitoring Letter Report
C Round 6 Long-Term Monitoring Letter Report
D Round 7 Long-Term Monitoring Letter Report
E Human Health Risk Assessment Data

NOTE: For Appendixes B, C, and D, data validation and laboratory reports were submitted with the original letter reports and are not included in these appendixes.

Acronyms and Abbreviations

Al	aluminum
As	arsenic
ASTM	American Society for Testing and Materials
Be	beryllium
BERA	Baseline Ecological Risk Assessment
bgs	below ground surface
BRA	Baseline Risk Assessment
Cd	cadmium
CLEAN II	Comprehensive Long-Term Environmental Action Navy II
Cu	copper
cm/s	centimeter per second
Co	cobalt
COPCs	chemicals of potential concern
Cr	chromium
CSFs	Carcinogenic Slope Factors
CT	Central Tendency
CTO	Contract Task Order
Cu	copper
cy	cubic yards
DAF	Dilution and Attenuation Factor
DD	Decision Document
EECA	Engineering Evaluation Cost Analysis
ELCR	Excess Lifetime Carcinogenic Risk
EPC	Exposure Point Concentration
ERA	Ecological Risk Assessment
°F	degrees Fahrenheit
Fe	iron
FFA	Federal Facilities Agreement
FWES	Foster Wheeler Environmental Services
HEAST	Health Effects Assessment Summary Tables
Hg	mercury
HHRA	Human Health Risk Assessment
HI	hazard index
HQ	hazard quotient
HRSD	Hampton Roads Sanitation District
IAS	Initial Assessment Study
IEUBK	Integrated Exposure Uptake Biokinetic
IR	Installation Restoration

IRI	Interim Remedial Investigation
IRIS	Integrated Risk Information System
LANTDIV	Naval Facilities Engineering Command, Atlantic Division
LOAEL	Lowest Observed Adverse Effect Level
LTM	long-term monitoring
MCL	Maximum Contaminant Level
MFs	Modification Factors
mg	milligrams
mg/kg	milligrams per kilogram
mg/l	milligrams per liter
MLW	mean low water
Mn	manganese
mph	miles per hour
msl	mean sea level
NAB	Naval Amphibious Base
NCEA	National Center for Environmental Assessment
Ni	nickel
NOAEL	No Observed Adverse Effect Level
NPL	National Priorities List
PAHs	Petroleum Aromatic Hydrocarbons
Pb	lead
PCB	polychlorinated biphenyl
PRAP	Proposed Remedial Action Plan
PRGs	Preliminary Remediation Goals
RA	Remedial Action
RAB	Restoration Advisory Board
RAGS	Risk Assessment Guidance for Superfund
RBCs	Risk Based Concentrations
RfDs	reference doses
RGH	Rogers, Golden, & Halpern
RI	Remedial Investigation
RME	Reasonable Maximum Exposure
RVS	Round 1 Verification Step
SDWA	Safe Drinking Water Act
SERA	Screening Ecological Risk Assessment
SQL	Sample Quantitation Limit
SSLs	Soil Screening Levels
SVOCs	semivolatile organic compounds
SWMU	Solid Waste Management Unit
TAL	Target Analyte List
TCL	Target Compound List
Tl	thallium
TOC	total organic carbon

TPH	total petroleum hydrocarbon
UCL	Upper Confidence Limit
UFs	Uncertainty Factors
USEPA	United States Environmental Protection Agency
UTL	Upper Tolerance Limit
V	vanadium
VAWQSHH	Virginia Water Quality Standards for Human Health
VDCR	Virginia Department of Conservation and Recreation
VDEQ	Virginia Department of Environmental Quality
VSWCB	Virginia State Water Control Board
VSWMR	Virginia Solid Waste Management Regulations
VOCs	Volatile Organic Compounds
WQSs	Water Quality Standards
Zn	zinc
µg/dl	micrograms per deciliter
µg/kg	micrograms per kilogram
µg/l	micrograms per liter

SECTION 1

Introduction

This report presents the revised Remedial Investigation (RI) and revised Human Health Risk Assessment (HHRA) for Site 7 at the Naval Amphibious Base (NAB) Little Creek in Virginia Beach, Virginia. Site 7 consists of the former Amphibious Base Landfill. This RI/HHRA was prepared by CH2M HILL under the Naval Facilities Engineering Command, Atlantic Division (LANTDIV), Comprehensive Long-Term Environmental Action Navy II (CLEAN II) Contract N62470-95-D-6007, Contract Task Order (CTO) 159, for submittal to LANTDIV, the U.S. Environmental Protection Agency (USEPA), and the Virginia Department of Environmental Quality (VDEQ).

An initial RI, HHRA, and preliminary feasibility study (FS) were performed for Site 7 (along with five other sites) at NAB Little Creek by Foster Wheeler Environmental Services (FWES) in November 1994; however, the document was not reviewed by the USEPA. In May 1999, the USEPA added NAB Little Creek to the National Priorities List (NPL). In the past, the VDEQ provided primary regulatory oversight at NAB Little Creek. After the base was placed on the NPL, the USEPA took a more active role in providing regulatory and technical oversight to support the Installation Restoration (IR) Program at the base. A Federal Facilities Agreement (FFA) was negotiated and drafted between the Navy, the USEPA, and the VDEQ; however, this document has not been finalized. As part of the FFA negotiation process, all past and proposed work at IR sites and Solid Waste Management Units (SWMUs) was reviewed, and a course of action for future work requirements at each site was developed.

As part of this course of action, the USEPA required that the HHRA for Site 7 be revised because it was not conducted in accordance with current USEPA guidance and must be completed utilizing the Risk Assessment Guidance for Superfund (RAGS) Part D methodology. USEPA has also required that an ecological risk assessment (ERA) be conducted for Site 7. A brief summary of the key findings of the ERA titled "*Draft Ecological Risk Assessment Site 7*" and dated December 2002 is presented in Section 5. The complete Final ERA will be submitted as a separate document concurrently with this document.

In addition to NAB Little Creek falling under NPL requirements, semi-annual data have been collected from Site 7 since 1999 through the long-term monitoring (LTM) program implemented by CH2M HILL. These recent data provide a more complete picture of the nature and extent of contamination migration in the groundwater, allow better evaluation of the potential impacts to surface water and sediments in a small pond in the northeast portion of the site and in the drainage canal along the western portion of the site, and fill data gaps for the HHRA and ERA.

1.1 Objectives and Approach

This revised RI/HHRA report has been developed to meet regulatory requirements as well as the following objectives:

- Present a summary of the findings from the RI performed by FWES;
- Evaluate the latest results from the LTM at Site 7 by CH2M HILL (Rounds 5, 6, and 7); and
- Revise the HHRA using RAGS Part D methodology and determine if the site poses unacceptable risks to human health.

1.2 Report Organization

This RI/HHRA report comprises the following sections:

- Section 1 – Introduction
- Section 2 – Site 7 Description and Previous Investigations
- Section 3 – FWES RI and LTM Program Results
- Section 4 – Human Health Risk Assessment
- Section 5 – Ecological Risk Assessment Summary
- Section 6 – Focused Feasibility Study
- Section 7 – References

Figures and tables referenced within the text are provided at the end of each section.

Appendixes to the combined RI/HHRA are provided in Volume II as follows:

- Appendix A consists of those sections of the original FWES RI (i.e. boring logs, well diagrams, water level data, surface soil sample descriptions) related to Site 7;
- Appendix B consists of the "*Round 5 Long-Term Monitoring Letter Report*" prepared by CH2M HILL (June 2001);
- Appendix C consists of the "*Round 6 Long-Term Monitoring Letter Report*" prepared by CH2M HILL (March 2002);
- Appendix D consists of the "*Round 7 Long-Term Monitoring Letter Report*" prepared by CH2M HILL (August 2002); and
- Appendix E contains the revised HHRA data.

1.3 NAB Little Creek Location and History

NAB Little Creek is located in the Tidewater region of Virginia, near the mouth of the Chesapeake Bay in Virginia Beach, Virginia. The location of the base is presented in Figure 1-1. The naval base is located within the city limits of Virginia Beach and consists of 2,147 acres. It is surrounded by residential, commercial, industrial, and recreational developments. On the western portion of the naval base are Little Creek Cove and Desert Cove, which empty into Little Creek Channel, which empties into the Chesapeake Bay.

There are several lakes on or adjacent to the naval base, including Lake Bradford, Lake Chubb, Little Creek Reservoir, Lake Smith Reservoir, and Lake Whitehurst. Overland drainage from the sources at the NAB Little Creek flows into Little Creek Cove, Desert Cove, and the Chesapeake Bay.

NAB Little Creek grew out of four bases constructed during World War II – the Amphibious Training Base, Naval Frontier Base, and Camps Bradford and Shelton. It consisted of three annexes named for the former owners of the property – Shelton on the east, Bradford in the center, and Whitehurst to the west. A Secretary of the Navy letter in July 1945 disestablished the separate bases and established the Naval Amphibious Base Little Creek with a commissioning date of August 10, 1945. In 1946, NAB Little Creek was designated a permanent base. NAB Little Creek personnel provide support services to 27 homeported ships and more than 80 tenant commands. The combination of operational support and training facilities are geared predominantly to expeditionary warfare operations.

NAB Little Creek employs approximately 12,500 personnel. The population on the base increases during the summer when a significant number of midshipmen and Navy and Marine Corps reservists train in amphibious/expeditionary warfare. Some 3,650 military personnel and their families live in base housing. In addition, approximately 3,000 civilians are employed at NAB Little Creek.

Operations that have occurred at NAB Little Creek include: vehicle and boat maintenance, boat painting and sandblasting, construction and repair of buildings and piers, mixing and application of pesticides, electroplating of musical instruments, laundry and dry cleaning, medical and dental treatment, and generation of steam for heat.

1.4 Basewide Environmental Setting

Little Creek Harbor occupies most of the western portion of the base, and is directly connected with Chesapeake Bay via the Little Creek Channel (Figure 1-2). Desert Cove and Little Creek Cove branch off from the eastern part of the harbor. Both coves and the harbor are tidal, marine environments.

Little Creek Harbor and Little Creek Cove receive stormwater runoff from a large area of both Virginia Beach and Norfolk. According to Norfolk and Virginia Beach storm drainage maps, approximately 16,500 acres of land drains into Little Creek Harbor and Little Creek Cove; NAB Little Creek makes up only about 2,000 acres of this total drainage area. Many industrial areas, including Norfolk International Airport, a Norfolk Southern railroad terminal, and the nearby HRSD wastewater treatment plant are also present within this drainage area.

Although the base is mostly urbanized, small pockets of forested habitats are scattered throughout, primarily in the eastern and south-central portions of the base. A broken line of vegetated primary and secondary dunes extends along the entire 2.25-mile length of the Chesapeake Bay shoreline. The shoreline inside of the harbor is almost entirely developed and lined with bulkheads with the exception of the southern and eastern portions of Little Creek Cove. There are approximately 7 miles of shoreline within the harbor and coves.

A large percentage of the landmass that makes up NAB Little Creek is composed of fill material. Much of the landmass surrounding Little Creek Cove, Desert Cove, and Little Creek Channel was formed with dredge material from pier construction when the base was developed in the 1940s.

There are seven land management units on NAB Little Creek totaling approximately 1,918 acres. Wetlands occupy approximately 166 acres of the base. The shorelines of several freshwater lakes and ponds found in the northeastern portion of the base are bounded by freshwater forested, scrub/shrub, and emergent wetlands. A drainage canal flows south-southwest from the largest of these lakes (Lake Bradford) to near the southern base boundary, where it turns west and connects to the southeastern corner of Little Creek Cove (Figure 1-2). This canal contains freshwater over most of its length but becomes tidal and marine for several thousand feet prior to its connection with the cove. Tidal marine wetlands on the base are generally confined to this portion of the canal and the southern shore of Little Creek Cove.

1.4.1 Physiographic Features

1.4.1.1 Climate

The average temperature at NAB Little Creek is 60° F. As a result of mild winters and summers tempered by cool periods associated with northwesterly cold fronts or north-easterly winds off of the Atlantic Ocean, summertime temperatures rarely reach 100° F. The average annual snowfall is 8.5 inches. Occasionally, winters pass without measurable snowfall and most light snows melt within 24 hours. The highest recorded annual snowfall of 42 inches occurred in the winter of 1979-80. The growing season averages 244 days (range of 208 to 279 days). The average date of the first frost is November 21 and the average date for the last frost is March 22. The average annual precipitation is 45 inches and more than half of this total is well distributed throughout the growing season. The average relative humidity is 62 percent. The prevailing wind is from the southwest in summer and the northeast in winter, at an average wind speed of 10 miles per hour (mph). During the hurricane season (June to September), winds greater than 75 mph may occur accompanied by torrential rainfall.

1.4.1.2 Topography

NAB Little Creek is located in the Atlantic Coastal Plain. The topography is nearly level to gently sloping with the exception of the dune areas. Elevations range from mean sea level (msl) along the beaches and tidal marshes to approximately 12 feet above msl in the inland developed areas. The most uneven terrain occurs in the dune areas along the Chesapeake Bay where elevations reach 30 feet or higher.

1.4.1.3 Soils

The surface soil covering 90 percent of the base consists of dredge spoils and imported fill. Fourteen discrete soil mapping units delineating major soil types have been identified within the limits of the base. The uppermost geologic unit is the Columbia Group. The Columbia Group is approximately 60 feet thick where the upper 20 to 40 feet consists of unconsolidated fine sands and silts. The soil underlying the fill material typically consists of fine sands and silts with low to moderate permeability. This upper layer of soil is

predominantly underlain by relatively impermeable sediment composed of silt, clay, and sandy clay.

1.4.1.4 Surface Water

NAB Little Creek is located on the southern shore of the Chesapeake Bay. Little Creek Harbor is a tidal estuary with a semi-diurnal tidal range of approximately 2.6 feet. The spring tidal range is 3.1 feet and the mean tide is 1.3 feet above mean low water (MLW). Storm-induced tide levels have been recorded ranging from 2 feet below MLW to 8.5 feet above MLW. Tidal currents in the entrance channel average 0.9 knots. In the absence of freshwater flow, tidal mixing flushes the harbor. The flushing rate is estimated to be relatively long, on the order of weeks. The Northwest Branch of Little Creek flows into the harbor from the west through Fisherman's Cove. Lake Whitehurst and Lake Smith have unlined overflow channels that discharge into the harbor from the south. During severe storm events, the bypass line from the HRSD wastewater treatment plant discharges into the southeastern corner of Little Creek Cove.

The source of potable water for the base is the city of Norfolk municipal water supply system, which primarily uses surface water. Lake Smith, which serves as a secondary drinking water supply for the city of Norfolk, lies immediately south of the base (Figure 1-2). Subsurface flow in the city reservoirs migrates toward Little Creek Harbor because the reservoir water level is higher than the harbor elevation.

Rainfall at NAB Little Creek that is not lost through infiltration or evaporation eventually drains to Little Creek Harbor; the only exception is rainfall on the beach area, which drains directly to the Chesapeake Bay. The eastern half of the base drains first to Chubb Lake or Lake Bradford. The interconnected lakes are drained by a canal that flows southwest, crossing under D Street and Nider Boulevard, and then turning northwest toward Little Creek Cove. A weir on the canal located near Nider Boulevard is used to adjust the level of the two lakes. The golf course area drains to five small lakes, which are interconnected through pipes and channels. While most of this flow is lost, some flow from these lakes can reach Little Creek Cove during extreme rainfall events.

The harbor is classified as a Type IIB water body by the VDEQ. Type IIB implies the body of water is tidal and in a coastal zone. The average dissolved oxygen level is 5.0 milligrams per liter (mg/l) and the pH is typically between 6.0 and 9.0. Shellfishing is precluded by high fecal coliform levels; however, swimming is permitted. Commercial fishing is not allowed, although sport fishing is common in the western portion of the harbor.

1.4.1.5 Geology and Hydrogeology

NAB Little Creek is located in the outer Atlantic Coastal Plain Physiographic Province, which is characterized by low elevations and gently sloping relief. The base is underlain by a thick wedge of unconsolidated deposits dipping southeastward toward the Atlantic Ocean, reaching a thickness of 3,000 feet along the shore.

The uppermost geologic unit is the Columbia Group. The Columbia Group is approximately 60 feet thick. The upper 20 to 40 feet consist of unconsolidated fine sands and silts, but at NAB Little Creek, approximately 90 percent of the surface soil consists of dredge spoils and imported fill. During the major expansion of facilities at NAB Little Creek, 12,000,000 cubic

yards were dredged from the harbor. Still other soils had been imported for achieving final grades during contract construction. As a result of this activity, most of the surface has been affected or disturbed by construction or grading activities (Rogers, Golden, & Halpern, 1984). The unconsolidated sediments beneath the fill layer possess low to moderate permeability and together comprise the Columbia Aquifer. The lower 20 to 40 feet consist of relatively impermeable silt, clay, and sandy clay. The shallow groundwater zone generally extends from ground surface to approximately 20 feet below msl in the sediments of the Columbia formation.

The Chesapeake Group underlies the Columbia Group. The uppermost unit in the Chesapeake Group is the Yorktown Formation. It is capped by the Yorktown confining unit, which separates the Columbia Aquifer from the underlying Yorktown Aquifer. The Yorktown Formation is approximately 90 to 100 feet thick near the base and is composed of silt and clay and partially consolidated coarse sand, gravel, and shell fragments. The Chesapeake Group also includes several additional older formations that form deeper aquifers.

The two significant shallow aquifers in the area are the Columbia Aquifer, located in the upper 20 to 40 feet of the Columbia Group, and the deeper Yorktown Aquifer. The Columbia Aquifer comprises the shallow water-table aquifer and is reportedly thin and discontinuous in the area surrounding the base. The depth to the water table ranges from zero to 8 feet below the ground surface (bgs). The deeper Yorktown Aquifer is semi-confined beneath a clay layer in the upper Yorktown Formation. Water-bearing zones within the Yorktown Aquifer consist of fine to coarse sand, gravel, and shells. This aquifer generally lies 50 to 150 feet below the surface. Groundwater at NAB Little Creek, in both the Columbia Aquifer and the Yorktown Aquifer, flows to the north and discharges into the Chesapeake Bay.

Throughout the eastern portion of the Coastal Plain, the Yorktown Aquifer is used extensively for domestic and public water supply, as well as for industrial purposes. In the area surrounding the base, it is reported that the Yorktown Aquifer is not used as a potable source of supply.

Although the aquifers of the deeper Pamunkey Group can produce water of notable quality and quantity and are used in other areas of the Virginia Coastal Plain, large-scale municipal wells in the Tidewater area typically bypass these aquifers for the even more productive Cretaceous aquifers. The City of Norfolk supplies potable water to NAB Little Creek and the surrounding residential area with surface water from Lake Whitehurst and Lake Smith, located south of the site. Groundwater from four deep wells, screened in the Upper/Middle or Middle Potomac Aquifers, is used as a secondary source in drought or emergency conditions.

1.4.2 Habitat and Biota

1.4.2.1 Flora

The majority of NAB Little Creek is highly developed with little native vegetative cover in most areas. However, the areas that are vegetated support a fairly diverse variety of habitats, and consequently, a diversity of flora. Plant species are present in maritime forests; interdunal swale wetlands; hardwood, mixed pine-hardwood, and pine forest tracts; and

tidal marshes located at NAB Little Creek. Typical freshwater wetland plant communities, forested, scrub-shrub, and emergent wetland plant communities are also present.

1.4.2.2 Fauna

The fauna of NAB Little Creek is generally typical of a highly urbanized region. The most common larger mammals on NAB Little Creek include gray and red foxes, raccoon, Virginia opossum, eastern cottontail, gray squirrel, and muskrat. Most of these species are highly adaptable and can exist under a broad range of habitat conditions. Both freshwater and estuarine fish communities are present at NAB Little Creek, however, the reptile and amphibian community at NAB Little Creek is fairly low in species diversity.

One of the most diverse faunal communities present at NAB Little Creek is the bird community. The base hosts a number of year-round resident species as well as migratory species. In an effort to help with a nationwide species recovery effort, the base participates in an osprey monitoring program and actively places nesting platforms out for new pairs of osprey. In 1993, three osprey nesting platforms were erected and several baseball field lights were modified with platforms to provide additional nesting opportunities. In 1995, three more platforms were installed and an osprey nest monitoring program was implemented. Eleven osprey nests and/or nesting platforms were recorded on NAB Little Creek in 1996.

1.4.2.3 Rare, Threatened, and Endangered Species

A survey was conducted in 1989 by the Virginia Department of Conservation and Recreation (VDCR) for rare, threatened, and endangered species at NAB Little Creek (VDCR-DNH, 1990). No state or federally listed threatened or endangered species were found at NAB Little Creek. However, three state-listed rare plants were identified. The Virginia Beach pinweed (*Lechea maritima var. virginica*) was found on the fore dunes and secondary dunes in the open herbaceous and scrub zones between the maritime forest and the beach. Since that survey, the VDCR has down-listed this species from the rare plant list to the plant watch list. The bluejack oak (*Quercus incana*) was also found in the maritime forests of the secondary dunes. Finally, Spanish moss (*Tillandsia usneoides*) was found in the eastern half of Scout Island, which is surrounded by Lake Bradford and Lake Chubb. These species are all relatively common within their geographic ranges, but are rare in Virginia.

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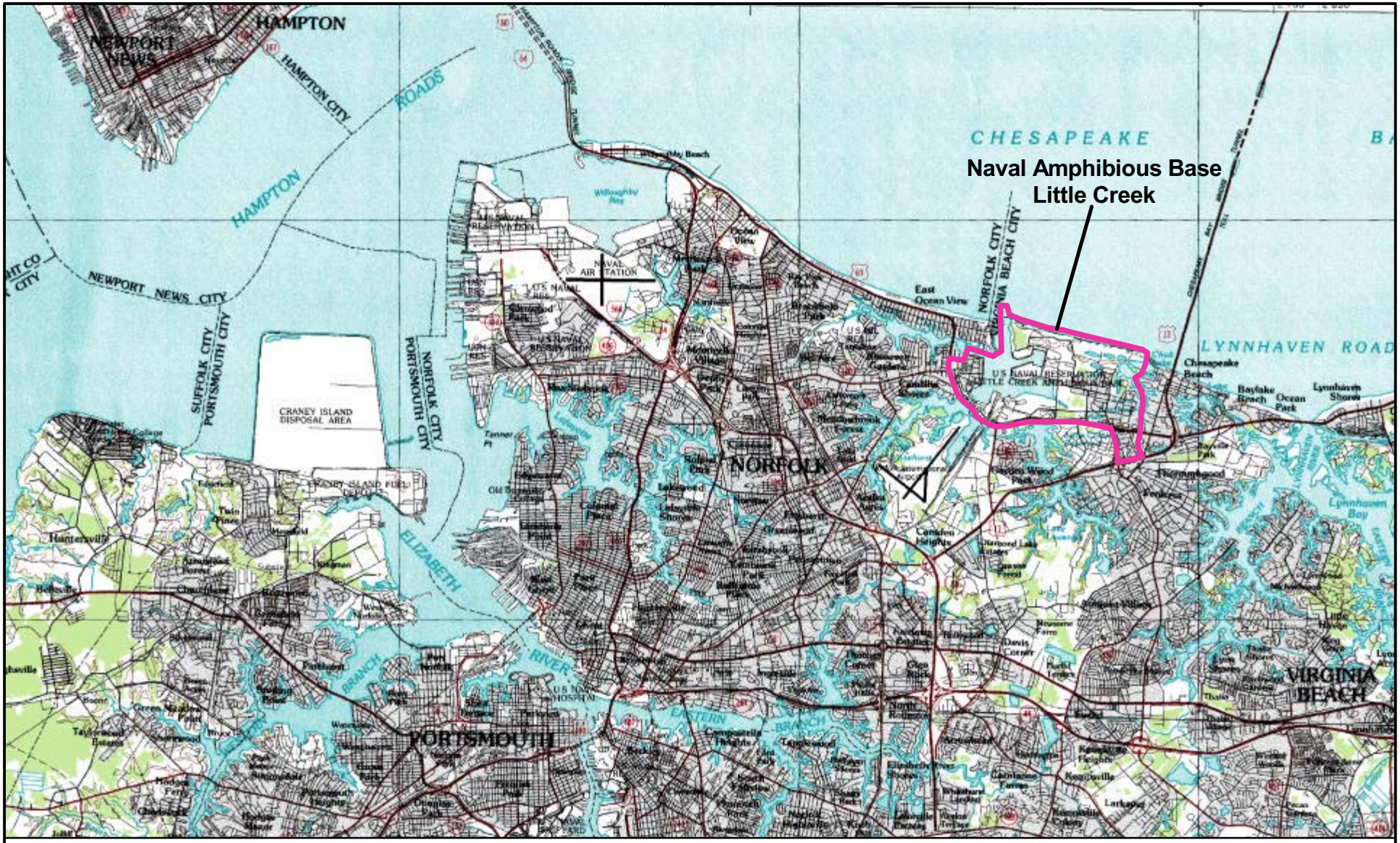

LEGEND

Activity Boundary

N

Figure 1-1
Base Location Map
NAB Little Creek
Virginia Beach, Virginia

CH2MHILL

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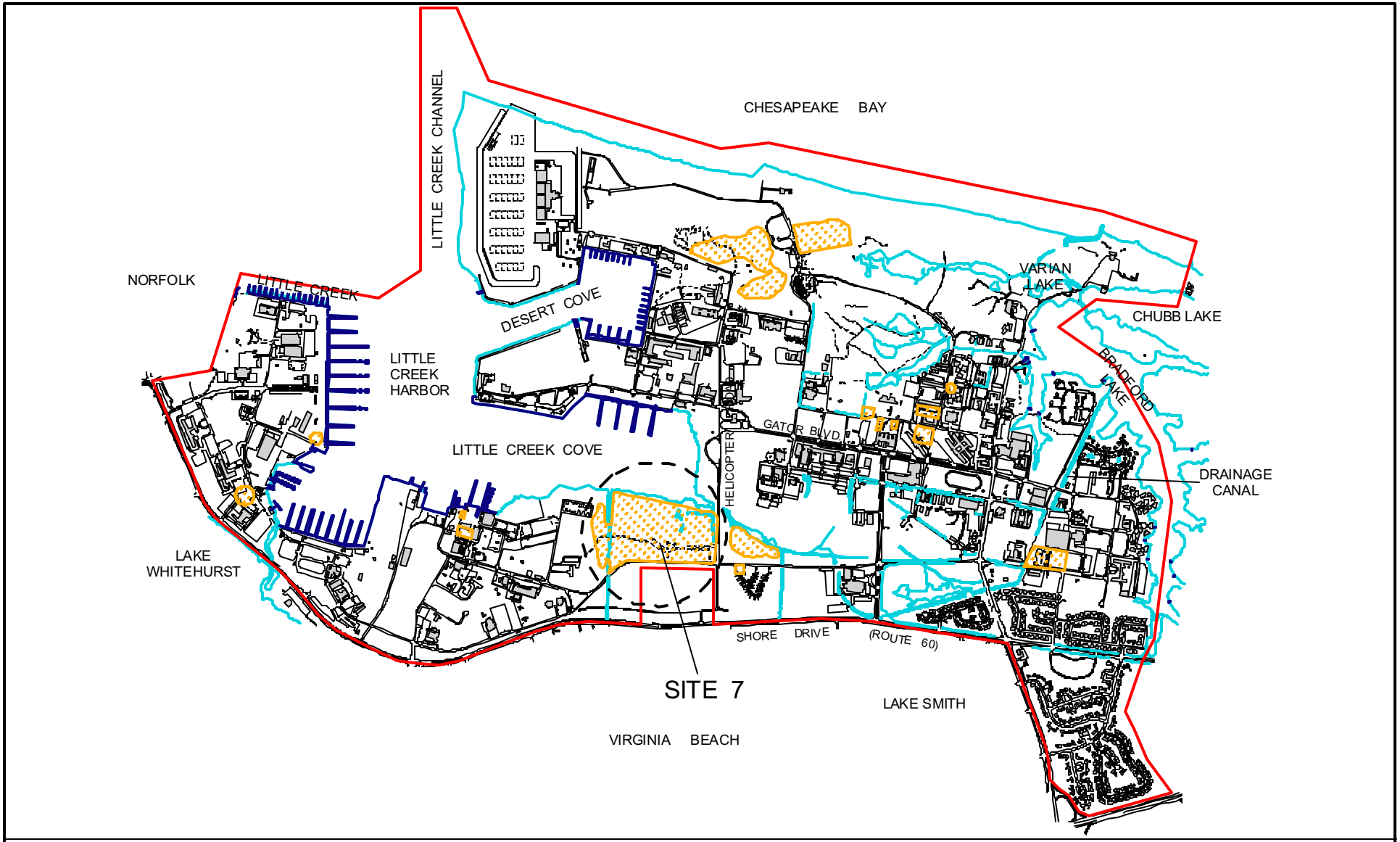

LEGEND

- Buildings
- Site Boundaries
- Water Features
- Piers and Docks
- Activity Boundary

N

0 800 1600 Feet

Figure 1-2
Site 7 Location Map
NAB Little Creek
Virginia Beach, Virginia

CH2MHILL

SECTION 2

Site 7 Description and Previous Investigations

This section presents a description of Site 7 at NAB Little Creek, a summary of the information found in the *Final Remedial Investigation/Feasibility Study* performed by FWES in November 1994, and the results of Rounds 5, 6, and 7 of the LTM program completed by CH2M HILL in February 2001, September 2001, and July 2002, respectively.

Excerpts from the 1994 FWES RI report pertaining to Site 7 can be found in Appendix A. Appendix A includes text, figures, lab data, soil boring logs, well construction diagrams, and water level information. The complete letter reports for Rounds 5, 6, and 7 of the LTM program are found in Appendixes B, C, and D, respectively.

2.1 Site 7 Description and History

Site 7, formerly the Amphibious Base Landfill, was operated between 1962 and 1979. The site is located in the south-central part of NAB Little Creek. The area of the landfill has been determined to be approximately 38 acres (Figure 2-1). It is bordered on the east by Helicopter Road, on the south by Amphibious Drive, and on the north by Little Creek Cove. Vehicle access to the landfill is controlled by two locked gates across access roads on the site's eastern and western sides. A chain-link fence runs along the site's southern boundary. Little Creek Cove borders the site's northern boundary. Pedestrian access along the eastern and western borders is deterred by dense vegetation. In the western portion of Site 7, a channel runs south to north, isolating a portion of the landfill known as the lobe.

The area immediately surrounding Site 7 is primarily industrial and includes the base's former construction debris landfill to the east, a wastewater treatment plant operated by HRSD to the south, and the base's Duration Force Vehicle Compound and an ammunition magazine to the west. The nearest full-time residents to the site are approximately 2,000 feet to the southeast. The location of the nearest water-supply well is not known; however, there are no water-supply wells downgradient (north) of Site 7, between the site and Little Creek Cove.

A non conforming permit was issued to allow disposal on an interim basis at Site 7, as site conditions were not conducive for land-filling. The permit is provided as Appendix B of the Final ERA for Site 7 (CH2MHILL, November 2004). The Amphibious Base Landfill was initially operated as a trench-type landfill with open burning of refuse in the trenches. Trenches were excavated to a depth where groundwater filled the trench as quickly as it could be excavated. This commonly resulted in standing water in the trenches during waste disposal operations. The manner in which the landfill was operated makes it difficult to establish the degree of combustion or fate of any particular item disposed in the landfill. The landfill was later operated as an area landfill, with refuse spread over the ground and covered regularly. This aspect of the operation has resulted in the current surface topography and elevation.

It is estimated that the landfill contains approximately 500,000 cubic yards (cy) of waste (RGH, 1984). A significant majority of this total is presumed to be composed of non-hazardous solid waste from base housing and other residential activities at the installation.

Specific records documenting the types and quantities of waste placed in the landfill are not available. Because the landfill received all waste generated by NAB Little Creek during its operation, it likely received potentially hazardous materials.

Waste oils and metals segregated from the wastes were placed in the landfill starting in 1970. A hazardous waste management plan for the base was not implemented until 1979, the year the landfill closed. After closure, the landfill continued to be used as a metal collection and transfer site, temporary storage site for wastes, and a burn area for scrap wood and trees. Open burning was halted in 1984. Waste storage activities at the site ceased permanently in 1994 and parts of the landfill were covered with a 6-inch layer of topsoil and a cover of vegetation was established.

A Decision Document for Site 7 was signed in 1998 and as part of the selected remedy, a remedial action was taken to remove debris piles and to place a soil cover over approximately 12 acres of the site. Figure 2-1 shows the area of Site 7 that received this soil cover. A total of 685 cy of debris, including wood, concrete, tires, and metal scrap were disposed off-site. A minimum of 6 inches of topsoil was placed over the southwestern and central portions of the landfill to provide cover for site waste and promote the establishment of a vegetative cover on the landfill's bare areas. Before placing the topsoil, general fill materials were placed in low areas to allow the site to drain properly. A total of 11,260 cy of topsoil and 8,640 cy of general fill material were placed during the construction project.

2.1.1 Topography

Site 7 is relatively level with gentle slopes along the landfill boundaries. The elevations at the site range from 16 feet above msl in the southwestern portion to sea level along the boundary with Little Creek Cove. The southern and western portions of the landfill are generally grassy. Tidally-influenced wetlands cover the northern and eastern portions of the site. These wetlands are inundated at high tide.

The site drains to Little Creek Cove by direct and indirect means. A gravel access road in the southern half of the site acts as a drainage divide. Runoff from the southern portion of the site is captured in the roadside ditch and directed to one of the channels along the eastern and western sides of the site. These channels discharge to Little Creek Cove. The central portion of the site drains north directly into Little Creek Cove.

2.1.2 Geology and Hydrogeology

The groundwater monitoring wells at Site 7 are all screened in the shallow Columbia Aquifer. Groundwater in the Columbia Aquifer beneath Site 7 flows is predominantly north towards the low-lying marsh and Little Creek Cove (Figure 2-2). The most recent ground-water level measurements were collected during Round 7 of the LTM (March 2002) and are depicted on Figure 2-2. A tidal study was conducted as part of the 1994 RI by FWES (Appendix A) and the results indicated that shallow groundwater may also flow toward the tidally-influenced canal in localized areas and the rate of groundwater to surface water discharge increases in response to a low tide. Additionally, it is likely that localized shallow groundwater flows toward the small pond in the northeast portion of the site. There are no groundwater supply wells downgradient of Site 7 between the site and where groundwater discharges to surface water.

The soils present at Site 7 are composed of either dredge fill material or native soils. There are little or no urban land soils present, as the site formerly operated as a landfill. Surface soils on the landfill area generally consist of silty sand. The sand ranges from fine to coarse in size based on visual classification during previous investigations. Near the wetlands, the surface soil tends to have organic and clay components.

Drilling activities were performed as part of FWES's 1994 RI. These activities were focused on investigating the natural materials around the landfill, the depth of water, and the soils that most likely underlie the landfill. Soil borings were not completed within the landfill itself.

FWES prepared geological cross-sections based on the soil borings. The cross-sections are provided in Appendix A. In general, the natural areas of the site are overlain by a layer of sand followed at varying depths by a clay layer. The sand layer was 16 feet thick at its thickest point, in the southwest portion of the site, and pinched out toward the east and northeast (wetland areas). The clay layer appears to be the layer underlying the landfill. The thickness of the clay layer was not determined but was estimated to be at least 5 feet. In one boring, the clay layer was at least 32 feet thick. FWES collected a sample of the clay material via Shelby tube sampling techniques and determined its permeability to be 2.9×10^{-8} centimeters/second (cm/s).

2.2 Previous Investigations

2.2.1 Initial Assessment Study (IAS)

An IAS at NAB Little Creek was completed in December 1984 by Rogers, Golden, and Halpern (RGH, 1984) of Philadelphia, Pennsylvania. Its purpose was to identify and assess sites posing a potential threat to human health or the environment due to contamination resulting from prior hazardous waste management activities. The study consisted of the collection and evaluation of archival and activity records relating to waste generation, handling and disposal, the characterization of physical conditions at the site such as soil and hydrogeology, and the identification of migration pathways and potential receptors.

The IAS concluded that Site 7 posed a potential threat to human health and the environment and; therefore, warranted further evaluation in a confirmation study. The confirmation study was to include quarterly sampling for 1 year. Nine groundwater monitoring wells, fully penetrating the uppermost water-bearing zone, which is the Columbia Aquifer, were recommended to be installed around the perimeter of the landfill. Two groundwater level monitoring points were recommended for installation in the landfill itself, penetrating at least 5 feet below the water table. Three surface water level measuring points were specified to permit correlation of surface and groundwater flow regimes. Two surface water samples were also recommended, along the detailed reconnaissance of the landfill to identify any visible signs of contamination and establish boundaries of the disposal area. Concerns of the IAS included the delineation of the landfill, especially the southern boundary, and its closest approach to Lake Smith Reservoir. These recommendations were incorporated into the "*Round 1 Verification Step*" (RVS) described below.

2.2.2 Round 1 Verification Step (RVS)

The RVS, the first step in the confirmation study process, was completed in October 1986 by CH2M HILL (CH2M HILL, 1986). The purpose of the study was to verify the presence and/or absence of contamination at Site 7. The scope of work for the RVS activities at Site 7 was established based in part on the recommendations presented in the IAS.

As part of the work conducted for the RVS, nine groundwater samples, five surface water samples, and five sediment samples were collected. Nine monitoring wells were installed at Site 7 to facilitate the collection of the groundwater samples. Five surface water and sediment samples were collected to investigate impacts on nearby surface water bodies and determine whether contaminated run-off was migrating from Site 7.

The results of the RVS report indicated that little or no contamination was migrating from the landfill. However, because the source of the elevated inorganic constituents in the groundwater and surface water could not be adequately assessed, the RVS recommended that the second round of samples be collected from the nine monitoring wells and the five surface water locations. In addition, the report also recommended that three surface water samples be collected at locations farther from the landfill shoreline (approximately 300 feet), and that one surface water sample be collected from the drainage canal east of the landfill to assist in determining the source of surface water contamination.

2.2.3 Interim Remedial Investigation (IRI)

The IRI was conducted in 1991 by Ebasco Environmental Consultants to address the recommendations of the RVS and determine whether further characterization activities or remedial actions (RAs) were warranted at Site 7 (Ebasco, 1991). Additional sampling was performed per the recommendations of the RVS.

The IRI concluded the second round of sampling conducted at Site 7 confirmed the interpretations presented in the RVS report that the landfill was not releasing contaminants to the groundwater. The IRI recommended that the status of the landfill be determined with regard to Virginia Solid Waste Landfill Regulations. Also, to complete a risk assessment, a limited program of soil sampling was recommended in the bare areas used for staging at that time. Results from the IRI sampling are summarized in the 1994 FWES RI excerpts provided in Appendix A.

2.2.4 Remedial Investigation/Feasibility Study (RI/FS) by FWES

During 1993 and 1994, FWES conducted a RI/FS (FWES, 1994) of Site 7 and the other sites identified in the IAS. Pertinent excerpts from this report are presented as Appendix A. The investigation included surface and subsurface soil, surface water, sediment, and groundwater sampling. In addition to the analytical sampling, a tidal survey, surface soil characterization, and subsurface soil permeability testing were conducted.

Figure 2-3 presents all sample locations investigated by the FWES 1994 RI including groundwater, surface water, surface soil, Shelby tube, sediment, and subsurface soil. Analytical results for these samples were compared against common regulatory criteria to identify Chemicals of Concern (COCs) at Site 7. The subsurface soil, surface soil, and sediment sample results were compared to the soil concentrations listed in the USEPA

Region III Risk-Based Concentration (RBC) Table for residential soils. These RBCs were used as screening criteria. The groundwater sample results were compared to both the Federal Maximum Contaminant Levels (MCLs) and the Virginia State Water Control Board (VSWCB) Water Quality Standards (WQSs), September 1992. Furthermore, groundwater results were compared to background concentrations prior to COC determination (Allied Environmental, 1991). The Federal MCLs and VSWCB WQSs were applied to surface water sample results for comparison purposes only.

The RI/FS included a "*Phase 1 Baseline Risk Assessment*" (BRA) for ecology and human health. Based on the results of the RI, the ecological assessment concluded that copper, lead, and zinc exceeded criteria in the open water around Site 7. Exceeded standards suggest that these chemicals may enter the food chain and cause adverse acute and chronic effects on some resident wildlife. In the sediment, zinc was determined to be a possible contaminant that may enter the food chain as well.

The Human Health Risk Assessment that was performed based on the BRA and RI results concluded that lead concentrations detected in the surface soil, groundwater, and surface water at Site 7 pose a health risk for children from 0 to 7 years of age. The Integrated Exposure Uptake Biokinetic (IEUBK) model results showed that there is a high probability that child blood levels exceed USEPA's blood level of concern. However, the only risk for the current scenario at Site 7 appears to be via surface water ingestion for a trespasser child, with arsenic being the risk driver. A number of health risks exist for the future scenario, including ingestion of surface soil, subsurface soil, groundwater, and surface water for a resident child, with arsenic, iron, and manganese contributing substantially to the index exceedances.

The BRA concluded that carcinogenic and non-carcinogenic risks exist at Site 7 for a number of media, pathways, and receptors. Site 7 remedial activities were recommended to reduce several metals, specifically lead and the polychlorinated biphenyl (PCB), aroclor-1260 when present in the surface water, groundwater, and surface soil. Additional investigations were recommended to confirm these findings, augment this study, and accurately delineate the location of the risk-controlling chemicals for design purposes.

FWES prepared the FS to make preliminary assessments of the remedial action to be implemented and to identify data gaps requiring further investigation. In the FS, the remediation alternatives dealt primarily with the covering of the landfill area. The FS recommendations were that the landfill be covered with a layer of topsoil and vegetative cover, the groundwater and surface water be monitored, and that institutional controls be placed on the property to prevent potential risks to human health.

2.2.5 Feasibility Study Revision by FWES

In 1997, FWES revised the FS created in 1994 to provide a more detailed analysis of remedial alternatives. Prior to 1997, subsurface soils had not been fully investigated. The FS was also revised to focus on the intent of site remediation under the IR program, which is to mitigate human health risks rather than restore the site to natural conditions. Further assessment of ecological risks were also addressed in the 1997 FS. Alternative actions for soils/wastes, groundwater, and surface water were discussed in the FS. For soils, the remedial actions evaluated included soil containment with a multi-media cap, soil/waste removal for off-site

disposal, and soil treatment using chemical fixation in specific areas. For groundwater, the remedial action alternatives included the use of a multi-media cap, vertical barriers to groundwater flow, and ex-situ treatment of the groundwater with chemical precipitation. For surface water, the remedial action alternatives included vertical barriers, stormwater collection, and run-on/run-off controls. Additionally, land-use restrictions in conjunction with, or in lieu of, remedial action were evaluated. A "no action" alternative was presented for comparison purposes. Based upon the detailed analysis and comparison of alternatives, FWES recommended that institutional controls be adopted at Site 7 and the landfill surface be covered with soil and seeded to promote a vegetative cover at the site.

2.2.6 Proposed Remedial Action Plan (PRAP)

In October 1997, CH2M HILL prepared a PRAP to present the recommendations of the FS to the public (CH2M HILL, 1997b). The PRAP summarized the findings of the RI, the BRA, and the remedial alternatives presented in the FS. FWES's recommendation that Site 7 be placed under institutional controls and have a soil cover placed over the landfill was highlighted as the preferred alternative. The PRAP was presented to the NAB Little Creek Restoration Advisory Board (RAB) on June 17, 1997. Meeting attendees included VDEQ and USEPA regulators, representatives from LANTDIV, representatives from NAB Little Creek, and CH2M HILL.

2.2.7 Decision Document (DD)

In January 1998, CH2M HILL produced a final DD for Site 7 (CH2M HILL, 1998). The DD reiterated the preferred action for Site 7 institutional controls in conjunction with the placement of a soil/vegetative cover on the landfill area. This remedy was selected because it is protective of human health and the environment, it complies with federal and state requirements that are legally applicable or relevant and appropriate to the remedial action, and it is cost-effective.

2.2.8 Remedial Action (RA) – Soil Cover

During 1998, the Navy implemented the preferred alternative at Site 7. The remedial action followed the *Draft Work Plan for Debris Removal Activities at Site No. 7* (OHM, 1997) and was based on a design by CH2M HILL. Debris piles including concrete and metal were removed from the site and disposed at an off-site landfill by OHM Remediation Services Corporation (OHM, 1999). Tire piles were recycled. The top surface of the landfill received a cover of topsoil, approximately 6 inches thick, and was subsequently seeded. The soil cover work was conducted by Hudgins Contracting Corporation. The areal extent of the soil cover is approximately 14 acres as shown on Figure 2-1.

2.3 Current Investigations: Long-Term Monitoring

In 1999, a 5-year semi-annual site monitoring program began based on the information outlined in the "*Project Plans for the Long-Term Monitoring Program at Site 7: Amphibious Base Landfill*" prepared by CH2M HILL in October 1997 (CH2M HILL, 1997a). The monitoring program included the sampling of six groundwater wells and seven co-located surface water and sediment sampling points. The groundwater wells selected for LTM were six of

the nine well locations from the FWES 1994 RI. Sampling Rounds 1 through 4, out of 10 total proposed rounds, were conducted according to this monitoring plan.

In 2001, a revised project plan for the LTM at Site 7 (Rounds 5 through 10) was prepared by CH2M HILL (CH2M HILL, 2001). The purpose of the revision was to incorporate six new surface water/sediment locations in the monitoring program and to plan for a one-time collection of three surface soil and co-located subsurface soil samples that were collected during Round 5 to fill data gaps in the revised HHRA. Round 5 was performed in February 2001, Round 6 was performed in September 2001, and Round 7 was performed in July 2002. Rounds 8, 9 and 10 are to be completed in the future according to the current semi-annual monitoring schedule. After the completion of Round 10, a 5-year review will be conducted of the overall LTM. The letter reports for Rounds 5, 6, and 7 are presented as Appendixes B, C, and D, respectively. Figure 2-2 shows the monitoring well sampling locations as well as groundwater elevations for Round 7, the most recent LTM event. Figures 3-1 through 3-5 show the LTM sample locations for the different media at Site 7, specifically groundwater, surface water, sediment, surface soil, and subsurface soil.

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Site Boundary

N

0 200 400 Feet

Figure 2-1
Site 7 - Soil Cover Area
NAB Little Creek
Virginia Beach, Virginia

CH2MHILL

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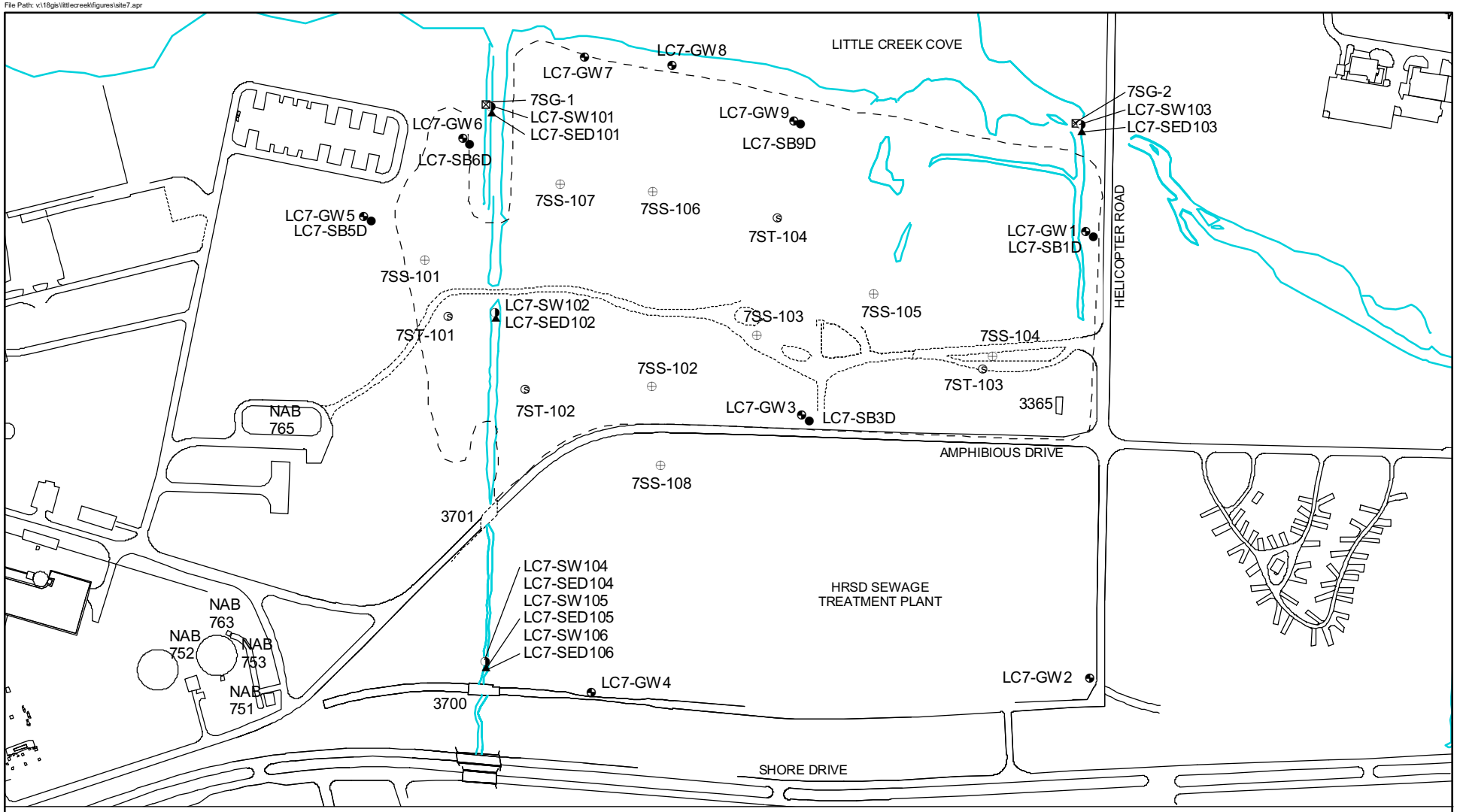

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- ⊠ Staff Gauge
- ◐ Existing Monitoring Well
- ◑ Surface Water
- ⊕ Surface Soil Sample
- Ⓢ Shelby Tube
- ▲ Sediment
- ● Soil Boring
- – – Site Boundary

N

0 200 400 Feet

Figure 2-3
Sampling Locations - FWES 1994 RI
Site 7
NAB Little Creek
Virginia Beach, VA

CH2MHILL

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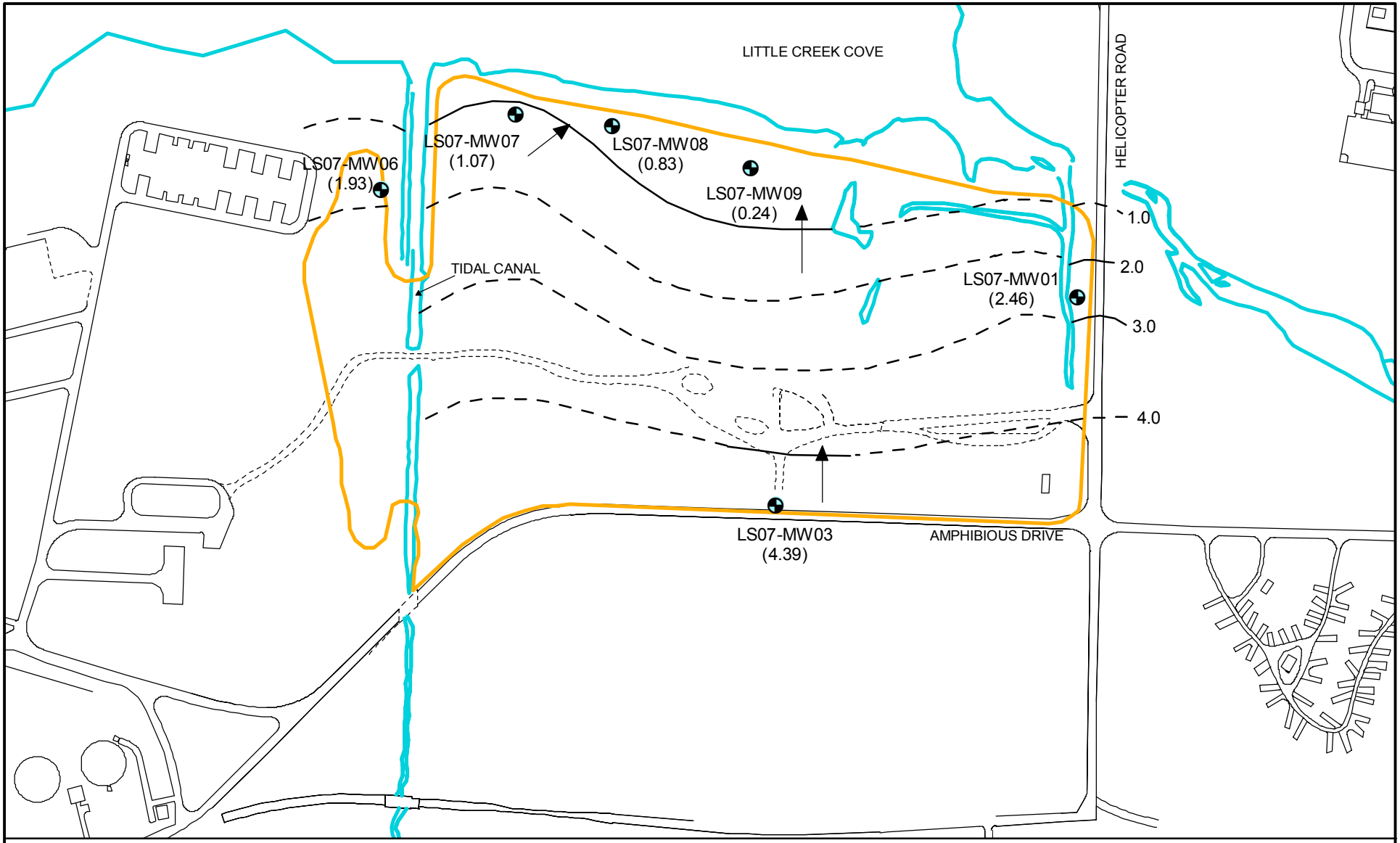

LEGEND

Site Boundary

LS07-MW01 (1.95) Groundwater Monitoring Well

Groundwater Flow Direction

1.5 Groundwater Contour (Dashed Where Inferred)

Note: Groundwater Elevations in ft. above msl

N

0 200 400 Feet

Figure 2-2
Site 7 - Groundwater Elevations
Round 7 of LTM Program - March 4, 2002
NAB Little Creek
Virginia Beach, Virginia

CH2MHILL

SECTION 3

FWES RI and LTM Program Results

3.1 Results from the FWES RI

Site 7 was the subject of an RI/FS performed by FWES in 1994. Soil, groundwater, surface water, and sediment samples were collected from Site 7 at locations shown on Figure 2-3 to characterize contamination present at the site. Appendix A contains relevant excerpts from the FWES RI.

3.1.1 Surface Soil Analytical Results

Eight surface soil samples were collected from 0-6 inches bgs. These samples were analyzed for Target Compound List (TCL) volatile organic compounds (VOCs), TCL semivolatile organic compounds (SVOCs), TCL pesticides and PCBs, Target Analyte List (TAL) metals and cyanide, total petroleum hydrocarbons (TPH), and total organic carbon (TOC). VOCs were detected at two of the eight surface soil sampling locations at Site 7. SVOCs, TAL metals, and TOC were detected at all eight surface soil sampling locations and pesticides and TPH were detected at only one location. Tables 5-1 through 5-6 in Appendix A present the surface soil analytical results. The RI compared soil sample results to soil concentrations listed in the USEPA Region III RBC Table for residential soils, January 1994. The concentrations of the PCB aroclor-1260 and the SVOC benzo(a)pyrene exceeded the respective RBCs in the surface soil.

3.1.2 Subsurface Soil Analytical Results

Five subsurface soil samples were collected immediately above the water table at depths ranging from 0-9 feet bgs. These samples were analyzed for TCL VOCs, TCL SVOCs, TCL pesticides and PCBs, TAL metals and cyanide, and TPH. VOCs were detected at three of the five sampling locations; SVOCs and TPH were detected at two of the five locations; TAL metals were detected at every sampling location, but pesticides or PCBs were not detected at any of the locations. Tables 5-7 through 5-11 in Appendix A present the subsurface soil analytical data. The RI compared soil sample results to soil concentrations listed in the USEPA Region III RBC Table for residential soils, January 1994. Beryllium and lead exceeded RBCs in the subsurface soil.

3.1.3 Groundwater Analytical Results

Nine groundwater samples were collected from groundwater monitoring wells at Site 7. Groundwater samples were analyzed for TCL VOCs, TAL total and dissolved metals, and anions, including bicarbonate alkalinity, alkalinity, chloride, and sulfate.

Nine groundwater samples were collected for VOCs analysis, but due to a sample identification discrepancy, two samples had to be disregarded. Of the seven groundwater samples analyzed for VOCs, only one had a positive detection. Total and dissolved TAL

metals and anions were detected in all nine monitoring wells. Tables 5-12 through 5-14 in Appendix A present the groundwater analytical data.

Groundwater results were compared to concentrations found in base background wells (Allied Environmental, 1991) prior to comparing to RBCs. Constituents with site concentrations exceeding the background concentrations were compared to the Federal Maximum Contaminant Levels (MCLs), promulgated under the Safe Drinking Water Act (SDWA) in May 1993 and the May 1992 Virginia State Water Control Board (VSWCB) Water Quality Standards (WQSs).

In groundwater, TAL metals were the only compounds detected above the respective standards. Barium exceeded its drinking water health advisory reference doses (RfD) in the groundwater. Iron, manganese, and zinc all exceeded the respective primary or secondary MCLs. Dissolved manganese exceeded its secondary MCL as well as its WQS.

3.1.4 Surface Water Analytical Results

Six surface water samples were collected at Site 7. These samples were analyzed for TCL VOCs, TAL metals, and anions. VOCs were detected in three of the six sampling locations, while TAL metals and anions were found in all surface water samples. Tables 5-15 through 5-17 in Appendix A present the surface water analytical results. In surface water, TAL metals above the respective primary or secondary MCLs include lead and manganese. Iron exceeded its WQS in all surface water samples but is considered to be a background constituent at the site. Zinc also exceeded the applicable WQS.

3.1.5 Sediment Analytical Results

Six sediment samples were collected at Site 7. Sample locations were co-located with surface water sample locations. These samples were analyzed for TCL VOCs, TAL metals and cyanide, and anions. VOCs were detected at three of the six sediment sampling locations, while TAL metals and anions were detected at all of the sampling locations. Table 5-18 through 5-21 in Appendix A present the sediment analytical data.

Various TAL metals, specifically aluminum, copper, iron, manganese and zinc were detected in the Site 7 sediment. However, none of these constituents had concentrations exceeding USEPA screening criteria, including MCLs and RBCs.

3.1.6 Shelby Tube Results

Four Shelby tube samples of site soils were collected from a depth of 0 to 2 feet during the FWES 1994 RI. Sample locations are shown on Figure 2-3. The results from McCallum Testing Laboratories for Hydrometer/Grain Size (ASTM D 422), Atterberg Limits (ASTM D 4318), Specific Gravity (ASTM D 854), and Constant Head Permeability (ASTM D 2434) can be found in Appendix A.

3.2 Long-Term Monitoring Results

The following sections summarize the results from the most recent LTM rounds (Rounds 5 though 7) which occurred in February 2001, September 2001, and March 2002, respectively. 0.The "*Revised Project Plans for the Long-Term Monitoring Program at Site 7 (Rounds 5 through*

10) NAB Little Creek" (CH2M HILL, 2001) was implemented beginning with this round. The revised plans included the sampling of six additional co-located surface water and sediment locations. Also, three co-located surface and subsurface soil samples were collected only during Round 5 to fill data gaps in the HHRA. Appendixes B, C, and D contain the letter reports for Rounds 5 though 7 of the LTM, respectively. Complete analytical results can be found in the corresponding appendixes, including raw and detects analytical data.

The analytical results for all media were compared against appropriate regulatory and risk-based standards and criteria identified below. Screening criteria were used to identify constituents that may pose a potential risk at the site. Groundwater data were compared to USEPA Region III RBCs for tap water and Federal MCLs. Surface water data were compared to USEPA Region III RBCs for tap water and Virginia Water Quality Standards for Human Health (WQSHH). Sediment, surface soil, and subsurface soil were all compared to USEPA Region III RBCs for residential soil. Constituents detected in site groundwater and soils were also compared to the background 95% upper tolerance levels (UTLs) from the "*Background Investigation for Naval Amphibious Base Little Creek*" (CH2M HILL, December 2000). Tables 3-1 through 3-5 show constituents that were detected in one or more samples for a given matrix. These tables also contain the screening criteria and background UTLs that were used to evaluate the data, with detected concentrations that exceed the screening criteria shaded in the tables. The distribution of parameters in site media based on the evaluation approach described above are shown on Figures 3-1 through 3-5.

The inorganic constituents calcium, magnesium, potassium, and sodium are not typical in waste streams characteristic of the activities conducted at Site 7. These common metals are not considered potential site-related compounds and, therefore, do not warrant detailed attention or discussion. Additionally, with the exception of magnesium, there are no human health screening criteria for these metals.

3.2.1 Groundwater Analytical Results

During Rounds 5, 6, and 7, six groundwater samples were analyzed for TCL VOCs, TCL SVOCs, TCL pesticides/PCBs, and TAL metals and cyanide. Table 3-1 lists all constituents that were detected in the groundwater samples. A shaded cell indicates that the parameter exceeded the RBC and/or MCL screening criteria. An outlined cell indicates the parameter exceeded the 95 percent background UTL for groundwater. Sample locations and the distribution of potential contaminants in groundwater are shown on Figure 3-1.

Volatile Organic Compounds. Four VOCs (2-butanone, acetone, carbon disulfide, and toluene) were detected at low estimated concentrations during one or more rounds of sampling. Carbon disulfide and toluene were not detected in background and no UTLs were established for 2-butanone and acetone. None of the detected VOCs exceeded the RBCs for tap water or the MCLs.

Semivolatile Organic Compounds. Five SVOCs were detected at relatively low concentrations. Only two of the detected SVOCs (hexachlorobenzene and hexachlorobutadiene) exceeded MCL and RBC criteria for tap water at LS07-MW07 from Round 5. No UTL was established for these SVOCs during the background investigation because the analytes were not detected.

Pesticides and Polychlorinated Biphenyls. No pesticides or PCBs were detected in Site 7 groundwater.

Inorganics. Twenty-three TAL total metals and twenty TAL dissolved metals were detected in the groundwater samples during one or more sampling events. The following total and dissolved metals exceeded the screening criteria values at least once: aluminum (Al), arsenic (As), chromium (Cr), cobalt (Co), copper (Cu), iron (Fe), manganese (Mn), thallium (Tl), and zinc (Zn). Al, As, beryllium (Be), Cu, Fe, lead (Pb), Mn, mercury (Hg), nickel (Ni), vanadium (V), and Zn exceeded the screening criteria for dissolved metals. Due to the frequent exceedances of inorganics in the groundwater, results are presented below in tabular format.

Screening Criteria	Total Metals Exceedances
RBC	As, Fe, Mn, Tl
MCL	As, Fe, Mn, Tl
Background 95% UTL	Al, Cr, Co, Cu, Mn, Tl, Zn, Cyanide
Screening Criteria	**Dissolved Metals Exceedances**
RBC	As, Fe, Mn
MCL	As
Background 95% UTL	Al, Be, Cu, Fe, Pb, Mn, Hg, Ni, V, Zn

3.2.2 Surface Water Analytical Results

During Rounds 5, 6, and 7, thirteen surface water samples were analyzed for TCL VOCs and TAL metals and cyanide. Table 3-2 lists all constituents that were detected in the surface water samples. A shaded cell indicates that the parameter exceeded the RBC and/or the Virginia Water Quality Standards Human Health (VAWQSHH) criteria. Sample locations and the distribution of potential contaminants in surface water are shown on Figure 3-2.

Volatile Organic Compounds. Eight VOCs were detected at low estimated concentrations during one or more rounds of sampling. Only three VOCs exceeded RBC criteria, while none exceeded VAWQSHH. 1,1,2,2-Tetrachloroethane exceeded criteria for Round 6 at LS07-SW203, while bromodichloromethane exceeded criteria for Round 7 at locations LS07-SW202, LS07-SW211, and LS07-SW212. Chloroform had the highest and most frequent exceedances of the RBC for Round 7 at locations LS07-SW203, LS07-SW211, and LS07-SW212 and for Round 5 at LS07-SW204 and LS07-SW210.

Inorganics. Twenty-two TAL total metals and nineteen TAL dissolved metals were detected in the surface water samples during one or more rounds of sampling. Only arsenic and mercury exceeded screening criteria values for both total and dissolved metals. Thallium exceeded criteria for dissolved metals only.

Total and dissolved arsenic were detected and exceeded criteria in all three rounds of sampling at locations LS07-SW203 and LS07-SW213. For Round 7, total and dissolved arsenic exceeded criteria at all but two sample locations: LS07-SW203 and LS07-SW213. For Round 5, total arsenic exceeded criteria at six of the 13 sample locations, while four locations

were in exceedance of dissolved arsenic. For Round 6, four of the 13 sample locations had exceedances of total arsenic, while only location LS07-SW203 exceeded criteria for dissolved arsenic.

While mercury did not exceed RBCs during any of the sampling events, it was detected at concentrations exceeding the VAWQSHH criteria for Rounds 5 and 7 at various locations. For Round 5, total mercury exceeded VAWQSHH criteria at locations LS07-SW201, LS07-SW208, and LS07-SW212 and at locations LS07-SW202, LS07-SW211, and LS07-SW212 for Round 7. Dissolved mercury exceeded criteria at LS07-SW204 and LS07-SW213 for Round 5, and at LS07-SW202 for Round 7.

Thallium exceeded the RBC at one location only. This occurred at LS07-SW207 for Round 7 of the LTM program.

3.2.3 Sediment Analytical Results

During Rounds 5, 6, and 7, thirteen sediment samples, co-located with the surface water samples, were analyzed for TCL SVOCs, TCL pesticides/PCBs, TAL total metals and cyanide, TOC, pH, and grain size. Table 3-3 lists all constituents that were detected in the sediment samples. A shaded cell in the table indicates that the parameter exceeded the RBC for residential soil. Sample locations and the distribution of potential contaminants in sediment at Site 7 are shown on Figure 3-3.

Semivolatile Organic Compounds. Twenty-eight SVOCs were detected during one or more round(s) of sampling. However, only three compounds exceeded RBC criteria for residential soil. Benzo(a)pyrene exceeded its RBC value for Round 5 at locations LS07-SD201, LS07-SD202, and LS07-SD212, and for Round 6 at LS07-SD204 and LS07-SD212. Only one exceedance of benzo(a)pyrene was detected during Round 7 at LS07-SD204. Benzo(a)anthracene and benzo(b)fluoroanthene exceeded the respective RBC values during Round 6 only, at sample location LS07-SD204.

Pesticides and Polychlorinated Biphenyls. Of the ten pesticides/PCBs detected, none exceeded RBC criteria for residential soil for Rounds 5 through 7 of the LTM program.

Inorganics. Twenty-three TAL total metals were detected in the sediment samples during one or more of the sampling rounds. However, the only three total metals to exceed RBC levels were iron, arsenic, and vanadium. Total iron only exceeded its RBC value at LS07-SD208 for Round 6.

Total arsenic, however, was much more prevalent and had a much higher frequency of exceeding the RBC criteria. For Round 6, total arsenic exceeded the RBC at all 13 sediment sample locations. For both Rounds 5 and 7, total arsenic exceeded RBC criteria at all but two sediment sample locations.

Total vanadium concentrations exceeded the RBC sporadically across the site and over sampling rounds.

3.2.4 Soil Analytical Results

During Round 5 only, three co-located surface and sub-surface soil samples were analyzed for TCL SVOC, TCL pesticides/PCBs, and TAL total metals and cyanide. Table 3-4 lists all

constituents that were detected in the surface soil samples. A shaded cell in the table indicates that the parameter exceeded the RBCs for residential soil. Surface soil locations and the distribution of potential contaminants in the surface soil at Site 7 are shown on Figure 3-4. Table 3-5 lists all constituents detected in the subsurface soil samples. Subsurface soil sample locations are shown on Figure 3-5.

3.2.4.1 Surface Soil

Semivolatile Organic Compounds. Three SVOCs were detected in the surface soil at Site 7; however, none exceeded the respective RBC value for residential soil.

Pesticides/Polychlorinated Biphenyls. While four different pesticides/PCBs were detected in the surface soil at Site 7, none exceeded the respective RBC.

Inorganics. Twenty-one TAL total metals were detected in the surface soil samples during one or more rounds of sampling. However, only arsenic and vanadium exceeded the RBC criteria for residential soil. The arsenic exceedance occurred at one of the three sample locations, LS07-SS201. The arsenic concentration did not exceed the background UTL. The vanadium concentration (26 mg/kg) at LS07-SS201 exceeded the RBC of 24 mg/kg.

Lead and nickel concentrations at LS07-SS203 exceeded the background UTLs.

3.2.4.2 Subsurface Soil

Semivolatile Organic Compounds. No SVOCs were detected or exceeded screening criteria in the subsurface soil at Site 7 during the LTM program.

Pesticides/Polychlorinated Biphenyls. Seven pesticides/PCBs were detected at Site 7 at the three subsurface soil sample locations. However, these constituents did not exceed the screening criteria.

Inorganics. Nineteen total metals were detected in the subsurface soil at Site 7. Barium, beryllium, chromium, cobalt, iron, lead, nickel, and zinc exceeded the background UTLs at LS07-SB201 and LS07-SB203. However, none of the RBCs for residential soil were exceeded.

3.3 Contaminant Fate and Transport

During the most recent sampling rounds, iron and manganese were the only constituents found above background concentrations. Dissolved iron exceeds background at MW09, but soil iron concentrations are well below background concentrations at Site 7. Total and dissolved manganese slightly exceeds background at location MW06, but soil manganese concentrations were found at concentrations below background. Therefore, groundwater does not appear to be impacted by site impacted soil and is not a contaminant migration pathway.

Arsenic was elevated above screening criteria in sediment at location SD210, which is downgradient of surface soil location SS201 where arsenic was found above comparison criteria but below background concentrations. Surface runoff with entrained site impacted soil does not appear to be a contaminant migration pathway to sediments.

The compounds detected in groundwater that are also detected in surface water are well below background concentrations. Therefore, the discharge of site impacted groundwater to surface water is not a likely migration pathway.

Sediment and surface water arsenic concentrations are equivalent at most Site 7 locations. The dissolution of arsenic, present in the sediments at Site 7, is a likely source of arsenic to surface water.

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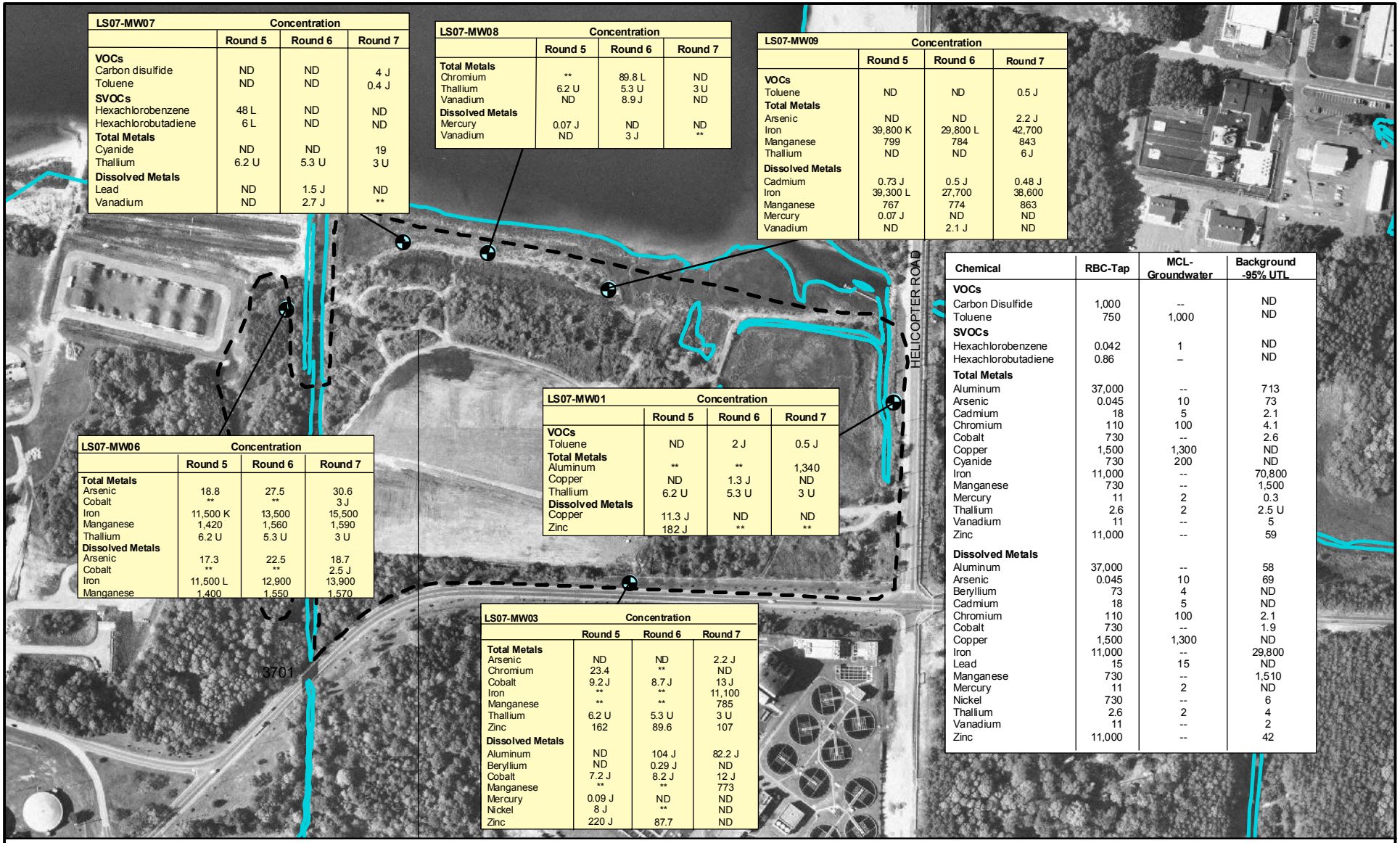

LS07-MW07	Concentration		
	Round 5	Round 6	Round 7
VOCs			
Carbon disulfide	ND	ND	4 J
Toluene	ND	ND	0.4 J
SVOCs			
Hexachlorobenzene	48 L	ND	ND
Hexachlorobutadiene	6 L	ND	ND
Total Metals			
Cyanide	ND	ND	19
Thallium	6.2 U	5.3 U	3 U
Dissolved Metals			
Lead	ND	1.5 J	ND
Vanadium	ND	2.7 J	**

LS07-MW08	Concentration		
	Round 5	Round 6	Round 7
Total Metals			
Chromium	**	89.8 L	ND
Thallium	6.2 U	5.3 U	3 U
Vanadium	ND	8.9 J	ND
Dissolved Metals			
Mercury	0.07 J	ND	ND
Vanadium	ND	3 J	**

LS07-MW09	Concentration		
	Round 5	Round 6	Round 7
VOCs			
Toluene	ND	ND	0.5 J
Total Metals			
Arsenic	ND	ND	2.2 J
Iron	39,800 K	29,800 L	42,700
Manganese	799	784	843
Thallium	ND	ND	6 J
Dissolved Metals			
Cadmium	0.73 J	0.5 J	0.48 J
Iron	39,300 L	27,700	38,600
Manganese	767	774	863
Mercury	0.07 J	ND	ND
Vanadium	ND	2.1 J	ND

LS07-MW06	Concentration		
	Round 5	Round 6	Round 7
Total Metals			
Arsenic	18.8	27.5	30.6
Cobalt	**	**	3 J
Iron	11,500 K	13,500	15,500
Manganese	1,420	1,560	1,590
Thallium	6.2 U	5.3 U	3 U
Dissolved Metals			
Arsenic	17.3	22.5	18.7
Cobalt	**	**	2.5 J
Iron	11,500 L	12,900	13,900
Manganese	1,400	1,550	1,570

LS07-MW01	Concentration		
	Round 5	Round 6	Round 7
VOCs			
Toluene	ND	2 J	0.5 J
Total Metals			
Aluminum	**	**	1,340
Copper	ND	1.3 J	ND
Thallium	6.2 U	5.3 U	3 U
Dissolved Metals			
Copper	11.3 J	ND	ND
Zinc	182 J	**	**

LS07-MW03	Concentration		
	Round 5	Round 6	Round 7
Total Metals			
Arsenic	ND	ND	2.2 J
Chromium	23.4	**	ND
Cobalt	9.2 J	8.7 J	13 J
Iron	**	**	11,100
Manganese	**	**	785
Thallium	6.2 U	5.3 U	3 U
Zinc	162	89.6	107
Dissolved Metals			
Aluminum	ND	104 J	82.2 J
Beryllium	ND	0.29 J	ND
Cobalt	7.2 J	8.2 J	12 J
Manganese	**	**	773
Mercury	0.09 J	ND	ND
Nickel	8 J	**	ND
Zinc	220 J	87.7	ND

Chemical	RBC-Tap	MCL-Groundwater	Background -95% UTL
VOCs			
Carbon Disulfide	1,000	--	ND
Toluene	750	1,000	ND
SVOCs			
Hexachlorobenzene	0.042	1	ND
Hexachlorobutadiene	0.86	–	ND
Total Metals			
Aluminum	37,000	--	713
Arsenic	0.045	10	73
Cadmium	18	5	2.1
Chromium	110	100	4.1
Cobalt	730	--	2.6
Copper	1,500	1,300	ND
Cyanide	730	200	ND
Iron	11,000	--	70,800
Manganese	730	--	1,500
Mercury	11	2	0.3
Thallium	2.6	2	2.5 U
Vanadium	11	--	5
Zinc	11,000	--	59
Dissolved Metals			
Aluminum	37,000	--	58
Arsenic	0.045	10	69
Beryllium	73	4	ND
Cadmium	18	5	ND
Chromium	110	100	2.1
Cobalt	730	--	1.9
Copper	1,500	1,300	ND
Iron	11,000	--	29,800
Lead	15	15	ND
Manganese	730	--	1,510
Mercury	11	2	ND
Nickel	730	--	6
Thallium	2.6	2	4
Vanadium	11	--	2
Zinc	11,000	--	42

LEGEND

- Monitoring Well Locations
- Site Boundary
- Water Features

Notes:
All concentrations are in UG/L.
-- - No criteria established
** - Not detected above screening criteria

J - Reported value is estimated
K - Biased high
L - Biased low
ND - Not Detected

N

0 200 400 Feet

Figure 3-1
Compounds and Analytes Exceeding Comparison Criteria for Groundwater
Site 7 - RI/HHRA
NAB Little Creek
Virginia Beach, Virginia

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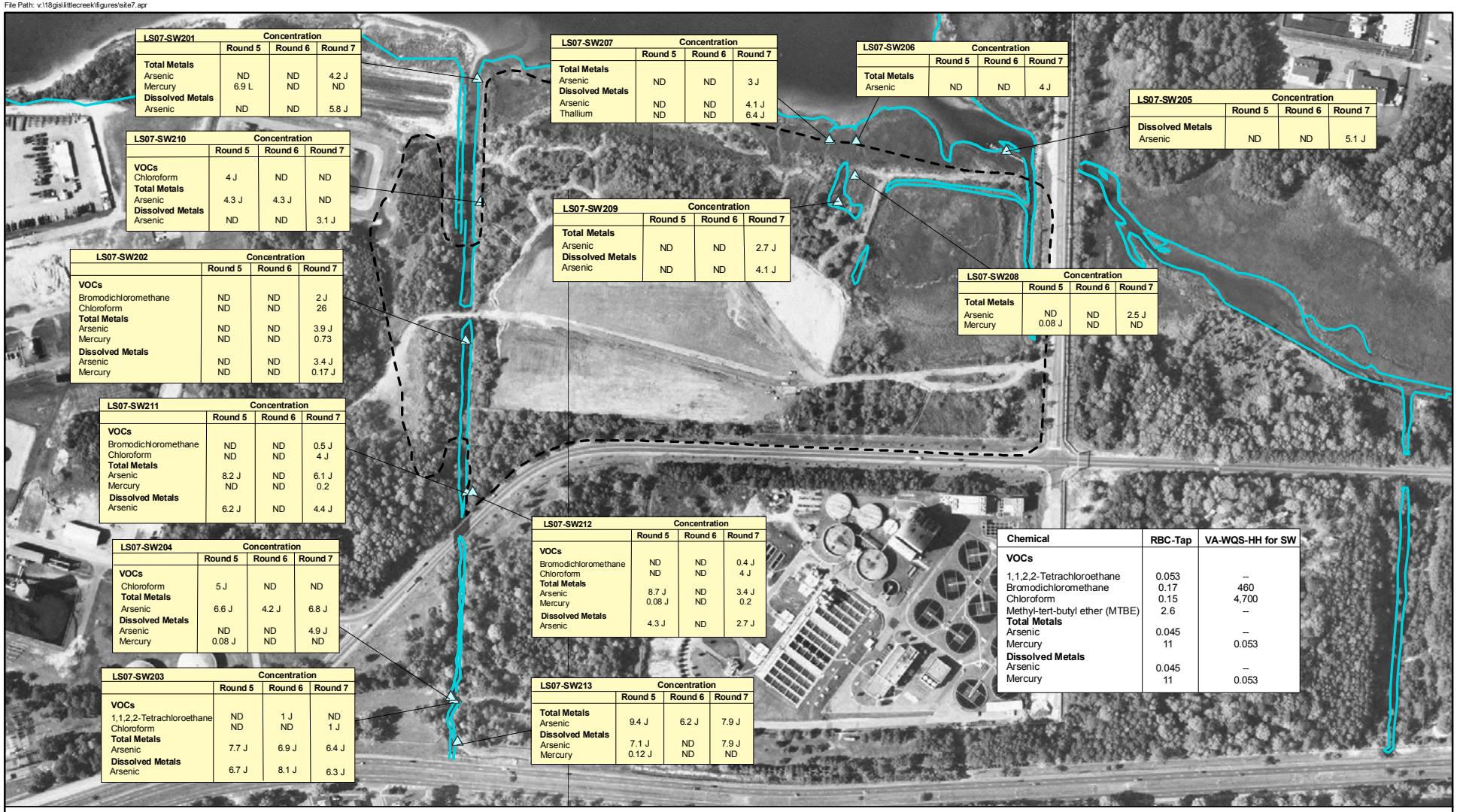

LS07-SW201	Concentration		
	Round 5	Round 6	Round 7
Total Metals			
Arsenic	ND	ND	4.2 J
Mercury	6.9 L	ND	ND
Dissolved Metals			
Arsenic	ND	ND	5.8 J

LS07-SW207	Concentration		
	Round 5	Round 6	Round 7
Total Metals			
Arsenic	ND	ND	3 J
Dissolved Metals			
Arsenic	ND	ND	4.1 J
Thallium	ND	ND	6.4 J

LS07-SW206	Concentration		
	Round 5	Round 6	Round 7
Total Metals			
Arsenic	ND	ND	4 J

LS07-SW205	Concentration		
	Round 5	Round 6	Round 7
Dissolved Metals			
Arsenic	ND	ND	5.1 J

LS07-SW210	Concentration		
	Round 5	Round 6	Round 7
VOCs			
Chloroform	4 J	ND	ND
Total Metals			
Arsenic	4.3 J	4.3 J	ND
Dissolved Metals			
Arsenic	ND	ND	3.1 J

LS07-SW209	Concentration		
	Round 5	Round 6	Round 7
Total Metals			
Arsenic	ND	ND	2.7 J
Dissolved Metals			
Arsenic	ND	ND	4.1 J

LS07-SW208	Concentration		
	Round 5	Round 6	Round 7
Total Metals			
Arsenic	ND	ND	2.5 J
Mercury	0.08 J	ND	ND

LS07-SW202	Concentration		
	Round 5	Round 6	Round 7
VOCs			
Bromodichloromethane	ND	ND	2 J
Chloroform	ND	ND	26
Total Metals			
Arsenic	ND	ND	3.9 J
Mercury	ND	ND	0.73
Dissolved Metals			
Arsenic	ND	ND	3.4 J
Mercury	ND	ND	0.17 J

LS07-SW211	Concentration		
	Round 5	Round 6	Round 7
VOCs			
Bromodichloromethane	ND	ND	0.5 J
Chloroform	ND	ND	4 J
Total Metals			
Arsenic	8.2 J	ND	6.1 J
Mercury	ND	ND	0.2
Dissolved Metals			
Arsenic	6.2 J	ND	4.4 J

LS07-SW212	Concentration		
	Round 5	Round 6	Round 7
VOCs			
Bromodichloromethane	ND	ND	0.4 J
Chloroform	ND	ND	4 J
Total Metals			
Arsenic	8.7 J	ND	3.4 J
Mercury	0.08 J	ND	0.2
Dissolved Metals			
Arsenic	4.3 J	ND	2.7 J

LS07-SW204	Concentration		
	Round 5	Round 6	Round 7
VOCs			
Chloroform	5 J	ND	ND
Total Metals			
Arsenic	6.6 J	4.2 J	6.8 J
Dissolved Metals			
Arsenic	ND	ND	4.9 J
Mercury	0.08 J	ND	ND

LS07-SW203	Concentration		
	Round 5	Round 6	Round 7
VOCs			
1,1,2,2-Tetrachloroethane	ND	1 J	ND
Chloroform	ND	ND	1 J
Total Metals			
Arsenic	7.7 J	6.9 J	6.4 J
Dissolved Metals			
Arsenic	6.7 J	8.1 J	6.3 J

LS07-SW213	Concentration		
	Round 5	Round 6	Round 7
Total Metals			
Arsenic	9.4 J	6.2 J	7.9 J
Dissolved Metals			
Arsenic	7.1 J	ND	7.9 J
Mercury	0.12 J	ND	ND

Chemical	RBC-Tap	VA-WQS-HH for SW
VOCs		
1,1,2,2-Tetrachloroethane	0.053	--
Bromodichloromethane	0.17	460
Chloroform	0.15	4,700
Methyl-tert-butyl ether (MTBE)	2.6	--
Total Metals		
Arsenic	0.045	--
Mercury	11	0.053
Dissolved Metals		
Arsenic	0.045	--
Mercury	11	0.053

LEGEND

- Surface Water Sample Locations
- Site Boundary
- Water Features

Notes:
VA-WQS-HH for Surface Water are shown.
All concentrations are in UG/L.
J - Reported value is estimated
L- Biased low
ND - Not Detected
-- - No criteria established

N

0 200 400 Feet

Figure 3-2
Compounds and Analytes Exceeding
Comparison Criteria for Surface Water
Site 7 - RI/HHRA
NAB Little Creek
Virginia Beach, Virginia

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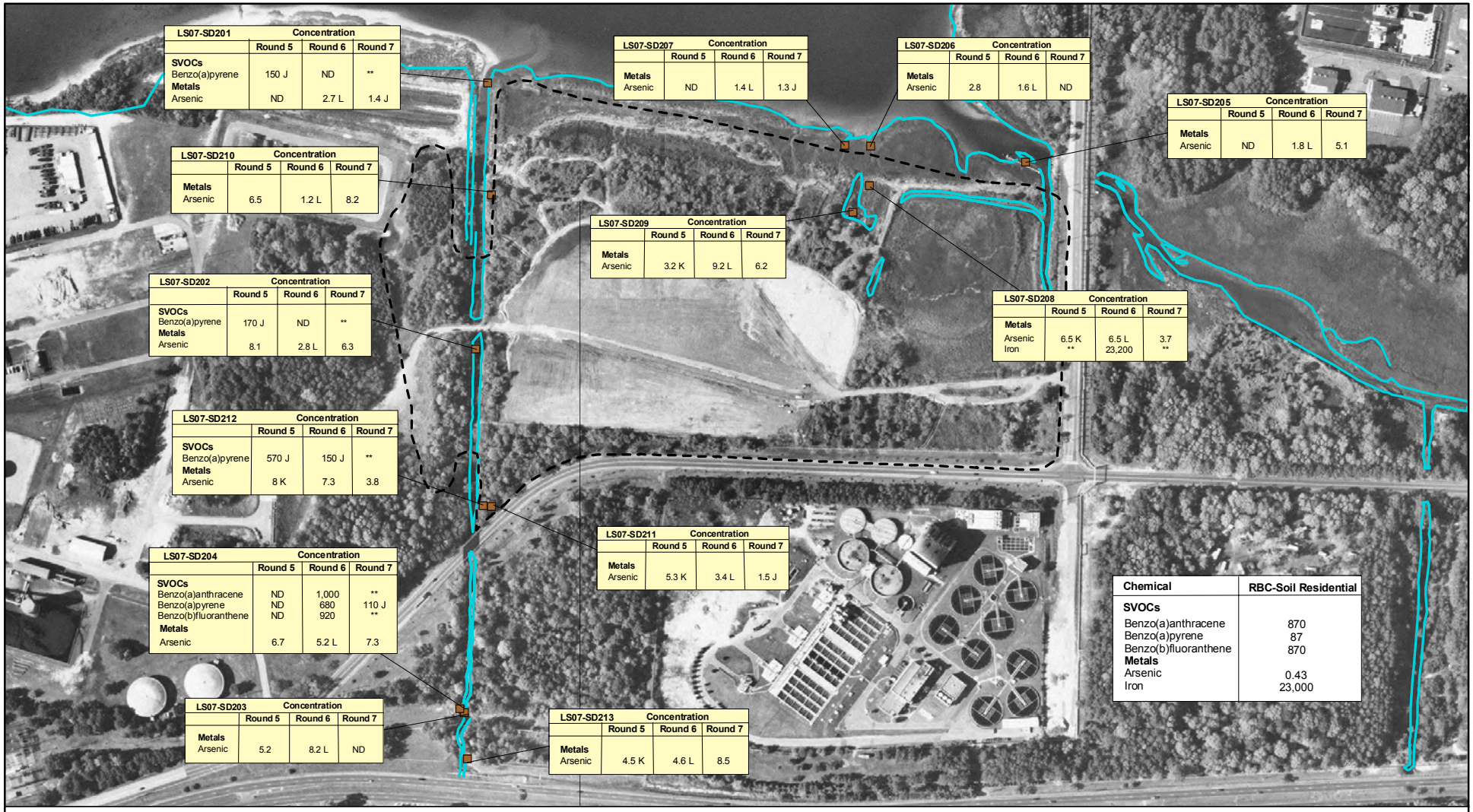

LEGEND

- Sediment Sample Locations
- Site Boundary
- Water Features

Notes:
SVOC concentrations are in UG/KG.
Metals concentrations are in MG/KG.
J - Reported value is estimated
K - Biased high
L- Biased low
ND - Not Detected
** - Not detected above screening criteria

N

0 200 400 Feet

Figure 3-3
Compounds and Analytes Exceeding Comparison Criteria for Sediment
Site 7 - RI/HHRA
NAB Little Creek
Virginia Beach, Virginia

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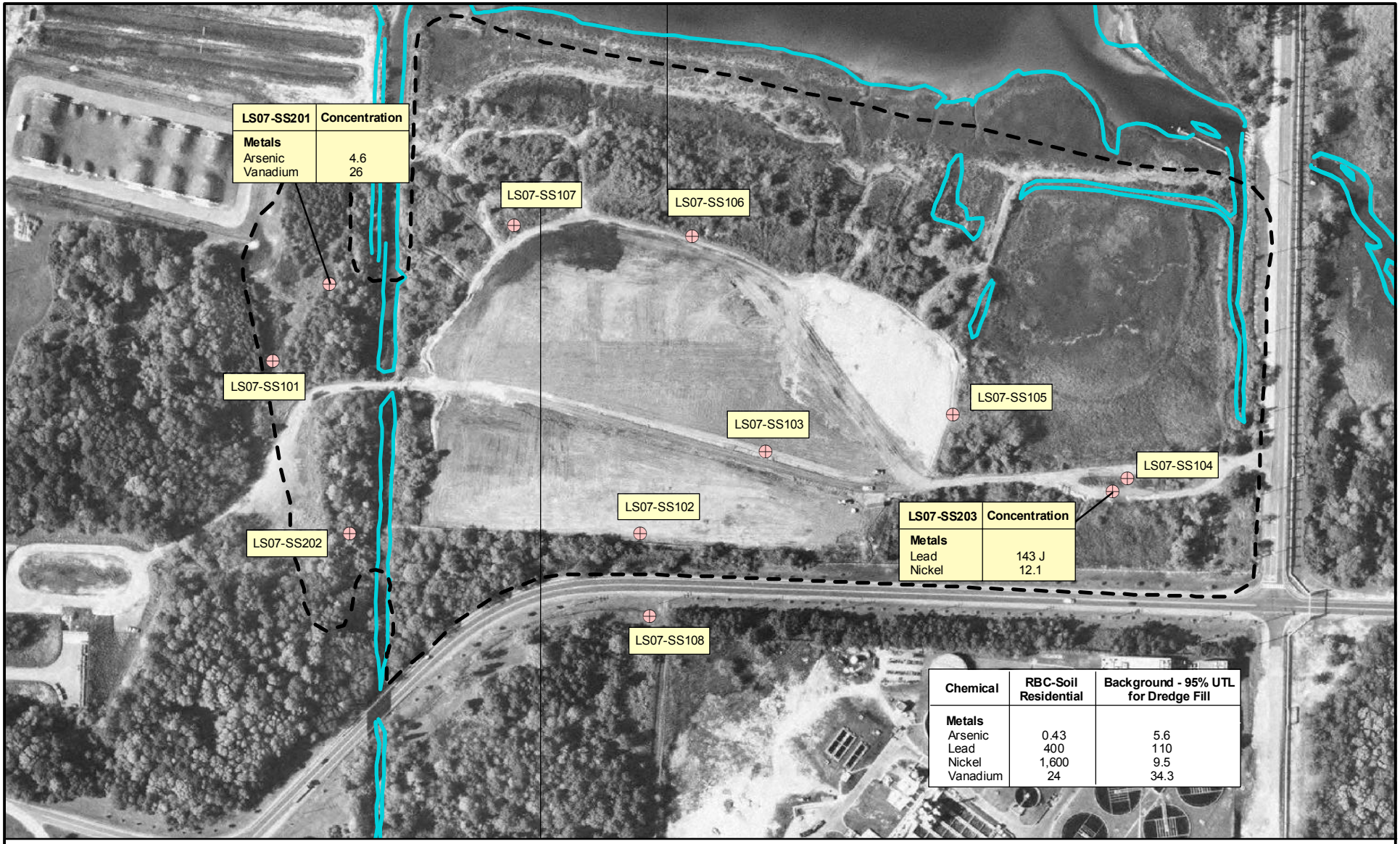

LS07-SS201	Concentration
Metals	
Arsenic	4.6
Vanadium	26

LS07-SS203	Concentration
Metals	
Lead	143 J
Nickel	12.1

Chemical	RBC-Soil Residential	Background - 95% UTL for Dredge Fill
Metals		
Arsenic	0.43	5.6
Lead	400	110
Nickel	1,600	9.5
Vanadium	24	34.3

LEGEND

- Surface Soil Sample Locations
- Site Boundary
- Water Features

Notes:
Metals concentrations are in MG/KG.

N

0 200 400 Feet

Figure 3-4
Compounds and Analytes Exceeding Comparison Criteria for Surface Soil
Site 7 - RI/HHRA
NAB Little Creek
Virginia Beach, Virginia

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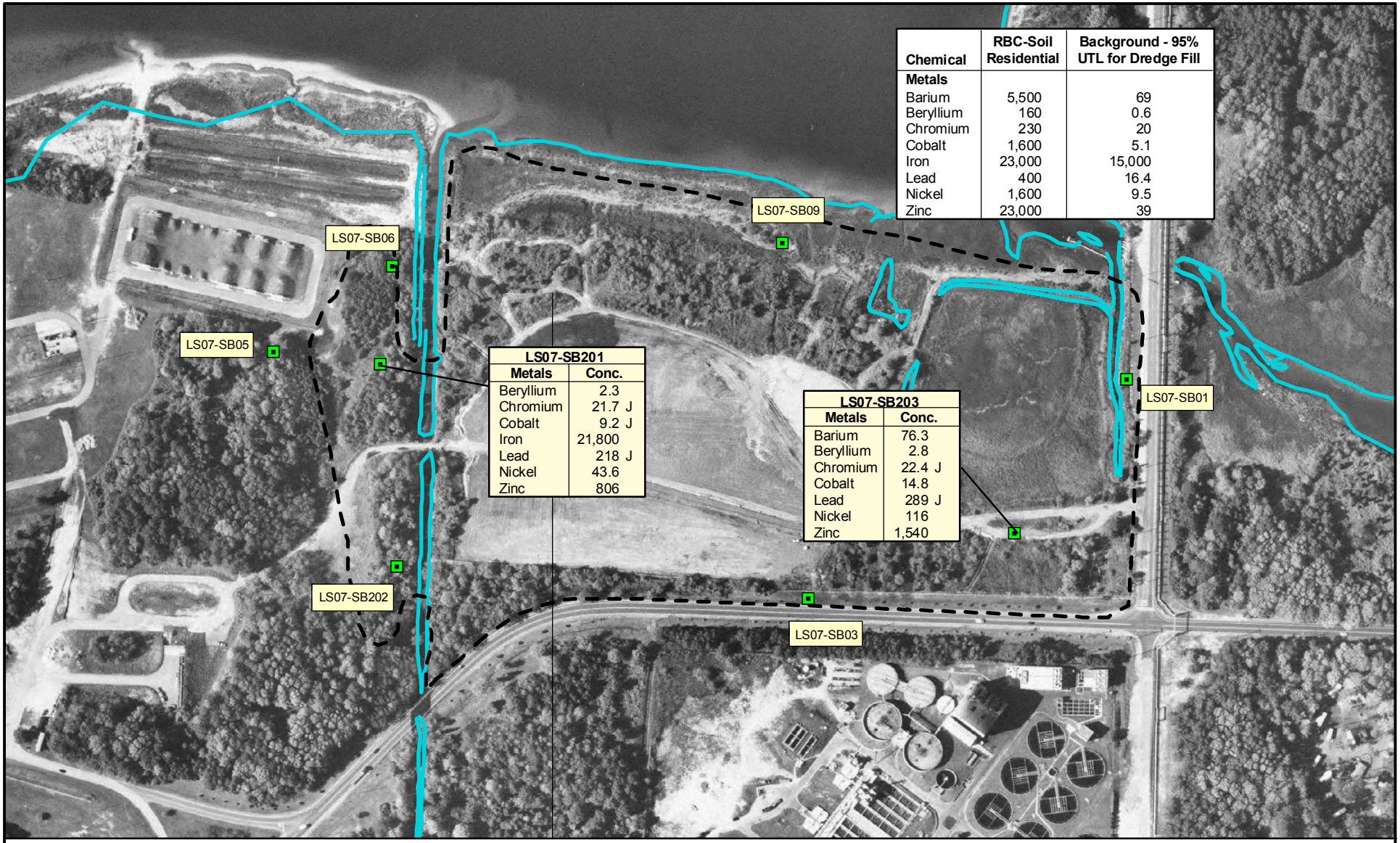

Chemical	RBC-Soil Residential	Background - 95% UTL for Dredge Fill
Metals		
Barium	5,500	69
Beryllium	160	0.6
Chromium	230	20
Cobalt	1,600	5.1
Iron	23,000	15,000
Lead	400	16.4
Nickel	1,600	9.5
Zinc	23,000	39

LS07-SB201

Metals	Conc.
Beryllium	2.3
Chromium	21.7 J
Cobalt	9.2 J
Iron	21,800
Lead	218 J
Nickel	43.6
Zinc	806

LS07-SB203

Metals	Conc.
Barium	76.3
Beryllium	2.8
Chromium	22.4 J
Cobalt	14.8
Lead	289 J
Nickel	116
Zinc	1,540

LEGEND

- Subsurface Soil Locations
- Water Features
- Site Boundary

Notes:
No compounds exceeded the RBC-Soil Residential.

N

0 200 400 Feet

Figure 3-5
Subsurface Soil Locations
Site 7 - RI/HHRA
NAB Little Creek
Virginia Beach, Virginia

CH2MHILL

Table 3-1
Groundwater Detections and Exceedances of Screening Criteria
Rounds 5, 6, and 7 LTM
Site 7 RI
NAB Little Creek
Virginia Beach, Virginia

Station ID	RBC-Tapwater	MCL	Background 95% UTL	LS07-MW01					LS07-MW03			LS07-MW06				LS07-MW07		
Sample ID				LS07-MW01-01A	LS07-MW01-01C	LS07-MW01P-01C	LS07-MW01-02A	LS07-MW01P-02A	LS07-MW03-01A	LS07-MW03-01C	LS07-MW03-02A	LS07-MW06-01A	LS07-MW06P-01A	LS07-MW06-01C	LS07-MW06-02A	LS07-MW07-01A	LS07-MW07-01C	LS07-MW07-02A
Sample Date				02/26/01	09/13/01	09/13/01	03/05/02	03/05/02	02/26/01	09/20/01	03/05/02	02/26/01	02/26/01	09/13/01	03/05/02	02/27/01	09/10/01	03/04/02
LTM Round				Round 5	Round 6	Round 6	Round 7	Round 7	Round 5	Round 6	Round 7	Round 5	Round 5	Round 6	Round 7	Round 5	Round 6	Round 7
Chemical Name																		
Volatile Organic Compounds (UG/L)																		
2-Butanone	6,968	--	--	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Acetone	5,475	--	--	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	6 J	10 U	10 U	10 U	10 U	10 U	10 U
Carbon disulfide	1,000	--	ND	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	4 J
Toluene	750	1,000	ND	10 U	2 J	2 J	0.4 J	0.5 J	10 U	10 U	0.4 J	10 U	10 U	10 U	10 U	10 U	10 U	0.4 J
Semivolatile Organic Compounds (UG/L)																		
Di-n-butylphthalate	3,700	--	--	10 UJ	12	11 U	10 U	10 U	10 UJ	7 B	10 U	10 UJ	10 UJ	12 U	10 U	10 UL	1.9 J	10 U
Hexachlorobenzene	0.042	1	ND	10 UJ	11 U	11 U	10 U	10 U	10 UJ	10 U	10 U	10 UJ	10 UJ	12 U	10 U	48 L	11 U	10 U
Hexachlorobutadiene	0.86	--	ND	10 UJ	11 U	11 U	10 U	10 U	10 UJ	10 U	10 U	10 UJ	10 UJ	12 U	10 U	6 L	11 U	10 U
Hexachloroethane	4.8	--	ND	10 UJ	11 U	11 U	10 U	10 U	10 UJ	10 U	10 U	10 UJ	10 UJ	12 U	10 U	2 L	11 U	10 U
bis(2-Ethylhexyl)phthalate	4.8	6	--	10 UJ	11 U	1 J	1 B	14 B	10 UJ	10 U	10 U	10 UJ	10 UJ	12 U	0.6 B	10 UL	11 U	1 B
Pesticide/Polychlorinated Biphenyls (UG/L)																		
No Detections																		
Total Metals (UG/L)																		
Aluminum	37,000	--	713	88.6 B	124 J	137 J	1,340	932	156 B	135 J	94.9 J	54.5 B	65.2 B	11.7 U	233	64.6 B	25.5 B	44 U
Arsenic	0.045	10	73	4.2 U	3.9 U	3.9 U	1.7 U	1.7 U	4.2 U	3.9 U	2.2 J	18.8	17.6	27.5	30.6	4.2 U	3.9 U	1.7 U
Barium	2,600	2,000	130	3.5 J	6.3 J	6 J	6.6 B	5.7 B	28.6 J	29.8 J	39.9 B	16 J	16.2 J	17.6 J	21.1 B	53.4 J	58.8 J	65.9 J
Beryllium	73	4	0.5	0.1 U	0.2 U	0.2 U	0.3 U	0.3 U	0.1 U	0.3 J	0.3 U	0.1 U	0.1 U	0.2 U	0.3 U	0.1 U	0.2 U	0.3 U
Cadmium	18	5	2.1	0.6 U	0.3 U	0.3 U	0.3 U	0.3 U	0.6 U	0.3 U	0.3 U	0.6 U	0.6 U	0.3 U	0.3 U	0.6 U	0.3 U	0.3 U
Calcium	--	--	129,000	8,180	16,300	15,300	7,580	7,770	25,000	22,900	34,900	133,000	133,000	148,000	143,000	296,000	283,000	344,000
Chromium	110	100	4.1	0.5 U	1.6 J	0.73 J	0.9 UL	0.9 UL	23.4	1.1 J	0.9 UL	0.5 U	0.5 U	0.93 J	0.9 UL	2.4 J	2.2 B	4.1 B
Cobalt	730	--	2.6	0.7 U	0.7 U	0.7 U	2 U	2 U	9.2 J	8.7 J	13 J	2 J	1.9 J	1.6 J	3 J	1.3 J	0.7 U	2 U
Copper	1,500	1,300	ND	2.6 B	0.6 U	1.3 J	3.1 B	3 B	2 B	1.2 B	1.8 U	0.95 B	1.5 B	0.6 U	2.6 B	0.86 B	1.7 B	2.3 B
Cyanide	730	200	ND	0.65 U	5 U	5 U	0.8 U	0.8 U	0.65 U	5 U	0.8 U	0.65 U	0.65 U	5 U	0.8 U	0.65 U	5 U	19
Iron	11,000	--	70,800	3,450 K	3,450	3,370	2,950	2,460	8,260 K	9,420	11,100	11,500 K	11,400 K	13,500	15,500	88.4 B	14.1 UL	32.1 J
Lead	15	15	2.4U	1.7 UL	1.4 U	1.4 U	1.6 U	1.6 U	1.7 UL	1.4 U	1.6 U	1.7 UL	1.7 UL	1.4 U	1.6 U	1.7 UL	1.4 U	1.6 U
Magnesium	--	--	456,000	14,500	36,900	34,400	19,300	20,000	10,600	9,430	16,400	113,000	113,000	125,000	125,000	625,000	594,000	731,000
Manganese	730	--	1,500	51.8	62.8	60.1	33	31.9	565	558	785	1,410	1,420	1,560	1,590	189	170	242
Mercury	11	2	0.3	0.08 J	0.1 U	0.1 U	0.1 U	0.1 U	0.08 J	0.1 U	0.1 U	0.06 U	0.08 J	0.1 U	0.1 U	0.06 U	0.1 U	0.1 U
Nickel	730	--	14	1.4 J	1 U	1 U	1 U	1 U	7.9 J	5.1 J	4.1 J	1.3 U	1.3 U	1 U	1 U	1.8 J	1 U	1.5 J
Potassium	--	--	36,800	11,600 J	25,300	23,900	17,400 J	17,800 J	9,040 J	9,330	12,600 J	25,600 J	25,600 J	22,200	29,400 J	282,000 J	195,000	316,000 J
Selenium	180	50	8	4.8 U	4.2 U	4.2 U	1.9 U	1.9 U	4.8 U	4.2 U	1.9 U	4.8 U	4.8 U	4.2 U	2.3 J	4.8 U	4.2 U	1.9 U
Silver	180	--	2	0.63 B	1 U	1 U	0.5 U	0.5 U	0.5 U	1 U	0.5 U	0.5 U	0.5 U	1 U	0.5 U	1.5 B	1 U	0.5 U
Sodium	--	--	337,000	138,000	400,000	374,000	189,000	196,000	47,700 B	41,100	78,600	306,000	309,000	389,000	326,000	4,380,000	4,750,000	4,980,000
Thallium	2.6	2	2.5U	6.2 U	5.3 U	5.3 U	3 U	3 U	6.2 U	5.3 U	3 U	6.2 U	6.2 U	5.3 U	3 U	6.2 U	5.3 U	3 U
Vanadium	11	--	5	2 B	1.9 J	2 J	4.3 J	3.4 J	1.1 B	1.1 U	1.7 U	0.81 B	0.72 B	1.1 U	1.7 U	2 B	3.4 J	1.7 U
Zinc	11,000	--	59	19 J	0.87 J	0.6 U	4.6 UL	4.6 UL	162	89.6	107	12.4 J	31.6 L	4.3 J	4.6 UL	1.1 UL	4.4 B	4.6 UL
Dissolved Metals (UG/L)																		
Aluminum	37,000	--	58	70.7 B	11.7 U	11.7 U	65.6 U	65.6 U	158 B	104 J	82.2 J	49.3 B	59.4 B	12.6 J	65.6 U	15.1 U	11.7 U	65.6 U
Arsenic	0.045	10	69	4.2 U	3.9 U	3.9 U	2.4 U	2.4 U	4.2 U	3.9 U	2.4 U	17.3	16.1	22.5	18.7	4.2 U	3.9 U	2.4 U
Barium	2,600	2,000	136	3.4 J	5.3 J	5.6 J	2.9 B	2.4 B	29.3 J	29.7 J	35.8 B	16 J	14 J	17.6 J	19.6 B	54.2 J	59.8 J	60 J
Beryllium	73	4	ND	0.1 U	0.2 U	0.2 U	0.2 U	0.2 U	0.1 U	0.29 J	0.2 U	0.1 U	0.1 U	0.2 U	0.2 U	0.1 U	0.2 U	0.2 U
Cadmium	18	5	ND	0.6 U	0.3 U	0.3 U	0.3 U	0.3 U	0.6 U	0.3 U	0.3 U	0.6 U	0.6 U	0.3 U	0.3 U	0.6 U	0.3 U	0.3 U
Calcium	--	--	136,000	8,000	14,100	15,100	7,610	6,540	27,300	23,900	35,900	132,000	116,000	147,000	144,000	298,000	292,000	328,000
Chromium	110	100	2.1	0.9 J	0.7 U	0.7 U	0.6 U	0.6 U	0.5 U	0.7 U	0.6 U	0.56 J	0.5 U	0.7 U	0.6 U	1.3 J	2 B	0.76 J
Cobalt	730	--	1.9	0.7 U	0.7 U	0.7 U	0.7 U	0.7 U	9.2 J	8.2 J	12 J	1.5 J	1.3 J	1.8 J	2.5 J	0.7 U	0.7 U	0.7 U
Copper	1,500	1,300	ND	11.3 J	0.6 U	0.6 U	4.3 U	4.3 U	5.1 B	0.6 U	4.3 U	1.7 B	5.4 B	0.6 U	4.3 U	1.1 B	1.9 B	4.3 U
Iron	11,000	--	29,800	3,660 L	3,130	3,260	1,320	1,390	7,940 L	9,400	10,800	11,500 L	10,100 L	12,900	13,900	21.7 B	14.1 U	56.4 B
Lead	15	15	ND	1.7 UL	1.4 U	1.4 U	1.8 U	1.8 U	1.7 UL	1.4 U	1.8 U	1.7 UL	1.7 UL	1.4 U	1.8 U	1.7 UL	1.5 J	1.8 UL
Magnesium	--	--	49,000	13,300	31,400	33,800	17,400	14,500	11,700	9,990	16,000	111,000	96,900	124,000	123,000	633,000	617,000	745,000
Manganese	730	--	1,510	53	56.7	60	29.8	28.7	603	581	773	1,400	1,230	1,550	1,570	197	171	260
Mercury	11	2	ND	0.06 U	0.1 U	0.1 U	0.1 U	0.1 U	0.09 J	0.1 U	0.1 U	0.07 U	0.06 U	0.1 U	0.1 U	0.06 U	0.1 U	0.1 U
Nickel	730	--	6	2.8 J	1 U	1 U	1.3 U	1.3 U	8 J	4.6 J	7.8 B	2.2 J	2 J	1 U	1.7 B	1.3 U	1.4 J	1.3 U
Potassium	--	--	35,500	11,100 J	22,500	23,600	17,200 J	14,900 J	9,750 J	9,750	13,700 J	24,800 J	20,900 J	21,800	30,500 J	282,000 J	208,000	313,000 J
Sodium	--	--	360,000	128,000	344,000	365,000	188,000 J	150,000 J	57,700	45,100	75,300 J	299,000	265,000	380,000	387,000 J	4,460,000	5,020,000	5,980,000 J
Thallium	2.6	2	4	6.2 U	5.3 U	5.3 U	6 U	6 U	6.2 U	5.3 U	6 U	6.2 U	6.2 U	5.3 U	6 U	6.2 U	5.3 U	6 U
Vanadium	11	--	2	1.7 B	1.1 U	1.5 J	0.94 J	1.4 J	0.73 B	1.1 U	0.88 J	0.7 U	0.7 U	1.1 U	0.8 U	0.75 B	2.7 J	2 J
Zinc	11,000	--	42	182 J	1.3 J	0.72 J	2.2 B	2 U	220 J	87.7	109 B	54.6 J	144 J	6 J	7.4 B	2.4 B	2.4 B	2.2 B

Notes:
Exceeds RBC - Tapwater
Exceeds MCL
Exceeds Background UTL
LTM - Long-Term Monitoring
MCL - Maximum Contaminant Level
ND - Not detected in Background
RBC - Risk-Based Concentration
UTL - Upper Tolerance Limit
-- No criteria available
B - Not detected above the associated blank concentration
J - Reported value is estimated
K - Reported value may be biased high
L - Reported value may be biased low

Table 3-1
Groundwater Detections and Exceedances of Screening Criteria
Rounds 5, 6, and 7 LTM
Site 7 RI
NAB Little Creek
Virginia Beach, Virginia

Station ID	RBC-Tapwater	MCL	Background 95% UTL	LS07-MW01					LS07-MW03			LS07-MW06				LS07-MW07		
Sample ID				LS07-MW01-01A	LS07-MW01-01C	LS07-MW01P-01C	LS07-MW01-02A	LS07-MW01P-02A	LS07-MW03-01A	LS07-MW03-01C	LS07-MW03-02A	LS07-MW06-01A	LS07-MW06P-01A	LS07-MW06-01C	LS07-MW06-02A	LS07-MW07-01A	LS07-MW07-01C	LS07-MW07-02A
Sample Date				02/26/01	09/13/01	09/13/01	03/05/02	03/05/02	02/26/01	09/20/01	03/05/02	02/26/01	02/26/01	09/13/01	03/05/02	02/27/01	09/10/01	03/04/02
LTM Round				Round 5	Round 6	Round 6	Round 7	Round 7	Round 5	Round 6	Round 7	Round 5	Round 5	Round 6	Round 7	Round 5	Round 6	Round 7
Chemical Name																		

U - Analyte not detected

Table 3-1
Groundwater Detections and Exceedances of Screening Criteria
Rounds 5, 6, and 7 LTM
Site 7 RI
NAB Little Creek
Virginia Beach, Virginia

Station ID	RBC-Tapwater	MCL	Background 95% UTL	LS07-MW08			LS07-MW09		
Sample ID				LS07-MW08-01A	LS07-MW08-01C	LS07-MW08-02A	LS07-MW09-01A	LS07-MW09-01C	LS07-MW09-02A
Sample Date				02/27/01	09/10/01	03/04/02	02/27/01	09/10/01	03/04/02
LTM Round				Round 5	Round 6	Round 7	Round 5	Round 6	Round 7
Chemical Name									
Volatile Organic Compounds (UG/L)									
2-Butanone	6,968	--	--	10 U	1 J	10 U	10 U	10 U	10 U
Acetone	5,475	--	--	7 J	2 B	10 U	10 J	2.4 B	10 U
Carbon disulfide	1,000	--	ND	10 U	10 U	10 U	10 U	10 U	10 U
Toluene	750	1,000	ND	10 U	10 U	10 U	10 U	10 U	0.5 J
Semivolatile Organic Compounds (UG/L)									
Di-n-butylphthalate	3,700	--	--	10 U	5.6 J	10 U	10 U	4 J	10 U
Hexachlorobenzene	0.042	1	ND	10 U	11 U	10 U	10 U	11 U	10 U
Hexachlorobutadiene	0.86	--	ND	10 U	11 U	10 U	10 U	11 U	10 U
Hexachloroethane	4.8	--	ND	10 U	11 U	10 U	10 U	11 U	10 U
bis(2-Ethylhexyl)phthalate	4.8	6	--	10 U	11 U	10 U	10 U	1 J	3 B
Pesticide/Polychlorinated Biphenyls (UG/L)									
No Detections									
Total Metals (UG/L)									
Aluminum	37,000	--	713	19.4 B	30.3 B	44 U	15.1 U	15.8 B	44 U
Arsenic	0.045	10	73	4.2 U	3.9 U	1.7 U	4.2 U	3.9 U	2.2 J
Barium	2,600	2,000	130	34.1 J	41.6 J	58.4 B	71.4 J	87.5 J	83.3 J
Beryllium	73	4	0.5	0.1 U	0.2 U	0.3 U	0.1 U	0.2 U	0.3 U
Cadmium	18	5	2.1	0.66 J	0.3 U	0.3 U	0.6 U	0.54 J	1.4 B
Calcium	--	--	129,000	266,000	276,000	354,000	271,000	277,000	290,000
Chromium	110	100	4.1	0.78 J	89.8 L	1.1 B	0.5 U	0.7 UL	1 B
Cobalt	730	--	2.6	0.7 U	0.88 J	2 U	0.7 U	0.7 U	2 U
Copper	1,500	1,300	ND	1.5 B	3.7 B	2.6 B	0.7 U	2.7 B	2.8 B
Cyanide	730	200	ND	0.65 U	5 U	0.8 U	0.65 U	5 U	0.93 B
Iron	11,000	--	70,800	30.9 B	2,010 L	25.1 J	39,800 K	29,800 L	42,700
Lead	15	15	2.4U	1.7 UL	1.4 U	1.6 U	1.7 UL	1.4 U	1.6 U
Magnesium	--	--	456,000	583,000	576,000	697,000	777,000	768,000	804,000
Manganese	730	--	1,500	120	177	295	799	784	843
Mercury	11	2	0.3	0.07 U	0.1 U	0.1 U	0.08 J	0.1 U	0.1 U
Nickel	730	--	14	1.5 J	12.5 J	1 U	1.3 U	1 U	1 U
Potassium	--	--	36,800	272,000 J	201,000	320,000 J	346,000 J	258,000	364,000 J
Selenium	180	50	6	4.8 U	4.2 U	1.9 U	4.8 U	4.2 U	1.9 U
Silver	180	--	2	0.5 U	1 U	0.5 U	0.5 U	1 U	0.57 J
Sodium	--	--	337,000	4,110,000	4,750,000	4,910,000	5,790,000	6,520,000	6,310,000
Thallium	2.6	2	2.5U	6.2 U	5.3 U	3 U	6.2 U	5.3 U	6 J
Vanadium	11	--	5	0.87 B	8.9 J	1.7 U	0.7 U	1.5 J	1.7 U
Zinc	11,000	--	59	1.1 UL	6.3 B	4.6 UL	1.1 UL	3.8 B	4.6 UL
Dissolved Metals (UG/L)									
Aluminum	37,000	--	58	19.1 B	22.3 B	65.6 U	65.8 B	16.8 B	65.6 U
Arsenic	0.045	10	69	4.2 U	3.9 U	2.4 U	4.2 U	3.9 U	2.4 U
Barium	2,600	2,000	136	37.9 J	42.3 J	52.5 J	69.4 J	84.1 J	73.7 J
Beryllium	73	4	ND	0.1 U	0.2 U	0.2 U	0.1 U	0.2 U	0.2 U
Cadmium	18	5	ND	0.6 U	0.3 U	0.3 U	0.73 J	0.5 J	0.48 J
Calcium	--	--	136,000	301,000	273,000	328,000	262,000	272,000	285,000
Chromium	110	100	2.1	1.7 J	3.7 B	1.6 J	0.5 U	0.7 U	0.6 U
Cobalt	730	--	1.9	0.7 U	0.7 U	0.7 U	0.7 U	0.7 U	0.7 U
Copper	1,500	1,300	ND	2 B	2.9 B	4.3 U	2.3 B	1.5 B	4.3 U
Iron	11,000	--	29,800	36.2 B	14.1 U	44.8 B	39,300 L	27,700	38,600
Lead	15	15	ND	1.7 UL	1.4 U	1.8 UL	1.7 UL	1.4 U	1.8 UL
Magnesium	--	--	49,000	624,000	571,000	711,000	732,000	751,000	887,000
Manganese	730	--	1,510	145	174	304	767	774	863
Mercury	11	2	ND	0.07 J	0.1 U	0.1 U	0.07 J	0.1 U	0.1 U
Nickel	730	--	6	2.3 J	1.3 J	2.2 J	1.7 J	1 U	2.6 J
Potassium	--	--	35,500	298,000 J	203,000	308,000 J	329,000 J	250,000	373,000 J
Sodium	--	--	360,000	4,470,000	4,780,000	5,750,000 J	5,420,000	6,380,000	6,640,000 J
Thallium	2.6	2	4	6.2 U	5.3 U	6 U	6.2 U	5.3 U	6 U
Vanadium	11	--	2	0.7 U	3 J	1.8 J	0.71 B	2.1 J	0.8 U
Zinc	11,000	--	42	57.9 B	3.6 B	2 U	33.2 B	3.3 B	3.6 B

Notes:
Exceeds RBC - Tapwater
Exceeds MCL
Exceeds Background UTL
LTM - Long-Term Monitoring
MCL - Maximum Contaminant Level
ND - Not detected in Background
RBC - Risk-Based Concentration
UTL - Upper Tolerance Limit
-- No criteria available
B - Not detected above the associated blank concentration
J - Reported value is estimated
K - Reported value may be biased high
L - Reported value may be biased low

Table 3-1
Groundwater Detections and Exceedances of Screening Criteria
Rounds 5, 6, and 7 LTM
Site 7 RI
NAB Little Creek
Virginia Beach, Virginia

Station ID	**RBC-Tapwater**	**MCL**	**Background 95% UTL**	LS07-MW08			LS07-MW09		
Sample ID				LS07-MW08-01A	LS07-MW08-01C	LS07-MW08-02A	LS07-MW09-01A	LS07-MW09-01C	LS07-MW09-02A
Sample Date				02/27/01	09/10/01	03/04/02	02/27/01	09/10/01	03/04/02
LTM Round				Round 5	Round 6	Round 7	Round 5	Round 6	Round 7
Chemical Name									

U - Analyte not detected

Table 3-2
Surface Water Exceedances of Screening Criteria
Rounds 5, 6, and 7 LTM
Site 7 RI
NAB Little Creek
Virginia Beach, Virginia

Station ID	RBC-Tapwater	VAWQS-HH for Surface Water	LS07-SW201			LS07-SW202				LS07-SW203					LS07-SW204			
Sample ID			LS07-SW201-01A	LS07-SW201-01C	LS07-SW201-02A	LS07-SW202-01A	LS07-SW202-01C	LS07-SW202P-01C	LS07-SW202-02A	LS07-SW203-01A	LS07-SW203P-01A	LS07-SW203-01C	LS07-SW203-02A	LS07-SW203P-02A	LS07-SW204-01A	LS07-SW204-01C	LS07-SW204P-01C	LS07-SW204-02A
Sample Date			03/01/01	09/11/01	03/04/02	03/02/01	09/13/01	09/13/01	03/05/02	03/01/01	03/01/01	09/13/01	03/05/02	03/05/02	03/02/01	09/13/01	09/13/01	03/05/02
LTM Round			Round 5	Round 6	Round 7	Round 5	Round 6	Round 6	Round 7	Round 5	Round 5	Round 6	Round 7	Round 7	Round 5	Round 6	Round 6	Round 7
Chemical Name																		
Volatile Organic Compounds (UG/L)																		
1,1,2,2-Tetrachloroethane	0.053	--	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	1 J	10 U	10 U	10 U	1 B	10 U	10 U
Acetone	5,475	--	10 U	10 U	10 U	10 U	10 U	10 U	15 J	10 U	10 U	1 J	10 U	6 J	5 J	4 J	2 J	10 U
Bromodichloromethane	0.17	460	10 U	10 U	10 U	10 U	10 U	10 U	2 J	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chlorobenzene	110	21,000	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chloroform	0.15	4,700	10 U	10 U	10 U	10 U	10 U	10 U	26	10 U	10 U	10 U	1 J	1 J	5 J	10 U	10 U	10 U
Methyl-tert-butyl ether (MTBE)	2.6	--	10 U	10 U	10 U	10 U	1 J	1 J	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Methylene chloride	4.1	16,000	10 U	10 U	10 U	10 U	10 U	10 U	0.5 B	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Toluene	750	200,000	10 U	10 U	10 U	10 U	1 J	1 J	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Total Metals (UG/L)																		
Aluminum	37,000	--	15.1 U	131 J	183 J	243 B	379	1,590	175 J	47.4 B	83.4 B	11.7 U	65.6 U	65.6 U	395	257	177 J	73.4 J
Antimony	15	4,300	2.5 U	3.6 U	4 U	2.5 U	3.6 U	3.6 U	4 U	2.5 U	2.5 U	3.6 U	4 U	4 U	2.5 U	3.6 U	3.6 U	4 U
Arsenic	0.045	--	4.2 U	3.9 U	4.2 J	4.2 U	3.9 U	3.9 U	3.9 J	7.2 J	7.7 J	6.9 J	6.4 J	6.4 J	6.6 J	4.2 J	3.9 U	6.8 J
Barium	2,600	--	15.7 J	22.1 J	20.9 B	15.4 J	21.8 J	21.5 J	70.3 J	20.3 J	21.6 J	19 J	22.4 B	21.4 B	72.4 J	28.9 J	27.3 J	20.7 B
Beryllium	73	--	0.1 U	0.2 U	0.2 U	0.1 U	0.2 U	0.2 U	0.2 U	0.1 U	0.1 U	0.2 U	0.2 U	0.2 U	0.1 U	0.2 U	0.2 U	0.2 U
Cadmium	18	--	0.6 U	0.3 U	0.3 U	0.63 J	0.3 U	0.3 U	0.3 U	0.6 U	0.6 U	0.3 U	0.3 U	0.3 U	0.6 U	0.3 U	0.3 U	0.3 U
Calcium	--	--	234,000	252,000	279,000	160,000	274,000	267,000	71,700	28,400	30,200	43,600	27,900	27,200	73,800	83,100	83,300	25,600
Chromium	110	--	1.6 J	0.7 U	0.6 U	2.8 J	0.7 U	0.7 U	13.2	0.87 J	1.8 J	0.7 U	0.66 J	0.68 J	5.9 J	1.1 J	0.7 U	0.97 J
Cobalt	730	--	1.1 J	0.7 U	0.83 J	0.7 J	0.7 U	0.7 U	5.3 J	2.3 J	2.5 J	1.5 J	2.1 J	2.4 J	4.2 J	2.4 J	1.4 J	2.1 J
Copper	1,500	--	3.6 B	4.9 B	4.3 UL	3.9 B	2.8 J	2.4 J	4.9 B	2.9 B	3.3 B	0.6 U	4.3 UL	4.3 UL	5.6 B	2 J	1.5 J	4.3 UL
Cyanide	730	215,000	0.65 UL	5 U	0.84 B	0.65 UL	5 U	5 U	10.4	0.65 UL	0.65 UL	5 U	1.3 B	1.6 B	6 L	5 U	5 U	1.5 B
Iron	11,000	--	267 B	147 B	597	574	821	787	433	2,960	3,000	2,540	2,130	2,050	5,350	1,350	1,160	2,490
Lead	15	--	1.7 UL	1.4 U	1.8 UL	1.7 UL	1.6 J	1.4 U	1.8 UL	1.7 UL	3.5 L	1.4 U	1.8 UL	1.8 UL	2.4 J	1.4 U	2.8 B	1.8 UL
Magnesium	--	--	757,000	809,000	920,000	507,000	830,000	818,000	35,000	35,700	38,300	93,500	19,500	18,900	119,000	203,000	203,000	18,000
Manganese	730	--	0.1 U	44.8	0.3 U	39.8	25.7	25.7	88.1	329	350	288	364	358	164	186	184	357
Mercury	11	0.053	6.9 L	0.1 U	0.1 U	0.07 B	0.1 U	0.1 U	0.73	0.08 R	0.07 R	0.1 U	0.11 U	0.1 U	0.08 R	0.1 U	0.1 U	0.1 U
Nickel	730	4,600	1.9 J	1.1 J	1.9 J	2.1 J	1 U	1.7 J	12.9 J	1.3 U	1.7 J	1 U	1.4 J	1.3 U	5 J	1 J	1 U	1.3 U
Potassium	--	--	384,000	291,000	476,000 J	269,000	289,000	285,000	54,900 J	15,500	16,900	34,700	10,400 J	9,960 J	60,200	80,900	81,200	8,730 J
Silver	180	--	0.7 B	1 U	0.9 U	0.51 B	1 U	1 U	0.9 U	0.53 B	0.5 U	1 U	0.9 U	0.9 U	0.64 B	1 U	1 U	0.9 U
Sodium	--	--	5,640,000	6,750,000	7,350,000 J	3,730,000	7,180,000	7,100,000	1,560,000 J	251,000	268,000	806,000	177,000 J	169,000 J	1,100,000	1,830,000	1,830,000	131,000 J
Vanadium	11	--	0.7 U	2.9 J	1.5 J	0.7 U	3.1 J	4.1 J	4.3 J	1.1 J	1.1 J	1.1 U	1 J	1.1 J	4.3 J	2.3 J	1.6 J	0.88 J
Zinc	11,000	--	1.1 UL	14.1 B	12 J	22.3 B	7.4 J	8.5 J	193 J	62	48.1	5.9 J	18 J	11.5 J	280	20.1	14.8 J	13.5 J
Dissolved Metals (UG/L)																		
Aluminum	37,000	--	89.5 B	11.7 U	65.6 U	17.6 B	11.7 U	11.7 U	124 J	78.7 B	38.2 B	11.7 U	65.6 U	65.6 U	105 B	11.7 U	59.6 J	65.6 U
Arsenic	0.045	--	4.2 U	3.9 U	5.8 J	4.2 U	3.9 U	3.9 U	3.4 J	6.7 J	5.7 J	8.1 J	6.3 J	6.1 J	4.2 U	3.9 U	3.9 U	4.9 J
Barium	2,600	--	16.8 J	20.6 J	21.3 J	20.7 J	20 J	20.1 J	65.1 J	21.3 J	17.8 J	19.8 J	20.2 J	21.4 J	64.4 J	27.8 J	30.6 J	19.8 J
Calcium	--	--	249,000	261,000	295,000	229,000	265,000	265,000	68,900	30,400	24,900	44,700	26,400	27,600	70,400	104,000	118,000	25,800
Chromium	110	--	0.75 J	0.7 U	0.6 U	0.87 J	0.7 U	0.7 U	9.6 J	0.5 U	17.1	22.9 J	0.6 U	0.6 U	0.51 J	0.7 U	0.7 U	0.6 U
Cobalt	730	--	1.2 J	0.7 U	0.7 U	0.7 U	0.7 U	0.7 U	5.3 J	2.1 J	1.7 J	1.8 J	2.3 J	2.6 J	5.7 J	1.8 J	1.9 J	2.3 J
Copper	1,500	--	2.8 B	3.3 B	4.3 U	1.2 B	4.2 J	0.99 J	4.3 U	2.2 B	3.7 B	2.1 B	4.3 U	4.3 U	2.6 B	0.681 J	1.2 J	4.3 U
Iron	11,000	--	128 B	14.1 U	232	85.3 B	107	125	219	2,440 K	2,080 K	3,200 L	1,310	1,320	669 K	14.1 U	14.1 U	1,220
Lead	15	--	1.7 UL	1.4 U	1.8 U	1.7 UL	1.4 U	1.4 U	1.8 U	3.5 L	1.7 UL	1.4 U	1.8 U	1.8 U	1.7 UL	1.8 J	1.4 U	1.8 U
Magnesium	--	--	793,000	852,000	993,000	715,000	797,000	819,000	33,400	38,400	31,500	94,200	18,700	19,400	63,900	265,000	303,000	17,900
Manganese	730	--	0.1 U	21.4	0.3 U	43.1	16.9	18.4	82.8	349	289	303	338	357	80.3	168	156	346
Mercury	11	0.053	0.07 U	0.1 U	0.1 U	0.07 U	0.1 U	0.1 U	0.17 J	0.07 U	0.08 U	0.1 U	0.1 U	0.1 U	0.08 J	0.1 U	0.1 U	0.1 U
Nickel	730	4,600	2.4 J	1.2 J	1.9 J	2.2 J	1.1 J	1 U	13.1 J	1.8 J	10.3 J	1.8 J	2.3 J	1.9 J	6.7 J	1 U	1 U	1.8 J
Potassium	--	--	335,000	303,000	519,000 J	372,000	276,000	283,000	53,500 J	16,600	13,000	35,100	10,500 J	10,900 J	33,300	91,100	104,000	9,460 J
Silver	180	--	1.1 B	1 U	0.9 U	0.5 U	1 U	1 U	0.9 U	0.5 U	0.5 U	1 U	0.9 U	0.9 U	0.5 U	1 U	1 U	0.9 U
Sodium	--	--	5,940,000 K	6,990,000	7,900,000 J	5,450,000 K	6,880,000	7,040,000	1,520,000 J	259,000 K	214,000 K	824,000	181,000 J	188,000 J	850,000 K	2,370,000	2,720,000	149,000 J
Thallium	2.6	--	6.2 U	5.3 U	6 U	6.2 U	5.3 U	5.3 U	6 U	6.2 U	6.2 U	5.3 U	6 U	6 U	6.2 U	5.3 U	5.3 U	6 U
Vanadium	11	--	0.7 U	2 J	0.8 U	0.7 U	2.2 J	2.3 J	4.1 J	0.7 U	0.83 J	2.2	0.8 U	0.8 U	3.9 J	1.1 U	1.1 U	1.4 J
Zinc	11,000	--	14.8 B	11 J	13 B	24.2 J	2.6 J	2.4 J	182 J	62.4 J	78.7 J	5.5 B	12.1 B	13.6 B	397 J	14 J	23.8	11.3 B

Notes:
Exceeds RBC-Tapwater and/or VAWQS-HH
LTM - Long-Term Monitoring
RBC - Risk-Based Concentration
VAWQS-HH - Virginia Water Quality Standards Human Health
B - Not detected above the associated blank concentration
J - Reported value is estimated
K - Reported value may be biased high
L - Reported value may be biased low
R - Unreliable result
U - Analyte not detected
-- No criteria available

Table 3-2
Surface Water Exceedances of Screening Criteria
Rounds 5, 6, and 7 LTM
Site 7 RI
NAB Little Creek
Virginia Beach, Virginia

Station ID	RBC-Tapwater	VAWQS-HH for Surface Water	LS07-SW205			LS07-SW206			LS07-SW207			LS07-SW208			LS07-SW209			LS07-SW210	
Sample ID			LS07-SW205-01A	LS07-SW205-01C	LS07-SW205-02A	LS07-SW206-01A	LS07-SW206-01C	LS07-SW206-02A	LS07-SW207-01A	LS07-SW207-01C	LS07-SW207-02A	LS07-SW208-01A	LS07-SW208-01C	LS07-SW208-02A	LS07-SW209-01A	LS07-SW209-01C	LS07-SW209-02A	LS07-SW210-01A	LS07-SW210-01C
Sample Date			03/01/01	09/11/01	03/04/02	03/02/01	09/11/01	03/04/02	03/02/01	09/11/01	03/04/02	03/08/01	09/11/01	03/04/02	03/08/01	09/11/01	03/04/02	03/02/01	09/10/01
LTM Round			Round 5	Round 6	Round 7	Round 5	Round 6	Round 7	Round 5	Round 6	Round 7	Round 5	Round 6	Round 7	Round 5	Round 6	Round 7	Round 5	Round 6
Chemical Name																			
Volatile Organic Compounds (UG/L)																			
1,1,2,2-Tetrachloroethane	0.053	--	10 U	1 B	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Acetone	5,475	--	10 U	1 J	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	7 J	10 U
Bromodichloromethane	0.17	460	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chlorobenzene	110	21,000	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chloroform	0.15	4,700	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	4 J	10 U
Methyl-tert-butyl ether (MTBE)	2.6	--	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	2.1 J
Methylene chloride	4.1	16,000	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	0.6 B	10 U	10 U	10 U	10 U	10 U
Toluene	750	200,000	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Total Metals (UG/L)																			
Aluminum	37,000	--	112 B	450	65.6 U	30.5 B	374	76.9 J	17.8 B	294	65.6 U	143 B	245	244	516	326	490	117 B	156 J
Antimony	15	4,300	2.5 U	3.6 U	4 U	2.5 U	3.6 U	4 U	2.5 U	5.2 J	4 U	2.5 U	3.6 U	4 U	2.5 U	3.6 U	4 U	2.5 U	3.6 U
Arsenic	0.045	--	4.2 U	3.9 U	2.4 U	4.2 U	3.9 U	4 J	4.2 U	3.9 U	3 J	4.2 U	3.9 U	2.5 J	4.2 U	3.9 U	2.7 J	4.3 J	4.3 J
Barium	2,600	--	14.9 J	19.2 J	22.4 B	14.3 J	20.1 J	22.5 B	10.2 J	20.5 J	22.3 B	17.2 J	30.2 J	30.2 B	12 J	32.5 J	43 B	32.7 J	21.6 J
Beryllium	73	--	0.1 U	0.2 U	0.2 U	0.1 U	0.2 U	0.2 U	0.1 U	0.2 U	0.2 U	0.1 U	0.2 U	0.2 U	0.1 U	0.2 U	0.2 U	0.1 U	0.2 U
Cadmium	18	--	0.6 U	0.3 U	0.3 U	0.6 U	0.3 U	0.3 U	0.67 J	0.3 U	0.3 U	0.6 U	0.3 U	0.3 U	0.6 U	0.3 U	0.3 U	0.6 U	0.3 U
Calcium	--	--	186,000	264,000	286,000	229,000	263,000	288,000	165,000	268,000	285,000	182,000	268,000	279,000	72,100	274,000	252,000	164,000	266,000
Chromium	110	--	1.8 J	0.7 U	0.6 U	1.3 J	0.7 U	0.6 U	1.5 J	0.77 J	0.6 U	2.1 J	0.7 U	0.6 U	1.9 J	0.7 U	0.6 U	1.4 J	0.7 U
Cobalt	730	--	1.1 J	0.7 U	0.7 U	0.7 U	0.7 U	0.82 J	1.1 J	0.84 J	0.7 U	0.76 J	0.8 U	0.7 U	0.7 U	0.7 U	0.7 U	2.2 J	0.7 U
Copper	1,500	--	3.9 B	5.4 B	4.3 UL	2.6 B	8.5 B	4.3 UL	3.7 B	8.8 B	4.3 UL	4 B	5.1 B	4.3 UL	5 B	8.1 B	7.1 B	3.7 B	4.8 B
Cyanide	730	215,000	0.65 UL	5 U	0.8 U	0.65 UL	5 U	0.8 U	0.65 UL	5 U	1.1 B	NA	5 U	0.83 B	1.3 B	5 U	1.3 B	0.65 UL	5 U
Iron	11,000	--	590	14.1 U	315	190 B	358	403	134 B	241	362	353 B	813	881	840 J	1,060	1,880	708	19.8 B
Lead	15	--	1.7 UL	1.5 J	1.8 UL	1.7 UL	1.4 U	1.8 UL	1.7 UL	1.4 U	1.8 UL	1.7 U	1.9 J	1.8 UL	1.7 U	4.2	2.5 J	1.7 UL	1.4 U
Magnesium	--	--	594,000	829,000	967,000	726,000	842,000	949,000	537,000	862,000	952,000	576,000	852,000	930,000	218,000	865,000	786,000	482,000	844,000
Manganese	730	--	21	16.9	11.4 J	0.1 U	27.7	7.8 J	0.1 U	27.8	7.9 J	4.7 B	42.1	27.7	10 J	43.1	68.7	66.4	23.8
Mercury	11	0.053	0.07 R	0.1 U	0.1 U	0.07 R	0.1 U	0.1 U	0.07 R	0.1 U	0.1 U	0.08 J	0.1 U	0.1 U	0.07 U	0.1 U	0.1 U	0.07 R	0.1 U
Nickel	730	4,600	2.2 J	2 J	1.8 J	1.3 U	1 U	1.4 J	1.6 J	1 U	2.2 J	2.5 B	1.4 J	1.3 U	2.1 B	1 J	1.7 J	2 J	1 U
Potassium	--	--	315,000	301,000	498,000 J	378,000	301,000	492,000 J	284,000	306,000	489,000 J	309,000 J	305,000	483,000 J	124,000 J	310,000	422,000 J	261,000	302,000
Silver	180	--	1.1 B	1 U	0.9 U	0.5 U	1 U	0.9 U	0.87 B	1.4 J	0.9 U	0.92 B	1 U	0.9 U	0.51 B	1 U	0.9 U	0.5 U	1 U
Sodium	--	--	4,390,000	7,190,000	7,820,000 J	5,550,000	7,180,000	7,480,000 J	3,970,000	7,170,000	7,570,000 J	4,370,000 K	7,100,000	7,510,000 J	1,690,000 K	7,290,000	6,040,000 J	3,670,000	7,040,000
Vanadium	11	--	0.7 U	3 J	0.8 U	0.7 U	3.5 J	1.5 J	0.7 U	4.7 J	0.8 U	0.7 U	3 J	0.8 U	1 J	3.1 J	2 J	0.7 U	2.6 J
Zinc	11,000	--	9.3 B	11.5 B	57.3 J	1.1 UL	12.2 J	10.5 J	2.5 B	17.3 B	12.5 J	1.1 UL	16.3 J	29.6 J	17.7 B	30	39.5 J	84	10.1 B
Dissolved Metals (UG/L)																			
Aluminum	37,000	--	15.9 B	11.7 U	65.6 U	79.6 B	11.7 U	65.6 U	34.5 B	11.7 U	65.6 U	15.1 U	11.7 U	65.6 U	74.6 B	11.7 U	65.6 U	57.3 B	13.5 B
Arsenic	0.045	--	4.2 U	3.9 U	5.1 J	4.2 U	3.9 U	2.4 U	4.2 U	3.9 U	4.1 J	4.2 U	3.9 U	2.4 U	4.2 U	3.9 U	4.1 J	4.2 U	3.9 U
Barium	2,600	--	15.4 J	19.1 J	22.9 J	14.2 J	20.4 J	22.4 J	14.7 J	20.1 J	22.9 J	15.6 J	30.2 J	30.7 J	11.8 J	33.1 J	44.2 J	34.9 J	19.6 J
Calcium	--	--	197,000	269,000	292,000	227,000	267,000	288,000	246,000	265,000	291,000	171,000	274,000	285,000	73,100	270,000	248,000	182,000	253,000
Chromium	110	--	0.67 J	0.7 U	0.6 U	0.9 J	2.1 J	0.6 U	0.82 J	0.7 U	0.6 U	0.5 U	0.7 U	0.6 U	1.3 J	0.7 U	0.6 U	1.7 J	0.7 U
Cobalt	730	--	0.7 U	0.7 U	0.7 U	0.7 U	0.7 U	0.7 U	0.7 U	0.7 U	0.7 U	1.1 J	0.7 U	0.7 U	0.7 U	0.7 U	0.7 U	3.4 J	0.7 U
Copper	1,500	--	1.9 B	3.2 B	4.3 U	2.6 B	3.1 J	4.3 U	2 B	3.5 B	4.3 U	4.7 B	2.1 J	4.3 U	3.3 B	1.4 B	4.3 U	3.4 B	3.2 B
Iron	11,000	--	21 B	282 U	212	66.7 B	14.1 U	235	61.2 B	282 U	215	116 B	14.1 U	242	45 B	14.1 U	153	66.4 B	14.1 U
Lead	15	--	1.7 UL	1.4 U	1.8 U	1.7 UL	1.4 U	1.8 U	1.7 UL	1.4 U	1.8 U	1.7 U	1.4 U	1.8 U	1.7 U	1.4 U	1.8 U	1.7 UL	1.4 U
Magnesium	--	--	629,000	845,000	976,000	724,000	855,000	971,000	781,000	848,000	983,000	533,000	871,000	945,000	220,000	844,000	783,000	523,000	800,000
Manganese	730	--	15.5	6.3 J	9.8 J	0.1 U	18.6	5.3 J	0.1 U	17.9	6.2 J	2 B	40.4	26.3	6 B	41.3	64.3	81.5	13.7 J
Mercury	11	0.053	0.08 U	0.1 U	0.1 U	0.07 U	0.1 U	0.1 U	0.07 U	0.1 U	0.1 U	0.06 U	0.1 U	0.1 U	0.07 U	0.1 U	0.1 U	0.07 U	0.1 U
Nickel	730	4,600	1.8 J	1.2 J	2 J	3 J	1.5 J	1.3 J	1.5 J	1 U	1.9 J	1.7 B	2.8 J	1.3 U	2 B	1 U	2.3 J	4 J	1.2 J
Potassium	--	--	328,000	304,000	516,000 J	371,000	308,000	522,000 J	395,000	305,000	517,000 J	284,000 J	312,000	501,000 J	128,000 J	303,000	437,000 J	276,000	289,000
Silver	180	--	0.5 U	1 U	0.9 U	0.5 U	1 U	0.9 U	0.5 U	1 U	0.9 U	0.5 U	1 U	0.9 U	0.5 U	1 U	0.9 U	0.5 U	1 U
Sodium	--	--	4,620,000 K	7,170,000	7,730,000 J	5,470,000 K	7,170,000	7,790,000 J	5,950,000 K	7,150,000	7,490,000 J	3,980,000 K	6,890,000	7,450,000 J	1,680,000 K	7,120,000	5,930,000 J	3,940,000 K	6,770,000
Thallium	2.6	--	6.2 U	5.3 U	6 U	6.2 U	5.3 U	6 U	6.2 U	5.3 U	6.4 J	6.2 U	5.3 U	6 U	6.2 U	5.3 U	6 U	6.2 U	5.3 U
Vanadium	11	--	0.7 U	1.8 J	0.8 U	0.7 U	3.4 J	0.8 U	0.7 U	2.6 J	0.8 U	0.7 U	1.6 J	0.8 U	0.7 U	1.1 U	0.8 U	1.2 J	2.1 J
Zinc	11,000	--	1.1 U	3.1 B	13.6 B	41.2 J	3.4 J	9.6 B	1.1 U	4.2 J	9.3 B	1.1 UL	5.6 J	18.7 B	21 B	4.2 J	8.3 B	99.6 J	6 B

Notes:
Exceeds RBC-Tapwater and/or VAWQS-HH
LTM - Long-Term Monitoring
RBC - Risk-Based Concentration
VAWQS-HH - Virginia Water Quality Standards Human Health
B - Not detected above the associated blank concentration
J - Reported value is estimated
K - Reported value may be biased high
L - Reported value may be biased low
R - Unreliable result
U - Analyte not detected
-- No criteria available

Table 3-2
Surface Water Exceedances of Screening Criteria
Rounds 5, 6, and 7 LTM
Site 7 RI
NAB Little Creek
Virginia Beach, Virginia

Station ID	**RBC-Tapwater**	**VAWQS-HH for Surface Water**	
Sample ID			LS07-SW210-02A
Sample Date			03/04/02
LTM Round			Round 7
Chemical Name			
Volatile Organic Compounds (UG/L)			
1,1,2,2-Tetrachloroethane	0.053	--	10 U
Acetone	5,475	--	10 U
Bromodichloromethane	0.17	460	10 U
Chlorobenzene	110	21,000	10 U
Chloroform	0.15	4,700	10 U
Methyl-tert-butyl ether (MTBE)	2.6	--	10 U
Methylene chloride	4.1	16,000	0.3 B
Toluene	750	200,000	10 U
Total Metals (UG/L)			
Aluminum	37,000	--	288
Antimony	15	4,300	4 U
Arsenic	0.045	--	2.4 U
Barium	2,600	--	22.4 B
Beryllium	73	--	0.2 U
Cadmium	18	--	0.3 U
Calcium	--	--	295,000
Chromium	110	--	0.6 U
Cobalt	730	--	1.5 J
Copper	1,500	--	5.7 B
Cyanide	730	215,000	0.8 U
Iron	11,000	--	803
Lead	15	--	1.8 UL
Magnesium	--	--	984,000
Manganese	730	--	5.3 J
Mercury	11	0.053	0.1 U
Nickel	730	4,600	1.9 J
Potassium	--	--	512,000 J
Silver	180	--	0.9 U
Sodium	--	--	8,110,000 J
Vanadium	11	--	2.7 J
Zinc	11,000	--	11.3 J
Dissolved Metals (UG/L)			
Aluminum	37,000	--	65.6 U
Arsenic	0.045	--	3.1 J
Barium	2,600	--	22.3 J
Calcium	--	--	296,000
Chromium	110	--	0.6 U
Cobalt	730	--	0.7 U
Copper	1,500	--	4.3 U
Iron	11,000	--	234
Lead	15	--	1.8 U
Magnesium	--	--	988,000
Manganese	730	--	0.3 U
Mercury	11	0.053	0.1 U
Nickel	730	4,600	1.8 J
Potassium	--	--	528,000 J
Silver	180	--	0.9 U
Sodium	--	--	7,940,000 J
Thallium	2.6	--	6 U
Vanadium	11	--	0.8 U
Zinc	11,000	--	9.1 B

Notes:
Exceeds RBC-Tapwater and/or VAWQS-HH
LTM - Long-Term Monitoring
RBC - Risk-Based Concentration
VAWQS-HH - Virginia Water Quality Standards Human Health
B - Not detected above the associated blank concentration
J - Reported value is estimated
K - Reported value may be biased high
L - Reported value may be biased low
R - Unreliable result
U - Analyte not detected
-- No criteria available

Table 3-2
Surface Water Exceedances of Screening Criteria
Rounds 5, 6, and 7 LTM
Site 7 RI
NAB Little Creek
Virginia Beach, Virginia

Station ID	RBC-Tapwater	VAWQS-HH for Surface Water	LS07-SW211			LS07-SW212			LS07-SW213			
Sample ID			LS07-SW211-01A	LS07-SW211-01C	LS07-SW211-02A	LS07-SW212-01A	LS07-SW212-01C	LS07-SW212-02A	LS07-SW213-01A	LS07-SW213P-01A	LS07-SW213-01C	LS07-SW213-02A
Sample Date			03/08/01	09/13/01	03/05/02	03/08/01	09/13/01	03/05/02	03/08/01	03/08/01	09/13/01	03/05/02
LTM Round			Round 5	Round 6	Round 7	Round 5	Round 6	Round 7	Round 5	Round 5	Round 6	Round 7
Chemical Name												
Volatile Organic Compounds (UG/L)												
1,1,2,2-Tetrachloroethane	0.053	--	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Acetone	5,475	--	10 U	10 U	10 U	4 J	2 J	10 U	10 U	10 U	10 U	10 U
Bromodichloromethane	0.17	460	10 U	10 U	0.5 J	10 U	10 U	0.4 J	10 U	10 U	10 U	10 U
Chlorobenzene	110	21,000	10 U	10 U	0.6 J	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chloroform	0.15	4,700	10 U	10 U	4 J	10 U	10 U	4 J	10 U	10 U	10 U	10 U
Methyl-tert-butyl ether (MTBE)	2.6	--	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Methylene chloride	4.1	16,000	10 U	10 U	0.5 B	10 U	2 J	0.4 B	10 U	10 U	10 U	0.4 B
Toluene	750	200,000	10 U	10 U	0.7 J	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Total Metals (UG/L)												
Aluminum	37,000	--	280 B	431	148 J	1,050	258	65.6 U	297 B	301 B	416	65.6 U
Antimony	15	4,300	2.5 U	3.6 U	4 U	2.5 U	3.6 U	4 U	2.5 U	2.5 U	3.6 U	4 U
Arsenic	0.045	--	8.2 J	3.9 U	6.1 J	8.7 J	3.9 U	3.4 J	7.8 J	9.4 J	6.2 J	7.9 J
Barium	2,600	--	41.2 J	27.8 J	29.6 B	46.3 J	35.9 J	28.1 B	30.4 J	36.8 J	34 J	13 B
Beryllium	73	--	0.1 U	0.2 U	0.2 U	0.14 J	0.2 U	0.2 U	0.1 U	0.1 U	0.2 U	0.2 U
Cadmium	18	--	0.6 U	0.3 U	0.3 U	0.6 U	0.3 U	0.3 U	0.6 U	0.6 U	0.3 U	0.3 U
Calcium	--	--	70,200	207,000	41,700	99,800	91,100	39,200	48,600	65,800	165,000	18,400
Chromium	110	--	1.7 J	0.97 J	3.2 J	3.7 J	1.3 J	2.4 J	2 J	1.4 J	1.2 J	0.6 U
Cobalt	730	--	3.1 J	1.3 J	2.6 J	3.5 J	1.2 J	2.6 J	2.6 J	3.4 J	1.5 J	0.7 U
Copper	1,500	--	3.7 B	2.6 J	4.3 UL	8.3 B	8.2 J	4.3 UL	4.7 B	4.9 B	1.7 J	4.3 UL
Cyanide	730	215,000	0.65 U	5 U	3.7 B	0.65 U	5 U	3.5 B	0.65 U	0.65 U	5 U	0.82 B
Iron	11,000	--	3,280 J	989	1,730	4,360 J	2,360	747	2,750 J	2,870 J	1,620	1,470
Lead	15	--	1.7 U	1.4 U	1.8 UL	2.6 B	3.3	1.8 UL	1.7 U	1.7 U	1.9 J	1.8 UL
Magnesium	--	--	150,000	597,000	33,100	229,000	230,000	29,500	105,000	145,000	464,000	5,930
Manganese	730	--	361	89.8	250	331	281	235	331	387	154	176
Mercury	11	0.053	0.07 U	0.1 U	0.2	0.08 J	0.1 U	0.19 J	0.07 U	0.07 U	0.1 U	0.1 U
Nickel	730	4,600	1.7 B	1.9 J	4.2 J	2.6 B	1.7 J	3.6 J	2.3 B	2.8 B	1.1 J	1.3 U
Potassium	--	--	84,600 J	205,000	25,500 J	135,000 J	90,200	23,300 J	56,900 J	81,700 J	156,000	3,590 J
Silver	180	--	0.5 U	1 U	0.9 U	0.5 U	1 U	0.9 U	0.5 U	0.56 B	1 U	0.9 U
Sodium	--	--	1,160,000 K	5,280,000	585,000 J	1,750,000 K	1,950,000	516,000 J	794,000 K	1,100,000 K	4,060,000	12,600 J
Vanadium	11	--	1.4 J	3.6 J	2.2 J	4 J	1.7 J	1.2 J	1.2 J	1.5 J	2.1 J	0.82 J
Zinc	11,000	--	33.6 B	15.7 J	71 J	52.9 B	46.2	60.9 J	18.5 B	25.8 B	20.5	3.9 J
Dissolved Metals (UG/L)												
Aluminum	37,000	--	28.9 B	24.4 J	65.6 U	17 B	20.8 J	65.6 U	41.2 B	44.1 B	11.7 U	65.6 U
Arsenic	0.045	--	6.2 J	3.9 U	4.4 J	4.3 J	3.9 U	2.7 J	5.7 J	7.1 J	3.9 U	7.9 J
Barium	2,600	--	44.2 J	26.4 J	27.9 J	43.2 J	33.2 J	27.1 J	35.7 J	35.9 J	34.4 J	12.7 J
Calcium	--	--	82,300	210,000	39,800	115,000	90,900	40,700	70,000	71,500	147,000	18,600
Chromium	110	--	0.84 J	0.7 U	0.72 J	1.2 J	0.7 U	0.71 J	1.2 J	1.2 J	0.7 U	0.6 U
Cobalt	730	--	3.6 J	1.6 J	3.1 J	2.8 B	1.6 J	2.8	3.4 J	3.2 J	0.73 J	0.7 U
Copper	1,500	--	2.6 B	2.3 J	4.3 U	2.8 J	1.7 B	4.3 U	2.7 B	2.4 B	3.3 B	4.3 U
Iron	11,000	--	1,860	523	221	183 B	949	181	1,540	1,580	66.1 J	1,190
Lead	15	--	1.7 U	1.4 U	1.8 U	1.7 U	1.4 U	1.8 U	1.7 U	1.7 U	1.4 U	1.8 U
Magnesium	--	--	176,000	605,000	29,600	269,000	228,000	32,000	156,000	158,000	415,000	5,970
Manganese	730	--	390 J	95.3	238	321 J	278	246	375 J	382 J	153	182
Mercury	11	0.053	0.07 U	0.1 U	0.1 U	0.07 U	0.1 U	0.1 U	0.12 J	0.08 J	0.1 U	0.1 U
Nickel	730	4,600	1.8 B	1 U	5.4 J	2.4 B	1.3 J	4.7 J	1.8 B	1.7 B	1 U	1.3 U
Potassium	--	--	101,000 J	207,000	24,900 J	158,000 J	90,200	25,500 J	87,800 J	88,600 J	150,000	3,710 J
Silver	180	--	0.54 J	1 U	0.9 U	0.5 U	1 U	0.9 U	0.57 J	0.67 J	1 U	0.9 U
Sodium	--	--	1,310,000 K	5,310,000	551,000 J	2,100,000 K	1,920,000	550,000 J	1,200,000 K	1,200,000 K	3,760,000	13,000 J
Thallium	2.6	--	6.2 U	5.3 U	6 U	6.2 U	5.3 U	6 U	6.2 U	6.2 U	5.3 U	6 U
Vanadium	11	--	0.7 U	2.2 J	1.1 J	0.7 U	1.1 J	0.88 J	0.7 U	0.7 U	1.1 U	0.8 U
Zinc	11,000	--	18.6 B	18 J	61 J	18.4 B	34.4	56.9 J	18.3 B	18.5 B	15.6 J	5.7 B

Notes:
Exceeds RBC-Tapwater and/or VAWQS-HH
LTM - Long-Term Monitoring
RBC - Risk-Based Concentration
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-- No criteria available

Table 3-3
Sediment Exceedances of Screening Criteria
Rounds 5, 6, and 7 LTM
Site 7 RI
NAB Little Creek
Virginia Beach, Virginia

Station ID	RBC-Soil Residential	LS07-SD201			LS07-SD202				LS07-SD203				LS07-SD204				
Sample ID		LS07-SD201-01A	LS07-SD201-01C	LS07-SD201-02A	LS07-SD202-01A	LS07-SD202-01C	LS07-SD202P-01C	LS07-SD202-02A	LS07-SD203-01A	LS07-SD203P-01A	LS07-SD203-01C	LS07-SD203-02A	LS07-SD204-01A	LS07-SD204-01C	LS07-SD204P-01C	LS07-SD204-02A	LS07-SD204P-02A
Sample Date		03/01/01	09/11/01	03/04/02	03/02/01	09/13/01	09/13/01	03/05/02	03/01/01	03/01/01	09/13/01	03/05/02	03/02/01	09/13/01	09/13/01	03/05/02	03/05/02
LTM Round		Round 5	Round 6	Round 7	Round 5	Round 6	Round 6	Round 7	Round 5	Round 5	Round 6	Round 7	Round 5	Round 6	Round 6	Round 7	Round 7
Chemical Name																	
Semivolatile Organic Compounds (UG/KG)																	
2-Methylnaphthalene	1,600,000	810 U	420 U	460 U	1,000 U	440 U	470 U	19 J	2,300 U	2,300 U	480 U	23 J	11,000 U	490 U	100 J	52 J	78 J
4-Methylphenol	390,000	810 U	420 U	460 U	1,000 U	440 U	470 U	570 U	2,300 U	2,300 U	480 U	400 U	11,000 U	490 U	480 U	470 U	510 U
Acenaphthene	4,700,000	810 U	420 U	22 J	1,000 U	440 U	470 U	20 J	2,300 U	2,300 U	480 U	49 J	11,000 U	490 U	250 J	17 J	23 J
Acenaphthylene	--	810 U	420 U	460 U	1,000 U	440 U	470 U	570 U	2,300 U	2,300 U	480 U	400 U	11,000 U	490 U	480 U	470 U	510 U
Acetophenone	7,800,000	810 U	420 U	52 B	1,000 U	440 U	470 U	61 B	2,300 U	2,300 U	480 U	23 B	11,000 U	490 U	480 U	31 B	29 B
Anthracene	23,000,000	810 U	420 U	71 J	1,000 U	440 U	470 U	49 J	2,300 U	2,300 U	480 U	130 J	11,000 U	490 U	590	41 J	67 J
Benzaldehyde	7,800,000	810 U	420 U	16 J	1,000 U	440 U	470 U	48 B	2,300 U	2,300 U	480 U	6 B	11,000 U	490 U	480 U	18 B	22 B
Benzo(a)anthracene	870	200 J	420 U	61 J	210 J	440 U	470 U	98 J	2,300 U	2,300 U	80 J	210 J	11,000 U	140 J	1,000	150 J	150 J
Benzo(a)pyrene	87	150 J	420 U	47 J	170 J	440 U	470 U	78 J	2,300 U	2,300 U	55 J	63 J	11,000 U	120 J	680	110 J	110 J
Benzo(b)fluoranthene	870	190 J	420 U	73 J	190 J	440 U	470 U	140 J	2,300 U	2,300 U	75 J	190 J	11,000 U	160 J	920	140 J	170 J
Benzo(g,h,i)perylene	2,300,000	110 J	420 U	460 U	1,000 U	440 U	470 U	570 U	2,300 U	2,300 U	480 U	400 U	11,000 U	85 J	450 J	470 U	510 U
Benzo(k)fluoranthene	8,700	180 J	420 U	75 J	140 J	440 U	470 U	76 J	2,300 U	2,300 U	480 U	130 J	11,000 U	54 J	360 J	98 J	98 J
Butylbenzylphthalate	16,000,000	810 U	420 U	460 U	1,000 U	440 U	470 U	570 U	2,300 U	2,300 U	480 U	400 U	11,000 U	490 U	480 U	51 J	21 J
Carbazole	32,000	810 U	420 U	29 J	1,000 U	440 U	470 U	21 J	2,300 U	2,300 U	480 U	75 J	11,000 U	490 U	290 J	35 J	32 J
Chrysene	87,000	290 J	420 U	98 J	320 J	440 U	470 U	110 J	2,300 U	2,300 U	100 J	190 J	11,000 U	140 J	890	140 J	160 J
Di-n-butylphthalate	7,800,000	810 U	420 U	460 U	1,000 U	440 U	50 J	67 J	2,300 U	2,300 U	480 U	400 U	11,000 U	490 U	480 U	470 U	510 U
Di-n-octylphthalate	1,600,000	810 UJ	420 U	47 J	1,000 UJ	440 U	470 U	570 U	2,300 UJ	2,300 UJ	480 U	400 U	11,000 UJ	490 U	480 U	470 U	510 U
Dibenz(a,h)anthracene	87	810 U	420 U	460 U	1,000 U	440 U	470 U	19 J	2,300 U	2,300 U	480 U	45 J	11,000 U	490 U	480 U	29 J	29 J
Dibenzofuran	310,000	810 U	420 U	21 J	1,000 U	440 U	470 U	16 J	2,300 U	2,300 U	480 U	40 J	11,000 U	490 U	230 J	21 J	31 J
Diethylphthalate	63,000,000	810 U	420 U	460 U	1,000 U	440 U	470 U	570 U	2,300 U	2,300 U	480 U	400 U	11,000 U	490 U	480 U	470 U	510 U
Fluoranthene	3,100,000	380 J	420 U	260 J	360 J	440 U	470 U	310 J	2,300 U	2,300 U	140 J	510	11,000 U	200 J	2,100	280 J	330 J
Fluorene	3,100,000	810 U	420 U	37 J	1,000 U	440 U	470 U	570 U	2,300 U	2,300 U	480 U	67 J	11,000 U	490 U	360 J	470 U	29 J
Indeno(1,2,3-cd)pyrene	870	100 J	420 U	29 J	1,000 U	440 U	470 U	43 J	2,300 U	2,300 U	480 U	58 J	11,000 U	71 J	380 J	56 J	57 J
Naphthalene	1,600,000	810 U	420 U	460 U	1,000 U	440 U	470 U	570 U	2,300 U	2,300 U	480 U	50 J	11,000 U	490 U	200 J	28 J	44 J
Phenanthrene	2,300,000	120 J	420 U	130 J	200 J	440 U	470 U	130 J	2,300 U	2,300 U	110 J	480	11,000 U	120 J	2,400	180 J	250 J
Phenol	47,000,000	810 U	420 U	460 U	1,000 U	440 U	470 U	570 U	2,300 U	2,300 U	480 U	400 U	11,000 U	490 U	480 U	470 U	510 U
Pyrene	2,300,000	340 J	420 U	200 J	330 J	440 U	470 U	250 J	2,300 U	2,300 U	150 J	270 J	11,000 U	180 J	1,400	240 J	290 J
bis(2-Ethylhexyl)phthalate	46,000	87 B	420 U	230 B	460 J	440 U	100 J	150 B	2,300 U	2,300 U	73 J	230 B	11,000 U	59 J	480 U	99 B	130 B
Pesticide/Polychlorinated Biphenyls (UG/KG)																	
4,4'-DDD	2,700	4 U	4.2 U	4.7 U	5.2 U	4.4 U	4.7 U	5.7 U	15	12	13 J	4 U	23	2.1 J	2.1 J	3.5 J	5.1 U
4,4'-DDE	1,900	4 U	4.2 U	4.7 U	5.2 U	4.4 U	4.7 U	5 J	4.6 U	4.7 U	7.1 J	4 U	13 J	1.6 J	1.8 J	3.1 J	5.1 U
4,4'-DDT	1,900	4 U	4.2 U	4.7 U	14 J	4.4 U	4.7 U	5.7 U	4.6 U	4.7 U	2.8 J	4 U	5.3 U	1.2 J	1.2 J	4.7 U	5.1 U
Aroclor-1260	320	40 U	42 U	47 U	260	44 U	120 J	150 J	46 U	47 U	48 UJ	40 U	53 U	49 U	48 U	47 U	51 U
Endosulfan I	470,000	2.1 U	2.1 U	1.2 J	2.9 J	2.2 U	2.3 U	2.9 U	2.3 U	2.4 U	2.4 UJ	2 U	2.7 U	2.4 U	2.4 U	2.4 U	2.6 U
Endrin	23,000	4 U	4.2 U	4.7 U	20 J	4.4 U	4.7 U	5.7 U	4.6 U	4.7 U	4.8 UJ	4 U	5.3 U	4.9 U	4.8 U	4.7 U	5.1 U
Endrin ketone	23,000	4 U	4.2 U	4.7 U	5.2 U	4.4 U	4.7 U	5.7 U	4.6 U	4.7 U	4.8 UJ	4 U	5.3 U	4.9 U	4.8 U	4.7 U	5.1 U
alpha-Chlordane	1,800	2.1 U	2.1 U	2.4 U	2.7 U	2.2 U	2.3 U	2.8 J	2.3 U	2.4 U	2.4 UJ	2 U	2.7 U	2.4 U	2.4 U	2.4 U	2.6 U
beta-BHC	350	2.1 U	2.1 U	2.4 U	2.7 U	2.2 U	2.3 U	2.9 U	2.3 U	2.4 U	2.4 UJ	2 U	2.7 U	2.4 U	2.4 U	2.4 U	2.6 U
gamma-Chlordane	1,800	2.1 U	2.1 U	NA	3.1	2.2 U	2.3 U	NA	2.3 U	2.4 U	2.4 UJ	NA	2.7 U	2.4 U	2.4 U	NA	NA
Total Metals (MG/KG)																	
Aluminum	78,000	1,530	3,940	1,860	5,880	2,890	3,590	4,230	4,130	3,310	4,620	279	3,390	3,800	4,910	1,930	2,090
Antimony	31	0.714 R	0.76 UL	0.409 UL	2.9 J	0.84 UL	0.88 UL	0.519 UL	0.797 R	0.862 R	0.91 L	0.354 UL	0.722 R	1 L	0.88 UL	0.422 UL	0.45 UL
Arsenic	0.43	2.4 B	2.7 L	1.4 J	8.1	1.9 L	2.8 L	6.3	5.2	5.2	8.2 L	0.401 U	6.7	4.9 L	5.2 L	6.4	7.3
Barium	5,500	7.2 J	9 J	8.7 J	20.2 J	9.1 J	7.5 J	20.7 B	16.9 J	14.4 J	47.6 J	2.8 B	21.9 J	28.6 J	17.2 J	19.4 J	20.5 J
Beryllium	160	0.05 B	0.19 J	0.24 B	0.29 B	0.24 J	0.16 J	0.42 B	0.32 B	0.26 B	0.05 U	0.13 B	0.14 B	0.31 B	0.24 B	0.36 B	0.39 B
Cadmium	39	0.082 U	0.06 U	0.082 U	0.1 U	0.07 U	0.08 J	0.28 B	0.091 U	0.099 U	0.24 J	0.071 U	0.083 U	0.08 J	0.12 B	0.12 B	0.18 B
Calcium	--	898 J	559 J	536 J	1,500 B	371 J	436 J	1,200 B	821 J	729 J	2,070	96.5 B	942 B	890 J	640 J	1,000 B	1,030 B
Chromium	230	3.8	8.9	5.1 L	13.1	6	7.2	10.5	8.9	7.4	14.9	0.5 B	10.2	10.1	10.3	6.4 B	7.1 B
Cobalt	1,600	0.91 B	1.4 J	0.86 J	4.2 J	1.4 J	1.5 J	2.8 J	2.5 J	2.1 J	3.7 J	0.472 U	2.1 J	2.1 J	2.9 J	1.8 J	2 J
Copper	3,100	11 J	3.9 B	16.8 B	3,060 J	24.4 L	16.3 L	41.8 B	24.5 J	22.6 J	49.4 L	0.84 B	39.8 J	30.1 L	12.2 L	37.7 B	38.1 B
Iron	23,000	3,090	5,980	4,970	13,900	3,360	3,990	12,800	7,240	6,430	8,150	1,260	7,660	7,090	7,500	8,020	8,400
Lead	400	6.3 J	4.9	8.4	172 J	45.5	14.2	34.1	10.6 J	9.4 J	29	3	21.9 J	19.2	9.4	22.2	23.8
Magnesium	--	611 J	1,440	1,070 J	1,830 B	781 J	1,130 J	1,720 J	991 J	702 J	1,030 J	103 B	895 J	1,090 J	1,410	644 J	696 J
Manganese	1,600	19.9	48.5	23.5	80	22	23.7	73.5	45.6	36.2	84.9	3.1 B	64.2	58.7	47.8	59.8	61.4
Mercury	23	0.02 R	0.013 J	0.076 B	0.03 R	0.023	0.02 J	0.15 B	0.03 R	0.03 R	0.06	0.057 U	0.03 R	0.03 J	0.04	0.093 B	0.1 B
Nickel	1,600	2.4 B	3.9 J	1.9 B	50.7 L	10.7	3.4 J	6.6 B	8.3 J	8 J	41.5	0.236 U	28.8 L	9.5 J	9.7 J	20.3	23.8
Potassium	--	367 J	868	544 J	1,170 B	555 J	780 J	963 J	596 J	454 J	547 J	56 B	392 B	567 J	871 J	224 J	247 J
Selenium	390	0.796 UL	0.89 U	0.518 UL	0.974 UL	0.98 U	1 U	1.1 J	0.99 J	0.961 UL	1.1 U	0.448 UL	0.805 UL	1.1 U	1 U	0.535 UL	0.98 J
Silver	390	0.163 U	0.21 U	0.136 U	0.57 J	0.23 U	0.34 J	0.173 U	0.182 U	0.197 U	0.54 J	0.118 U	0.44 J	0.25 U	0.25 U	0.35 J	0.48 J
Sodium	--	1,850 J	2,100	3,330	2,740 B	2,330	3,610	2,790	870 B	846 B	743 J	348 B	962 B	1,460	1,440	655 B	674 B
Thallium	5.5	1.04 U	1.1 U	0.818 R	1.27 U	1.2 U	1.3 U	1.04 R	1.3 J	1.3 J	2.1 J	0.708 R	1.05 U	1.3 U	1.3 U	0.844 R	0.9 R
Vanadium	24	6 J	9.4 J	8.2 J	30.7	11.2 J	14.7	21.7	29.5	30	248	2.4 J	195	39.3	24.2	137	150
Zinc	23,000	32.7 L	27	52.8	188 L	108	32.8	209	45.7 L	43.4 L	87.8	9.8 B	104 L	83.9	50.1	110	112
Wet Chemistry																	
% Solids	--	18.4	79.7	NA	25.7	75	NA	NA	7.3	7	NA	NA	11.2	NA	NA	NA	NA
Total organic carbon (TOC) (MG/KG)	--	5,950	2,290	6,724	15,100	5,540	9,540	25,310	21,100	25,000	43,100	3,101	23,700	21,900	22,700	32,360	18,830
pH	--	7.85	8.69	7.72	7.86	6.88	6.67	7.86	7.07	7.22	7.03	7.88	7.38	6.68	6.81	7.43	7.51

Notes:
Exceeds RBC-Soil Residential
LTM - Long-Term Monitoring
RBC - Risk-Based Concentration
J - Reported value is estimated
K - Reported value may be biased high
L - Reported value may be biased low
B - Not detected above the associated blank concentration
R - Unreliable result
U - Not detected

Table 3-3
Sediment Exceedances of Screening Criteria
Rounds 5, 6, and 7 LTM
Site 7 RI
NAB Little Creek
Virginia Beach, Virginia

Station ID	**RBC-Soil Residential**	LS07-SD201			LS07-SD202				LS07-SD203				LS07-SD204				
Sample ID		LS07-SD201-01A	LS07-SD201-01C	LS07-SD201-02A	LS07-SD202-01A	LS07-SD202-01C	LS07-SD202P-01C	LS07-SD202-02A	LS07-SD203-01A	LS07-SD203P-01A	LS07-SD203-01C	LS07-SD203-02A	LS07-SD204-01A	LS07-SD204-01C	LS07-SD204P-01C	LS07-SD204-02A	LS07-SD204P-02A
Sample Date		03/01/01	09/11/01	03/04/02	03/02/01	09/13/01	09/13/01	03/05/02	03/01/01	03/01/01	09/13/01	03/05/02	03/02/01	09/13/01	09/13/01	03/05/02	03/05/02
LTM Round		Round 5	Round 6	Round 7	Round 5	Round 6	Round 6	Round 7	Round 5	Round 5	Round 6	Round 7	Round 5	Round 6	Round 6	Round 7	Round 7
Chemical Name																	

-- No criteria available
NA - Not analyzed

Table 3-3
Sediment Exceedances of Screening Criteria
Rounds 5, 6, and 7 LTM
Site 7 RI
NAB Little Creek
Virginia Beach, Virginia

Station ID	RBC-Soil Residential	LS07-SD205			LS07-SD206			LS07-SD207			LS07-SD208			
Sample ID		LS07-SD205-01A	LS07-SD205-01C	LS07-SD205-02A	LS07-SD206-01A	LS07-SD206-01C	LS07-SD206-02A	LS07-SD207-01A	LS07-SD207-01C	LS07-SD207-02A	LS07-SD208-01A	LS07-SD208P-01A	LS07-SD208-01C	LS07-SD208-02A
Sample Date		03/01/01	09/11/01	03/04/02	03/02/01	09/11/01	03/04/02	03/02/01	09/11/01	03/04/02	03/08/01	03/08/01	09/11/01	03/04/02
LTM Round		Round 5	Round 6	Round 7	Round 5	Round 6	Round 7	Round 5	Round 6	Round 7	Round 5	Round 5	Round 6	Round 7
Chemical Name														
Semivolatile Organic Compounds (UG/KG)														
2-Methylnaphthalene	1,600,000	440 U	410 U	500 U	950 U	410 U	400 U	2,300 U	450 UJ	430 U	1,400 U	NA	640 U	570 U
4-Methylphenol	390,000	440 U	410 U	500 U	130 J	410 U	400 U	2,300 U	450 UJ	430 U	1,400 U	NA	640 U	570 U
Acenaphthene	4,700,000	440 U	410 U	500 U	950 U	410 U	400 U	2,300 U	450 UJ	430 U	1,400 U	NA	640 U	570 U
Acenaphthylene	–	440 U	410 U	500 U	950 U	410 U	400 U	2,300 U	450 UJ	430 U	1,400 U	NA	640 U	20 J
Acetophenone	7,800,000	440 U	410 U	100 B	950 U	410 U	88 B	2,300 U	450 UJ	58 B	1,400 U	NA	962	260 B
Anthracene	23,000,000	440 U	410 U	500 U	170 J	410 U	400 U	2,300 U	450 UJ	430 U	1,400 U	NA	640 U	24 J
Benzaldehyde	7,800,000	440 U	410 U	52 B	130 J	410 U	12 B	2,300 U	450 UJ	12 B	1,400 U	NA	340 J	28 B
Benzo(a)anthracene	870	440 U	410 U	500 U	110 J	410 U	400 U	2,300 U	450 UJ	430 U	1,400 U	NA	640 U	70 J
Benzo(a)pyrene	87	440 U	410 U	500 U	950 U	410 U	400 U	2,300 U	450 UJ	14 J	1,400 U	NA	64 J	60 J
Benzo(b)fluoranthene	870	45 J	410 U	500 U	950 U	410 U	18 J	2,300 U	450 UJ	20 J	190 J	NA	130 J	120 J
Benzo(g,h,i)perylene	2,300,000	440 U	410 U	500 U	950 U	410 U	400 U	2,300 U	450 UJ	430 U	1,400 U	NA	640 U	570 U
Benzo(k)fluoranthene	8,700	440 U	410 U	500 U	100 J	410 U	400 U	2,300 U	450 UJ	430 U	150 J	NA	640 U	89 J
Butylbenzylphthalate	16,000,000	440 U	410 U	500 U	950 U	410 U	400 U	2,300 U	450 UJ	430 U	1,400 U	NA	640 U	570 U
Carbazole	32,000	440 U	410 U	500 U	950 U	410 U	400 U	2,300 U	450 UJ	430 U	1,400 U	NA	640 U	570 U
Chrysene	87,000	440 U	410 U	500 U	200 J	410 U	400 U	2,300 U	450 UJ	430 U	210 J	NA	76 J	100 J
Di-n-butylphthalate	7,800,000	440 U	410 U	500 U	950 U	410 U	400 U	2,300 U	450 UJ	430 U	1,400 U	NA	640 U	570 U
Di-n-octylphthalate	1,600,000	440 UJ	410 U	40 J	950 UJ	410 U	400 U	2,300 UJ	450 UJ	75 J	1,400 U	NA	640 U	56 J
Dibenz(a,h)anthracene	87	440 U	410 U	500 U	950 U	410 U	400 U	2,300 U	450 UJ	430 U	1,400 U	NA	640 U	20 J
Dibenzofuran	310,000	440 U	410 U	500 U	950 U	410 U	400 U	2,300 U	450 UJ	430 U	1,400 U	NA	640 U	570 U
Diethylphthalate	63,000,000	440 U	410 U	500 U	950 U	410 U	400 U	2,300 U	450 UJ	12 J	1,400 U	NA	640 U	570 U
Fluoranthene	3,100,000	58 J	68.4 J	20 J	260 J	410 U	45 J	2,300 U	450 UJ	10 J	580 J	NA	230 J	270 J
Fluorene	3,100,000	440 U	410 U	500 U	950 U	410 U	400 U	2,300 U	450 UJ	430 U	1,400 U	NA	640 U	570 U
Indeno(1,2,3-cd)pyrene	870	440 U	410 U	500 U	950 U	410 U	400 U	2,300 U	450 UJ	11 J	1,400 U	NA	640 U	60 J
Naphthalene	1,600,000	440 U	410 U	500 U	950 U	410 U	400 U	2,300 U	450 UJ	430 U	1,400 U	NA	640 U	570 U
Phenanthrene	2,300,000	440 U	410 U	500 U	950 U	410 U	400 U	2,300 U	450 UJ	430 U	1,400 U	NA	640 U	29 J
Phenol	47,000,000	440 U	410 U	500 U	950 U	410 U	29 J	2,300 U	450 UJ	430 U	1,400 U	NA	130 J	63 J
Pyrene	2,300,000	72 J	55 J	28 J	210 J	410 U	42 J	2,300 U	450 UJ	26 J	440 J	NA	170 J	240 J
bis(2-Ethylhexyl)phthalate	46,000	370 B	410 U	110 B	120 B	410 U	62 B	2,300 U	450 UJ	89 B	1,400 U	NA	66 J	150 B
Pesticide/Polychlorinated Biphenyls (UG/KG)														
4,4'-DDD	2,700	4.4 U	4.1 U	5 U	4.8 U	4.1 U	4 U	4.6 U	4.5 UJ	4.3 U	7.1 U	NA	6.4 U	5.7 UJ
4,4'-DDE	1,900	4.4 U	4.1 U	5 U	4.8 U	4.1 U	4 U	4.6 U	4.5 UJ	4.3 U	7.1 U	NA	6.4 U	5.7 UJ
4,4'-DDT	1,900	4.4 U	4.1 U	5 U	4.8 U	4.1 U	4 U	4.6 U	4.5 UJ	4.3 U	7.1 U	NA	6.4 U	5.7 UJ
Aroclor-1260	320	44 U	41 U	50 U	48 U	41 U	40 U	46 U	45 UJ	43 U	71 U	NA	74 J	57 UJ
Endosulfan I	470,000	2.3 U	2 U	2.6 U	2.5 U	2 U	2 U	2.3 U	2.2 UJ	2.2 U	3.6 U	NA	3.2 U	2.9 UJ
Endrin	23,000	4.4 U	4.1 U	5 U	4.8 U	4.1 U	4 U	4.6 U	4.5 UJ	4.3 U	7.1 U	NA	6.4 U	5.7 UJ
Endrin ketone	23,000	4.4 U	4.1 U	5 U	4.8 U	4.1 U	4 U	4.6 U	4.5 UJ	4.3 U	7.1 U	NA	6.4 U	5.7 UJ
alpha-Chlordane	1,800	2.3 U	2 U	2.6 U	2.5 U	2 U	2 U	2.3 U	2.2 UJ	2.2 U	3.6 U	NA	3.2 U	2.9 UJ
beta-BHC	350	2.3 U	2 U	2.6 U	2.5 U	2 U	2 U	2.3 U	2.2 UJ	2.2 U	3.6 U	NA	3.2 U	2.9 UJ
gamma-Chlordane	1,800	2.3 U	2 U	NA	2.5 U	2 U	NA	2.3 U	2.2 UJ	NA	3.6 U	NA	3.2 U	NA
Total Metals (MG/KG)														
Aluminum	78,000	1,840	2,380	5,600	2,660	1,310	187	490	1,660	2,470	8,510	NA	12,300	5,320
Antimony	31	0.77 R	0.77 UL	0.447 UL	0.67 R	0.77 UL	0.35 UL	0.738 R	0.83 UL	0.378 UL	1.21 R	NA	3.2 UL	0.518 UL
Arsenic	0.43	2.2 B	1.8 L	5.1	2.8	1.6 L	0.396 U	0.97 B	1.4 L	1.3 J	6.5 K	NA	6.5 L	3.7
Barium	5,500	4.4 J	9.5 J	12.4 B	5.5 J	3.8 B	0.81 B	1.6 B	4.1	5.8 B	17 J	NA	32.8 J	14.9 B
Beryllium	160	0.044 U	0.16 J	0.37 B	0.04 B	0.1 J	0.07 U	0.042 U	0.13 B	0.23 B	0.32 B	NA	0.65 J	0.49 B
Cadmium	39	0.088 U	0.08 J	0.089 U	0.077 U	0.07 J	0.07 U	0.084 U	0.09 B	0.076 U	0.21 B	NA	1.6 J	0.33 B
Calcium	–	661 J	9,260	1,350 J	894 B	344 J	70.5 B	149 B	346	448 B	1,180 J	NA	5,090	1,610 J
Chromium	230	4.3	4.8	11.5	5.8	3.4	0.21 UL	1.5 J	4.6	6.8	15.9 L	NA	31.7	12.1
Cobalt	1,600	0.84 B	0.8 J	3 J	1.2 J	0.43 J	0.466 U	0.21 B	0.52	1.2 J	3.6 J	NA	5.6	2.9 J
Copper	3,100	11.2 J	4.4 B	7.7 B	14.7 J	4.4 B	0.42 U	3.6 J	5 L	4 B	34.4 L	NA	43.7 L	16.8 B
Iron	23,000	3,350	3,570	10,900	3,990	1,910	459	727	2,590	4,840	13,300	NA	23,200	12,500
Lead	400	5.4 J	4.4	9.8	6 J	3.8	1.4 K	2 J	5.3	28.9	21.9 J	NA	47.1	21
Magnesium	–	783 J	830 J	2,300	954 B	524 J	134 B	356 B	759	1,180 J	2,680 L	NA	4,240	2,320
Manganese	1,600	18.3	20.8	74.9	26.4	11.8	2 B	4.5 B	15.2	35.5	68 L	NA	172	68.8
Mercury	23	0.03 R	0.02 J	0.08 B	0.03 R	0.011 J	0.061 U	0.03 R	0.02 U	0.059 U	0.12 J	NA	0.196	0.18 B
Nickel	1,600	2.4 B	1.9 J	5.6 B	2.8 B	1.2 J	0.233 U	0.92 B	1.4 B	2.2 B	10 J	NA	15.1	7.1 B
Potassium	–	422 J	526 J	1,410 J	636 B	359 J	95.7 J	196 B	472	644 J	1,990 J	NA	2,520	1,310 J
Selenium	390	0.858 UL	0.9 U	0.566 UL	0.77 J	0.9 U	0.443 UL	0.822 UL	0.97 U	0.479 UL	1.5 B	NA	1.4 U	0.656 UL
Silver	390	1.2 J	0.21 U	0.149 U	0.153 U	0.21 U	0.117 U	0.169 U	0.23 U	0.126 U	0.8 J	NA	0.88 J	0.173 U
Sodium	–	2,120 J	2,020	4,150	2,320 B	1,830	606 B	2,120 B	2,830	2,510	10,600 B	NA	6,860	4,630
Thallium	5.5	1.12 U	1.1 U	0.893 R	0.976 U	1.1 U	0.699 R	1.8 J	1.2 U	0.757 R	1.76 UL	NA	1.8 U	1.04 R
Vanadium	24	5.4 J	6.6 J	16	6.7 J	3.8 J	0.73 J	1.7 J	5	7 J	21.9 L	NA	34.8	17.3
Zinc	23,000	38.2 L	26.9	30	38.5 L	20.4	3.1 J	8.7 B	19.7	33.1	137 L	NA	351	103
Wet Chemistry														
% Solids	–	8.1	81.4	NA	17.8	81.5	NA	3.3	NA	NA	48	59.1	52.4	NA
Total organic carbon (TOC) (MG/KG)	–	4,520	2,300	6,566	4,380	2,680	2,615	2,690	2,580	2,790	23,300	NA	20,400	17,780
pH	–	7.67	8.62	8.19	7.23	8.37	7.55	6.89	8.12	7.94	7.79	NA	8.47	8.32

Notes:
Exceeds RBC-Soil Residential
LTM - Long-Term Monitoring
RBC - Risk-Based Concentration
J - Reported value is estimated
K - Reported value may be biased high
L - Reported value may be biased low
B - Not detected above the associated blank concentration
R - Unreliable result
U - Not detected

Table 3-3
Sediment Exceedances of Screening Criteria
Rounds 5, 6, and 7 LTM
Site 7 RI
NAB Little Creek
Virginia Beach, Virginia

Station ID	**RBC-Soil Residential**	LS07-SD205			LS07-SD206			LS07-SD207			LS07-SD208			
Sample ID		LS07-SD205-01A	LS07-SD205-01C	LS07-SD205-02A	LS07-SD206-01A	LS07-SD206-01C	LS07-SD206-02A	LS07-SD207-01A	LS07-SD207-01C	LS07-SD207-02A	LS07-SD208-01A	LS07-SD208P-01A	LS07-SD208-01C	LS07-SD208-02A
Sample Date		03/01/01	09/11/01	03/04/02	03/02/01	09/11/01	03/04/02	03/02/01	09/11/01	03/04/02	03/08/01	03/08/01	09/11/01	03/04/02
LTM Round		Round 5	Round 6	Round 7	Round 5	Round 6	Round 7	Round 5	Round 6	Round 7	Round 5	Round 5	Round 6	Round 7
Chemical Name														

-- No criteria available
NA - Not analyzed

Table 3-3
Sediment Exceedances of Screening Criteria
Rounds 5, 6, and 7 LTM
Site 7 RI
NAB Little Creek
Virginia Beach, Virginia

Station ID	RBC-Soil Residential	LS07-SD209			LS07-SD210			LS07-SD211			LS07-SD212				LS07-SD213		
Sample ID		LS07-SD209-01A	LS07-SD209-01C	LS07-SD209-02A	LS07-SD210-01A	LS07-SD210-01C	LS07-SD210-02A	LS07-SD211-01A	LS07-SD211-01C	LS07-SD211-02A	LS07-SD212-01A	LS07-SD212P-01A	LS07-SD212-01C	LS07-SD212-02A	LS07-SD213-01A	LS07-SD213-01C	LS07-SD213-02A
Sample Date		03/08/01	09/11/01	03/04/02	03/02/01	09/10/01	03/04/02	03/08/01	09/13/01	03/05/02	03/08/01	03/08/01	09/13/01	03/05/02	03/08/01	09/13/01	03/05/02
LTM Round		Round 5	Round 6	Round 7	Round 5	Round 6	Round 7	Round 5	Round 6	Round 7	Round 5	Round 5	Round 6	Round 7	Round 5	Round 6	Round 7
Chemical Name																	
Semivolatile Organic Compounds (UG/KG)																	
2-Methylnaphthalene	1,600,000	2,300 U	600 U	20 J	2,700 U	410 U	540 U	2,400 U	490 U	410 R	930 U	2,200 U	460 U	38 J	430 U	450 U	420 U
4-Methylphenol	390,000	2,300 U	600 U	630 U	2,700 U	410 U	540 U	2,400 U	490 U	410 U	930 U	2,200 U	460 U	540 U	430 U	450 U	420 U
Acenaphthene	4,700,000	2,300 U	600 U	210 J	2,700 U	410 U	540 U	2,400 U	490 U	410 R	930 U	2,200 U	460 U	540 U	430 U	450 U	420 U
Acenaphthylene	–	2,300 U	600 U	24 J	2,700 U	410 U	540 U	2,400 U	490 U	410 R	930 U	2,200 U	460 U	540 U	430 U	450 U	420 U
Acetophenone	7,800,000	2,300 U	270 J	64 B	2,700 U	71 J	110 B	2,400 U	490 U	33 B	930 U	2,200 U	460 U	29 B	430 U	450 U	19 B
Anthracene	23,000,000	2,300 U	600 U	44 J	2,700 U	410 U	540 U	2,400 U	490 U	410 R	930 U	2,200 U	62 J	26 J	430 U	450 U	420 U
Benzaldehyde	7,800,000	2,300 U	100 J	14 B	2,700 U	43 J	19 B	2,400 U	490 U	11 B	930 U	2,200 U	460 U	25 B	430 U	450 U	13 B
Benzo(a)anthracene	870	2,300 U	600 U	120 J	2,700 U	410 U	20 J	2,400 U	120 J	410 R	930 U	570 J	190 J	77 J	430 U	450 U	420 U
Benzo(a)pyrene	87	2,300 U	600 U	75 J	2,700 U	410 U	13 J	2,400 U	71 J	410 R	930 U	570 J	150 J	68 J	430 U	450 U	420 U
Benzo(b)fluoranthene	870	2,300 U	140 J	160 J	2,700 U	41 J	27 J	2,400 U	100 J	410 R	930 U	570 J	230 J	85 J	430 U	450 U	420 U
Benzo(g,h,i)perylene	2,300,000	2,300 U	600 U	630 U	2,700 U	410 U	540 U	2,400 U	490 U	410 R	930 U	2,200 U	110 J	540 U	430 U	450 U	420 U
Benzo(k)fluoranthene	8,700	2,300 U	600 U	94 J	2,700 U	410 U	540 U	2,400 U	490 U	410 R	930 U	540 J	60 J	63 J	430 U	450 U	420 U
Butylbenzylphthalate	16,000,000	2,300 U	600 U	630 U	2,700 U	410 U	540 U	2,400 U	490 U	410 R	930 U	2,200 U	460 U	540 U	430 U	450 U	420 U
Carbazole	32,000	2,300 U	600 U	630 U	2,700 U	410 U	540 U	2,400 U	490 U	410 R	930 U	2,200 U	460 U	540 U	430 U	450 U	420 U
Chrysene	87,000	2,300 U	68 J	160 J	2,700 U	410 U	32 J	2,400 U	85 J	410 R	110 J	730 J	170 J	91 J	430 U	450 U	420 U
Di-n-butylphthalate	7,800,000	2,300 U	600 U	630 U	2,700 U	410 U	540 U	2,400 U	490 U	410 R	930 U	2,200 U	460 U	540 U	430 U	50 J	420 U
Di-n-octylphthalate	1,600,000	2,300 U	600 U	630 U	2,700 UJ	410 U	540 U	2,400 U	490 U	410 R	930 U	2,200 U	460 U	160 J	430 U	450 U	420 U
Dibenz(a,h)anthracene	87	2,300 U	600 U	630 U	2,700 U	410 U	540 U	2,400 U	490 U	410 R	930 U	2,200 U	460 U	25 J	430 U	450 U	420 U
Dibenzofuran	310,000	2,300 U	600 U	25 J	2,700 U	410 U	540 U	2,400 U	490 U	410 R	930 U	2,200 U	460 U	23 J	430 U	450 U	420 U
Diethylphthalate	63,000,000	2,300 U	600 U	630 U	2,700 U	410 U	540 U	2,400 U	490 U	410 R	930 U	2,200 U	460 U	540 U	430 U	450 U	420 U
Fluoranthene	3,100,000	490 J	140 J	640	2,700 U	50 J	47 J	2,400 U	87 J	410 R	140 J	1,100 J	350 J	180 J	430 U	450 U	420 U
Fluorene	3,100,000	2,300 U	600 U	630 U	2,700 U	410 U	540 U	2,400 U	490 U	410 R	930 U	2,200 U	460 U	18 J	430 U	450 U	420 U
Indeno(1,2,3-cd)pyrene	870	2,300 U	600 U	61 J	2,700 U	410 U	540 U	2,400 U	490 U	410 R	930 U	250 J	93 J	46 J	430 U	450 U	420 U
Naphthalene	1,600,000	2,300 U	600 U	63 J	2,700 U	410 U	540 U	2,400 U	490 U	410 R	930 U	2,200 U	460 U	19 J	430 U	450 U	420 U
Phenanthrene	2,300,000	2,300 U	600 U	44 J	2,700 U	410 U	540 U	2,400 U	490 U	410 R	120 J	680 J	240 J	94 J	430 U	450 U	420 U
Phenol	47,000,000	2,300 U	600 U	630 U	2,700 U	410 U	540 U	2,400 U	490 U	410 U	930 U	2,200 U	460 U	540 U	430 U	450 U	420 U
Pyrene	2,300,000	370 J	166 U	480 J	2,700 U	50 J	53 J	2,400 U	82 J	410 R	150 J	1,000 J	320 J	160 J	430 U	450 U	420 U
bis(2-Ethylhexyl)phthalate	46,000	2,300 U	69 J	110 B	2,700 U	43 J	130 B	2,400 U	490 U	48 B	930 U	2,200 U	120 J	160 B	430 U	450 U	48 B
Pesticide/Polychlorinated Biphenyls (UG/KG)																	
4,4'-DDD	2,700	4.6 U	6 U	6.3 U	5.3 UJ	4.1 U	5.4 U	4.8 U	4.9 U	4.1 U	4.7 U	4.5 U	4.6 U	5.4 U	4.2 U	4.5 U	4.2 U
4,4'-DDE	1,900	4.6 U	6 U	6.3 U	5.3 UJ	4.1 U	5.4 U	4.8 U	4.9 U	4.1 U	4.7 U	4.5 U	4.6 U	3 J	4.2 U	4.5 U	4.2 U
4,4'-DDT	1,900	4.6 U	6 U	6.3 U	5.3 UJ	4.1 U	5.4 U	4.8 U	4.9 U	4.1 U	4.7 U	4.5 U	4.6 U	5.4 U	4.2 U	4.5 U	4.2 U
Aroclor-1260	320	46 U	100 J	37 J	53 UJ	41 U	54 U	48 U	49 U	41 U	44 J	51 J	46 U	78	42 U	45 U	42 U
Endosulfan I	470,000	2.4 U	3 U	3.3 U	2.7 UJ	2 U	2.8 U	2.5 U	2.4 U	2.1 U	2.4 U	2.3 U	2.3 U	2.8 U	2.2 U	2.2 U	2.2 U
Endrin	23,000	4.6 U	6 U	6.3 U	5.3 UJ	4.1 U	5.4 U	4.8 UL	4.9 U	4.1 U	4.7 U	4.5 U	4.6 U	5.4 U	4.2 U	4.5 U	4.2 U
Endrin ketone	23,000	4.6 U	6 U	6.3 U	5.3 UJ	4.1 U	5.4 U	12	4.9 U	4.1 U	4.7 U	4.5 U	4.6 U	5.4 U	4.2 U	4.5 U	4.2 U
alpha-Chlordane	1,800	2.4 U	3 U	3.3 U	2.7 UJ	2 U	2.8 U	2.5 U	2.4 U	2.1 U	2.4 U	2.3 U	2.3 U	2.8 U	2.2 U	2.2 U	2.2 U
beta-BHC	350	2.4 U	3 U	3.3 U	2.7 UJ	2 U	2.8 U	2.5 U	2.4 U	2.7	2.4 U	2.3 U	2.3 U	4.1 J	2.2 U	2.2 U	8.7 J
gamma-Chlordane	1,800	2.4 U	3 U	NA	2.7 UJ	2 U	NA	2.5 U	2.4 U	NA	2.4 U	2.3 U	2.3 U	NA	2.2 U	2.2 U	NA
Total Metals (MG/KG)																	
Aluminum	78,000	3,810	14,000	9,150	8,430	1,490	10,600	2,210	2,610	933	4,490	3,350	3,260	3,650	3,880	2,860	658
Antimony	31	0.82 R	1.1 UL	0.577 UL	0.949 R	0.73 UL	0.493 UL	0.723 R	0.93 UL	0.365 UL	0.867 R	0.863 R	0.91 U	0.489 UL	0.636 R	0.84 UL	0.378 UL
Arsenic	0.43	3.2 K	9.2 L	6.2	6.5	1.2 L	8.2	5.3 K	3.4 L	1.5 J	8 K	7.5 K	7.3	9.8	4.5 K	4.6 L	8.5
Barium	5,500	11.5 J	33.1 J	24.6 J	14.6 J	4.3 J	21.5 J	8.1 J	9.6 J	5.9 B	15.9 J	14.1 J	16 J	16.2 B	11.9 J	8.6 J	2.9 B
Beryllium	160	0.1 B	0.71 J	0.62 B	0.31 B	0.15 J	0.64 B	0.2 B	0.18 B	0.15 B	0.29 B	0.22 B	0.27 J	0.47 B	0.05 B	0.13 B	0.15 B
Cadmium	39	0.1 B	0.484 J	0.59 B	0.108 U	0.07 J	0.12 B	0.083 U	0.08 B	0.073 U	0.099 U	0.099 U	0.25 J	0.31 B	0.073 U	0.07 U	0.076 U
Calcium	–	2,720 L	4,600	2,800	1,350 B	333 J	1,230 J	519 J	622 J	290 B	866 J	883 J	911 J	881 B	149 J	380 J	180 B
Chromium	230	8.6 L	28	22.8	15.4	3.9	22.5	6.8 L	6.5	2.4 B	12 L	14.1 L	12.9	11.2	4.4 L	4.1	0.56 B
Cobalt	1,600	1.8 J	6.2 J	4.8 J	3.5 J	0.71 J	5 J	2 J	1.4 J	0.9 J	2.8 J	2.6 J	2.7 J	3.4 J	2.4 J	1.9 J	0.505 U
Copper	3,100	17.5 L	25.8 L	23.9 B	15.9 J	5.7 B	11 B	30.5 L	12.1 L	11.1 B	46.6 L	47.9 L	95	49.2 B	5.5 L	6.9 L	2.4 B
Iron	23,000	7,400	22,800	19,800	13,700	3,290	21,000	6,840	5,410	3,090	11,300	9,830	12,100	14,000	3,160	3,420	3,490
Lead	400	11.5 J	26.6	25.3	9.4 J	5.9	14.1	27.7 J	11.4	7.7	29.6 J	55.4 J	36.8 K	30.3	7.6 J	9.5	4.1
Magnesium	–	1,200 L	4,540	4,410	2,640 B	624 J	4,540	684 J	937 J	474 J	1,080 J	937 J	1,060 J	1,530 J	321 J	442 J	219 J
Manganese	1,600	50.5 L	149	156	102	18.3	164	33.9 L	23.8	22.5	56.1 L	53.4 L	50.6	66	13.7 L	17.2	7.9
Mercury	23	0.08 J	0.201	0.12 B	0.04 R	0.022	0.093 B	0.1 B	0.03	0.052 U	0.1 B	0.1 B	0.04	0.078 U	0.06 B	0.01 U	0.061 U
Nickel	1,600	5.1 J	15.6	11.9 J	8.3 J	1.7 J	12.1 J	10 L	2.9 J	2.2 B	9.5 J	8.2 J	10.5	9.5 J	2.6 J	1.9 B	0.252 U
Potassium	–	893 J	2,730	2,230	1,670 B	379 J	2,610	476 J	571 J	298 J	764 J	593 J	571 J	760 J	188 B	234 J	92.4 B
Selenium	390	0.914 UL	1.3 U	0.731 UL	1.2 J	0.86 U	0.625 UL	0.805 UL	1.1 U	0.462 UL	0.966 UL	0.961 UL	1.6 K	0.75 J	0.708 UL	0.98 U	0.479 UL
Silver	390	0.188 R	0.31 U	0.192 U	0.217 U	0.2 U	0.164 U	0.165 R	0.26 U	0.122 U	0.198 R	0.197 R	0.25 U	0.163 U	0.145 R	0.23 U	0.126 U
Sodium	–	5,010 B	6,350	5,980	3,650 B	1,810	6,440	3,940 B	2,690	1,250	4,000 B	3,900 B	1,950	2,980	2,340 B	515 J	285 B
Thallium	5.5	1.2 J	1.6 U	1.15 R	1.38 U	1.1 U	0.987 R	1.05 UL	1.4 U	0.73 R	1.26 UL	1.26 UL	1.3 U	0.977 R	0.926 UL	1.2 U	0.757 R
Vanadium	24	11.6 J	33.8	25.6	19.8	5.3 J	29.2	18.2 L	10.3 J	7.4 J	24.9 L	24.2 L	31.1	29.1	8.7 J	7.1 J	3.3 J
Zinc	23,000	79.1 L	150	156	39.2 L	26.5	49.9	110 L	41.9	47.6 B	174 L	164 L	171	211	11.4 L	13.3	14.3 B
Wet Chemistry																	
% Solids	–	26.7	55.2	NA	70.3	82	NA	11.2	NA	NA	17.9	NA	NA	NA	19.5	NA	NA
Total organic carbon (TOC) (MG/KG)	–	11,600	14,400	14,860	9,410	3,140	24,040	10,300	12,800	4,265	29,300	11,300	28,700	30,370	3,660	5,570	7,713
pH	–	7.53	8.49	8.02	7.38	8.48	7.97	7.62	6.98	7.31	7.54	7.45	3.96	7.92	6.16	6.04	7.44

Notes:
Exceeds RBC-Soil Residential
LTM - Long-Term Monitoring
RBC - Risk-Based Concentration
J - Reported value is estimated
K - Reported value may be biased high
L - Reported value may be biased low
B - Not detected above the associated blank concentration
R - Unreliable result
U - Not detected

Table 3-3
Sediment Exceedances of Screening Criteria
Rounds 5, 6, and 7 LTM
Site 7 RI
NAB Little Creek
Virginia Beach, Virginia

Station ID	**RBC-Soil Residential**	LS07-SD209			LS07-SD210			LS07-SD211			LS07-SD212				LS07-SD213		
Sample ID		LS07-SD209-01A	LS07-SD209-01C	LS07-SD209-02A	LS07-SD210-01A	LS07-SD210-01C	LS07-SD210-02A	LS07-SD211-01A	LS07-SD211-01C	LS07-SD211-02A	LS07-SD212-01A	LS07-SD212P-01A	LS07-SD212-01C	LS07-SD212-02A	LS07-SD213-01A	LS07-SD213-01C	LS07-SD213-02A
Sample Date		03/08/01	09/11/01	03/04/02	03/02/01	09/10/01	03/04/02	03/08/01	09/13/01	03/05/02	03/08/01	03/08/01	09/13/01	03/05/02	03/08/01	09/13/01	03/05/02
LTM Round		Round 5	Round 6	Round 7	Round 5	Round 6	Round 7	Round 5	Round 6	Round 7	Round 5	Round 5	Round 6	Round 7	Round 5	Round 6	Round 7
Chemical Name																	

-- No criteria available
NA - Not analyzed

Table 3-4
Surface Soil Exceedances of Screening Criteria
Round 5 LTM
Site 7 RI
NAB Little Creek
Virginia Beach, Virginia

Station ID	RBC-Soil Residential	Background - 95% UTL for Dredge Fill	LS07-SS201		LS07-SS202	LS07-SS203
Sample ID			LS07-SS201-00	LS07-SS201P-00	LS07-SS202-00	LS07-SS203-00
Sample Date			02/28/01	02/28/01	02/28/01	02/28/01
Chemical Name						
Semivolatile Organic Compounds (UG/KG)						
Benzo(b)fluoranthene	870	--	50 J	80 J	360 U	420 U
Benzo(k)fluoranthene	8,700	--	400 U	45 J	360 U	420 U
Chrysene	87,000	--	45 J	70 J	360 U	420 U
Pesticide/Polychlorinated Biphenyls (UG/KG)						
Aroclor-1254	320	--	38 U	43 U	36 U	60
Aroclor-1260	320	--	38 U	43 U	36 U	99 J
alpha-Chlordane	1,800	--	2 U	2.2 U	1.9 U	20
gamma-Chlordane	1,800	--	2 U	2.2 U	1.9 U	15
Total Metals (MG/KG)						
Aluminum	78,000	8,500	6,180	4,660	2,070	5,800
Antimony	31	--	1.1 J	0.841 UL	0.647 UL	1.9 J
Arsenic	0.43	5.6	4.1	4.6	2.3 B	3.7 B
Barium	5,500	69	24.3 J	18.6 J	7.8 J	31.1 J
Calcium	--	1,817	441 J	426 J	515 J	400 J
Chromium	230	20	14 J	11 J	4.8 J	13.4 J
Cobalt	1,600	5.1	2 J	1.4 J	0.62 B	1.7 J
Copper	3,100	--	37.9 J	32.8 J	6.5 J	55.4 J
Cyanide	1,600	--	0.07 U	0.07 U	0.09 J	0.09 U
Iron	23,000	15,000	8,840	7,910	3,310	7,540
Lead	400	110	41.9 J	40 J	11.8 J	143 J
Magnesium	--	1,347	949 J	795 J	435 J	369 J
Manganese	1,600	267	34.9 K	27.9 K	19.6 K	28 K
Mercury	23	--	0.03 U	0.03 U	0.03 J	0.2
Nickel	1,600	9.5	6.8 J	5.7 J	2.2 B	12.1
Potassium	--	1,435	666 J	631 J	434 J	276 B
Selenium	390	--	0.93 J	0.937 UL	0.721 UL	0.834 UL
Sodium	--	623	422 J	300 J	132 B	116 B
Thallium	5.5	--	1.20 U	1.23 U	1 J	1.09 U
Vanadium	24	34.3	26	23	10	21.6
Zinc	23,000	123	55.2	48.4 B	13.2 B	146

Notes:

Exceeds RBC-Soil Residential

Exceeds Background UTL

There were no exceedances of both RBC-Soil Residential and Background 95% UTL for Dredge Fill.

LTM - Long-Term Monitoring

RBC - Risk-Based Concentration

UTL - Upper Tolerance Limit

B - Not detected above the associated blank concentration

J - Reported value is estimated

K - Reported value may be biased high

L - Reported value may be biased low

U - Analyte not detected

Table 3-4
Surface Soil Exceedances of Screening Criteria
Round 5 LTM
Site 7 RI
NAB Little Creek
Virginia Beach, Virginia

Station ID	**RBC-Soil Residential**	**Background - 95% UTL for Dredge Fill**	LS07-SS201		LS07-SS202	LS07-SS203
Sample ID			LS07-SS201-00	LS07-SS201P-00	LS07-SS202-00	LS07-SS203-00
Sample Date			02/28/01	02/28/01	02/28/01	02/28/01
Chemical Name						

-- No criteria available

Table 3-5
Subsurface Soil Exceedances of Screening Criteria
Round 5 LTM
Site 7 RI
NAB Little Creek
Virginia Beach, Virginia

Station ID	**RBC-Soil Residential**	**Background - 95% UTL for Dredge Fill**	LS07-SB201	LS07-SB202	LS07-SB203
Sample ID			LS07-SB201-02	LS07-SB202-02	LS07-SB203-02
Sample Date			02/28/01	02/28/01	02/28/01
Chemical Name					
Semivolatile Organic Compounds (UG/KG)					
No Detections					
Pesticide/Polychlorinated Biphenyls (UG/KG)					
4,4'-DDD	2,700	--	4.6	3.5 U	20
4,4'-DDE	1,900	240	10	3.5 U	5.8 J
Aroclor-1242	320	--	50	35 U	41 U
Aroclor-1254	320	--	42 U	35 U	110
Aroclor-1260	320	--	42 U	35 U	110
alpha-Chlordane	1,800	--	2.2 U	1.8 U	16
gamma-Chlordane	1,800	--	2.2 U	1.8 U	15
Total Metals (MG/KG)					
Aluminum	78,000	8,500	7,510	1,450	4,170
Antimony	31	--	0.809 UL	0.556 UL	1.3 J
Barium	5,500	69	54.6	3.8 J	76.3
Beryllium	160	0.6	2.3	0.032 U	2.8
Calcium	--	1,817	2,470	1,180	1,590
Chromium	230	20	21.7 J	3.3 J	22.4 J
Cobalt	1,600	5.1	9.2 J	0.89 B	14.8
Copper	3,100	--	747 J	3.5 J	396 J
Iron	23,000	15,000	21,800	1,950	12,300
Lead	400	16.4	218 J	2.1 J	289 J
Magnesium	--	1,347	1,170 L	295 J	475 J
Manganese	1,600	267	133 K	26.2 K	126 K
Mercury	23	--	0.03 J	0.02 U	0.12
Nickel	1,600	9.5	43.6	2.9 B	116
Potassium	--	1,435	1,080 J	237 B	213 B
Selenium	390	--	0.902 UL	0.619 UL	0.8 J
Sodium	--	623	515 J	53.8 B	784 J
Vanadium	24	34.3	23.5	4 J	14.7
Zinc	23,000	39	806	14.7 B	1,540

Notes:

Exceeds RBC-Soil Residential

Exceeds Background UTL

LTM - Long-Term Monitoring

RBC - Risk-Based Concentration

UTL - Upper Tolerance Limit

B - Not detected above the associated blank concentration

J - Reported value is estimated

K - Reported value may be biased high

L - Reported value may be biased low

Table 3-5
Subsurface Soil Exceedances of Screening Criteria
Round 5 LTM
Site 7 RI
NAB Little Creek
Virginia Beach, Virginia

Station ID	**RBC-Soil Residential**	**Background - 95% UTL for Dredge Fill**	LS07-SB201	LS07-SB202	LS07-SB203
Sample ID			LS07-SB201-02	LS07-SB202-02	LS07-SB203-02
Sample Date			02/28/01	02/28/01	02/28/01
Chemical Name					

U - Analyte not detected
-- No criteria available

SECTION 4

Human Health Risk Assessment

4.1 Introduction

Section 4 presents the results of the human health risk assessment for Site 7, NAB Little Creek. This risk assessment was prepared using conservative assumptions. Exposure pathways were evaluated for current and potential future site use based on current site conditions. The risk assessment incorporates the general methodology described in *Risk Assessment Guidance for Superfund (RAGS), Volume 1, Human Health Evaluation Manual, Part A* (USEPA, 1989) and *Part D* (USEPA, 1998), and USEPA Region III Technical Guidance Manuals for Risk Assessment. Many of the interim deliverables required for *RAGS Part D* (USEPA, 1998) were submitted to USEPA as they were completed. The interim deliverables are included in Appendix E as Tables 1 through 6, along with the additional tables required for *RAGS Part D*, Tables 7 through 10.

The results of this baseline human health risk assessment will be used to:

- Document if there is a potential for risks to human health that may warrant further action
- Assist in identifying the areas and media that may need to be remediated
- Provide a basis for selecting action levels and remediation goals

Section 4 ends with a summary of the risk assessment results. The preliminary remediation goals (PRGs) will be developed as part of the feasibility study.

4.1.1 Site Overview

This section provides a brief overview of NAB Little Creek and Site 7. More detailed information is presented in Section 2.

Site 7, the Amphibious Base Landfill, is about 38 acres and is located in the south-central portion of the installation. The area is bounded on the north by the southeast shoreline of Little Creek Cove, on the east by Helicopter Road, on the south by Amphibious Drive and the HRSD sewage treatment plant, and on the west by an undeveloped area and an ordnance magazine. The area was originally an arm of Little Creek Cove that was filled with dredge spoils prior to its use as a landfill. A chain link fence borders the landfill to the east and south, and Little Creek Cove borders the northern side of the site. Two entrances with locked gates and a gravel access road control access to the site. Restricted access signs are in place around the perimeter of the site.

The current appearance of the landfill ranges from small stands of mature trees on the western portion of the site to tall, thick grasses in the central and eastern portions of the site. The area bordering Little Creek Cove is well vegetated, with numerous trees, dense brush, and tall grasses. All of the visible debris has been removed from the landfill surface and additional cover soil and topsoil were added to the site's open areas in May 1998. The landfill was constructed so that the central portion is comprised of a broad flat area bounded by gentle slopes on all sides.

4.1.2 Conceptual Model

The conceptual exposure model presents an overview of site conditions, potential contaminant migration pathways, and exposure pathways to potential receptors. Figure 4-1 presents the conceptual exposure model for Site 7. This figure identifies the potential contaminant migration pathways and the potential exposure pathways by which a human receptor may contact site-related constituents. Table 1 in Appendix E presents an evaluation of the potential exposure pathways and scenarios for Site 7 and identifies the pathways that were chosen for evaluation in the risk assessment and the rationale for these choices.

As shown on Figure 4-1, the main sources of constituents at Site 7 are the materials disposed in the landfill. Most of the waste in the landfill is presumed to be composed of non-hazardous solid waste from base housing and other residential and commercial activities at the installation. However, because the landfill received all waste generated by NAB Little Creek during its operation, it is likely that it also received potentially hazardous materials. Waste oils and metals were placed in the landfill starting in 1970. Potential receptors of contamination present at and migrating from the landfill include current maintenance workers, current and future site workers, current and future trespassers/visitors, future residents, future industrial workers, and future construction workers. The potential pathways by which these receptors could become exposed to contaminants in soil, surface water, sediment, or groundwater are depicted in Figure 4-1. A detailed description of potential exposure pathways for each receptor population is presented in Section 4.2.2.3.

Exposure to surface soil and subsurface soil was evaluated separately for four different areas within Site 7: the weigh station area, "the ear" to the west of the landfill, the perimeter of the site, and the area of the landfill covered with clean fill. These areas were evaluated separately because exposure may occur individually at each of these areas rather than to the soil throughout the entire site. Exposure to surface water and sediment was evaluated separately for four different areas on or adjacent to Site 7, specifically the canal on the west side of Site 7, the canal on the east side of Site 7, the Pond, and Little Creek Cove. As with the soil, exposure to these areas may occur individually rather than to surface water and sediment throughout the entire site.

Detailed discussions of the nature and extent of contamination and the potential contaminant migration pathways are presented in Section 3. Such information has been used to identify potential human receptors and exposure pathways, which is presented in Section 4.3.

4.1.3 Scope of Human Health Risk Assessment

The primary objective of the human health risk assessment is to assess the potential health risks to current and future human receptors as a result of exposure to contamination present at and migrating from Site 7 under current site conditions. The risk assessment is comprised of the following components:

- **Identification of Chemicals of Potential Concern**—Identification and selection of the chemicals of potential concern (COPCs) based on constituents detected at the site. COPCs represent the subset of all chemicals detected at the site that provide the largest contribution to total site risks.

- **Exposure Assessment**—Identification of the potential pathways for human exposure and estimation of the magnitude, frequency, and duration of these exposures.
- **Toxicity Assessment**—Assessment of the potential adverse effects of the COPCs and development of toxicity values used to develop numerical risk estimates.
- **Risk Characterization**—Integration of the results of the exposure assessment and toxicity assessment to develop numerical risk estimates and to characterize the potential health risks associated with exposure to site-related constituents.
- **Uncertainty Assessment**—Identification and discussion of sources of uncertainty in the risk assessment. This is the most conservative exposure scenario to be evaluated for unrestricted land-use.

The risk assessment is based on the following major assumptions:

- No additional remediation is implemented at the site.
- Concentrations remain constant during the exposure periods.
- Future use of the site may include residential (including residential use of the groundwater).

4.2 Identification of COPCs

The identification of COPCs includes the collection, evaluation, and screening of data. Data collection and evaluation involve gathering and reviewing the available site information and developing a data set of acceptable quality for risk assessment. Once the data collection and evaluation are completed, the data are further screened to focus on those constituents that need to be evaluated quantitatively in the risk assessment.

Section 4.2.1 identifies the data set used for the risk assessment. Section 4.2.2 discusses the screening methodology used to reduce the risk assessment data set to the constituents of primary concern with respect to human health. Section 4.2.3 identifies the COPCs that were quantitatively assessed in the risk assessment.

4.2.1 Data Summary and Evaluation

Foster Wheeler Environmental Services (FWES) performed a Remedial Investigation/ Feasibility Study (FWES, 1994) for Site 7 in 1994. Groundwater, surface and subsurface soil, surface water, and sediment samples were collected at the site.

NAB Little Creek, including Site 7, was placed on the National Priorities List (NPL) in 1999. This required the collection of additional data and the preparation of an amendment to the FWES RI/FS. Since 1998, five rounds of groundwater, surface water, and sediment sampling have been conducted. The most recent data were collected in February 2002. In February 2001, surface and subsurface soil samples were collected from the weigh station area, the east side of the landfill, and the area to the west of the landfill.

Table 4-1 lists the samples collected from each medium that were evaluated in the risk assessment. Data from the three most recent sampling events, Rounds 5, 6, and 7 that included groundwater, surface water, and sediment sampling, were included in the risk assessment. These sampling events were conducted in February/March 2001, October 2001,

and February 2002. The groundwater, surface water, and sediment data collected prior to these dates were not included in the risk assessment because these more recent samples are most representative of current site conditions for these media. Soil data collected during the FWES RI/FS and during the February 2002 sampling event were evaluated in the risk assessment.

4.2.1.1 Surface and Subsurface Soil

Soil data were separated into four exposure groupings based on location and expected exposure for evaluation in the human health risk assessment. Soil samples collected from the weigh station area, the area to the west of the landfill, the perimeter of the site, and the area of the landfill covered with clean fill were evaluated separately. Figure 2-3 identifies the locations of the surface and subsurface soil samples collected at Site 7. The soil data evaluated in the risk assessment are included in Section 3, Tables 3-4 and 3-5, and Appendixes B through D.

4.2.1.2 Groundwater

Shallow aquifer groundwater data collected during Rounds 5, 6, and 7 were evaluated in the risk assessment. Both filtered and unfiltered samples were analyzed for inorganic constituents. Following USEPA guidance (USEPA, 1992b), data from the unfiltered samples were used to evaluate the potable water exposure scenarios (residential and industrial scenarios) and the direct contact scenario (construction worker scenario). Figure 3-1 identifies the locations of the monitoring wells sampled at Site 7. The groundwater data evaluated in the risk assessment are included in Section 3, Table 3-1, and Appendixes B through D.

4.2.1.3 Surface Water

Surface water data were separated into four exposure groupings, based on location and expected exposure, for evaluation in the risk assessment. Surface water samples collected from the canal on the west side of Site 7, the canal on the east side of Site 7, the Pond, and Little Creek Cove were evaluated separately. Surface water samples collected during Rounds 5, 6, and 7 were evaluated in the risk assessment because these data are most representative of current conditions (as opposed to the data collected during the previous rounds). Figure 3-2 identifies the locations of the surface water samples collected at Site 7. The surface water data evaluated in the risk assessment are included in Section 3, Table 3-2, and Appendixes B through D.

4.2.1.4 Sediment

As with the surface water, sediment data were separated into four exposure groupings for evaluation in the risk assessment. Sediment samples collected from the canal on the west side of Site 7, the canal on the east side of Site 7, the Pond, and Little Creek Cove were evaluated separately. Sediment samples collected during Rounds 5, 6, and 7 were evaluated in the risk assessment because these data are most representative of current conditions. Figure 3-3 identifies the locations of the sediment samples collected at Site 7. The sediment data evaluated in the risk assessment are included in Section 3, Table 3-3, and Appendixes B through D.

4.2.2 Selection of COPCs

All of the constituents detected in the data used for the risk assessment were screened following the procedures described below. The purpose of the screening was to focus the list of detected constituents on those of greatest potential concern for human health. The constituents that were selected as COPCs were evaluated quantitatively in the risk assessment. Constituents that were not detected in any of the samples were not retained as COPCs.

The selection of COPCs was based on the criteria presented in USEPA Region III guidelines (USEPA, 1993) and USEPA's *RAGS Part D* (USEPA, 1998). The maximum concentration of each detected constituent in each media grouping was compared to the criteria discussed below to select the COPCs by media grouping. If the maximum concentration of a constituent exceeded the criteria, the constituent was selected as a COPC. Appendix E includes the tables used to screen the Site 7 data (Table 2-1 through 2-26).

Constituents detected in each media grouping were selected or eliminated as COPCs based on the following comparisons:

- Soil data were compared to the USEPA Region III RBCs for residential soil (USEPA, 2003a). RBCs that are based on noncarcinogenic effects were divided by 10 to account for exposure to multiple constituents. RBCs based on carcinogenic effects were used as presented in the RBC table. Constituents with a maximum detected concentration below the RBC were not retained as COPCs. Lead concentrations in soil were compared to the USEPA residential child soil screening value of 400 mg/kg as determined by the Integrated Exposure Uptake Biokinetic (IEUBK) Model. If the lead concentration exceeded the screening value, it was evaluated quantitatively for the site worker using the adult lead model and quantitatively for the resident using the IEUBK model.

- Soil data were also compared to the USEPA Region III Soil Screening Levels (SSLs) based on a Dilution and Attenuation Factor (DAF) of 20 (USEPA, 2003a) to determine if soil is a potential concern based on the transport pathway of soil to groundwater. However, the results of this comparison were not used to select COPCs, but are discussed qualitatively in Section 4.3.2.2.

- Air concentrations were estimated from the soil data using the methodology presented in USEPA's *Soil Screening Guidance*, (USEPA, 1996a). These calculated air concentrations were compared to the USEPA Region III RBCs for ambient air (USEPA, 2003a). RBCs that are based on noncarcinogenic effects were divided by 10 to account for exposure to multiple constituents. RBCs based on carcinogenic effects were used as presented in the RBC table. Constituents with a maximum detected concentration below the respective RBC were not retained as COPCs.

- Groundwater data were compared to the USEPA Region III RBCs for tap water (USEPA, 2003a). RBCs that are based on noncarcinogenic effects were divided by 10 to account for exposure to multiple constituents. RBCs based on carcinogenic effects were used as presented in the RBC table. Constituents with a maximum detected concentration below the RBC were not retained as COPCs. Lead concentrations in groundwater were compared to the lead Safe Drinking Water Act action level of 15 µg/l. If the lead

concentration exceeded the screening value, it was discussed qualitatively for the construction worker and evaluated quantitatively for the resident using the IEUBK model.

- Surface water data were compared the USEPA Region III tap water RBCs (USEPA, 2003a), with the RBCs based on carcinogenic effects multiplied by ten. Ten times the tap water RBCs was used as the surface water screening level in accordance with USEPA Region III guidance because exposure to surface water is expected to be significantly less than exposure to groundwater, and there are no appropriate screening levels for surface water based on trespasser/visitor exposure. RBCs based on noncarcinogenic effects were used as presented in the RBC table. Constituents with maximum detected concentrations below the RBC were not retained as COPCs. Lead concentrations in surface water were compared to the Safe Drinking Water Act action level of 15 µg/l. If the lead concentration exceeded the screening value, it was discussed qualitatively.
- Sediment data were compared to the USEPA Region III residential soil RBCs (USEPA, 2003a), with the RBCs based on carcinogenic effects multiplied by ten. Ten times the residential soil RBC is used following USEPA Region III guidance because exposure to sediment is expected to be significantly less than exposure to soil, and there are no screening levels for sediment. RBCs based on noncarcinogenic effects were used as presented in the RBC table. Constituents with maximum detected concentrations below the RBC were not retained as COPCs. Lead concentrations in sediment were compared to the USEPA residential child soil screening value of 400 mg/kg as determined by the IEUBK Model. If the lead concentration exceeded the screening value, it was discussed qualitatively.
- Constituents that are essential human nutrients (magnesium, calcium, potassium, and sodium) were not considered further in the quantitative risk assessment.

4.2.3 Summary of COPCs

Table 4-2 identifies the chemicals that were selected as COPCs for each of the media groupings. For the most part, the COPCs for all of the media groupings are inorganic constituents. Additionally, aroclor-1260 or benzo(a)pyrene was selected as a COPC for some of the soil groupings. For one of the surface water groupings, the canal on the west side of the site, three VOCs were retained as COPCs. VOCs were not detected in any of the other surface water groupings, except for acetone, which was detected in the canal on the east side of the site but was not retained as a COPC. No COPCs were retained for any of the surface soil or combined surface and subsurface soil groupings for the soil to air exposure pathways, and no COPCs were retained for the surface water in the canal on the east side of the site or the sediment in Little Creek Cove.

4.3 Exposure Assessment

Exposure assessment evaluates potential human exposure to the COPCs present at or migrating from the site. The purpose of exposure assessment is to identify and evaluate the contaminant sources, release mechanisms, exposure pathways, exposure routes, and receptors for the site, and quantify the exposure. Exposure can occur when contaminants

migrate from a source to an exposure point, or when a receptor comes into direct contact with contaminated media.

The three components of exposure assessment include:

- Characterization of exposure setting
- Identification of exposure pathways
- Quantification of exposure

4.3.1 Characterization of Exposure Setting

Characterization of exposure setting consists of two parts: 1) characterization of the site with respect to the physical characteristics and 2) characterization of the site with respect to human populations at or near the site.

4.3.1.1 Physical Setting

A discussion of the physical characteristics, including physiography, geology, and hydrogeology of Site 7 is presented in detail in Section 2. Regionally, in Southeastern Virginia, the Columbia Aquifer, which is the shallow aquifer, may be used as a potable water supply or for watering lawns or filling swimming pools. Near NAB Little Creek; however, the Columbia Aquifer is not used as a domestic potable supply or for any other purpose. Throughout the eastern portion of the Coastal Plain, the Yorktown Aquifer (which underlies the Yorktown Confining Unit, which in turn underlies the Columbia Aquifer) is used extensively for domestic and potable water supply, as well as for industrial purposes. In the area surrounding the base, it is reported that the Yorktown Aquifer is not used as a potable water supply source. However, a series of four groundwater supply wells located on the NAB Little Creek golf course are screened in the Yorktown Aquifer. Used for golf course irrigation, these wells are approximately 5,000 feet northwest of Site 7. The discharge from these wells is piped directly to a storage pond (Lake No. 3).

The City of Norfolk supplies potable water to NAB Little Creek and the surrounding residential areas with groundwater from the Upper Middle or Middle Potomac Aquifers (which are deeper than the Yorktown Aquifer). Lake Whitehurst and Lake Smith, located south of the site, are reserve water supplies.

It should be noted (based on data obtained to date at NAB Little Creek) that both the Columbia Aquifer and the Yorktown Aquifer beneath Site 7 discharge to surface water bodies on base and/or the Chesapeake Bay and do not flow, or have the potential to flow, outside the boundaries of the base.

4.3.1.2 Potentially Exposed Populations

NAB Little Creek employs approximately 12,500 personnel. The population of the base increases during the summer when a significant number of midshipmen and Navy and Marine Corps reservists train in amphibious/expeditionary warfare. Approximately 3,650 military personnel and their family members live on the base. In addition, approximately 3,000 civilians are employed at NAB Little Creek (USEPA NPL Site Narrative Listing, 2002).

Site 7 is not currently used by NAB Little Creek. The majority of the site is fenced, with the exception of the side adjacent to Little Creek Cove. Additionally, the site is posted with no

trespassing signs. Although these measures make trespassing unlikely, exposure to site surface soil was evaluated for adolescent trespassers. Furthermore, because maintenance workers mow the grass adjacent to Site 7 every few weeks, it was assumed, as a conservative evaluation, that a maintenance worker may be exposed to the surface soil. The one-third of Site 7 that was used for waste disposal has been covered by clean fill so exposure to potentially contaminated soil in that area cannot occur currently but was evaluated in the risk assessment under future site use.

The future use of Site 7 will likely remain similar to current land-use. However, this risk assessment includes residential exposure pathways to provide upper-bound risks associated with unrestricted land-use. This risk assessment also includes exposure pathways associated with industrial land-use to evaluate risks under a more reasonable future land-use scenario.

To conservatively evaluate residential and industrial land-uses, it was assumed a future resident or industrial worker could be exposed to the soil (both surface soil and subsurface soil disturbed during site development) at Site 7. Exposure to surface and subsurface soil could occur for a construction worker performing any type of excavation activities at Site 7. Additionally, exposure to surface soil and combined surface and subsurface soil from the area west of the landfill, the weigh station area, the covered area, and the site perimeter was evaluated separately in the risk assessment.

Exposure to surface water and sediment in the canal on the west side of Site 7, the canal on the east side of Site 7, the pond, and Little Creek Cove was evaluated separately. The populations potentially exposed to these media are assumed to be adult and adolescent trespassers/visitors. Additionally, Little Creek Cove is used for scuba diving training by the base and, therefore, exposure to surface water and sediment in Little Creek Cove was evaluated for base personnel under the site worker exposure scenario. Ingestion of fish from Little Creek Cove was evaluated qualitatively since there are fish in the cove and people can fish there.

Groundwater is not currently used as a potable water supply at Site 7. The Columbia Aquifer is not a water supply at the base and is not a likely future potable water source for NAB Little Creek. The upper aquifer is not capable of supporting a potable supply due to its low yield. Additionally, there are no downgradient users of the upper aquifer since groundwater flow is toward Little Creek Cove. Groundwater between Little Creek Cove and Site 7 is brackish and influenced by the tide. Although unlikely, wells could be placed in upgradient locations on Site 7. While the Columbia Aquifer is unsuitable for use as a potable water supply in the vicinity of Little Creek NAB, potable use of groundwater by residential users was evaluated to assess a potential worst-case exposure scenario. It was also assumed that a construction worker could be exposed to shallow groundwater beneath the site during construction or excavation activities. The depth to groundwater beneath Site 7 ranges from 5 to 7 feet, which is within the reasonable depth of a potential excavation.

Groundwater in the deep confined aquifer (Yorktown Aquifer) is not currently used at the base, with the exception of four irrigation wells at the Little Creek golf course that are used infrequently to fill storage ponds on the golf course. As previously stated in Section 1.4.1.5, the Yorktown Aquifer flows to the north under NAB Little Creek and discharges directly to the Chesapeake Bay. Based on what was observed at Site 7, the Yorktown Aquifer is separated from the Columbia Aquifer by a clay confining layer that is approximately 30 to

40 feet thick. Consequently, it is unlikely that contamination has migrated from Site 7 to the Yorktown Aquifer, and exposure to Yorktown Aquifer groundwater was not evaluated in the risk assessment.

4.3.2 Identification of Exposure Pathways

To determine the potential health risks associated with site-related contamination, potential exposure pathways need to be identified. The exposure pathway describes a mechanism by which a receptor may be exposed to a chemical or physical agent at or originating from the site. An exposure pathway must be complete to be considered a dose contributor to a receptor. A complete exposure pathway has four elements:

- A source or a release from a source
- An environmental transport medium
- An exposure point (receptor location)
- A route of intake (inhalation, direct contact, or incidental ingestion)

The potential exposure pathways were identified in the conceptual exposure model (Figure 4-1), are summarized in Table 4-3, and are shown in greater detail in Appendix E, Table 1.

4.3.2.1 Contaminant Sources

The source of contamination at Site 7 is the materials disposed in the landfill. According to the IAS, the landfill operated from 1962 to 1979. Most of the waste disposed in the landfill is presumed to be composed of non-hazardous solid waste from base housing and other residential and commercial activities at the installation. However, because the landfill received all wastes generated by NAB Little Creek while it was operating, it also may have received potentially hazardous materials.

Waste oils and metals segregated from the wastes were placed in the landfill starting in 1970. The landfill was closed in 1979. After closure, the landfill area continued to be used as a metal collection and transfer site, a temporary storage for wastes, and a burn area for scrap wood and trees. Currently, no collection and transfer activity, or temporary storage of construction debris and miscellaneous rubble occurs on site. Open burning was halted in 1984, and waste storage activities were moved to another location in 1994.

4.3.2.2 Release and Transport Mechanisms

Contaminant fate and transport, including contaminant mobility and persistence, and the potential contaminant migration pathways and release mechanisms at the site, are discussed in detail in Section 3 and are summarized here.

The primary contaminant release and transport mechanisms at Site 7 appear to be leaching from the landfill material to the soil, leaching from the soil and landfill material to the shallow groundwater, and potentially transporting to the surface water and sediment from shallow groundwater and surface runoff. A few of the metals detected in soil were detected at maximum concentrations above the USEPA Region III SSL, based on a DAF of 20. The SSL identifies chemical concentrations in soil that may impact groundwater above either risk-based levels or drinking water standards. While the SSL is based on highly conservative assumptions that overstate the potential for contaminant transport from soil to

groundwater, the presence of concentrations higher than SSLs indicate an increased potential for metals in soil to be leaching to groundwater. Many of these inorganic constituents detected in soil at concentrations above the SSLs were detected in the groundwater. However, since these are naturally occurring constituents, the detected concentrations may be related to background conditions or may be site-related.

A few VOCs were detected in the surface water samples collected from the canal on the west side of site. These VOCs were not detected in samples from any of the other media collected at the site.

4.3.2.3 Exposure Points and Exposure Routes

Exposure points are the locations on- and off-site where humans could contact site-related contamination. On-site exposure points include the surface and subsurface soil, the pond, the canals on the east and west side of the landfill, and the Columbia Aquifer beneath Site 7. The off-site exposure points are Little Creek Cove, the upper aquifer downgradient of Site 7, prior to discharge to the Little Creek Cove and the Chesapeake Bay, and the bay itself. Groundwater from the Columbia Aquifer is not currently used as a water supply between the bay and the site; however, a construction worker could be exposed to shallow groundwater during excavation activities. Even though the Columbia Aquifer is an unsuitable potable water supply, groundwater use by residents was assessed to evaluate a potential worst-case exposure scenarios. The Chesapeake Bay was not evaluated as an off-site exposure point, for it is assumed that any site-related contamination reaching the bay via groundwater would be diluted by surface water flow to less than detectable levels.

Table 1 in Appendix E and Table 4-3 list all of the exposure routes that were evaluated in the risk assessment. As shown in Table 1, Appendix E, and discussed above, groundwater is not currently a potable water supply. As previously stated, for the purpose of the risk assessment to assess a worst-case exposure scenario, groundwater was evaluated as a potable source of groundwater for residential receptors. It was assumed that adult residents would be exposed to groundwater through ingestion and dermal contact while showering, and child residents could be exposed through ingestion and dermal contact while bathing. Groundwater use by future industrial workers was also evaluated since future industrial use of the site is possible. Additionally, a construction worker could be exposed to shallow groundwater in the Columbia Aquifer during construction or excavation activities. The construction worker would be exposed to shallow groundwater by dermal contact. None of the COPCs retained for groundwater are volatile; therefore, inhalation of VOCs while showering by the adult resident or inhalation of VOCs during excavation work by a construction worker were not quantified in the risk assessment.

As discussed above, Site 7 is not currently used by NAB Little Creek. The majority of the site is fenced, with the exception of the side adjacent to Little Creek Cove. Additionally, the site is posted with no trespassing signs. Although these measures make trespassing unlikely, exposure to site surface soil was evaluated for adolescent trespassers. Furthermore, because maintenance workers mow the grass adjacent to Site 7 every few weeks, it was assumed, as a conservative evaluation, that a maintenance worker may be exposed to the surface soil. Therefore, current receptors that may contact surface soil include adolescent trespassers and maintenance workers. These receptors could potentially be exposed to the surface soil through incidental ingestion and dermal contact. Inhalation of particulate emissions is not a

complete exposure pathway since no COPCs were retained for the surface soil to air pathway.

Although the site is fenced and posted, exposure to surface water and sediment within and adjacent to Site 7 (the pond, Little Creek Cove, and the canals on the east and west of the site) may occur. It is assumed that the only populations that would potentially be exposed to these media are adult and adolescent trespassers/visitors. Little Creek Cove is used for scuba diving training by the base and, therefore, in addition to the adult and adolescent trespassers/visitors, base personnel may be exposed to surface water and sediment in Little Creek Cove. Such exposure may occur through incidental ingestion and dermal contact. In addition, people may fish in Little Creek Cove and ingest fish that are caught. This pathway was qualitatively evaluated in this assessment.

A construction worker performing any type of excavation activity in the areas being evaluated at Site 7 would be exposed to surface and subsurface soil. Additionally, to present upper-bound risks associated with unrestricted and industrial land-uses, future resident and industrial worker exposures to the soil (both surface and disturbed subsurface soil) at Site 7 were included in the quantitative risk estimates, for exposure to combined surface and subsurface soil by these receptors could occur through incidental ingestion and dermal contact. COPCs were not retained for the soil to air pathway because inhalation of fugitive emissions is not a complete pathway.

In summary, the exposure pathways quantified under current land-use are:

- Maintenance Worker: incidental ingestion of and dermal contact with surface soil (surface soil from the weigh station area, the area west of the landfill, and the perimeter of the site were evaluated separately).
- Adolescent Trespasser/Visitor: incidental ingestion of, and dermal contact with surface soil (surface soil from the weigh station area, the area west of the landfill, and the perimeter of the site were evaluated separately); incidental ingestion and dermal contact with surface water; incidental ingestion and dermal contact with sediment (surface water and sediment from the canal on the west side of Site 7, the canal on the east site of Site 7, the Pond, and Little Creek Cove were evaluated separately).
- Adult Trespasser/Visitor: incidental ingestion and dermal contact with surface water; incidental ingestion and dermal contact with sediment (surface water and sediment from the canal on the west side of Site 7, the canal on the east site of Site 7, the Pond, and Little Creek Cove were evaluated separately).
- Site Worker: incidental ingestion and dermal contact with surface water; incidental ingestion and dermal contact with sediment (surface water and sediment from Little Creek Cove were evaluated for this receptor) during scuba diving training.

Exposure pathways quantified under future land-use include the current exposure pathways and the following additional pathways:

- Adult Resident: ingestion of groundwater and dermal contact with groundwater while showering; incidental ingestion of and dermal contact with combined surface and subsurface soil (soil from the weigh station area, the area west of the landfill, the

perimeter of the site, and the area of the landfill covered with clean fill were evaluated separately).

- Child Resident: ingestion of groundwater and dermal contact with groundwater while bathing; incidental ingestion of and dermal contact with combined surface and subsurface soil (soil from the weigh station area, the area west of the landfill, the perimeter of the site, and the area of the landfill covered with clean fill were evaluated separately).
- Industrial Worker: ingestion of groundwater; incidental ingestion of and dermal contact with combined surface and subsurface soil (soil from the weigh station area, the area west of the landfill, the area to the west of the landfill, the perimeter of the site, and the area of the landfill covered with clean fill were evaluated separately).
- Construction Worker: dermal contact with groundwater; incidental ingestion of and dermal contact with combined surface and subsurface soil (soil from the weigh station area, the area west of the landfill, the perimeter of the site, and the area of the landfill covered with clean fill were evaluated separately).

4.3.3 Quantification of Exposure

Quantification of exposure involves estimating the exposure point concentration (EPC) and chemical intake.

4.3.3.1 Exposure Concentrations

The EPC is the concentration at the point of contact. EPCs may be measured directly or calculated using fate and transport models. All of the EPCs for this assessment were measured directly.

The reasonable maximum exposure (RME) EPCs were calculated as the 95 percent upper confidence limit (95% UCL) of the arithmetic mean concentration. The maximum detected concentration was used in place of the 95% UCL when the calculated 95% UCL was greater than the maximum detected value. The Shapiro-Wilk W-test was used to determine if the data fit a lognormal or normal distribution. If the W-test could not conclusively show that the data fit a lognormal or normal distribution, the distribution the data most closely fit was used to determine the 95% UCL. For data sets with fewer than five samples, the maximum detected concentration was used as the RME EPC.

The 95% UCL for a lognormal distribution was calculated as follows:

$$95\%\ UCL = \exp(TM + 0.5*s^2 + (s*H/(n-1)^{0.5}))$$

Where:

exp	=	natural log
TM	=	transformed mean
s	=	standard deviation of the transformed data
H	=	H-statistic
n	=	sample size

The 95% UCL for a normal distribution was calculated as follows:

$$95\%\ UCL = NM+(t*s/(n)0.5)$$

Where:

NM	=	normal arithmetic mean
t	=	t-statistic
s	=	standard deviation
n	=	sample size

In calculating the 95% UCL, a value of one-half the sample quantitation limit (SQL) was assumed for cases where no detectable contaminant quantities were found in that specific sample, but the contaminant was detected in that data grouping. For duplicate samples, the higher of the two samples was chosen as representative of the sample concentration. Estimated values, flagged with a 'C,' 'J,' 'K,' or 'L' qualifier, were treated as detected concentrations. Data qualified with an 'R' (rejected) were not used in the risk assessment. Data qualified with a 'B,' indicating blank contamination, were assumed not detected and one-half the SQL was used as the sample concentration.

The EPCs are included in Appendix E, Tables 3.1 through 3.15. EPCs were calculated for all of the COPCs selected for quantitative evaluation for each of the exposure media groupings. When the central tendency (CT) risk calculations were performed, the arithmetic mean was used as the EPC. CT risks were only calculated for scenarios where the RME risk was above USEPA's target risk levels.

Since no clear contaminant plume was identified, the data for all of the wells were used in determining the groundwater EPCs. The unfiltered inorganic data were used to evaluate the construction worker, residential, and industrial worker scenarios following USEPA guidance (USEPA, 1992b). Due to the limited number of samples for some of the data groupings for soil, surface water, sediment, and groundwater, the maximum detected concentrations were used as the EPCs for a large number of constituents.

4.3.3.2 Estimation of Chemical Intakes

The quantification of exposure is based on an estimate of the average daily intake, which is the average amount of the chemical contaminant entering the receptor's body per day. Chemical intakes are generally expressed as follows:

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

Where:

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

The intake equation requires exposure parameters that are specific to each exposure pathway. Many of the exposure parameters have default values, which were used for this assessment. These assumptions, based on estimates of body weights, media intake levels,

and exposure frequencies and duration, are provided in USEPA guidance. Other assumptions were selected based on consideration of location-specific information. Appendix E, Tables 4.1 through 4.44 identify the exposure parameters and intake equations for each of the scenarios evaluated.

A dermal absorption factor is required for the dermal contact with soil and sediment exposure route. The absorption factors used for this evaluation were 14 percent for PCBs, 13 percent for PAHs, 3 percent for arsenic, and 1 percent for all other metals (USEPA, 2001). For the dermal contact with groundwater and surface water scenarios, skin permeability rate constants were obtained from USEPA's *Dermal Exposure Assessment Guidance* (USEPA, 1992a) and are shown in Appendix E, in the supplemental tables for the dermal exposure to groundwater and surface water pathways. For metals without measured values, the default skin permeability constant of 0.001 cm/hour was used. The additional parameters required to determine the dermally absorbed dose are also included in these supplemental tables.

The maximum detected concentration of lead in the weigh station area surface soil and the weigh station area combined surface and subsurface soil exceed USEPA's residential lead soil screening level of 400 mg/kg, and lead was included as a COPC for these data groupings. Lead was detected at a concentration above the screening level in only one of the two surface soil samples, and one of the three combined surface and subsurface soil samples. Risks associated with lead in the combined surface and subsurface soil were evaluated for the resident using USEPA's Integrated Exposure-Uptake Biokinetic (IEUBK) Model. The principle assumption associated with the use of IEUBK is that a child from age 0 to 7 is the receptor for potential exposure to lead in soil. Risks associated with lead in the surface soil and combined surface and subsurface soil were evaluated for the industrial worker using the adult lead model (USEPA, 1996b).

The results of the IEUBK model for the weigh station area combined surface and subsurface soil are shown in Appendix E. The IEUBK evaluation resulted in a geometric mean blood concentration of 4.74 micrograms per deciliter of blood (µg/dl) for children zero to 7 years old. Approximately 94.4 percent of this population had a blood lead level below USEPA's recommended level of 10 µg/dl. USEPA considers lead in soil not to be a health concern if 95 percent of the population has a blood lead level less than 10 µg/dl. Therefore, lead in soil may pose a very small health risk under residential use of the site. With the exception of the lead soil concentration, the default parameters associated with the IEUBK model were used in this evaluation (as shown in Appendix E,). The site-specific lead soil concentration (average lead soil concentration for combined surface and subsurface soil - 357 mg/kg) is below the residential lead soil screening level of 400 mg/kg. Additionally, lead was not detected in the groundwater. Using the detection limit of lead in the groundwater as the groundwater concentration (2.4 µg/l) in the IEUBK model would result in a blood lead level below USEPA's recommended level of 10 µg/dl for 95 percent of the population. Based on the results of the IEUBK model (if Site 7 were to be under an unrestricted land-use in the future) lead in the weigh station area combined surface and subsurface soil may pose a very small risk to future residents.

The results of the adult lead model are shown in Appendix E for the industrial worker. The adult lead model evaluation resulted in a geometric mean blood concentration of 2.4 µg/dl for adult women of child-bearing age for exposure to surface soil, and 2.3 µg/dl for

exposure to combined surface and subsurface soil. Approximately 97 percent of this population would have a blood lead level below USEPA's recommended level of 10 µg/dl. Therefore, lead in surface soil and combined surface and subsurface soil does not pose a risk to site workers. All of the default parameter values were used in the adult lead model with the exception of the soil concentration. For surface soil, the average concentration of 391 mg/kg was used, and for combined surface and subsurface soil the average concentration of 357 mg/kg was used.

Based on the results of the IEUBK Model and the adult lead model, the concentration of lead detected at Site 7 does not pose a significant health concern for potential human receptors.

4.4 Toxicity Assessment

The toxicity assessment weighs the available evidence regarding the potential for a particular chemical to cause adverse effects in exposed individuals and provides a numerical estimate of the relationship between the extent of exposure and the possible severity of adverse effects. The toxicity assessment consists of two steps: hazard identification (the process of determining the potential adverse effects from exposure to a chemical) and dose-response assessment (the process of quantitatively evaluating the toxicity information and characterizing the relationship between the dose of the contaminant administered or received and the incidence of adverse health effects in the exposed population). From this quantitative dose-response relationship, toxicity values (e.g., reference doses [RfDs] and slope factors) are derived.

USEPA has assessed the toxicity of many chemicals and has published the resulting toxicity information and toxicity values in the Integrated Risk Information System (IRIS; USEPA, 2003b)database. IRIS includes only those noncarcinogenic RfDs and carcinogenic slope factors (CSFs) that have been verified by USEPA workgroups. IRIS is USEPA's preferred source of toxicity information. If data were not available from IRIS, USEPA's National Center for Environmental Assessment (NCEA) data that are included in the USEPA Region III RBC Table (USEPA, 2003a) were used. HEAST (HEAST; USEPA, 1997), which is issued by USEPA's Office of Research and Development, was consulted when data were not available in IRIS or from NCEA.

Health effects are divided into two broad groups: noncarcinogenic and carcinogenic. This division is based on the different mechanisms of action currently associated with each category. Chemicals causing noncarcinogenic health effects were evaluated independently from those having carcinogenic effects. Some chemicals may produce both noncarcinogenic and carcinogenic effects and were evaluated in both groups. This section separately discusses noncarcinogenic and carcinogenic effects.

4.4.1 Toxicity Information for Noncarcinogenic Effects

Noncarcinogenic health effects include a variety of toxic effects on body systems, ranging from renal toxicity (toxicity to the kidneys) to central nervous system disorders. Noncarcinogenic health effects are grouped into two basic categories: acute toxicity and chronic toxicity. Acute toxicity can occur after a single exposure (usually at high doses) and the effect is most often seen immediately. Chronic toxicity describes effects that occur after repeated exposure (usually at low doses) and is seen weeks, months, or years after the initial

exposure. 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 an estimate of a daily exposure to the human population, including sensitive sub-populations, which is likely to be without appreciable risk of deleterious effects during a lifetime. Chronic RfDs, assumed to be protective for long-term exposure to a compound (7 years to a lifetime), may be overly protective if used to evaluate the potential for adverse health effects resulting from short-term exposure. NCEA develops subchronic RfDs for short-term exposure (2 weeks to 7 years). Subchronic RfDs have been peer-reviewed by USEPA and outside reviewers, but they have not undergone verification by an intra-USEPA workgroup and, as a result, are considered interim rather than verified toxicity values. Developed for both inhalation and oral exposures, chronic RfDs were used to evaluate the noncarcinogenic risks to all potential receptors for Site 7 except the construction scenario and subchronic RfDs were used to evaluate the noncarcinogenic risks to the construction worker. If a subchronic RfD was not available, the chronic RfD was used.

In the development of RfDs, all available studies examining the toxicity of a chemical following exposure are considered based on their scientific merit. The lowest dose level at which a toxic effect is observed is identified as the "lowest-observed-adverse-effect-level" (LOAEL) and the dose at which no effect is observed is identified as the "no-observed-adverse-effect-level" (NOAEL). Several uncertainty factors (UFs) are applied to the LOAEL or NOAEL to extrapolate these dose points to humans. These UFs range between 10 to 10,000. Additional modification factors (MFs) also are used based on the professional judgment of USEPA.

USEPA-derived oral and inhalation chronic and subchronic RfDs, and associated UFs and MFs, for the COPCs at NAB Little Creek Site 7 are listed in Tables 5.1 and 5.2 in Appendix E.

4.4.2 Information for Carcinogenic Effects

Potential carcinogenic effects from human exposure to chemicals are estimated quantitatively using oral CSFs, inhalation CSFs, or unit risk factors that convert estimated exposures directly to incremental lifetime cancer risks. CSFs may be derived from the results of chronic animal bioassays, human epidemiological studies, or both. To detect possible adverse effects in the relatively small test populations used in the studies, animal bioassays are usually conducted at dose levels that are much higher than levels likely to be produced by human exposure to environmental media. These high dose levels; however, must be extrapolated to lower doses. The USEPA-preferred linearized multistage model is usually used to estimate the largest linear slope (within the 95% UCL) at low extrapolated doses that are consistent with the data. The 95% UCL slope of the dose-response curve is subjected to various adjustments, including an inter-species scaling factor, to derive a CSF or inhalation unit risk factor for humans. It is assumed that if a cancer response occurs at the dose level in the study, there is some probability that a response will occur at all lower exposure levels (i.e., a dose-response relationship with no threshold is assumed). Conservative (e.g., health protective) assumptions are applied and the models are believed to provide an estimate of the upper limit on potential lifetime risk. The actual risks associated with exposure to a

potential carcinogen that are quantitatively evaluated using the CSF are not likely to exceed the estimated risks and are probably much lower or even zero.

In addition to deriving a quantitative estimate of carcinogenic potency, USEPA also assigns weight-of-evidence classifications to potential carcinogens. Chemicals are classified as Group A, Group B1, Group B2, Group C, Group D, or Group E carcinogens. The classifications are described as follows:

- Group A chemicals (known human carcinogens) are agents for which there is sufficient evidence to support the causal association between exposure to the agents in humans and cancer.
- Group B1 chemicals (probable human carcinogens) are agents for which there is limited evidence of possible carcinogenicity in humans.
- Group B2 chemicals (probable human carcinogens) are agents for which there is sufficient evidence of carcinogenicity in animals but inadequate or a lack of evidence for humans.
- Group C chemicals (possible human carcinogens) are agents for which there is limited evidence of carcinogenicity in animals and inadequate or a lack of human data.
- Group D chemicals (not classifiable as to human carcinogenicity) are agents with inadequate human and animal evidence of carcinogenicity or for which no data are available.
- Group E chemicals (evidence of noncarcinogenicity in humans) are agents for which there is no evidence of carcinogenicity from human or animal studies, or both.

USEPA-derived oral and inhalation CSFs for the COPCs at Site 7 are listed in Appendix E, Tables 6.1 and 6.2.

4.4.3 Derivation of Dermal RfDs and Slope Factors

Oral RfDs and CSFs were converted to dermal RfDs and CSFs using an oral to dermal adjustment factor. This factor was designed to convert the oral administered dose toxicity factors to dermal absorbed dose toxicity factors. The values used for this conversion were obtained from USEPA Region III (USEPA, 2001). The oral RfDs were converted to dermal RfDs by multiplying by the absorption factor, and the oral CSFs were converted to dermal CSFs by dividing by the absorption factor.

4.5 Risk Characterization

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

4.5.1 Methods for Evaluating Risk and Hazard

Potential human health risks are discussed independently for carcinogenic and noncarcinogenic contaminants because of the different toxicological endpoints, relevant exposure duration, and methods used to characterize risk. Some chemicals may produce both noncarcinogenic and carcinogenic effects and were evaluated in both groups. The methodology used to estimate noncarcinogenic hazards and carcinogenic risks are described below. Following the description of the methodology, the noncarcinogenic hazards and carcinogenic risks for Site 7 are discussed.

4.5.1.1 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):

Hazard Quotient (HQ) = Intake/RfD

The intake and RfD are expressed in the same units (mg/kg-day) and represent the same exposure period (i.e., chronic or subchronic). The intake and RfD also represent the same exposure route (i.e., oral intakes are divided by oral RfDs, dermal intakes are divided by dermal RfDs). A HQ that exceeds 1.0 (i.e., intake exceeds the RfD), indicates that a potential for adverse health effects is associated with exposure to that chemical.

To assess the potential for noncarcinogenic health effects posed by exposure to multiple chemicals, a "hazard index" approach is used (USEPA, 1986). This approach assumes that noncarcinogenic hazards associated with exposure to more than one chemical are additive; however, synergistic or antagonistic interactions between chemicals are not accounted for. The hazard index (HI) may exceed 1.0 even if all of the individual HQs are less than one. HIs may be added across exposure routes to estimate the total noncarcinogenic health effects to a receptor posed by exposure through multiple routes. A HI greater than one indicates that some potential for adverse noncarcinogenic health effects is associated with exposure to the contaminants of concern, possibly warranting remedial action. However, if the HI is greater than one, it is possible to separate the HI by target organ to determine if the HI for a specific target organ is greater than one. If the HI for each target organ is not above one, it can be assumed that there is no noncarcinogenic hazard above USEPA's targets to the receptor.

4.5.1.2 Carcinogenic Risk Estimation

The potential for carcinogenic effects due to exposure to site-related contamination 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. For example, a $2x10^{-6}$ ELCR means that for every one million people exposed to the carcinogen throughout their lifetimes, the incidence of cancer may increase by two cases. The background probability of developing cancer, from all known causes, is about one in two for men and one in three for women (American Cancer Society, 2002) or 500,000 per million for men and 333,000 per million for women.

The carcinogenic risk is calculated by multiplying the intake by the CSF.

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

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

The USEPA (USEPA, 1991) considers action to be warranted at a site when the total carcinogenic risk to a receptor exceeds 10^{-4}. Action is generally not required for risks falling within 10^{-4} to 10^{-6}; however, this is judged on a case-by-case basis. Risks less than 10^{-6} usually are not of concern to regulatory agencies.

4.5.1.3 Evaluation of Numerical Results

RME risks were evaluated for all media and exposure scenarios. Using upper-bound estimates of the exposure parameters and the RME EPC, CT risks were calculated for those scenarios that had risks that exceed USEPA target levels (HI of 1.0 and carcinogenic risk of 10^{-4}). CT risks were evaluated using median estimates of the exposure parameters and the CT EPC. The RME risks are summarized in Tables 4-4 through 4-6, and the CT risks are summarized in Tables 4-7 through 4-9. A summary of RME and CT risks for all media and exposure scenarios is presented in Table 4-10.

4.5.2 Soil

Risks were evaluated quantitatively for exposure to surface soil and exposure to combined surface and subsurface soil for each of the data groupings.

4.5.2.1 Surface Soil

RME risk estimates for exposure to surface soil from the weigh station area, the area to the west of the landfill, and the perimeter of the site were calculated for maintenance workers and adolescent trespassers/visitors under current and future site use (Appendix E, Tables 7.1.RME through 7.6.RME and Tables 8.1.RME through 8.6.RME). Exposure to surface soil via incidental ingestion and dermal contact was evaluated. No COPCs were retained for the inhalation of VOCs and fugitive dust pathways for any of the surface soil data groupings; therefore, the inhalation pathway was not quantified.

The noncarcinogenic hazards associated with exposure to all of the surface soil data groupings by industrial workers and adolescent trespassers/visitors are below USEPA's target HI of 1.0. The carcinogenic risks associated with exposure to all of the surface soil data groupings by these receptors are below USEPA's target risk range of $1x10^{-6}$ to $1x10^{-4}$.

4.5.2.2 Combined Surface and Subsurface Soil

RME risk estimates for exposure to combined surface and subsurface soil from the weigh station area, the area to the west of the landfill, the perimeter of the site, and the covered area were calculated for construction workers, industrial workers, and adult and child residents under potential future site use (Appendix E, Tables 7.24.RME through 7.39.RME, and Tables 8.23.RME through 8.34.RME). It was assumed these receptors would be exposed to soil through incidental ingestion and dermal contact. No COPCs were retained for the

inhalation of VOCs and fugitive dust pathway for any of the soil groupings; therefore, the inhalation pathway was not quantified.

The noncarcinogenic hazards associated with exposure to the combined surface and subsurface soil data from the weigh station area, the area west of the landfill, and the covered area by construction workers, industrial workers, and adult residents are below USEPA's target HI of 1.0.

The noncarcinogenic hazards associated with exposure to combined surface and subsurface soil from the weigh station area (2.3), the area west of the landfill (2.2), the perimeter of the site (5.5), and the covered area (1.6) by child residents exceed USEPA's target HI of 1.0. Vanadium is the only constituent (and only for the site perimeter soil) which contributes an HI above USEPA's target level. Vanadium and iron contribute the greatest to the hazard for all of the soil exposure areas. The noncarcinogenic hazards associated with exposure to combined surface and subsurface soil from the site perimeter by adult residents (1.8), industrial workers (1.6), and construction workers (1.2) also exceeds USEPA's target HI of 1.0. Vanadium is the main risk driver and the only constituent which contributes a HI above 1.0 (for all receptors except the construction worker).

A comparison of the combined surface and subsurface soil risk drivers at Site 7 to the Little Creek background soil data is discussed in Section 4.6.1.5. Elimination of constituents as COPCs based on the results of the background comparison does not affect the results of the risk evaluation.

The carcinogenic risks associated with construction workers, industrial workers, and lifetime residents exposure to the combined surface and subsurface soil at all of the areas are within or below USEPA's target risk range of $1x10^{-6}$ to $1x10^{-4}$.

Because the RME noncarcinogenic hazard for exposure to combined surface and subsurface soil from the weigh station area, the area west of the landfill, the perimeter of the site, and the covered area by a child resident, and combined surface and subsurface soil from the perimeter of the site by adult residents, industrial workers, and construction workers exceed USEPA's benchmark value, CT risk estimates were calculated (Appendix E, Tables 7.42.CT through7.48.CT). The CT noncarcinogenic hazards for all of the receptors associated with to exposure to the soil in these areas are below USEPA's target HI of 1.0.

4.5.3 Groundwater

Groundwater beneath the site is not currently used as a potable water supply and will not likely be used as a potable water supply in the future due to brackish water quality and low yield in the vicinity of Site 7. However, potable use of the Columbia Aquifer beneath Site 7 was evaluated to assess worst-case risks associated with exposure to groundwater at the site. Risk estimates for exposure to groundwater in the Columbia Aquifer were calculated for the following receptors:

- Child and adult residents assuming potential future residential use of the site (Appendix E, Tables 7.20.RME, 7.21.RME, and 8.20.RME);
- Industrial workers under future industrial use of the site (Appendix E, Tables 7.22.RME and 8.21.RME); and

- Construction workers exposed to groundwater in an open excavation (Appendix E, Tables 7.23.RME and 8.22.RME).

The RME noncarcinogenic hazards associated with potable residential use of the groundwater are above USEPA's target HI of 1.0. The HI for an adult and child resident are 3.0 and 7.0, respectively. This hazard is primarily associated with ingestion of arsenic, iron, and manganese in the groundwater. Each of these constituents pose a HI greater than one for the child resident, but for the adult resident none of the COPCs individually pose HIs above one, and there are no HIs above one for individual target organs for the adult. A comparison of the groundwater data to the Little Creek background groundwater data for the risk drivers is discussed in Section 4.6.1.5. Arsenic, iron, and manganese are present in the site groundwater at concentrations statistically similar to the background concentrations for groundwater. Elimination of these three background constituents as COPCs reduces the HI associated with potable use of the groundwater to below USEPA target levels.

The RME carcinogenic risk associated with use of the groundwater as a potable residential water supply (1.5×10^{-4}) exceeds USEPA's target risk range of 10^{-6} to 10^{-4}. The risk is associated with ingestion of the arsenic detected in the groundwater. Due to the limited number of groundwater samples available for evaluation in the risk assessment, the maximum detected concentration of arsenic was used as the EPC. A comparison of the groundwater data to the Little Creek background groundwater data for the risk drivers is discussed in Section 4.6.1.5. Arsenic, the only carcinogenic COPC for the groundwater, was detected in groundwater at concentrations statistically similar to the background groundwater. Elimination of arsenic as a COPC eliminates the carcinogenic risk associated with potable use of the groundwater.

The RME noncarcinogenic hazard associated with ingestion of the groundwater by future industrial workers equals USEPA's target HI of 1.0. None of the individual COPCs have hazard indices above USEPA's target level. The RME carcinogenic risk to the industrial workers is within USEPA's target risk range.

The RME noncarcinogenic risk to construction workers exposed to groundwater in the Columbia Aquifer is below USEPA's target HI. The RME carcinogenic risk is also below USEPA's target risk range.

CT HI estimates were calculated for the adult and child resident, and carcinogenic risk estimates were calculated for the lifetime resident. The CT HI for the adult resident is below USEPA's target HI; however, the CT HI for the child resident (2.2) exceeds USEPA's target level. While the hazard is primarily associated with ingestion of iron and manganese in the groundwater, none of the individual constituents or target organs have HIs above one. Also, as previously noted, concentrations of iron and manganese in groundwater at Site 7 are similar to background concentrations for the aquifer. The CT carcinogenic risk estimate for the lifetime resident is within USEPA's target risk range.

4.5.4 Surface Water

RME risk estimates for exposure to surface water from the canal on the west side of Site 7, the Pond, and Little Creek Cove were evaluated for an adult and adolescent trespasser/ visitor (Appendix E, Tables 7.7.RME, 7.8.RME, and 7.10.RME through 7.13.RME and Tables 8.7.RME, 8.8.RME, and 8.10.RME through 8.13.RME) and for surface water from Little Creek

Cove for a site worker (Appendix E, Tables 7.9.RME and 8.9.RME). Risks were not calculated for exposure to surface water from the canal on the east side of the site because no COPCs were retained.

The noncarcinogenic hazards associated with exposure to all of the surface water groupings by adult and adolescent trespassers/visitors and site workers are below USEPA's target HI of 1.0. The carcinogenic risks associated with exposure to all of the surface water data groupings by these receptors are also below or within USEPA's target risk of $1x10^{-6}$ to $1x10^{-4}$.

4.5.5 Sediment

RME risk estimates for exposure to sediment from the canal on the west side of Site 7, the canal on the east site of Site 7, and the Pond were evaluated for an adult and adolescent trespasser/visitor (Appendix E, Tables 7.14.RME through 7.19.RME and Tables 8.14.RME through 8.19.RME). Risks were not calculated for exposure to sediment from the Little Creek Cove because no COPCs were retained.

The noncarcinogenic hazards associated with exposure to all of the sediment groupings by adult and adolescent trespassers/visitors are below USEPA's target HI of 1.0. The carcinogenic risks associated with exposure to all of the sediment data groupings by these receptors are below or within USEPA's target risk of $1x10^{-6}$ to $1x10^{-4}$.

4.5.6 Fish Ingestion

A few of the inorganic constituents that were detected in Little Creek Cove surface water and sediment samples have the potential to bioaccumulate in fish. These constituents include arsenic, chromium, copper, lead, nickel, and zinc. Fish tissue samples were not collected at Site 7 and, therefore, a quantitative assessment of fish ingestion was not performed. The uncertainties associated with using bioconcentration factors and biaccumulation factors to estimate the fish tissue concentrations from surface water and sediment data, and then estimating the risks associated with ingestion of these fish are extremely large and, therefore, this was not done for the risk assessment. Based on the potential for a few of these inorganics to accumulate in fish tissue, there is the potential for adverse health effects to people who ingest fish caught in Little Creek Cove.

4.5.7 Summary of Total Risks Across Pathways and Media

Tables 4-5 and 4-6 and Appendix E (Tables 9.1.RME through 9.9.RME) summarize the RME total potential hazards and risks to each receptor. Tables 4-8 and 4-9, and Appendix E (Tables 9.10.CT through 9.12.CT) summarize the CT total potential hazards and risks to each receptor that had hazards and/or risks which exceeded USEPA's benchmark levels. Total potential hazards and risks were summarized for a current maintenance worker, current/future adult and adolescent trespasser/visitor, current/future site worker, future adult, child, and lifetime resident, future industrial worker, and future construction worker. Appendix E (Tables 10.1.RME through 10.4.RME, and 10.5.CT) show only the chemicals that contributed a hazard greater than 0.1 or a carcinogenic risk greater than 10^{-6} to receptors with noncarcinogenic hazards and/or carcinogenic risks greater than USEPA's benchmark levels of 1.0 for noncarcinogenic hazards and 10^{-4} for carcinogenic risks. These tables only

include those constituents that were determined to be present at Site 7 at concentrations statistically above background (see background discussion in Section 4.6.1.5).

The risk assessment results may be summarized as follows:

- **Current Maintenance Worker** (Appendix E, Table 9.1.RME): The HI is below USEPA benchmark value and the carcinogenic risk is below USEPA target risk range. There are no unacceptable health risks to this receptor for exposure to surface soil from the weigh station area, the area to the west of the landfill, and the perimeter of the site.
- **Current/Future Trespasser/Visitor, Adult** (Appendix E, Table 9.3.RME): The HI is below the USEPA benchmark value and the carcinogenic risk is within USEPA's target risk range. There are no unacceptable health risks to this receptor for exposure to surface water and sediment from the canal on the west side of Site 7, the canal on the east site of Site 7, the Pond, and Little Creek Cove.
- **Current/Future Trespasser/Visitor, Adolescent** (Appendix E, Table 9.2.RME): The HI is below the USEPA benchmark value and the carcinogenic risk is within USEPA's target risk range. There are no unacceptable health risks to this receptor for exposure to surface soil from the weigh station area, the area to the west of the landfill, the perimeter of the site, and surface water and sediment from the canal on the west side of Site 7, the canal on the east site of Site 7, the Pond, and Little Creek Cove.
- **Current/Future Site Worker** (Appendix E, Table 9.4.RME): The HI is below the USEPA benchmark value and the carcinogenic risk is below USEPA's target risk range. There are no unacceptable health risks to this receptor for exposure to surface water and sediment from Little Creek Cove.
- **Future Resident, Adult** (Appendix E, Table 9.5.RME): The HI is greater than 1.0 for exposure to shallow groundwater. Arsenic, iron, and manganese, which had concentrations similar to background levels, contribute the most to this risk; however, none of the individual hazards (by constituent or target organ) exceed USEPA's target value. The HI is greater than 1.0. for exposure to combined surface and subsurface soil from the perimeter of the site. Vanadium contributes the most to this hazard with an individual HQ above USEPA's target value. There are no unacceptable health risks to this receptor for exposure to combined surface and subsurface soil from the weigh station area, the area west of the landfill, or the covered area. The target organs CNS, kidney, and GI tract had HIs greater than 1.0 based on combined exposure to all media. The CT hazard (for groundwater exposure and exposure to combined surface and subsurface soil from the perimeter of the site) is below USEPA's benchmark value (Appendix E, Table 9.10.CT).
- **Future Resident, Child** (Appendix E, Table 9.6.RME): The HI exceeds 1.0 due to exposure to groundwater and combined surface and subsurface soil from the weigh station area, the area west of the landfill, the perimeter of the site, and the covered area. Arsenic, iron, and manganese in groundwater contribute HIs above 1.0, and vanadium in the site perimeter soil contributes an HI above 1.0. Arsenic, iron, and manganese had concentrations in the Site 7groundwater similar to background levels. The CT future child resident also has a HI above the USEPA benchmark value due to CT exposure to iron and manganese in the groundwater (Appendix E, Table 9.11.CT).

- **Future Lifetime Resident** (Appendix E, Table 9.7.RME): The carcinogenic risk to the age-adjusted future lifetime resident is above the target USEPA risk range. This risk is associated with exposure to arsenic in the groundwater. When background levels are considered, the carcinogenic risk to the lifetime resident exposed to groundwater is below USEPA's target risk range. The risks associated with soil from the weigh station area, the area west of the landfill, the perimeter of the site, and the covered area are below USEPA's target risk range. Based on exposure to groundwater, the CT future lifetime resident carcinogenic risk is within the USEPA target risk (Appendix E, Table 9.12.CT).
- **Future Industrial Worker** (Appendix E, Table 9.8.RME): The total HI is above USEPA benchmark value and the carcinogenic risk is within the USEPA target risk range associated with exposure to groundwater and combined surface and subsurface soil from the weigh station area, the area west of the landfill, the perimeter of the site, and the covered area. The individual hazards for each of the data groupings and media are equal to or below 1.0except for the combined surface and subsurface soil from the site perimeter. There are no unacceptable health risks to this receptor for exposure to combined surface and subsurface soil from the weigh station area, the area west of the landfill, the perimeter of the site, the covered area, or shallow groundwater. The kidney target organ had an HI greater than 1.0 based on combined exposure to all media. The CT hazard (for exposure to combined surface and subsurface soil from the perimeter of the site) is below USEPA's benchmark value (Appendix E, Table 9.14.CT).
- **Future Construction Worker** (Appendix E, Table 9.9.RME): The total HI is above the USEPA benchmark value and the carcinogenic risk is within the USEPA target risk range associated with exposure to groundwater and combined surface and subsurface soil from the weigh station area, the area west of the landfill, the perimeter of the site, and the covered area. The individual hazards for all of the data groupings and media are below 1.0, except for combined surface and subsurface soil from the site perimeter, which only slightly exceeded 1.0. The kidney target organ had an HI greater than 1.0 based on combined exposure to all media. The CT hazard (for exposure to combined surface and subsurface soil from the perimeter of the site) is below USEPA's benchmark value (Appendix E, Table 9.13.CT).

4.6 Summary of Human Health Risk Assessment

This section discusses the uncertainty associated with the human health risk assessment and summarizes the conclusions from the risk assessment.

4.6.1 Uncertainty

The risk measures used in Superfund 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 (USEPA, 1989).

4.6.1.1 Uncertainty in COPC Selection

The sampling conducted at Site 7 focused on areas of known or suspected contamination. The uncertainty associated with sampling and the possibility of missing a contaminated location is expected to be minimal based on the methods used to select the sampling locations. The general assumptions applied in the COPC selection process were conservative to ensure that true COPCs were not eliminated from the quantitative risk assessment and that the highest possible risk was estimated.

The metals retained as COPCs are a source of uncertainty in the risk assessment. The metals may not be related to site activities but may have been retained as COPCs based on the conservative screening process.

4.6.1.2 Uncertainty Associated with Exposure Assessment

Most of the exposure pathways evaluated at the site were assumed, and the exposure factors used for the quantitation of exposure were conservative and reflect worst-case or upper-bound assumptions on the exposure. The reliability of the values chosen for the exposure factors also contributes substantially to the uncertainty of the resulting risk estimates. Because most of the exposure factors are worst-case or upper-bound assumptions, the resulting risks are worst-case and are likely to considerably overestimate the actual risk.

It was assumed that the site may be used for residential purposes in the future to evaluate unrestricted land-use under the most conservative land-use scenario. Based on the nature of NAB Little Creek and the area of Site 7, residential use of the site is unlikely and unrealistic. It is also unlikely that the shallow groundwater would ever be used as a potable or industrial water supply due to the low yield of the shallow aquifer, brackish water conditions, and the availability of better water supplies.

The risk assessment assumed that the receptors could be exposed to each of the data groupings (i.e., all four soil groupings) for the whole exposure frequency and exposure duration of the receptor. Summing the exposure calculated for each of the data groupings represents an exposure that is not possible and in reality, a receptor may spend time at one of the units or split the time between the units. Therefore, the total hazards calculated for the industrial worker and construction worker that slightly exceed USEPA's target HI are not realistic, and the hazard would more realistically be a fraction of this number, resulting in a hazard below USEPA's target level. Ultimately, then the total hazards and risks calculated for each receptor represent an over-estimation of the actual risk.

Site-related contamination would be expected to decrease with time due to attenuation. The risk assessment assumed concentrations would remain constant throughout the exposure period, an assumption that results in an over-estimation of risk.

It was assumed that the receptor would be exposed to the most contaminated location at the site (and within each data grouping) for the full exposure duration. This is not likely since any receptor's area of activity is larger than this location. Consequently, this assumption also results in an over-estimation of risk. Additionally, for many constituents retained as COPCs for the groundwater and combined surface and subsurface soil, and for all of the surface soil COPCs, the maximum concentrations were used as the exposure point concentrations, due to the small number of samples available for the data groupings, which would further result in an over-estimation of risk.

Ingestion of fish caught from Little Creek Cove was not evaluated quantitatively in the risk assessment. Because some of the inorganic constituents detected in the sediment and surface water samples collected from Little Creek Cove have the potential to bioaccumulate in fish tissue, not including this evaluation in the risk assessment may underestimate the risk associated with exposure to Site 7. Although there is a potential for adverse health effects, opportunities for possible ingestion of fish from Little Creek Cove are restricted by the fencing surrounding the area and scuba training events. Therefore, potential risks from ingestion of fish are likely to be low and would not present unacceptable risks.

4.6.1.3 Uncertainty Associated with Toxicity Assessment

Uncertainty associated with the noncarcinogenic toxicity factors are included in Appendix E, Tables 5.1 and 5.2. Several uncertainty factors (UFs) were applied to extrapolate dose points from animal studies to humans. These UFs range between 10 to 10,000. Additional modification factors are also used based on the professional judgment of the USEPA. Consequently, there is a high degree of uncertainty in the noncarcinogenic toxicity criteria based on the available scientific data for each compound. The noncarcinogenic toxicity factors most likely overestimate actual toxicity.

CSFs developed by USEPA represent upper-bound estimates. Carcinogenic risks generated in this assessment should be regarded as upper-bound estimates on the 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) developed by this risk assessment.

The uncertainty associated with CSFs are mostly associated with the low dose extrapolation where carcinogenicity at low doses is assumed to be a straight line 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.

A large degree of uncertainty is associated with the oral to dermal adjustment factors (based on chemical-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.

4.6.1.4 Uncertainty in Risk Characterization

The uncertainties identified in each component of risk assessment ultimately contribute to uncertainty in risk characterization. The addition of risks and HIs across pathways and chemicals contributes to uncertainty based on the interaction of chemicals, such as additivity, synergism, potentiation, and susceptibility of exposed receptors. The simple assumption of additivity used for this site may or may not be accurate and may over- or under-estimate risks.

4.6.1.5 Effect of Comparison of Risk Drivers to Background Concentrations

The background data and statistical evaluation of the background data included in the *Final Background Investigation for Naval Base Little Creek, Virginia Beach, Virginia* by CH2M HILL, December 2000, was used to determine if the Site 7 groundwater risk drivers and combined surface and subsurface soil risk drivers for each soil data grouping with a hazard or risk

above USEPA's target levels may be present at concentrations similar to background concentrations for NAB Little Creek. The methodology discussed in the background investigation report was followed for this evaluation. The maximum detected site concentrations were compared to the 95% upper tolerance limits (UTLs) (for soil, the urban soil type was used), and a population-to-population comparison was conducted. For the population-to-population comparison, if the site data and background data fit the same distribution (i.e. both normal or log-normal), the student t-test was used. If the data did not fit the same distribution, the non-parametric Mann-Whitney U test was used. If both the comparison to the 95% UTL and the population-to-population comparison indicated that the site concentration is statistically similar to the background concentration, it was assumed that the site concentration is statistically similar to the background concentration. If one of these tests indicated that the site concentration is statistically greater than the background concentration, it was assumed that the site and background data are not statistically similar. Tables 11.1 through 11.2a in Appendix E present the background statistical evaluations.

Arsenic is the only constituent detected in any of the combined surface and subsurface soil groupings at a concentration statistically similar to background. Arsenic in the weigh station area and the area to the west of the landfill were detected in the soil at concentrations statistically similar to background. Elimination of arsenic as a COPC from soil for these two areas does not affect the results of the risk evaluation. None of the other risk drivers detected in any of the combined surface and subsurface soil is present at Site 7 at a concentration statistically similar to the background concentrations.

Arsenic, iron, and manganese are the Site 7 unfiltered groundwater COPCs that are present at concentrations statistically similar to background. since arsenic was the only carcinogenic COPC retained for the groundwater, elimination of arsenic as a groundwater COPC would eliminate the carcinogenic risk associated with exposure to the groundwater. Elimination of arsenic, iron, and manganese as groundwater COPCs reduces the estimated hazards associated with potable use of groundwater to below USEPA's target levels.

4.6.2 Summary

Risks were quantitatively evaluated for exposure to surface soil for current maintenance workers and adolescent trespassers/visitors; exposure to combined surface and subsurface soil for future construction workers, future industrial workers, and future adult and child residents; exposure to surface water and sediment for adult and adolescent trespassers/visitors and site workers (Little Creek Cove only); and exposure to groundwater for future adult and child residents, future industrial workers, and future construction workers.

For current site use, exposure to surface soil by industrial workers and adolescent trespassers/visitors and exposure to surface water and sediment for adult and adolescent trespassers/visitors and site workers (Little Creek Cove only) were evaluated. All noncarcinogenic hazards and carcinogenic risks for the current-use scenarios are within USEPA's target risk range. Therefore, there are no unacceptable risks or hazards based on current site use.

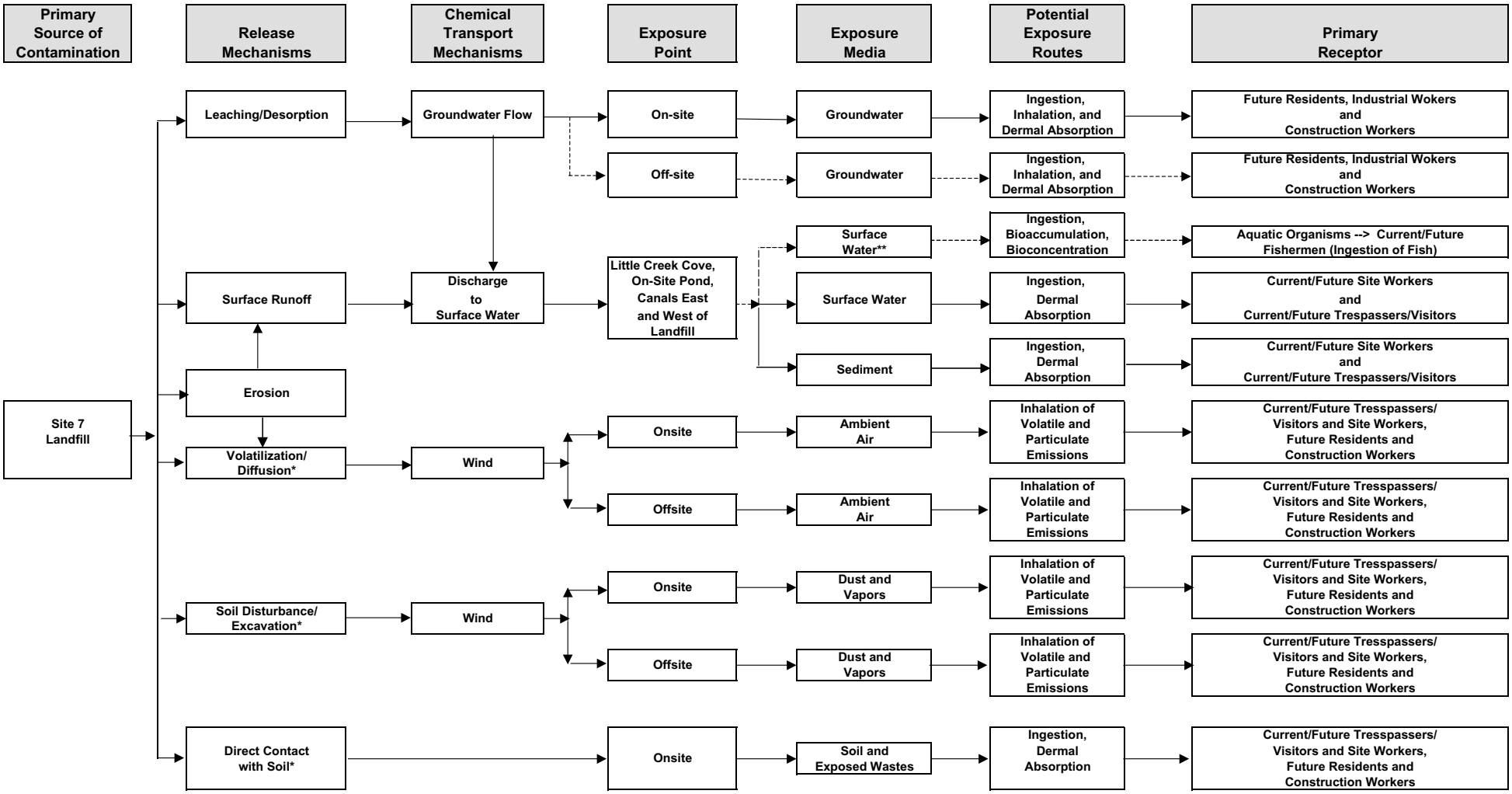
Future exposure by a child resident to combined surface and subsurface soil at the weigh station area, the area to the west of the landfill, the site perimeter, and the covered area may result in a noncarcinogenic hazard slightly above USEPA's target hazard of one. This hazard

is mainly associated with iron and vanadium in all four of these areas. Vanadium is the only constituent that contributes a hazard above USEPA's target level alone, and this is only for the site perimeter soil. Although the hazards in these areas are associated with naturally occurring constituents, the concentrations of these constituents are statistically greater than the background urban subsurface soil concentrations presented in the Little Creek Background Investigation (CH2M HILL, 2001). Noncarcinogenic hazards associated with exposure to the combined surface and subsurface soil from the site perimeter by all of the other potential future receptors also slightly exceeds USEPA's target level of 1.0, associated with the vanadium. The maximum detected vanadium concentration was used as the exposure point concentration. This concentration was an order of magnitude higher than the vanadium concentrations detected in the other four soil samples from the site perimeter soil. Risks associated with exposure to the combined surface and subsurface soil at the weigh station area, the area to the west of the landfill, and the covered area by all of the potential future receptors except for the child resident are within USEPA's target levels.

Future potable use of groundwater from the Columbia Aquifer was evaluated to conservatively estimate risks if unrestricted land-use and potable groundwater use were to occur at Site 7. However, it is extremely unlikely that the Columbia Aquifer groundwater will be used as a future source of potable water at NAB Little Creek due to low yield, brackish water quality, and availability of better water supplies. Additionally, industrial use of Site 7 without potable use of the groundwater is a more reasonable estimation of risks associated with potential future land-use.

In the case of the upper-bound residential exposures from potable use of Columbia Aquifer groundwater, there would be an unacceptable risk and hazard to both child and adult residents. The carcinogenic risk for groundwater is associated with arsenic, although arsenic was detected in the Site 7 groundwater at a concentration statistically similar to Little Creek background and, therefore, this risk may not be site-related but associated with background conditions at Little Creek. The noncarcinogenic hazard is associated with chromium, iron, and manganese. None of these constituents individually pose a hazard above USEPA target levels. Additionally, iron and manganese were detected in the Site 7 groundwater at concentrations statistically similar to background. Elimination of these two constituents as COPCs would result in a noncarcinogenic hazard below USEPA's target level. Therefore, the noncarcinogenic hazard calculated for potable use of the groundwater may be associated with background conditions and may not be site-related.

Future construction work involving contact with the groundwater and future potable use of the groundwater by industrial workers would result in risks within USEPA target levels. Therefore, groundwater at Site 7 does not require any further evaluation to meet USEPA target levels.



* Surface soil for current/future industrial worker and trespasser/visitor; subsurface soil for future industrial worker, trespasser/visitor, resident, and construction worker.
** Little Creek Cove only.

Complete Pathway
Incomplete Pathway

Figure 4-1
Conceptual Site Model for Potential Human Exposures
Site 7
NAB Little Creek
Virginia Beach, Virginia

WDC012820001.XLS

Table 4-1
Summary of Data Quantitatively Used in Risk Assessment
Site 7
NABLittle Creek
Virginia Beach, Virginia

Medium	Date of Sampling	Sample Location	Sample	Parameters
Soil				
Weigh Station Area				
Surface Soil	05/13/1993	LS07-SS104	07-SS-104	VOCs, SVOCs, Pest/PCBs, Metals
	02/28/2001	LS07-SS203	LS07-SS203-00	VOCs, SVOCs, Pest/PCBs, Metals
Subsurface Soil	02/28/2001	LS07-SB203	LS07-SB203-02	VOCs, SVOCs, Pest/PCBs, Metals
Area to West of Landfill, the "Ear"				
Surface Soil	02/28/2001	LS07-SS201	LS07-SS201-00	VOCs, SVOCs, Pest/PCBs, Metals
	02/28/2001	LS07-SS201	LS07-SS201P-00	VOCs, SVOCs, Pest/PCBs, Metals
	02/28/2001	LS07-SS202	LS07-SS202-00	VOCs, SVOCs, Pest/PCBs, Metals
Subsurface Soil	07/14/1993	LS07-SB06	07-SB-6D	VOCs, SVOCs, Pest/PCBs, Metals
	02/28/2001	LS07-SB201	LS07-SB201-02	VOCs, SVOCs, Pest/PCBs, Metals
	02/28/2001	LS07-SB202	LS07-SB202-02	VOCs, SVOCs, Pest/PCBs, Metals
Site Perimeter				
Surface Soil	05/13/1993	LS07-SS101	07-SS-101	VOCs, SVOCs, Pest/PCBs, Metals
	05/13/1993	LS07-SS108	07-SS-108	VOCs, SVOCs, Pest/PCBs, Metals
Subsurface Soil	07/14/1993	LS07-SB01	07-SB-101D	VOCs, SVOCs, Pest/PCBs, Metals
	07/14/1993	LS07-SB03	07-SB-103D	VOCs, SVOCs, Pest/PCBs, Metals
	07/14/1993	LS07-SB03	07-SB-110 (dup)	VOCs, SVOCs, Pest/PCBs, Metals
	07/14/1993	LS07-SB05	07-SB-105D	VOCs, SVOCs, Pest/PCBs, Metals
	07/14/1993	LS07-SB09	07-SB-9D	VOCs, SVOCs, Pest/PCBs, Metals
Covered Area				
Surface Soil (but	05/13/1993	LS07-SS102	07-SS-109	VOCs, SVOCs, Pest/PCBs, Metals
treated as	05/13/1993	LS07-SS102	07-SS-102	VOCs, SVOCs, Pest/PCBs, Metals
subsurface because	05/13/1993	LS07-SS103	07-SS-103	VOCs, SVOCs, Pest/PCBs, Metals
below landfill cover)	05/13/1993	LS07-SS105	07-SS-105	VOCs, SVOCs, Pest/PCBs, Metals
	05/13/1993	LS07-SS106	07-SS-106	VOCs, SVOCs, Pest/PCBs, Metals
	05/13/1993	LS07-SS107	07-SS-107	VOCs, SVOCs, Pest/PCBs, Metals
Surface Water				
Little Creek Cove				
	03/01/2001	LS07-SW201	LS07-SW201-01A	VOCs, Metals (total and dissolved)
	03/02/2001	LS07-SW206	LS07-SW206-01A	VOCs, Metals (total and dissolved)
	03/02/2001	LS07-SW207	LS07-SW207-01A	VOCs, Metals (total and dissolved)
	09/11/2001	LS07-SW201	LS07-SW201-01C	VOCs, Metals (total and dissolved)
	09/11/2001	LS07-SW206	LS07-SW206-01C	VOCs, Metals (total and dissolved)
	09/11/2001	LS07-SW207	LS07-SW207-01C	VOCs, Metals (total and dissolved)
	03/04/2002	LS07-SW201	LS07-SW201-02A	VOCs, Metals (total and dissolved)
	03/04/2002	LS07-SW206	LS07-SW206-02A	VOCs, Metals (total and dissolved)
	03/04/2002	LS07-SW207	LS07-SW207-02A	VOCs, Metals (total and dissolved)
Pond				
	03/08/2001	LS07-SW208	LS07-SW208-01A	VOCs, Metals (total and dissolved)
	03/08/2001	LS07-SW209	LS07-SW209-01A	VOCs, Metals (total and dissolved)
	09/11/2001	LS07-SW208	LS07-SW208-01C	VOCs, Metals (total and dissolved)
	09/11/2001	LS07-SW209	LS07-SW209-01C	VOCs, Metals (total and dissolved)
	03/04/2002	LS07-SW208	LS07-SW208-02A	VOCs, Metals (total and dissolved)
	03/04/2002	LS07-SW209	LS07-SW209-02A	VOCs, Metals (total and dissolved)

Table 4-1
Summary of Data Quantitatively Used in Risk Assessment
Site 7
NABLittle Creek
Virginia Beach, Virginia

Medium	Date of Sampling	Sample Location	Sample	Parameters
Canal on West Side of Site				
	03/02/2001	LS07-SW202	LS07-SW202-01A	VOCs, Metals (total and dissolved)
	03/01/2001	LS07-SW203	LS07-SW203P-01A	VOCs, Metals (total and dissolved)
	03/01/2001	LS07-SW203	LS07-SW203-01A	VOCs, Metals (total and dissolved)
	03/02/2001	LS07-SW204	LS07-SW204-01A	VOCs, Metals (total and dissolved)
	03/02/2001	LS07-SW210	LS07-SW210-01A	VOCs, Metals (total and dissolved)
	03/08/2001	LS07-SW211	LS07-SW211-01A	VOCs, Metals (total and dissolved)
	03/08/2001	LS07-SW212	LS07-SW212-01A	VOCs, Metals (total and dissolved)
	03/08/2001	LS07-SW213	LS07-SW213-01A	VOCs, Metals (total and dissolved)
	03/08/2001	LS07-SW213	LS07-SW213P-01A	VOCs, Metals (total and dissolved)
	09/13/2001	LS07-SW202	LS07-SW202P-01C	VOCs, Metals (total and dissolved)
	09/13/2001	LS07-SW202	LS07-SW202-01C	VOCs, Metals (total and dissolved)
	09/13/2001	LS07-SW203	LS07-SW203-01C	VOCs, Metals (total and dissolved)
	09/13/2001	LS07-SW204	LS07-SW204P-01C	VOCs, Metals (total and dissolved)
	09/13/2001	LS07-SW204	LS07-SW204-01C	VOCs, Metals (total and dissolved)
	09/10/2001	LS07-SW210	LS07-SW210-01C	VOCs, Metals (total and dissolved)
	09/13/2001	LS07-SW211	LS07-SW211-01C	VOCs, Metals (total and dissolved)
	09/13/2001	LS07-SW212	LS07-SW212-01C	VOCs, Metals (total and dissolved)
	09/13/2001	LS07-SW213	LS07-SW213-01C	VOCs, Metals (total and dissolved)
	03/05/2002	LS07-SW202	LS07-SW202-02A	VOCs, Metals (total and dissolved)
	03/05/2002	LS07-SW203	LS07-SW203P-02A	VOCs, Metals (total and dissolved)
	03/05/2002	LS07-SW203	LS07-SW203-02A	VOCs, Metals (total and dissolved)
	03/05/2002	LS07-SW204	LS07-SW204-02A	VOCs, Metals (total and dissolved)
	03/04/2002	LS07-SW210	LS07-SW210-02A	VOCs, Metals (total and dissolved)
	03/05/2002	LS07-SW211	LS07-SW211-02A	VOCs, Metals (total and dissolved)
	03/05/2002	LS07-SW212	LS07-SW212-02A	VOCs, Metals (total and dissolved)
	03/05/2002	LS07-SW213	LS07-SW213-02A	VOCs, Metals (total and dissolved)
Canal on East Side of Site				
	03/01/2001	LS07-SW205	LS07-SW205-01A	VOCs, Metals (total and dissolved)
	09/11/2001	LS07-SW205	LS07-SW205-01C	VOCs, Metals (total and dissolved)
	03/04/2002	LS07-SW205	LS07-SW205-02A	VOCs, Metals (total and dissolved)
Sediment				
Little Creek Cove				
	03/02/2001	LS07-SD206	LS07-SD206-01A	SVOCs, Pest/PCBs, Metals
	03/02/2001	LS07-SD207	LS07-SD207-01A	SVOCs, Pest/PCBs, Metals
	09/11/2001	LS07-SD206	LS07-SD206-01C	SVOCs, Pest/PCBs, Metals
	09/11/2001	LS07-SD207	LS07-SD207-01C	SVOCs, Pest/PCBs, Metals
	03/04/2002	LS07-SD206	LS07-SD206-02A	SVOCs, Pest/PCBs, Metals
	03/04/2002	LS07-SD207	LS07-SD207-02A	SVOCs, Pest/PCBs, Metals
Pond				
	03/08/2001	LS07-SD208	LS07-SD208P-01A	SVOCs, Pest/PCBs, Metals
	03/08/2001	LS07-SD208	LS07-SD208-01A	SVOCs, Pest/PCBs, Metals
	03/08/2001	LS07-SD209	LS07-SD209-01A	SVOCs, Pest/PCBs, Metals
	09/11/2001	LS07-SD208	LS07-SD208-01C	SVOCs, Pest/PCBs, Metals
	09/11/2001	LS07-SD209	LS07-SD209-01C	SVOCs, Pest/PCBs, Metals
	03/04/2002	LS07-SD208	LS07-SD208-02A	SVOCs, Pest/PCBs, Metals
	03/04/2002	LS07-SD209	LS07-SD209-02A	SVOCs, Pest/PCBs, Metals

Table 4-1
Summary of Data Quantitatively Used in Risk Assessment
Site 7
NABLittle Creek
Virginia Beach, Virginia

Medium	Date of Sampling	Sample Location	Sample	Parameters
Canal on West Side of Site				
	03/01/2001	LS07-SD201	LS07-SD201-01A	SVOCs, Pest/PCBs, Metals
	03/02/2001	LS07-SD202	LS07-SD202-01A	SVOCs, Pest/PCBs, Metals
	03/01/2001	LS07-SD203	LS07-SD203P-01A	SVOCs, Pest/PCBs, Metals
	03/01/2001	LS07-SD203	LS07-SD203-01A	SVOCs, Pest/PCBs, Metals
	03/02/2001	LS07-SD204	LS07-SD204-01A	SVOCs, Pest/PCBs, Metals
	03/02/2001	LS07-SD210	LS07-SD210-01A	SVOCs, Pest/PCBs, Metals
	03/08/2001	LS07-SD211	LS07-SD211-01A	SVOCs, Pest/PCBs, Metals
	03/08/2001	LS07-SD212	LS07-SD212P-01A	SVOCs, Pest/PCBs, Metals
	03/08/2001	LS07-SD212	LS07-SD212-01A	SVOCs, Pest/PCBs, Metals
	03/08/2001	LS07-SD213	LS07-SD213-01A	SVOCs, Pest/PCBs, Metals
	09/11/2001	LS07-SD201	LS07-SD201-01C	SVOCs, Pest/PCBs, Metals
	09/13/2001	LS07-SD202	LS07-SD202-01C	SVOCs, Pest/PCBs, Metals
	09/13/2001	LS07-SD202	LS07-SD202P-01C	SVOCs, Pest/PCBs, Metals
	09/13/2001	LS07-SD203	LS07-SD203-01C	SVOCs, Pest/PCBs, Metals
	09/13/2001	LS07-SD204	LS07-SD204-01C	SVOCs, Pest/PCBs, Metals
	09/13/2001	LS07-SD204	LS07-SD204P-01C	SVOCs, Pest/PCBs, Metals
	09/10/2001	LS07-SD210	LS07-SD210-01C	SVOCs, Pest/PCBs, Metals
	09/13/2001	LS07-SD211	LS07-SD211-01C	SVOCs, Pest/PCBs, Metals
	09/13/2001	LS07-SD212	LS07-SD212-01C	SVOCs, Pest/PCBs, Metals
	09/13/2001	LS07-SD213	LS07-SD213-01C	SVOCs, Pest/PCBs, Metals
	03/04/2002	LS07-SD201	LS07-SD201-02A	SVOCs, Pest/PCBs, Metals
	03/05/2002	LS07-SD202	LS07-SD202-02A	SVOCs, Pest/PCBs, Metals
	03/05/2002	LS07-SD203	LS07-SD203-02A	SVOCs, Pest/PCBs, Metals
	03/05/2002	LS07-SD204	LS07-SD204-02A	SVOCs, Pest/PCBs, Metals
	03/05/2002	LS07-SD204	LS07-SD204P-02A	SVOCs, Pest/PCBs, Metals
	03/04/2002	LS07-SD210	LS07-SD210-02A	SVOCs, Pest/PCBs, Metals
	03/05/2002	LS07-SD211	LS07-SD211-02A	SVOCs, Pest/PCBs, Metals
	03/05/2002	LS07-SD212	LS07-SD212-02A	SVOCs, Pest/PCBs, Metals
	03/05/2002	LS07-SD213	LS07-SD213-02A	SVOCs, Pest/PCBs, Metals
Canal on East Side of Site				
	03/01/2001	LS07-SD205	LS07-SD205-01A	SVOCs, Pest/PCBs, Metals
	09/11/2001	LS07-SD205	LS07-SD205-01C	SVOCs, Pest/PCBs, Metals
	03/04/2002	LS07-SD205	LS07-SD205-02A	SVOCs, Pest/PCBs, Metals
Groundwater				
	02/26/2001	LS07-MW01	LS07-MW01-01A	VOCs, SVOCs, Pest/PCBs, Metals (total and dissolved)
	02/26/2001	LS07-MW03	LS07-MW03-01A	VOCs, SVOCs, Pest/PCBs, Metals (total and dissolved)
	09/13/2001	LS07-MW01	LS07-MW01P-01C	VOCs, SVOCs, Pest/PCBs, Metals (total and dissolved)
	09/13/2001	LS07-MW01	LS07-MW01-01C	VOCs, SVOCs, Pest/PCBs, Metals (total and dissolved)
	09/20/2001	LS07-MW03	LS07-MW03-01C	VOCs, SVOCs, Pest/PCBs, Metals (total and dissolved)
	03/05/2002	LS07-MW01	LS07-MW01-02A	VOCs, SVOCs, Pest/PCBs, Metals (total and dissolved)
	03/05/2002	LS07-MW01	LS07-MW01P-02A	VOCs, SVOCs, Pest/PCBs, Metals (total and dissolved)
	03/05/2002	LS07-MW03	LS07-MW03-02A	VOCs, SVOCs, Pest/PCBs, Metals (total and dissolved)

Table 4-2
Summary of Chemicals of Potential Concern for the HHRA
Site 7
NAB Little Creek
Virginia Beach, Virginia

Groundwater	Surface Soil	Combined Surface and Subsurface Soil	Surface Water	Sediment
Upper Aquifer-Tap Water	***Weigh Station Area***	***Weigh Station Area***	***Little Creek Cove***	***Little Creek Cove***
Aluminum	Aroclor-1260	Aroclor-1260	Arsenic	None
Arsenic	Arsenic	Arsenic		
Chromium	Chromium	Chromium	***Pond***	***Pond***
Iron	Iron	Copper	Arsenic	Arsenic
Manganese	Lead	Iron		Iron
Vanadium	Manganese	Lead	***Canal on West Side of Site***	Vanadium
	Vanadium	Manganese	1,1,2,2-Tetrachloroethane	
Upper Aquifer-Excavation Pit		Vanadium	Bromodichloromethane	***Canal on West Side of Site***
Aluminum	***Area to West of Landfill, the "Ear"***		Chloroform	Arsenic
Arsenic	Arsenic	***Area to West of Landfill, the "Ear"***	Arsenic	Vanadium
Chromium	Iron	Arsenic		
Iron	Thallium	Copper	***Canal on East Side of Site***	***Canal on East Side of Site***
Manganese	Vanadium	Iron	none	Arsenic
Vanadium		Thallium		
	Site Perimeter	Vanadium		
	Benzo(a)pyrene			
	Arsenic	***Site Perimeter***		
	Iron	Benzo(a)pyrene		
	Vanadium	Aluminum		
		Arsenic		
		Iron		
		Vanadium		
		Covered Area		
		Aroclor-1260		
		Arsenic		
		Iron		
		Manganese		
		Vanadium		

Table 4-3
Potentially Complete Human Health Exposure Pathways
Conceptual Site Model
Site 7
NAB Little Creek
Virginia Beach, Virginia

Land Use	Contaminated Media	Potentially Exposed Populations	Exposure Route (Human Health)	Pathway Selected for Evaluation	Rationale
Current-Weigh Station Area, Area to West of Landfill the "Ear", and Site Perimeter					
Industrial	Surface Soil	Maintenance Worker	Ingestion, dermal contact, and inhalation	Yes	Site maintenance workers could contact surface soil while mowing grass or performing other activities at site and may inhale vapors and dust while working.
	Surface Soil	Trepassers/Visitors - Adolescents	Ingestion, dermal contact, and inhalation	Yes	Although access to site limited by fencing and Little Creek Cove, and no trespassing signs, trespasser exposure will be evaluated
Current/Future-Little Creek Cove					
Residential or Industrial	Surface Water	Trepassers/Visitors - Adult and Adolescents	Ingestion and dermal contact	Yes	Trespasser/Visistor could swim in Little Creek Cove
	Sediment		Ingestion and dermal contact	Yes	Trespasser/Visistor could swim in Little Creek Cove
	Fish Tissue	Fisher	Ingestion	Qualitative	People may fish in Little Creek Cove and ingest the fish.
Industrial	Surface Water	Site Worker	Ingestion and dermal contact	Yes	Cove may be used for scuba diving practice and training.
	Sediment		Ingestion and dermal contact	Yes	Cove may be used for scuba diving practice and training.
Current/Future-Pond, Canal on West Side of Site, and Canal on East Side of Site					
Residential or Industrial	Surface Water	Trepassers/Visitors - Adult and Adolescents	Ingestion and dermal contact	Yes	Although not likely due to limited access (only by boat), pond could be used for wading.
	Sediment		Ingestion and dermal contact	Yes	Although not likely due to limited access (only by boat), pond could be used for wadding.

Table 4-3
Potentially Complete Human Health Exposure Pathways
Conceptual Site Model
Site 7
NAB Little Creek
Virginia Beach, Virginia

Land Use	Contaminated Media	Potentially Exposed Populations	Exposure Route (Human Health)	Pathway Selected for Evaluation	Rationale
Future					
Residential	Groundwater	Residents - Adults and Children	Ingestion, dermal contact, and inhalation	Yes	Although unlikely because groundwater is brackish and discharges directly to Little Creek Cove, groundwater could be used as a potable water supply in the future. Children are assumed to take baths, not showers, resulting in minimal inhalation exposure.
	Surface and Subsurface Soil		Ingestion, dermal contact, and inhalation	Yes	Although unlikely, if site used for future residential development, residents could contact soil. If site used for future residential development, residents could inhale vapors and dust from soil.
Industrial	Groundwater	Industrial Worker	Ingestion and dermal contact	Yes	Assumed site workers would not shower regularly at base even if groundwater used as a potable water supply for base. Although unlikely because groundwater is brackish and discharges directly to Little Creek Cove, groundwater could be used as a potable water supply in the future.
	Surface and Subsurface Soil		Ingestion, dermal contact, and inhalation	Yes	If site used for industrial use in future, future industrial workers could contact surface and subsurface soil. If site used for industrial use in future, future industrial workers could inhale vapors and dust from soil.
Residential or Industrial	Groundwater	Construction Worker	Ingestion, dermal contact, and inhalation	Yes	Construction workers may contact groundwater during excavation activities. Ingestion of groundwater during construction activities expected to be minimal. Construction workers may inhale vapors from groundwater during excavation activities.
	Surface and Subsurface Soil		Ingestion, dermal contact, and inhalation	Yes	Exposure to soil during construction activities. Exposure to emissions from soil during construction activities.

Table 4-4
Summary of Media-Specific Risks and Hazards
Site 7
NAB Little Creek
Virginia Beach, Virginia

Media: Surface Soil

	Current Maintenance Worker Adult- Weigh Station Area								Current/Future Trespasser/Visitor Adolescents- Weigh Station Area							
	HQ				CR				HQ				CR			
Chemical	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**
Aroclor-1260	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	3.1E-08	7.3E-08	**1.0E-07**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	1.3E-07	9.4E-08	**2.3E-07**
Arsenic	0.0E+00	3.6E-04	1.8E-04	**5.4E-04**	0.0E+00	5.8E-08	2.9E-08	**8.7E-08**	0.0E+00	4.3E-03	6.5E-04	**4.9E-03**	0.0E+00	2.5E-07	3.8E-08	**2.9E-07**
Chromium	0.0E+00	4.1E-04	2.8E-03	**3.2E-03**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	4.9E-03	1.0E-02	**1.5E-02**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
Iron	0.0E+00	2.3E-03	3.9E-04	**2.7E-03**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	2.8E-02	1.4E-03	**2.9E-02**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
Lead	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
Manganese	0.0E+00	1.1E-03	4.7E-03	**5.8E-03**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	1.3E-02	1.7E-02	**3.0E-02**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
Vanadium	0.0E+00	1.7E-03	1.1E-02	**1.3E-02**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	2.1E-02	4.0E-02	**6.0E-02**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
TOTAL	**0.0E+00**	**5.9E-03**	**1.9E-02**	**2.5E-02**	**0.0E+00**	**8.9E-08**	**1.0E-07**	**1.9E-07**	**0.0E+00**	**7.0E-02**	**6.9E-02**	**1.4E-01**	**0.0E+00**	**3.8E-07**	**1.3E-07**	**5.1E-07**

	Current Maintenance Worker Adult-Area to West of Landfill, the "Ear"								Current Trespasser/Visitor Adolescents-Area to West of Landfill, the "Ear"							
	HQ				CR				HQ				CR			
Chemical	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**
Arsenic	0.0E+00	7.2E-04	3.7E-04	**1.1E-03**	0.0E+00	1.2E-07	5.9E-08	**1.7E-07**	0.0E+00	8.6E-03	1.3E-03	**9.9E-03**	0.0E+00	5.0E-07	7.5E-08	**5.7E-07**
Iron	0.0E+00	1.4E-03	2.3E-04	**1.6E-03**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	1.6E-02	8.3E-04	**1.7E-02**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
Thallium	0.0E+00	6.7E-04	1.1E-04	**7.8E-04**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	8.0E-03	4.0E-04	**8.4E-03**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
Vanadium	0.0E+00	1.2E-03	8.0E-03	**9.2E-03**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	1.5E-02	2.8E-02	**4.3E-02**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
TOTAL	**0.0E+00**	**4.0E-03**	**8.7E-03**	**1.3E-02**	**0.0E+00**	**1.2E-07**	**5.9E-08**	**1.7E-07**	**0.0E+00**	**4.8E-02**	**3.1E-02**	**7.8E-02**	**0.0E+00**	**5.0E-07**	**7.5E-08**	**5.7E-07**

	Current Maintenance Worker Adult-Site Perimeter								Current Trespasser/Visitor Adolescents-Site Perimeter							
	HQ				CR				HQ				CR			
Chemical	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**
Benzo(a)pyrene	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	5.5E-08	1.2E-07	**1.8E-07**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	2.4E-07	0.0E+00	**2.4E-07**
Arsenic	0.0E+00	5.5E-04	2.8E-04	**8.3E-04**	0.0E+00	8.8E-08	4.5E-08	**1.3E-07**	0.0E+00	6.5E-03	9.9E-04	**7.5E-03**	0.0E+00	3.8E-07	1.6E-07	**5.3E-07**
Iron	0.0E+00	1.1E-03	1.9E-04	**1.3E-03**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	1.4E-02	6.9E-04	**1.4E-02**	0.0E+00	0.0E+00	5.7E-08	**5.7E-08**
Vanadium	0.0E+00	9.5E-03	6.2E-02	**7.1E-02**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	1.1E-01	2.2E-01	**3.3E-01**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
TOTAL	**0.0E+00**	**1.1E-02**	**6.2E-02**	**7.4E-02**	**0.0E+00**	**1.4E-07**	**1.7E-07**	**3.1E-07**	**0.0E+00**	**1.3E-01**	**2.2E-01**	**3.5E-01**	**0.0E+00**	**6.1E-07**	**2.1E-07**	**8.3E-07**

Media: Surface Water

	Current/Future Trespasser/Visitor Adolescents-Little Creek Cove								Current/Future Trespasser/Visitor Adult-Little Creek Cove							
	HQ				CR				HQ				CR			
Chemical	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**
Arsenic	0.0E+00	6.3E-03	1.2E-03	**7.6E-03**	0.0E+00	3.7E-07	7.2E-08	**4.4E-07**	0.0E+00	4.6E-03	1.2E-03	**5.8E-03**	0.0E+00	7.1E-07	1.9E-07	**9.0E-07**
TOTAL	**0.0E+00**	**6.3E-03**	**1.2E-03**	**7.6E-03**	**0.0E+00**	**3.7E-07**	**7.2E-08**	**4.4E-07**	**0.0E+00**	**4.6E-03**	**1.2E-03**	**5.8E-03**	**0.0E+00**	**7.1E-07**	**1.9E-07**	**9.0E-07**

	Current/Future Trespasser/Visitor Adolescents-Pond								Current/Future Trespasser/Visitor Adult-Pond							
	HQ				CR				HQ				CR			
Chemical	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**
Arsenic	0.0E+00	4.9E-03	2.8E-04	**5.1E-03**	0.0E+00	2.8E-07	1.7E-08	**3.0E-07**	0.0E+00	3.5E-03	2.7E-04	**3.8E-03**	0.0E+00	5.5E-07	4.3E-08	**5.9E-07**
TOTAL	**0.0E+00**	**4.9E-03**	**2.8E-04**	**5.1E-03**	**0.0E+00**	**2.8E-07**	**1.7E-08**	**3.0E-07**	**0.0E+00**	**3.5E-03**	**2.7E-04**	**3.8E-03**	**0.0E+00**	**5.5E-07**	**4.3E-08**	**5.9E-07**

	Current/Future Trespasser/Visitor Adolescents-Canal on West Side of Site								Current/Future Trespasser/Visitor Adult-Canal on West Side of Site							
	HQ				CR				HQ				CR			
Chemical	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**
1,1,2,2-Tetrachloroethane	0.0E+00	9.7E-06	1.1E-05	**2.0E-05**	0.0E+00	1.5E-08	1.6E-08	**3.1E-08**	0.0E+00	7.1E-06	1.0E-05	**1.7E-05**	0.0E+00	2.9E-08	4.2E-08	**7.1E-08**
Bromodichloromethane	0.0E+00	5.8E-05	4.0E-05	**9.8E-05**	0.0E+00	9.3E-09	6.3E-09	**1.6E-08**	0.0E+00	4.2E-05	3.9E-05	**8.1E-05**	0.0E+00	1.8E-08	1.6E-08	**3.4E-08**
Chloroform	0.0E+00	4.1E-04	2.8E-04	**6.9E-04**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	3.0E-04	2.7E-04	**5.7E-04**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**

Table 4-4
Summary of Media-Specific Risks and Hazards
Site 7
NAB Little Creek
Virginia Beach, Virginia

Arsenic	0.0E+00	1.2E-02	7.0E-04	**1.3E-02**	0.0E+00	6.9E-07	4.1E-08	**7.4E-07**	0.0E+00	8.7E-03	6.8E-04	**9.4E-03**	0.0E+00	1.3E-06	1.1E-07	**1.5E-06**
TOTAL	**0.0E+00**	**1.2E-02**	**1.0E-03**	**1.4E-02**	**0.0E+00**	**7.2E-07**	**6.4E-08**	**7.8E-07**	**0.0E+00**	**9.1E-03**	**1.0E-03**	**1.0E-02**	**0.0E+00**	**1.4E-06**	**1.6E-07**	**1.6E-06**

Table 4-4
Summary of Media-Specific Risks and Hazards
Site 7
NAB Little Creek
Virginia Beach, Virginia

Media: Surface Water (continued)

	Current/Future Site Worker Adult-Little Creek Cove							
	HQ				CR			
Chemical	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**
Arsenic	0.0E+00	1.6E-03	1.1E-04	**1.8E-03**	0.0E+00	2.6E-07	1.8E-08	**2.8E-07**
TOTAL	**0.0E+00**	**1.6E-03**	**1.1E-04**	**1.8E-03**	**0.0E+00**	**2.6E-07**	**1.8E-08**	**2.8E-07**

Media: Sediment

	Current/Future Trespasser/Visitor Adolescents-Pond								Current/Future Trespasser/Visitor Adult-Pond							
	HQ				CR				HQ				CR			
Chemical	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**
Arsenic	0.0E+00	3.6E-03	1.9E-03	**5.5E-03**	0.0E+00	2.1E-07	1.1E-07	**3.2E-07**	0.0E+00	2.6E-03	1.6E-03	**4.2E-03**	0.0E+00	4.0E-07	2.5E-07	**6.5E-07**
Iron	0.0E+00	1.0E-02	1.8E-03	**1.2E-02**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	7.4E-03	1.5E-03	**8.9E-03**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
Vanadium	0.0E+00	4.4E-03	3.1E-02	**3.5E-02**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	3.2E-03	2.6E-02	**2.9E-02**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
TOTAL	**0.0E+00**	**1.8E-02**	**3.4E-02**	**5.3E-02**	**0.0E+00**	**2.1E-07**	**1.1E-07**	**3.2E-07**	**0.0E+00**	**1.3E-02**	**2.9E-02**	**4.2E-02**	**0.0E+00**	**4.0E-07**	**2.5E-07**	**6.5E-07**

	Current/Future Trespasser/Visitor Adolescents-Canal on West Side of Site								Current/Future Trespasser/Visitor Adult-Canal on West Side of Site							
	HQ				CR				HQ				CR			
Chemical	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**
Arsenic	0.0E+00	2.9E-03	1.5E-03	**4.4E-03**	0.0E+00	1.7E-07	9.0E-08	**2.6E-07**	0.0E+00	2.1E-03	1.3E-03	**3.4E-03**	0.0E+00	3.2E-07	2.0E-07	**5.2E-07**
Vanadium	0.0E+00	4.4E-03	3.1E-02	**3.5E-02**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	3.2E-03	2.6E-02	**2.9E-02**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
TOTAL	**0.0E+00**	**7.3E-03**	**3.2E-02**	**3.9E-02**	**0.0E+00**	**1.7E-07**	**9.0E-08**	**2.6E-07**	**0.0E+00**	**5.3E-03**	**2.7E-02**	**3.2E-02**	**0.0E+00**	**3.2E-07**	**2.0E-07**	**5.2E-07**

	Current/Future Trespasser/Visitor Adolescents-Canal on East Side of Site								Current/Future Trespasser/Visitor Adult-Canal on East Side of Site							
	HQ				CR				HQ				CR			
Chemical	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**
Arsenic	0.0E+00	2.4E-03	1.4E-03	**3.8E-03**	0.0E+00	1.4E-07	8.3E-08	**2.2E-07**	0.0E+00	1.7E-03	1.2E-03	**2.9E-03**	0.0E+00	2.7E-07	1.9E-07	**4.5E-07**
TOTAL	**0.0E+00**	**2.4E-03**	**1.4E-03**	**3.8E-03**	**0.0E+00**	**1.4E-07**	**8.3E-08**	**2.2E-07**	**0.0E+00**	**1.7E-03**	**1.2E-03**	**2.9E-03**	**0.0E+00**	**2.7E-07**	**1.9E-07**	**4.5E-07**

Media: Groundwater

	Future Resident Adult-Upper Aquifer - Tap Water								Future Resident Child - Upper Aquifer - Tap Water							
	HQ				CR				HQ				CR			
Chemical	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**
Aluminum	0.0E+00	1.1E-01	2.2E-04	**1.1E-01**	NA	NA	NA	**NA**	0.0E+00	2.5E-01	6.3E-04	**2.5E-01**	NA	NA	NA	**NA**
Arsenic	0.0E+00	6.2E-01	1.2E-03	**6.2E-01**	NA	NA	NA	**NA**	0.0E+00	1.4E+00	3.6E-03	**1.5E+00**	NA	NA	NA	**NA**
Chromium	0.0E+00	2.1E-01	1.7E-02	**2.3E-01**	NA	NA	NA	**NA**	0.0E+00	5.0E-01	4.9E-02	**5.5E-01**	NA	NA	NA	**NA**
Iron	0.0E+00	8.7E-01	1.7E-03	**8.7E-01**	NA	NA	NA	**NA**	0.0E+00	2.0E+00	5.0E-03	**2.0E+00**	NA	NA	NA	**NA**
Manganese	0.0E+00	8.4E-01	4.2E-02	**8.9E-01**	NA	NA	NA	**NA**	0.0E+00	2.0E+00	1.2E-01	**2.1E+00**	NA	NA	NA	**NA**
Vanadium	0.0E+00	2.4E-01	1.9E-02	**2.6E-01**	NA	NA	NA	**NA**	0.0E+00	5.7E-01	5.4E-02	**6.2E-01**	NA	NA	NA	**NA**
TOTAL	**0.0E+00**	**2.9E+00**	**8.1E-02**	**3.0E+00**	**NA**	**NA**	**NA**	**NA**	**0.0E+00**	**6.8E+00**	**2.3E-01**	**7.0E+00**	**NA**	**NA**	**NA**	**NA**

	Future Resident Age-Adjusted - Upper Aquifer - Tap Water								Future Industrial Worker Adult - Upper Aquifer - Tap Water							
	HQ				CR				HQ				CR			
Chemical	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**
Aluminum	NA	NA	NA	**NA**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	3.9E-02	0.0E+00	**3.9E-02**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**

Table 4-4
Summary of Media-Specific Risks and Hazards
Site 7
NAB Little Creek
Virginia Beach, Virginia

Arsenic	NA	NA	NA	**NA**	0.0E+00	1.5E-04	3.3E-07	**1.5E-04**	0.0E+00	2.2E-01	0.0E+00	**2.2E-01**	0.0E+00	3.6E-05	0.0E+00	**3.6E-05**
Chromium	NA	NA	NA	**NA**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	7.6E-02	0.0E+00	**7.6E-02**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
Iron	NA	NA	NA	**NA**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	3.1E-01	0.0E+00	**3.1E-01**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
Manganese	NA	NA	NA	**NA**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	3.0E-01	0.0E+00	**3.0E-01**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
Vanadium	NA	NA	NA	**NA**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	8.7E-02	0.0E+00	**8.7E-02**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
TOTAL	**NA**	**NA**	**NA**	**NA**	**0.0E+00**	**1.5E-04**	**3.3E-07**	**1.5E-04**	**0.0E+00**	**1.0E+00**	**0.0E+00**	**1.0E+00**	**0.0E+00**	**3.6E-05**	**0.0E+00**	**3.6E-05**

Table 4-4
Summary of Media-Specific Risks and Hazards
Site 7
NAB Little Creek
Virginia Beach, Virginia

Media: Groundwater (continued)

	Future Construction Worker Adult - Upper Aquifer - Excavation Pit							
	HQ				CR			
Chemical	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**
Aluminum	0.0E+00	0.0E+00	8.2E-04	**8.2E-04**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
Arsenic	0.0E+00	0.0E+00	4.7E-03	**4.7E-03**	0.0E+00	0.0E+00	3.0E-08	**3.0E-08**
Chromium	0.0E+00	0.0E+00	9.7E-03	**9.7E-03**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
Iron	0.0E+00	0.0E+00	6.6E-03	**6.6E-03**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
Manganese	0.0E+00	0.0E+00	1.6E-01	**1.6E-01**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
Vanadium	0.0E+00	0.0E+00	7.1E-02	**7.1E-02**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
TOTAL	**0.0E+00**	**0.0E+00**	**2.5E-01**	**1.8E-01**	**0.0E+00**	**0.0E+00**	**3.0E-08**	**3.0E-08**

Media: Soil* - Weigh Station Area

	Future Resident Adult								Future Resident Child							
	HQ				CR				HQ				CR			
Chemical	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**
Aroclor-1260	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	NA	NA	NA	**NA**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	NA	NA	NA	**NA**
Arsenic	0.0E+00	1.1E-02	4.2E-03	**1.5E-02**	NA	NA	NA	**NA**	0.0E+00	9.8E-02	5.5E-03	**1.0E-01**	NA	NA	NA	**NA**
Chromium	0.0E+00	1.2E-02	6.4E-02	**7.6E-02**	NA	NA	NA	**NA**	0.0E+00	1.1E-01	8.4E-02	**2.0E-01**	NA	NA	NA	**NA**
Copper	0.0E+00	1.4E-02	1.8E-03	**1.5E-02**	NA	NA	NA	**NA**	0.0E+00	1.3E-01	2.4E-03	**1.3E-01**	NA	NA	NA	**NA**
Iron	0.0E+00	6.8E-02	8.9E-03	**7.7E-02**	NA	NA	NA	**NA**	0.0E+00	6.3E-01	1.2E-02	**6.4E-01**	NA	NA	NA	**NA**
Lead	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	NA	NA	NA	**NA**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	NA	NA	NA	**NA**
Manganese	0.0E+00	3.2E-02	1.1E-01	**1.4E-01**	NA	NA	NA	**NA**	0.0E+00	3.0E-01	1.4E-01	**4.4E-01**	NA	NA	NA	**NA**
Vanadium	0.0E+00	5.0E-02	2.6E-01	**3.1E-01**	NA	NA	NA	**NA**	0.0E+00	4.7E-01	3.4E-01	**8.1E-01**	NA	NA	NA	**NA**
TOTAL	**0.0E+00**	**1.9E-01**	**4.4E-01**	**6.3E-01**	**NA**	**NA**	**NA**	**NA**	**0.0E+00**	**1.7E+00**	**5.8E-01**	**1.5E+00**	**NA**	**NA**	**NA**	**NA**

	Future Resident Age Adjusted								Future Indultrial Worker Adult							
	HQ				CR				HQ				CR			
Chemical	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**
Aroclor-1260	NA	NA	NA	**NA**	0.0E+00	2.9E-06	2.1E-06	**5.0E-06**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	6.4E-07	1.5E-06	**2.2E-06**
Arsenic	NA	NA	NA	**NA**	0.0E+00	5.4E-06	8.5E-07	**6.3E-06**	0.0E+00	7.5E-03	3.8E-03	**1.1E-02**	0.0E+00	1.2E-06	1.2E-08	**1.2E-06**
Chromium	NA	NA	NA	**NA**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	8.6E-03	5.9E-02	**6.7E-02**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
Copper	NA	NA	NA	**NA**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	9.7E-03	1.6E-03	**1.1E-02**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
Iron	NA	NA	NA	**NA**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	4.8E-02	8.2E-03	**5.6E-02**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
Lead	NA	NA	NA	**NA**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
Manganese	NA	NA	NA	**NA**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	2.3E-02	9.7E-02	**1.2E-01**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
Vanadium	NA	NA	NA	**NA**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	3.6E-02	2.3E-01	**2.7E-01**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
TOTAL	**NA**	**NA**	**NA**	**NA**	**0.0E+00**	**8.3E-06**	**3.0E-06**	**1.1E-05**	**0.0E+00**	**1.3E-01**	**4.0E-01**	**2.7E-01**	**0.0E+00**	**1.8E-06**	**1.5E-06**	**3.4E-06**

	Future Construction Worker Adult							
	HQ				CR			
Chemical	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**
Aroclor-1260	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	6.2E-08	2.3E-08	**8.5E-08**
Arsenic	0.0E+00	1.8E-02	1.4E-03	**1.9E-02**	0.0E+00	1.2E-07	9.2E-09	**1.2E-07**
Chromium	0.0E+00	3.1E-03	3.3E-03	**6.4E-03**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
Copper	0.0E+00	2.3E-02	6.2E-04	**2.4E-02**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
Iron	0.0E+00	1.2E-01	3.1E-03	**1.2E-01**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
Lead	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
Manganese	0.0E+00	5.5E-02	3.7E-02	**9.2E-02**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
Vanadium	0.0E+00	8.6E-02	8.8E-02	**1.7E-01**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
TOTAL	**0.0E+00**	**3.0E-01**	**1.3E-01**	**4.3E-01**	**0.0E+00**	**1.8E-07**	**3.2E-08**	**2.1E-07**

Table 4-4
Summary of Media-Specific Risks and Hazards
Site 7
NAB Little Creek
Virginia Beach, Virginia

Media: Soil* - Area to West of Landfill, the "Ear

	Future Resident Adult								Future Resident Child							
	HQ				CR				HQ				CR			
Chemical	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**
Arsenic	0.0E+00	2.1E-02	8.3E-03	**2.9E-02**	NA	NA	NA	**NA**	0.0E+00	2.0E-01	1.1E-02	**2.1E-01**	NA	NA	NA	**NA**
Copper	0.0E+00	2.6E-02	3.4E-03	**2.9E-02**	NA	NA	NA	**NA**	0.0E+00	2.4E-01	4.5E-03	**2.4E-01**	NA	NA	NA	**NA**
Iron	0.0E+00	1.0E-01	1.3E-02	**1.1E-01**	NA	NA	NA	**NA**	0.0E+00	9.3E-01	1.7E-02	**9.5E-01**	NA	NA	NA	**NA**
Thallium	0.0E+00	2.0E-02	2.6E-03	**2.2E-02**	NA	NA	NA	**NA**	0.0E+00	1.8E-01	3.4E-03	**1.9E-01**	NA	NA	NA	**NA**
Vanadium	0.0E+00	3.6E-02	1.8E-01	**2.2E-01**	NA	NA	NA	**NA**	0.0E+00	3.3E-01	2.4E-01	**5.7E-01**	NA	NA	NA	**NA**
TOTAL	**0.0E+00**	**2.0E-01**	**2.1E-01**	**4.1E-01**	**NA**	**NA**	**NA**	**NA**	**0.0E+00**	**1.9E+00**	**2.8E-01**	**2.2E+00**	**NA**	**NA**	**NA**	**NA**

	Future Resident Age-Adjusted								Future Industrial Worker Adult							
					CR				HQ				CR			
Chemical	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**
Arsenic	NA	NA	NA	**NA**	0.0E+00	1.1E-05	1.7E-06	**1.3E-05**	0.0E+00	1.5E-02	7.6E-03	**2.3E-02**	0.0E+00	2.4E-06	1.2E-06	**3.6E-06**
Copper	NA	NA	NA	**NA**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	1.8E-02	3.1E-03	**2.1E-02**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
Iron	NA	NA	NA	**NA**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	7.1E-02	1.2E-02	**8.3E-02**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
Thallium	NA	NA	NA	**NA**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	1.4E-02	2.4E-03	**1.6E-02**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
Vanadium	NA	NA	NA	**NA**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	2.5E-02	1.7E-01	**1.9E-01**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
TOTAL	**NA**	**NA**	**NA**	**NA**	**0.0E+00**	**1.1E-05**	**1.7E-06**	**1.3E-05**	**0.0E+00**	**1.4E-01**	**1.9E-01**	**3.3E-01**	**0.0E+00**	**2.4E-06**	**1.2E-06**	**3.6E-06**

	Future Construction Worker Adult							
					CR			
Chemical	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**
Arsenic	0.0E+00	3.6E-02	2.9E-03	**3.9E-02**	0.0E+00	2.3E-07	1.8E-08	**2.5E-07**
Copper	0.0E+00	4.4E-02	1.2E-03	**4.5E-02**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
Iron	0.0E+00	1.7E-01	4.5E-03	**1.8E-01**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
Thallium	0.0E+00	3.4E-02	8.9E-04	**3.4E-02**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
Vanadium	0.0E+00	6.1E-02	6.2E-02	**1.2E-01**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
TOTAL	**0.0E+00**	**3.5E-01**	**7.2E-02**	**4.2E-01**	**0.0E+00**	**2.3E-07**	**1.8E-08**	**2.5E-07**

Media: Soil* - Site Perimeter

	Future Resident Adult								Future Resident Child							
	HQ				CR				HQ				CR			
Chemical	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**
Benzo(a)pyrene	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	NA	NA	NA	**NA**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	NA	NA	NA	**NA**
Aluminum	0.0E+00	3.8E-02	5.1E-03	**4.3E-02**	NA	NA	NA	**NA**	0.0E+00	3.6E-01	6.7E-03	**3.6E-01**	NA	NA	NA	**NA**
Arsenic	0.0E+00	2.5E-02	9.7E-03	**3.4E-02**	NA	NA	NA	**NA**	0.0E+00	2.3E-01	1.3E-02	**2.4E-01**	NA	NA	NA	**NA**
Iron	0.0E+00	5.2E-02	6.9E-03	**5.9E-02**	NA	NA	NA	**NA**	0.0E+00	4.8E-01	9.1E-03	**4.9E-01**	NA	NA	NA	**NA**
Vanadium	0.0E+00	2.8E-01	1.4E+00	**1.7E+00**	NA	NA	NA	**NA**	0.0E+00	2.6E+00	1.9E+00	**4.4E+00**	NA	NA	NA	**NA**
TOTAL	**0.0E+00**	**3.9E-01**	**1.4E+00**	**1.8E+00**	**NA**	**NA**	**NA**	**NA**	**0.0E+00**	**3.7E+00**	**1.9E+00**	**5.5E+00**	**NA**	**NA**	**NA**	**NA**

	Future Resident Age-Adjusted								Future Industrial Worker Adult							
					CR				HQ				CR			
Chemical	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**
Benzo(a)pyrene	NA	NA	NA	**NA**	0.0E+00	4.9E-06	3.4E-06	**8.3E-06**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	1.1E-06	2.4E-06	**3.5E-06**
Aluminum	NA	NA	NA	**NA**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	2.7E-02	4.6E-03	**3.2E-02**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
Arsenic	NA	NA	NA	**NA**	0.0E+00	1.3E-05	2.0E-06	**1.5E-05**	0.0E+00	1.8E-02	8.9E-03	**2.6E-02**	0.0E+00	2.8E-06	2.9E-08	**2.8E-06**
Iron	NA	NA	NA	**NA**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	3.7E-02	6.3E-03	**4.3E-02**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
Vanadium	NA	NA	NA	**NA**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	2.0E-01	1.3E+00	**1.5E+00**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
TOTAL	**NA**	**NA**	**NA**	**NA**	**0.0E+00**	**1.8E-05**	**5.4E-06**	**2.3E-05**	**0.0E+00**	**2.8E-01**	**1.3E+00**	**1.6E+00**	**0.0E+00**	**3.9E-06**	**2.4E-06**	**6.4E-06**

Table 4-4
Summary of Media-Specific Risks and Hazards
Site 7
NAB Little Creek
Virginia Beach, Virginia

Media: Soil* - Site Perimeter (continued)

	Future Construction Worker Adult							
					CR			
Chemical	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**
Benzo(a)pyrene	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	1.1E-07	3.6E-08	**1.4E-07**
Aluminum	0.0E+00	6.6E-02	1.7E-03	**6.7E-02**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
Arsenic	0.0E+00	4.2E-02	3.3E-03	**4.5E-02**	0.0E+00	2.7E-07	2.1E-08	**2.9E-07**
Iron	0.0E+00	8.9E-02	2.4E-03	**9.1E-02**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
Vanadium	0.0E+00	4.7E-01	4.8E-01	**9.6E-01**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
TOTAL	**0.0E+00**	**6.7E-01**	**4.9E-01**	**1.2E+00**	**0.0E+00**	**3.8E-07**	**5.8E-08**	**4.3E-07**

Media: Soil* - Covered Area

	Future Resident Adult								Future Resident Child							
	HQ				CR				HQ				CR			
Chemical	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**
Aroclor-1260	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	NA	NA	NA	**NA**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	NA	NA	NA	**NA**
Arsenic	0.0E+00	9.6E-03	3.8E-03	**1.3E-02**	NA	NA	NA	**NA**	0.0E+00	9.0E-02	5.0E-03	**9.5E-02**	NA	NA	NA	**NA**
Iron	0.0E+00	4.7E-02	6.1E-03	**5.3E-02**	NA	NA	NA	**NA**	0.0E+00	4.3E-01	8.1E-03	**4.4E-01**	NA	NA	NA	**NA**
Manganese	0.0E+00	1.3E-02	4.2E-02	**5.4E-02**	NA	NA	NA	**NA**	0.0E+00	1.2E-01	5.5E-02	**1.7E-01**	NA	NA	NA	**NA**
Vanadium	0.0E+00	5.4E-02	2.7E-01	**3.3E-01**	NA	NA	NA	**NA**	0.0E+00	5.1E-01	3.6E-01	**8.7E-01**	NA	NA	NA	**NA**
TOTAL	**0.0E+00**	**1.2E-01**	**3.3E-01**	**4.5E-01**	**NA**	**NA**	**NA**	**NA**	**0.0E+00**	**1.1E+00**	**4.3E-01**	**1.6E+00**	**NA**	**NA**	**NA**	**NA**

	Future Resident Age-Adjusted								Future Industrial Worker Adult							
					CR				HQ				CR			
Chemical	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**
Aroclor-1260	NA	NA	NA	**NA**	0.0E+00	1.1E-05	8.1E-06	**1.9E-05**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	2.4E-06	5.8E-06	**8.3E-06**
Arsenic	NA	NA	NA	**NA**	0.0E+00	4.9E-06	7.8E-07	**5.7E-06**	0.0E+00	6.9E-03	3.5E-03	**1.0E-02**	0.0E+00	1.1E-06	1.1E-08	**1.1E-06**
Iron	NA	NA	NA	**NA**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	3.3E-02	5.6E-03	**3.9E-02**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
Manganese	NA	NA	NA	**NA**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	9.0E-03	3.8E-02	**4.7E-02**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
Vanadium	NA	NA	NA	**NA**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	3.9E-02	2.5E-01	**2.9E-01**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
TOTAL	**NA**	**NA**	**NA**	**NA**	**0.0E+00**	**1.6E-05**	**8.9E-06**	**2.5E-05**	**0.0E+00**	**8.8E-02**	**3.0E-01**	**3.9E-01**	**0.0E+00**	**3.6E-06**	**5.8E-06**	**9.4E-06**

	Future Construction Worker Adult							
					CR			
Chemical	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**
Aroclor-1260	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	0.0E+00	2.3E-07	8.7E-08	**3.2E-07**
Arsenic	0.0E+00	1.6E-02	1.3E-03	**1.8E-02**	0.0E+00	1.1E-07	8.4E-09	**1.1E-07**
Iron	0.0E+00	8.0E-02	2.1E-03	**8.2E-02**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
Manganese	0.0E+00	2.2E-02	1.4E-02	**3.6E-02**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
Vanadium	0.0E+00	9.3E-02	9.5E-02	**1.9E-01**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
TOTAL	**0.0E+00**	**2.1E-01**	**1.1E-01**	**3.2E-01**	**0.0E+00**	**3.4E-07**	**9.6E-08**	**4.4E-07**

[1] Adult inhalation cancer risk based on the adult showering scenario since it is the most conservative.

[2] Age-adjusted dermal cancer risk based on the child bathing scenario since it is the most conservative.

Table 4-5
Summary Table for All Pathways for All RME Exposure Scenarios
Site 7
NAB Little Creek
Virginia Beach, Virginia

	Exposure Pathways						Total Risk for Pathways	Total HI for Pathways	Percent Contribution by Pathway					
	Inhalation		Ingestion		Dermal				Inhalation		Ingestion		Dermal	
	Risk	HI	Risk	HI	Risk	HI			% Risk	% HI	% Risk	% HI	% Risk	% HI
Surface Soil - Weigh Station Area														
Current Maintenance Worker	0.0E+00	0.0E+00	8.9E-08	5.9E-03	1.0E-07	1.9E-02	**1.9E-07**	**2.5E-02**	0%	0%	46%	23%	54%	77%
Current/Future Trespasser/Visitor Adolescents	0.0E+00	0.0E+00	3.8E-07	7.0E-02	1.3E-07	6.9E-02	**5.1E-07**	**1.4E-01**	0%	0%	74%	51%	26%	49%
Surface Soil - Area to West of Landfill, the "Ear"														
Current Maintenance Worker	0.0E+00	0.0E+00	1.2E-07	4.0E-03	5.9E-08	8.7E-03	**1.7E-07**	**1.3E-02**	0%	0%	66%	32%	34%	68%
Current/Future Trespasser/Visitor Adolescents	0.0E+00	0.0E+00	5.0E-07	4.8E-02	7.5E-08	3.1E-02	**5.7E-07**	**7.8E-02**	0%	0%	87%	61%	13%	39%
Surface Soil - Site Perimeter														
Current Maintenance Worker	0.0E+00	0.0E+00	1.4E-07	1.1E-02	1.7E-07	6.2E-02	**3.1E-07**	**7.4E-02**	0%	0%	46%	15%	54%	85%
Current/Future Trespasser/Visitor Adolescents	0.0E+00	0.0E+00	6.1E-07	1.3E-01	2.1E-07	2.2E-01	**8.3E-07**	**3.5E-01**	0%	0%	74%	38%	26%	62%
Soil*- Weigh Station Area														
Future Resident Adult	NA	0.0E+00	NA	1.9E-01	NA	4.4E-01	**NA**	**6.3E-01**	NA	0%	NA	30%	NA	70%
Future Resident Child	NA	0.0E+00	NA	1.7E+00	NA	5.8E-01	**NA**	**2.3E+00**	NA	0%	NA	75%	NA	25%
Future Age-Adjusted Resident	0.0E+00	NA	8.3E-06	NA	3.0E-06	NA	**1.1E-05**	**NA**	0%	NA	74%	NA	26%	NA
Future Industrial Worker	0.0E+00	0.0E+00	1.8E-06	1.3E-01	1.5E-06	4.0E-01	**3.4E-06**	**5.4E-01**	0%	0%	55%	25%	45%	75%
Future Construction Worker	0.0E+00	0.0E+00	1.8E-07	3.0E-01	3.2E-08	1.3E-01	**2.1E-07**	**4.3E-01**	0%	0%	85%	69%	15%	31%
Soil*- Area to West of Landfill, the "Ear"														
Future Resident Adult	NA	0.0E+00	NA	2.0E-01	NA	2.1E-01	**NA**	**4.1E-01**	NA	0%	NA	49%	NA	51%
Future Resident Child	NA	0.0E+00	NA	1.9E+00	NA	2.8E-01	**NA**	**2.2E+00**	NA	0%	NA	87%	NA	13%
Future Age-Adjusted Resident	0.0E+00	0.0E+00	1.1E-05	NA	1.7E-06	NA	**1.3E-05**	**NA**	0%	NA	86%	NA	14%	NA
Future Industrial Worker	0.0E+00	0.0E+00	2.4E-06	1.4E-01	1.2E-06	1.9E-01	**3.6E-06**	**3.3E-01**	0%	0%	66%	43%	34%	57%
Future Construction Worker	0.0E+00	0.0E+00	2.3E-07	3.5E-01	1.8E-08	7.2E-02	**2.5E-07**	**4.2E-01**	0%	0%	93%	83%	7%	17%
Soil*- Site Perimeter														
Future Resident Adult	NA	0.0E+00	NA	3.9E-01	NA	1.4E+00	**NA**	**1.8E+00**	NA	0%	NA	22%	NA	78%
Future Resident Child	NA	0.0E+00	NA	3.7E+00	NA	1.9E+00	**NA**	**5.5E+00**	NA	0%	NA	66%	NA	34%
Future Age-Adjusted Resident	0.0E+00	NA	1.8E-05	NA	5.4E-06	NA	**2.3E-05**	**NA**	0%	NA	77%	NA	23%	NA
Future Industrial Worker	0.0E+00	0.0E+00	3.9E-06	2.8E-01	2.4E-06	1.3E+00	**6.4E-06**	**1.6E+00**	0%	0%	62%	18%	38%	82%
Future Construction Worker	0.0E+00	0.0E+00	3.8E-07	6.7E-01	5.8E-08	4.9E-01	**4.3E-07**	**1.2E+00**	0%	0%	87%	58%	13%	42%
Soil*- Covered Area														
Future Resident Adult	NA	0.0E+00	NA	1.2E-01	NA	3.3E-01	**NA**	**4.5E-01**	NA	0%	NA	27%	NA	73%
Future Resident Child	NA	0.0E+00	NA	1.1E+00	NA	4.3E-01	**NA**	**1.6E+00**	NA	0%	NA	73%	NA	27%
Future Age-Adjusted Resident	0.0E+00	NA	1.6E-05	NA	8.9E-06	NA	**2.5E-05**	**NA**	0%	NA	64%	NA	36%	NA
Future Industrial Worker	0.0E+00	0.0E+00	3.6E-06	8.8E-02	5.8E-06	3.0E-01	**9.4E-06**	**3.9E-01**	0%	0%	38%	23%	62%	77%
Future Construction Worker	0.0E+00	0.0E+00	3.4E-07	2.1E-01	9.6E-08	1.1E-01	**4.4E-07**	**3.2E-01**	0%	0%	78%	65%	22%	35%

Table 4-5
Summary Table for All Pathways for All RME Exposure Scenarios
Site 7
NAB Little Creek
Virginia Beach, Virginia

	Exposure Pathways						Total Risk for Pathways	Total HI for Pathways	Percent Contribution by Pathway					
	Inhalation		Ingestion		Dermal				Inhalation		Ingestion		Dermal	
	Risk	HI	Risk	HI	Risk	HI			% Risk	% HI	% Risk	% HI	% Risk	% HI
Groundwater														
Future Resident Adult	NA	0.0E+00	NA	2.9E+00	NA	8.1E-02	**NA**	**3.0E+00**	NA	0%	NA	97%	NA	3%
Future Resident Child	NA	0.0E+00	NA	6.8E+00	NA	2.3E-01	**NA**	**7.0E+00**	NA	0%	NA	97%	NA	3%
Future Age-Adjusted Resident	0.0E+00	NA	1.5E-04	NA	3.3E-07	NA	**1.5E-04**	**NA**	0%	NA	100%	NA	0%	NA
Future Industrial Worker	0.0E+00	0.0E+00	3.6E-05	1.0E+00	0.0E+00	0.0E+00	**3.6E-05**	**1.0E+00**	0%	0%	100%	100%	0%	0%
Future Construction Worker	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.0E-08	2.5E-01	**3.0E-08**	**2.5E-01**	0%	0%	0%	0%	100%	100%
Surface Water-Little Creek Cove														
Current/Future Trespasser/Visitor Adolescents	0.0E+00	0.0E+00	3.7E-07	6.3E-03	7.2E-08	1.2E-03	**4.4E-07**	**7.6E-03**	0%	0%	84%	84%	16%	16%
Current/Future Trespasser/Visitor Adult	0.0E+00	0.0E+00	7.1E-07	4.6E-03	1.9E-07	1.2E-03	**9.0E-07**	**5.8E-03**	0%	0%	79%	79%	21%	21%
Current/Future Site Worker Adult	0.0E+00	0.0E+00	2.6E-07	1.6E-03	1.8E-08	1.1E-04	**2.8E-07**	**1.8E-03**	0%	0%	93%	94%	7%	6%
Surface Water-Pond														
Current/Future Trespasser/Visitor Adolescents	0.0E+00	0.0E+00	2.8E-07	4.9E-03	1.7E-08	2.8E-04	**3.0E-07**	**5.1E-03**	0%	0%	94%	95%	6%	5%
Current/Future Trespasser/Visitor Adult	0.0E+00	0.0E+00	5.5E-07	3.5E-03	4.3E-08	2.7E-04	**5.9E-07**	**3.8E-03**	0%	0%	93%	93%	7%	7%
Surface Water-Canal on West Side of Site														
Current/Future Trespasser/Visitor Adolescents	0.0E+00	0.0E+00	7.2E-07	1.2E-02	6.4E-08	1.0E-03	**7.8E-07**	**1.4E-02**	0%	0%	92%	92%	8%	8%
Current/Future Trespasser/Visitor Adult	0.0E+00	0.0E+00	1.4E-06	9.1E-03	1.6E-07	1.0E-03	**1.6E-06**	**1.0E-02**	0%	0%	89%	90%	11%	10%
Sediment-Pond														
Current/Future Trespasser/Visitor Adolescents	0.0E+00	0.0E+00	2.1E-07	1.8E-02	1.1E-07	3.4E-02	**3.2E-07**	**5.3E-02**	0%	0%	65%	35%	35%	65%
Current/Future Trespasser/Visitor Adult	0.0E+00	0.0E+00	4.0E-07	1.3E-02	2.5E-07	2.9E-02	**6.5E-07**	**4.2E-02**	0%	0%	62%	31%	38%	69%
Sediment-Canal on West Side of Site														
Current/Future Trespasser/Visitor Adolescents	0.0E+00	0.0E+00	1.7E-07	7.3E-03	9.0E-08	3.2E-02	**2.6E-07**	**3.9E-02**	0%	0%	65%	18%	35%	82%
Current/Future Trespasser/Visitor Adult	0.0E+00	0.0E+00	3.2E-07	5.3E-03	2.0E-07	2.7E-02	**5.2E-07**	**3.2E-02**	0%	0%	62%	16%	38%	84%
Sediment-Canal on East Side of Site														
Current/Future Trespasser/Visitor Adolescents	0.0E+00	0.0E+00	1.4E-07	2.4E-03	8.3E-08	1.4E-03	**2.2E-07**	**3.8E-03**	0%	0%	62%	63%	38%	37%
Current/Future Trespasser/Visitor Adult	0.0E+00	0.0E+00	2.7E-07	1.7E-03	1.9E-07	1.2E-03	**4.5E-07**	**2.9E-03**	0%	0%	59%	59%	41%	41%

Risk = carcinogenic risk as determined by the risk calculations in Appendix.
HI = Hazard index as determined by the risk calculation in Appendix.
0% is <1% contribution by the pathway.

Table 4-6
Summary Table for Risks and Hazards Across Media for All RMEs
Site 7
NAB Little Creek
Virginia Beach, Virginia

Exposure Scenarios - Hazards and Risks

	Surface Soil Weigh Station Area		Surface Soil Area to the West of the Landfill, the "Ear"		Surface Soil Site Perimeter		Soil* Weigh Station Area		Soil* Area to the West of the Landfill, the "Ear"		Soil* Site Perimeter		Soil* Covered Area		Groundwater		Surface Water Little Creek Cove		Surface Water Pond		Surface Water Canal on West Side of Site		Sediment Pond		Sediment Canal on West Side of Site		Sediment Canal on East Side of Site		Total Risk for Pathways	Total HI for Pathways
	Risk	HI	Risk	HI	Risk	HI	Risk	HI	Risk	HI	Risk	HI	Risk	HI	Risk	HI	Risk	HI	Risk	HI	Risk	HI	Risk	HI	Risk	HI	Risk	HI		
Current Maintenance Worker	1.9E-07	2.5E-02	1.7E-07	1.3E-02	3.1E-07	7.4E-02	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	**6.8E-07**	**1.1E-01**
Current/Future Trespasser/Visitor Adolescents	5.1E-07	1.4E-01	5.7E-07	7.8E-02	8.3E-07	3.5E-01	--	--	--	--	--	--	--	--	--	--	4.4E-07	7.6E-03	3.0E-07	5.1E-03	7.8E-07	1.4E-02	3.2E-07	5.3E-02	2.6E-07	3.9E-02	2.2E-07	3.8E-03	**4.2E-06**	**6.9E-01**
Current/Future Trespasser/Visitor Adult	--	--	--	--			--	--	--	--	--	--	--	--	--	--	9.0E-07	5.8E-03	5.9E-07	3.8E-03	1.6E-06	1.0E-02	6.5E-07	4.2E-02	5.2E-07	3.2E-02	4.5E-07	2.9E-03	**4.7E-06**	**9.7E-02**
Current/Future Site Worker	--	--	--	--			--	--	--	--	--	--	--	--	--	--	2.8E-07	1.8E-03	--	--	--	--	--	--	--	--	--	--	**2.8E-07**	**1.8E-03**
Future Resident Adult	--	--	--	--			NA	6.3E-01	NA	4.1E-01	NA	1.8E+00	NA	4.5E-01	NA	3.0E+00	--	--	--	--	--	--	--	--	--	--	--	--	**NA**	**6.3E+00**
Future Resident Child	--	--	--	--			NA	2.3E+00	NA	2.2E+00	NA	5.5E+00	NA	1.6E+00	NA	7.0E+00	--	--	--	--	--	--	--	--	--	--	--	--	**NA**	**1.9E+01**
Future Age-Adjusted Resident	--	--	--	--			1.1E-05	NA	1.3E-05	NA	2.3E-05	NA	2.5E-05	NA	1.5E-04	NA	--	--	--	--	--	--	--	--	--	--	--	--	**2.2E-04**	**NA**
Future Industrial Worker	--	--	--	--			3.4E-06	5.4E-01	3.6E-06	3.3E-01	6.4E-06	1.6E+00	9.4E-06	3.9E-01	3.6E-05	1.0E+00	--	--	--	--	--	--	--	--	--	--	--	--	**5.8E-05**	**3.9E+00**
Future Construction Worker	--	--	--	--			2.1E-07	4.3E-01	2.5E-07	4.2E-01	4.3E-07	1.2E+00	4.4E-07	3.2E-01	3.0E-08	2.5E-01	--	--	--	--	--	--	--	--	--	--	--	--	**1.4E-06**	**2.6E+00**

Exposure Scenarios - Percent for Pathway

	Surface Soil						Soil* Weigh Station Area		Soil* Area to the West of the Landfill, the "Ear"		Soil* Site Perimeter		Soil* Covered Area		Groundwater		Surface Water Little Creek Cove		Surface Water Pond		Surface Water Canal on West Side of Site		Sediment Pond		Sediment Canal on West Side of Site		Sediment Canal on East Side of Site	
	% Risk	% HI	% Risk	% HI	% Risk	% HI	% Risk	% HI	% Risk	% HI	% Risk	% HI	% Risk	% HI	% Risk	% HI	% Risk	% HI	% Risk	% HI	% Risk	% HI	% Risk	% HI	% Risk	% HI	% Risk	% HI
Current Maintenance Worker	28%	23%	26%	11%	46%	66%	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Current/Future Trespasser/Visitor Adolescents	12%	20%	14%	11%	20%	51%	--	--	--	--	--	--	--	--	--	--	10%	1%	7%	1%	19%	2%	8%	8%	6%	6%	5%	1%
Current/Future Trespasser/Visitor Adult	--	--					--	--	--	--	--	--	--	--	--	--	19%	6%	13%	4%	33%	10%	14%	43%	11%	33%	10%	3%
Current/Future Site Worker	--	--					--	--	--	--	--	--	--	--	--	--	100%	100%	--	--	--	--	--	--	--	--	--	--
Future Resident Adult	--	--					NA	10%	NA	7%	NA	29%	NA	7%	NA	47%	--	--	--	--	--	--	--	--	--	--	--	--
Future Resident Child	--	--					NA	12%	NA	12%	NA	30%	NA	8%	NA	38%	--	--	--	--	--	--	--	--	--	--	--	--
Future Age-Adjusted Resident	--	--					5%	NA	6%	NA	10%	NA	11%	NA	68%	NA	--	--	--	--	--	--	--	--	--	--	--	--
Future Industrial Worker	--	--					6%	14%	6%	9%	11%	41%	16%	10%	61%	27%	--	--	--	--	--	--	--	--	--	--	--	--
Future Construction Worker	--	--					15%	17%	18%	16%	32%	45%	32%	12%	2%	10%	--	--	--	--	--	--	--	--	--	--	--	--

Table 4-7
Summary of Media-Specific Risks and Hazards For CT
Site 7
NAB Little Creek
Virginia Beach, Virginia

Media: Groundwater

	Future Resident Adult-Upper Aquifer - Tap Water								Future Resident Child - Upper Aquifer - Tap Water							
	HQ				CR				HQ				CR			
Chemical	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**
Aluminum	0.0E+00	3.8E-03	9.9E-06	**3.8E-03**	NA	NA	NA	**NA**	0.0E+00	1.3E-02	2.7E-05	**1.3E-02**	NA	NA	NA	**NA**
Arsenic	0.0E+00	9.2E-02	2.4E-04	**9.3E-02**	NA	NA	NA	**NA**	0.0E+00	3.1E-01	6.6E-04	**3.1E-01**	NA	NA	NA	**NA**
Chromium	0.0E+00	8.7E-03	8.9E-04	**9.6E-03**	NA	NA	NA	**NA**	0.0E+00	2.9E-02	2.5E-03	**3.1E-02**	NA	NA	NA	**NA**
Iron	0.0E+00	2.9E-01	7.5E-04	**2.9E-01**	NA	NA	NA	**NA**	0.0E+00	9.7E-01	2.1E-03	**9.8E-01**	NA	NA	NA	**NA**
Manganese	0.0E+00	2.2E-01	1.4E-02	**2.3E-01**	NA	NA	NA	**NA**	0.0E+00	7.3E-01	3.9E-02	**7.7E-01**	NA	NA	NA	**NA**
Vanadium	0.0E+00	2.1E-02	2.1E-03	**2.3E-02**	NA	NA	NA	**NA**	0.0E+00	7.0E-02	5.8E-03	**7.6E-02**	NA	NA	NA	**NA**
TOTAL	**0.0E+00**	**6.4E-01**	**1.8E-02**	**6.6E-01**	**NA**	**NA**	**NA**	**NA**	**0.0E+00**	**2.1E+00**	**5.0E-02**	**2.2E+00**	**NA**	**NA**	**NA**	**NA**

	Future Resident Age-Adjusted - Upper Aquifer - Tap Water							
	HQ				CR			
Chemical	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**
Aluminum	NA	NA	NA	**NA**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
Arsenic	NA	NA	NA	**NA**	0.0E+00	1.7E-05	3.9E-08	**1.7E-05**
Chromium	NA	NA	NA	**NA**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
Iron	NA	NA	NA	**NA**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
Manganese	NA	NA	NA	**NA**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
Vanadium	NA	NA	NA	**NA**	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**
TOTAL	**NA**	**NA**	**NA**	**NA**	**0.0E+00**	**1.7E-05**	**3.9E-08**	**1.7E-05**

Media: Soil* - Weigh Station Area

	Future Resident Child							
	HQ				CR			
Chemical	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**
Aroclor-1260	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	NA	NA	NA	**NA**
Arsenic	0.0E+00	2.8E-02	2.7E-03	**3.1E-02**	NA	NA	NA	**NA**
Chromium	0.0E+00	3.0E-02	3.8E-02	**6.7E-02**	NA	NA	NA	**NA**
Copper	0.0E+00	1.9E-02	6.0E-04	**1.9E-02**	NA	NA	NA	**NA**
Iron	0.0E+00	1.6E-01	5.2E-03	**1.7E-01**	NA	NA	NA	**NA**
Lead	0.0E+00	0.0E+00	0.0E+00	**0.0E+00**	NA	NA	NA	**NA**
Manganese	0.0E+00	4.4E-02	3.5E-02	**8.0E-02**	NA	NA	NA	**NA**
Vanadium	0.0E+00	1.0E-01	1.3E-01	**2.3E-01**	NA	NA	NA	**NA**
TOTAL	**0.0E+00**	**3.9E-01**	**2.1E-01**	**6.0E-01**	**NA**	**NA**	**NA**	**NA**

Media: Soil* - Area to West of Landfill, the "Ear

	Future Resident Child							
	HQ				CR			
Chemical	**Inh**	**Ing**	**Der**	**Total**	**Inh**	**Ing**	**Der**	**Total**
Arsenic	0.0E+00	2.6E-02	2.5E-03	**2.9E-02**	NA	NA	NA	**NA**
Copper	0.0E+00	1.9E-03	6.0E-05	**1.9E-03**	NA	NA	NA	**NA**
Iron	0.0E+00	8.1E-02	2.6E-03	**8.4E-02**	NA	NA	NA	**NA**

Table 4-7
Summary of Media-Specific Risks and Hazards For CT
Site 7
NAB Little Creek
Virginia Beach, Virginia

Thallium	0.0E+00	3.2E-02	1.0E-03	**3.3E-02**	NA	NA	NA	**NA**
Vanadium	0.0E+00	4.5E-02	5.5E-02	**1.0E-01**	NA	NA	NA	**NA**
TOTAL	**0.0E+00**	**1.9E-01**	**6.1E-02**	**2.5E-01**	**NA**	**NA**	**NA**	**NA**

Table 4-8
Summary Table for All Pathways for All CT Exposure Scenarios
Site 7
NAB Little Creek
Virginia Beach, Virginia

	Exposure Pathways						Total Risk for Pathways	Total HI for Pathways	Percent Contribution by Pathway					
	Inhalation		Ingestion		Dermal				Inhalation		Ingestion		Dermal	
	Risk	HI	Risk	HI	Risk	HI			% Risk	% HI	% Risk	% HI	% Risk	% HI
Soil* Weigh Station Area														
Future Resident Child	NA	0.0E+00	NA	3.9E-01	NA	2.1E-01	**NA**	**6.0E-01**	NA	0%	NA	65%	NA	35%
Soil* Area to West of Landfill, the "Ear"														
Future Resident Child	NA	0.0E+00	NA	1.9E-01	NA	6.1E-02	**NA**	**2.5E-01**	NA	0%	NA	75%	NA	25%
Soil* Site Perimeter														
Future Resident Adult	NA	0.0E+00	NA	3.0E-02	NA	9.2E-02	**NA**	**1.2E-01**	NA	0%	NA	24%	NA	76%
Future Resident Child	NA	0.0E+00	NA	8.3E-01	NA	1.2E-01	**NA**	**9.5E-01**	NA	0%	NA	87%	NA	13%
Future Industrial Worker	NA	0.0E+00	NA	2.8E-02	NA	4.8E-02	**NA**	**7.6E-02**	NA	0%	NA	37%	NA	63%
Future Construction Worker	NA	0.0E+00	NA	6.3E-02	NA	2.1E-02	**NA**	**8.4E-02**	NA	0%	NA	75%	NA	25%
Soil*- Covered Area														
Future Resident Child	NA	0.0E+00	NA	1.5E-01	NA	7.4E-02	**NA**	**2.3E-01**	NA	0%	NA	67%	NA	33%
Groundwater														
Future Resident Adult	NA	0.0E+00	NA	6.4E-01	NA	1.8E-02	**NA**	**6.6E-01**	NA	0%	NA	97%	NA	3%
Future Resident Child	NA	0.0E+00	NA	2.1E+00	NA	5.0E-02	**NA**	**2.2E+00**	NA	0%	NA	98%	NA	2%
Future Age-Adjusted Resident	0.0E+00	NA	1.7E-05	NA	3.9E-08	NA	**1.7E-05**	**NA**	0%	NA	100%	NA	0%	NA

Risk = carcinogenic risk as determined by the risk calculations in Appendix.
HI = Hazard index as determined by the risk calculation in Appendix.
0% is <1% contribution by the pathway.

Table 4-9
Summary Table for Risks and Hazards Across Media for All CTs
Site 7
NAB Little Creek
Virginia Beach, Virginia

	Exposure Scenarios										Total Risk for Pathways	Total HI for Pathways	Exposure Scen					
	Soil* Weigh Station Area		Soil* Area to West of Landfill, the "Ear"		Soil* Site Perimeter		Soil* Covered Area		Groundwater				Soil* Weigh Station Area		Soil* Area to West of Landfill, the "Ear"		Soil* Site Perimeter	
	Risk	HI	Risk	HI	Risk	HI	Risk	HI	Risk	HI			% Risk	% HI	% Risk	% HI	% Risk	% HI
Future Resident Adult	--	--	--	--	NA	1.2E-01	--	--	NA	6.6E-01	**NA**	**7.8E-01**	--	--	--	--	NA	16%
Future Resident Child	NA	6.0E-01	NA	2.5E-01	NA	9.5E-01	NA	2.3E-01	NA	2.2E+00	**NA**	**2.0E+00**	NA	30%	NA	12%	NA	47%
Future Age-Adjusted Resident	--	--	--	--	--	--	--	--	1.7E-05	NA	**1.7E-05**	**NA**	--	--	--	--	--	--

TABLE 4-10
Summary of Risk Results

Receptor	Media	Total Excess Lifetime Cancer Risk	Exposure Route with Carcinogenic Risk >1x10^{-4}	Associated COPCs with Carcinogenic Risk >1x10^{-4}	Total Noncarcinogenic Hazard Indices	Exposure Route with Hazard Quotient >1	Associated COPCs with Hazard Quotient >1
Current Maintenance Worker - Adult	Surface Soil	5x10^{-7}	NA	None	0.034	NA	None
Current/Future Trespasser/Visitor - Adolescent	Surface Soil, Surface Water, Sediment	4x10^{-6}	NA	None	0.27	NA	None
Current/Future Trespasser/Visitor - Adult	Surface Soil, Surface Water, Sediment	5x10^{-6}	NA	None	0.046	NA	None
Current/Future Site Worker - Adult	Surface Water	3x10^{-7}	NA	None	0.002	NA	None
Future Resident - Adult	Groundwater, Soil*	NA	NA	NA	3.9	Ingestion of Groundwater	None
Future Resident - Child	Groundwater, Soil*	NA	NA	NA	12.2	Ingestion of Groundwater Ingestion of Soil*	Arsenic, Iron, Manganese None
Future Resident - Child/Adult	Groundwater, Soil*	2x10^{-4}	Ingestion of Groundwater	Arsenic	NA	NA	NA
Future Resident - Adult (CT)	Groundwater	NA	NA	NA	0.62	NA	None
Future Resident - Child (CT)	Groundwater, Soil*	NA	NA	NA	3.3	Ingestion of Groundwater	None
Future Resident - Child/Adult (CT)	Groundwater, Soil*	2x10^{-5}	NA	None	NA	NA	NA
Future Industrial Worker - Adult	Groundwater, Soil*	5x10^{-5}	NA	None	1.9	NA	None
Future Construction Worker - Adult	Groundwater, Soil*	1x10^{-6}	NA	None	1.2	Ingestion and Dermal Contact with Soil*	None

* - Surface soil & subsurface soil combined.
NA - Not applicable.
CT - Central Tendency.
CT results included for those Reasonable Maximum Exposure (RME) scenarios with risks that exceed EPA target levels (hazard index of 1.0 and carcinogenic risk of 1x10^{-4}).
All exposure scenario results presented in Table X are based on Reasonable Maximum Exposure (RME) with the exception of the residential Central Tendency (CT) results.

SECTION 5

Ecological Risk Assessment Summary

The ecological risk assessment (ERA) for Site 7, entitled *Draft Final Ecological Risk Assessment Site 7-Amphibious Base Landfill,* April 2004, was documented separately. The ERA includes a screening ecological risk assessment (SERA), constituting Steps 1 and 2 of the process, and the first step (Step 3) of a baseline ecological risk assessment (BERA). The following summarizes the conclusions as presented in the ERA.

Potential risks in wetland/aquatic areas of the site with good habitat quality (cove and wetland) were low based upon the frequency and magnitude of screening value exceedances. The available data suggest that potential exposures and risks to lower trophic level receptors are possible in the central portion of the canal. Cyanide and carbon disulfide each exceeded their respective screening values in surface water samples 202 and 211, respectively. In sediments from the central portion of the canal, copper, lead, aroclor-1260, and five pesticides were identified as COCs. However, the habitat value of the drainage canal is minimal so exposures are likely to be low. The canal, which is approximately 25 ft wide in the vicinity of the landfill, is essentially a linear ditch. The banks of the canal are steep (typically vertical) and are lined with a narrow fringe of woody shrubs and dense stands of phragmites. Emergent vegetation is relatively uncommon within the banks of the canal likely due to the water depth (at least several feet of water is typically present at low tide). In addition, these potential risks are likely to be spatially restricted since the available data do not indicate that these chemicals are migrating to areas with better quality habitat (e.g., Little Creek Cove), although some migration up the canal (southward) may be occurring. The collapsed culvert under the access road that crosses the canal may be acting as a barrier to northward migration in the canal.

In terrestrial areas of the site, three metals (lead, vanadium, and zinc) exceeded surface soil screening values and background concentrations. The highest concentrations of these three metals generally occurred near the location of the former metal collection and transfer site. However, the screening values for these three metals were based upon effects to terrestrial flora. Based upon qualitative surveys, Site 7 is densely vegetated with a variety of herbaceous and small woody plants, with no areas of bare soils evident. Screening values based upon effects to soil fauna for these three metals were much higher than the plant-based screening values. Mean HQs based upon the soil fauna screening values would be less than one. Thus, risks to lower trophic level organisms are low in the terrestrial portions of the site. Risks to upper trophic level terrestrial receptors were low to negligible as there were no HQs greater than one for terrestrial-based food web exposures.

Based upon the results of this ERA, the Tier 1 Partnering Team has reached consensus to conduct an Interim Removal Action (IRA), on a non time critical basis, in the drainage canal rather than proceed to Step 4 of the ERA process. The action, which will be documented in an Engineering Evaluation/Cost Analysis (EE/CA), will consist of removing the top foot of sediment from the area between sample location 218 and the northern abutment of Amphibious Drive. The existing access road culvert will also be permanently removed.

Following the sediment removal, one foot of clean fill will be placed in the excavated area of the drainage canal. No confirmation sampling will be required. The Tier 1 Partnering Team also agreed that the remainder of Site 7 does not present an unacceptable risk to ecological receptors.

SECTION 6

References

Allied Environmental, 1991 and 1992. *Background Investigation for Naval Amphibious Base Little Creek.*

American Cancer Society. 2002. *Cancer Facts and Figures – 2002.* American Cancer Society, Atlanta, Georgia.

CH2M HILL, October 1986. *Final Progress Report Round 1 Verification Step.*

CH2M HILL, October 1997a. *Project Plans for the Long-Term Monitoring Program at Site 7.*

CH2M HILL, October 1997b. *Proposed Remedial Action Plan, Site 7.*

CH2M HILL, January 1998. *Decision Document, Site 7.*

CH2M HILL, December 2000. *Background Investigation for Naval Amphibious Base Little Creek.*

CH2M HILL, February 2001. *Draft Revised Project Plans for the Long-Term Monitoring Program at Site 7 (Rounds 5 through 10).*

CH2M HILL, June 2001. *Site 7 Round 5 Long-Term Monitoring Letter Report.*

CH2M HILL, March 2002. *Site 7 Round 6 Long-Term Monitoring Letter Report.*

CH2M HILL, August 2002. *Site 7 Round 7 Long-Term Monitoring Letter Report.*

Ebasco Environmental Consultants, November 1991. *Draft Final Interim Remedial Investigation.*

Foster Wheeler Environmental Corporation (FWES), November 1994. *Final Remedial Investigation/Feasibility Study.*

Foster Wheeler Environmental Corporation (FWES), February 1997. *Draft Final Feasibility Study.*

HEAST. 1997. *Health Effects Assessment Summary Tables, Annual Update.* USEPA, Environmental Criterion Assessment Office, Office of Research and Development, Cincinnati, OH.

OHM Remediation Services Corporation, July 1997. *Draft Work Plan for Debris Removal Activities at Site No. 7.*

OHM Remediation Services Corporation, January 1999. *Site 7 Remedial Action Closeout Report.*

Rogers, Golden, & Halpern (RGH), December 1984. *Initial Assessment Study.*

USEPA. 1986. *Guidelines for Health Risk Assessment of Chemical Mixtures.* Federal Register Vol. 51 34014-34014. September 24, 1986.

USEPA. 1989. *Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual, Part A, Interim Final*. Office of Solid Waste and Emergency Response. EPA/540/1-89/002. December 1989.

USEPA. 1991. *Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual, Part B, Interim Final*. Office of Solid Waste and Emergency Response.

USEPA. 1992a. *Dermal Exposure Assessment: Principles and Applications*. Interim Report. Office of Research and Development. EPA/600/8-91/011B. January 1992.

USEPA. 1992b. *Draft Guidance on the Selection of Analytical Metal Results from Monitoring Well Samples for Use in the Quantitative Assessment of Risk*. EPA Region III. August 10, 1992.

USEPA. 1993. *Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening*. Region III, Hazardous Waste Management Division, Office of Superfund Programs. EPA/903/R-93-001. January 1993.

USEPA, 1994. *Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities*. OSWER Directive #9355.4-12. July 14, 1994.

USEPA. 1995. *Assessing Dermal Exposure from Soil*. Region III Technical Guidance Manual, Risk Assessment. Hazardous Waste Management Division, Office of Superfund Programs. USEPA/903-K-003. December 1995.

USEPA. 1996a. *Soil Screening Guidance: User's Guide*. Office of Solid Waste and Emergency Response, Washington, D.C. EPA/540/R-96/018. April 1996.

USEPA. 1996b. *Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil*. December 1996.

USEPA. 1999. Oral Abs Values for Oral-to-Dermal Extrapolation per RAGS Appendix A. Last Updated April 8, 1999.

USEPA, Summer 2000. *Drinking Water Standards and Health Advisories.*

USEPA. 2001a. User's Guide for the Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK), Windows Version. EPA 9285.7-42. October 2001.

USEPA. 2001b. *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), Interim.* EPA/540/R/99/005. OSWER 9285.7-02EP. September 2001.

USEPA. 2002 *Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual Part D, Standardized Planning, Reporting, and Review of Superfund Risk Assessments*. May 2002.

USEPA, NPL Site Narrative Listing. http://epa.gov/reg3hwmd/super/VA/naval-amphibious/pad.htm Updated May 2002.

USEPA. 2003a. *EPA Region III Risk-Based Concentration Table*. October 15, 2003.

USEPA. 2003b. Integrated Risk Information System Database.